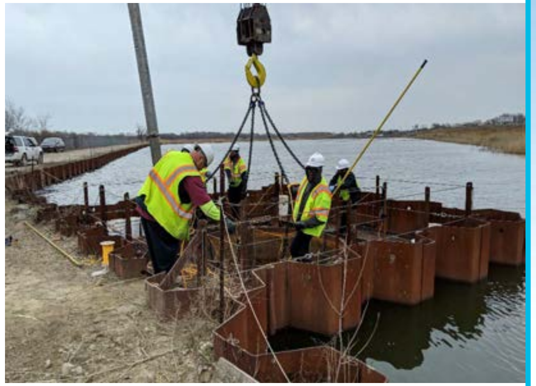
In-situ Solidification/Stabilization and Cutoff Wall Design and Construction

CDM Smith
Experience & Capabilities

Michael S Schultz, PE

Jagrut Jathal, PE

Meredith Passaro, PE



Standards of Practice and Lessons Learned

CDM Smith

Meeting Agenda

- Introduction
- Pre-Design Investigation
- Bench Scale/Treatability Study
- Pilot Study
- Construction Implementation
- Long-term Performance and Site

Introduction - Key Personnel

Michael S. Schultz, PE

Senior Vice President & Geotechnical Discipline Leader

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Jagrut Jathal, PE

Principal Geotechnical Engineer

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Meredith Passaro, PE

Geotechnical Engineer

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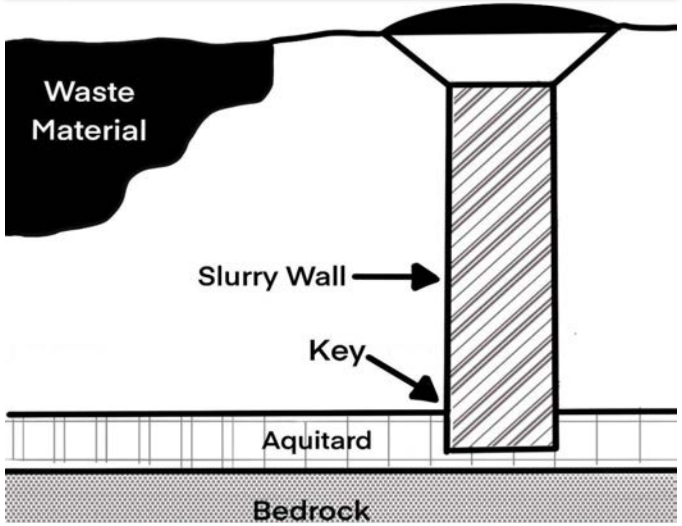
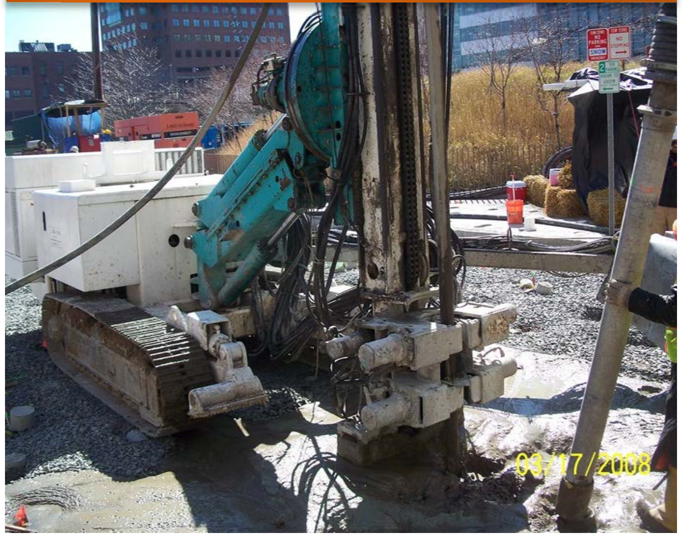
Definition of terms

Barrier Wall (Vertical Cutoff Wall)



Subsurface barrier to contain impacted groundwater, source areas and/or to redirect groundwater flow.

In-situ Solidification and Stabilization (ISS)



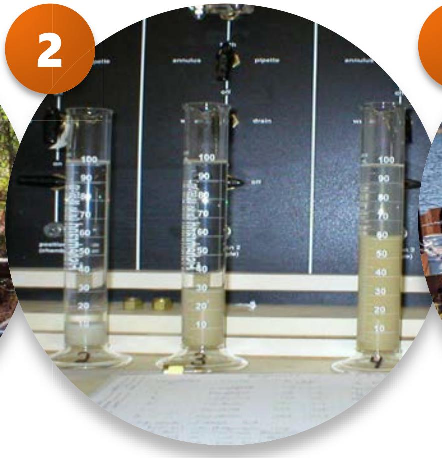
Uses of additives and processes to immobilize (solidification) or chemically bind (stabilization) contaminates.

Slurry Wall (Slurry Trench Cutoff Wall)

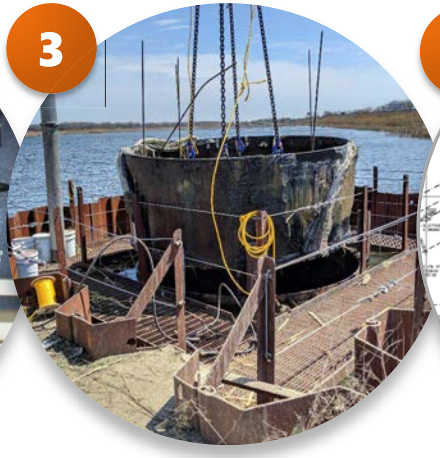
Soil Bentonite slurry is the most common type of vertical barrier wall but generally includes cement-bentonite, attapulgite and other less common barriers for waste contamination at hazardous waste sites.

Typical Project Lifecycle

Pre-Design Investigation



Bench Scale/ Treatability Study



Pilot Study

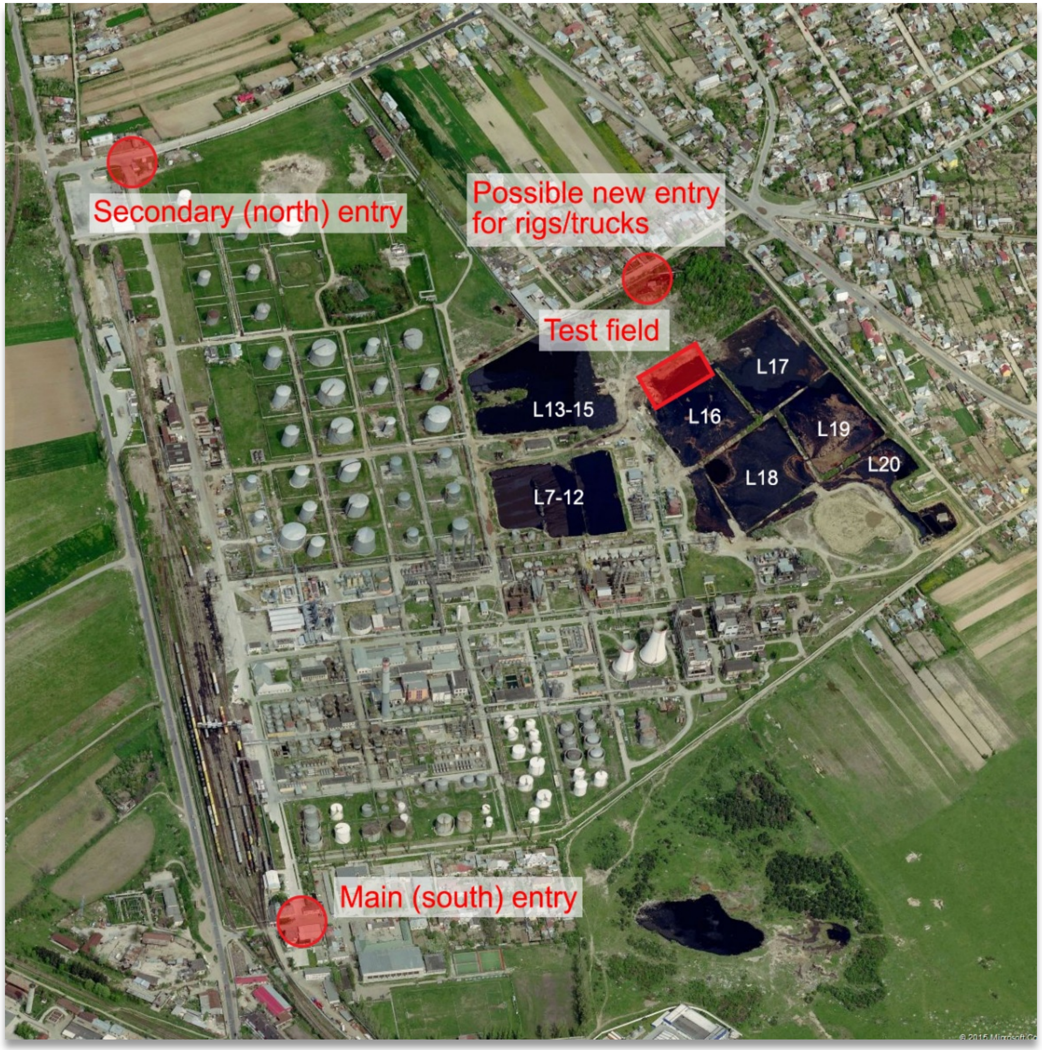
Design

Construction Implementation

Long-term Performance & Reuse

Existing Data Review

- ✓ **Identify Existing Subsurface Data**
- ✓ **Identify Site Constraints**
- ✓ **Identify Selected Remedy or Remedial Action Objectives**



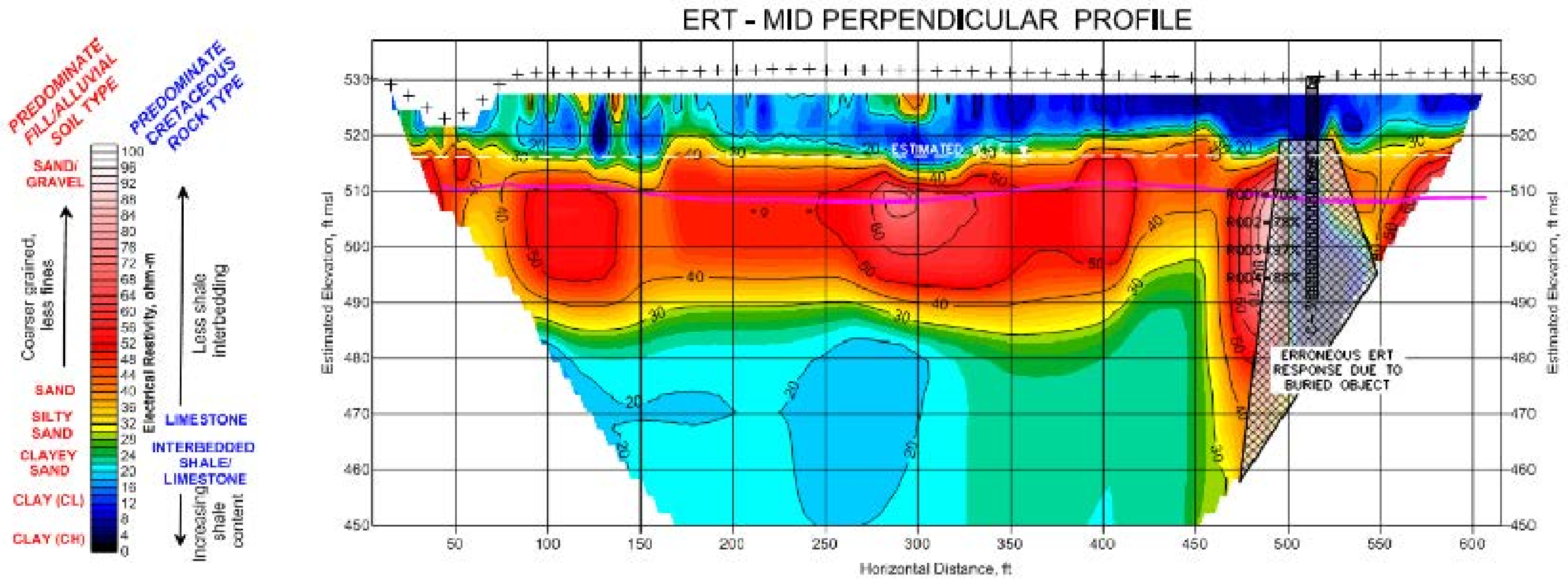
Preliminary Site Plan Evaluation Examples

Typical Data Requirements

Typical Data Requirements	Potential Design Impacts
Site accessibility and constraints	Construction mobilization and equipment considerations
Site Survey (Topo, Property limits, existing conditions)	Required for contract documents and construction.
Depth to confining strata or competent bedrock	ISS extents and/or depth and width of barrier wall
Degree of fractured rock	Determine if bedrock is adequate confining layer
Seismic Site Class and Fault Zones	Seismic and Liquefaction considerations.
Heterogeneity of subsurface conditions	Uniformity of ISS/Barrier Wall Implementation, installation level of effort
Vertical/Horizontal Hydraulic Conductivity	Confining strata characterization
Hydraulic conductivity of impacted soils	ISS/barrier wall mix design requirements (target hydraulic conductivity)
Groundwater Elevations	Barrier Wall height, ISS treatment extents
Excavated Soil Type	Backfill reuse evaluation, waste handling considerations
Chemistry of Soil, Groundwater, and Waste material (not only COCs)	Compatibility of ISS/Barrier Wall mix design with site conditions, waste handling considerations

Pre-Design Investigation (Non-Intrusive Techniques)

Investigation	Investigation Purposes	Investigation Methods
Geophysical Investigations/Surveys	• Karst Evaluation • Soil Stratigraphy and Parameter Evaluation • Partially Weathered Rock/Bedrock Interface • Seepage Evaluation • Structural Evaluation (existing sheet piles, etc.)	• Electrical Resistivity (ER) • Seismic Refraction (SR) • Multichannel Analysis of Surface Waves (MASW) • Ground Penetrating Radar (GPR)

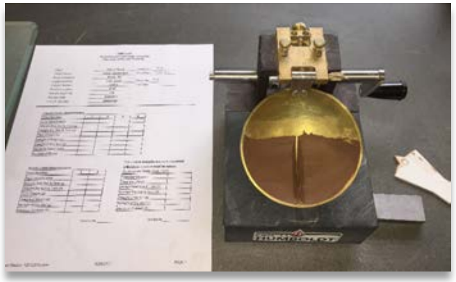


Pre-Design Investigation and Sample Collection

Investigation	Investigation Component
Soil and Rock Investigation	• Conduct Test Boring Using Standard Penetration Testing (SPT) (ASTM D1586) • Undisturbed Sample Collection (ASTM D1587) • Cone Penetration Testing (CPT) • Collect samples for geotechnical index testing and chemical characterization • Perform rock coring, as required
Groundwater Investigation	• Install Monitoring Wells • Conduct In situ Conductivity Testing • Collect samples for chemical characterization

Soil and Groundwater Laboratory Testing

Sample Type	Typical Laboratory Testing
Physical Soil	• Sieve Analysis (ASTM D6913, ASTM D1140, ASTM D7928) • Moisture Content (ASTM D2216) • Unified Soil Classification System (USCS) Classification (ASTM D2488) • Atterberg Limits (ASTM D4318) • Organic Content (ASTM D2974) • Bulk Density (ASTM D7263) • Specific Gravity (ASTM D854) • Triaxial Testing (shear strength) • Hydraulic Conductivity Using Flexible Wall Permeameter (ASTM D5084) • Consolidation/Compression Testing • Mineralogy (as required)
Groundwater	• Install Monitoring Wells • Conduct In situ Conductivity Testing • Collect samples for chemical characterization



Bench Scale/Treatability Study Goals and Sample Collection

Study Goals

- ✓ Determine most suitable ISS processes that can meet the remedial objectives.
- ✓ Evaluate and locally available ISS additives.
- ✓ Evaluate groundwater compatibility.
- ✓ Identify parameters for providing quality assurance/quality control of the selected ISS processes.

Sample Collection

- ✓ Collect adequate bulk volume of soil and groundwater samples to perform study.
- ✓ Various bulk sampling collection methods.

Bench Scale/Treatability Study Laboratory Testing

Sample Preparation

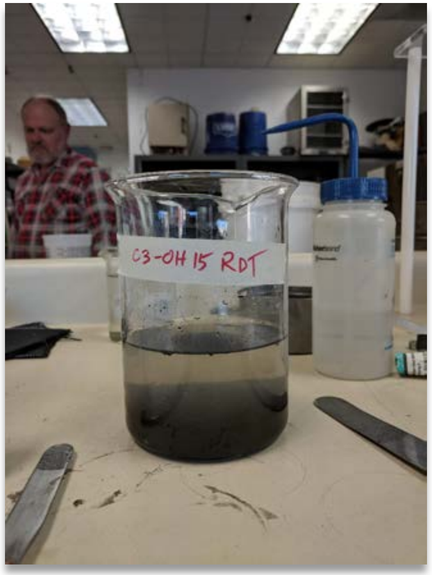
- Jar Testing
- Hanging bag/Rapid Dewatering Test
- Paint Filter Tests

Physical Soil Testing

- Unconfined Compression Test (ASTM D2166)
- Hydraulic Conductivity (ASTM D5084)

Leachate Testing

- Toxicity Characteristic Leaching Procedure (TCLP)(EPA 1311)
- Synthetic Precipitation Leaching Procedure (SPLP) (EPA 1312)
- Semi-Dynamic Leachate Testing



Slurry Compatibility and Physical Testing

Slurry Testing

- Unit Weight with mud balance (ASTM D4380)
- 10-minute Viscosity (Brookfield Viscometer)
- Marsh Funnel (API-13B-1)
- pH
- Free Swell Testing (ASTM D5890)

Workability Testing

- Concrete slump testing (ASTM D4380)
- Atterberg Limits (ASTM D4318)

Hydraulic Conductivity Testing

- Hydraulic Conductivity (ASTM D5084)

Compatibility Testing

- SW-846 Test Method 9100 – Saturated Hydraulic Conductivity, Saturated Leachate

Before Mixing

After Mixing

Free Swell Test

Compatibility Testing

Pilot Testing

- Often recommended that a pilot test be conducted for the selected ISS mix design and/or selected cut off wall technology prior to design
- The pilot study offers an opportunity to better understand additional issues and scaling up for full construction implementation
- Pilot test design to mimic key issues for implementation and contractor bidding to reduce uncertainty

Pre-Design, Bench Scale/Treatability Study & Pilot Study Phases

Case Study Review

Brunswick Wood Preserving Site

Brunswick, GA

How site constraints impacted additional investigations and bench scale studies informed design

Hunter's Point Naval Yard – Parcel E

San Francisco, CA

Lessons learned during pilot study implementation

Ralston Street Lagoon

Gary, IN

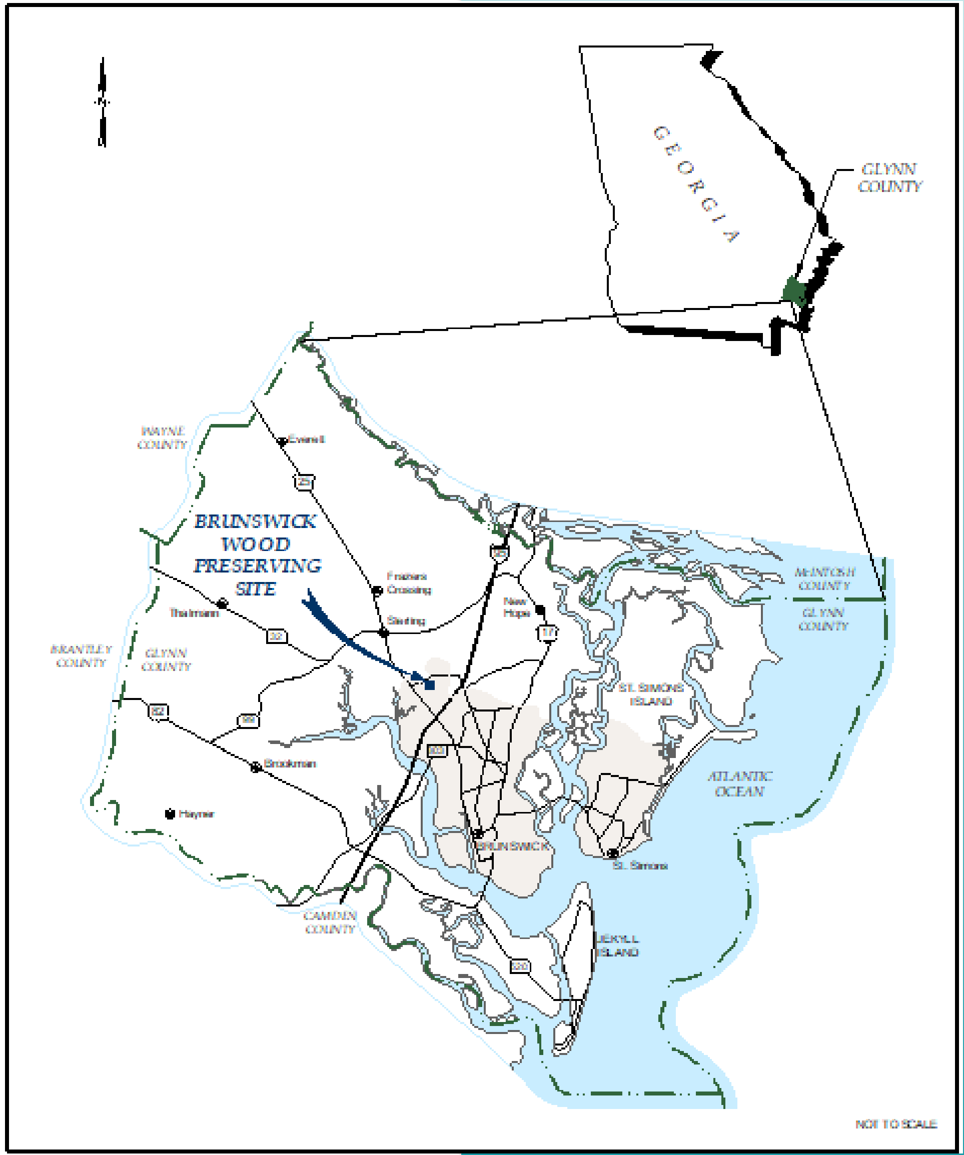
Multi-phased construction project with multiple pilot studies conducted

Brunswick Wood Preserving Site

Brunswick, GA

Site Overview and Background

- Site History and Use
- Contaminants of Concern
- Site Logistical Challenges
- Selected Remedial Action
  - Solidification and/or stabilization
  - Engineered Cap
  - Subsurface Barrier Wall, keyed into weathered limestone approximately 50-60 feet deep



Brunswick Wood Preserving Site

Brunswick, GA

Lessons Learned

- Existing Geotechnical Data Gaps
  - Geotechnical data on surface, subsurface soils and sediments at the site
  - Characterize the physical properties of the subsurface soils and limestone layer
  - Collect samples for stabilization/solidification studies
  - Conduct compatibility testing for barrier wall mixture

Hunter’s Point Naval Yard – Parcel E

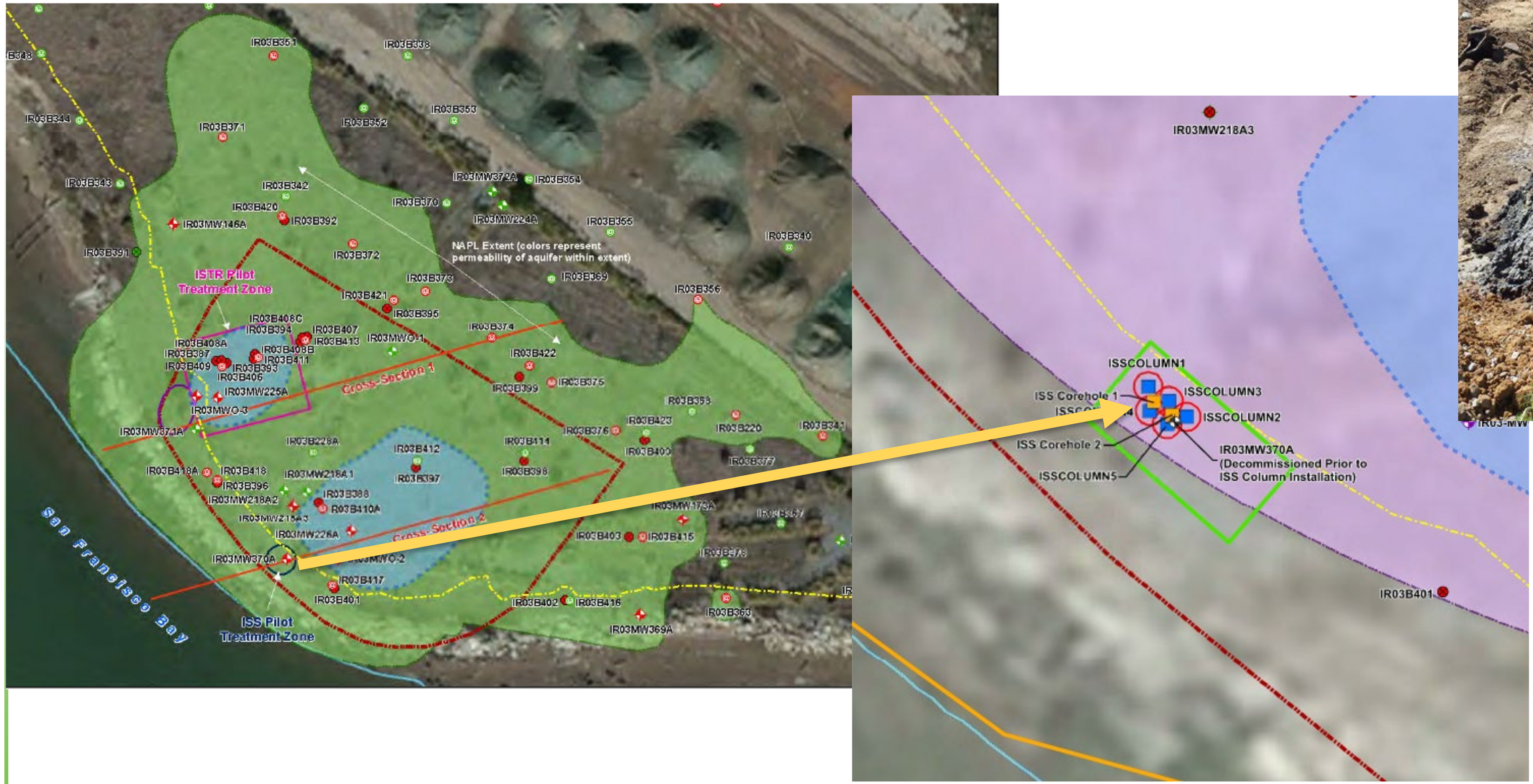
San Francisco, CA

Site Overview & Lessons Learned

- **Contaminants of Concern Detected:**
  - Free product (LNAPL)
  - VOCs, SVOCs, metals, Total petroleum hydrocarbons (TPH), and polychlorinated biphenyls (PCBs)
- **Lessons Learned:**
  - Numerous obstructions were encountered
  - Identify quantity of bay mud incorporated into the soil column
  - Number of passes was identified (total of 5).
  - Verification sampling and testing was able to confirm in-situ permeabilities
  - Slurry Compatibility Testing Conducted for seawater.

Hunter's Point Naval Yard – Parcel E

San Francisco, CA



Ralston Street Lagoon

Gary, IN

Project Overview and Design Approach

Contaminants of Concern:

- PCBs

Phase I Site Works (2001-2012):

- Raise perimeter berm
- Install steel sheet pile wall
- Install soil-bentonite slurry wall and weir structure for water collection and control

Pilot Studies Conducted (2013 – 2019):

- ISS Pilot Study
- Compression Cap Pilot Study
- Grand Calment Sediment ISS Evaluation

Ralston Street Lagoon

Gary, IN

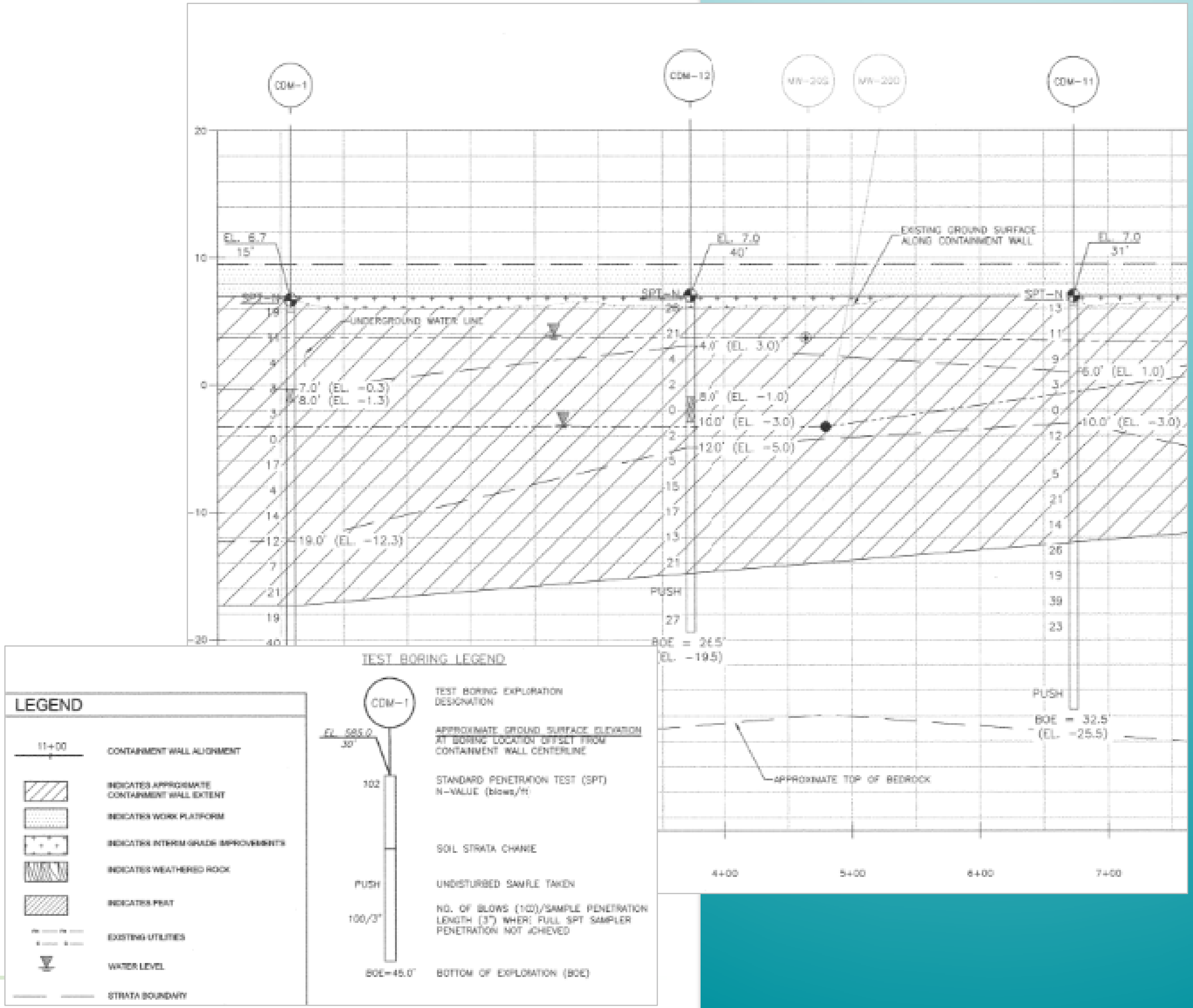
Design Phase - Basis of Design Development

Design Parameters:

- Soil Profile
- Groundwater Elevation
- Flood Considerations
- Seismic Considerations
- Future Site Use

Construction Considerations:

- Implementation/Construction Strategies and Sequencing
- Earthwork Considerations and Construction Monitoring



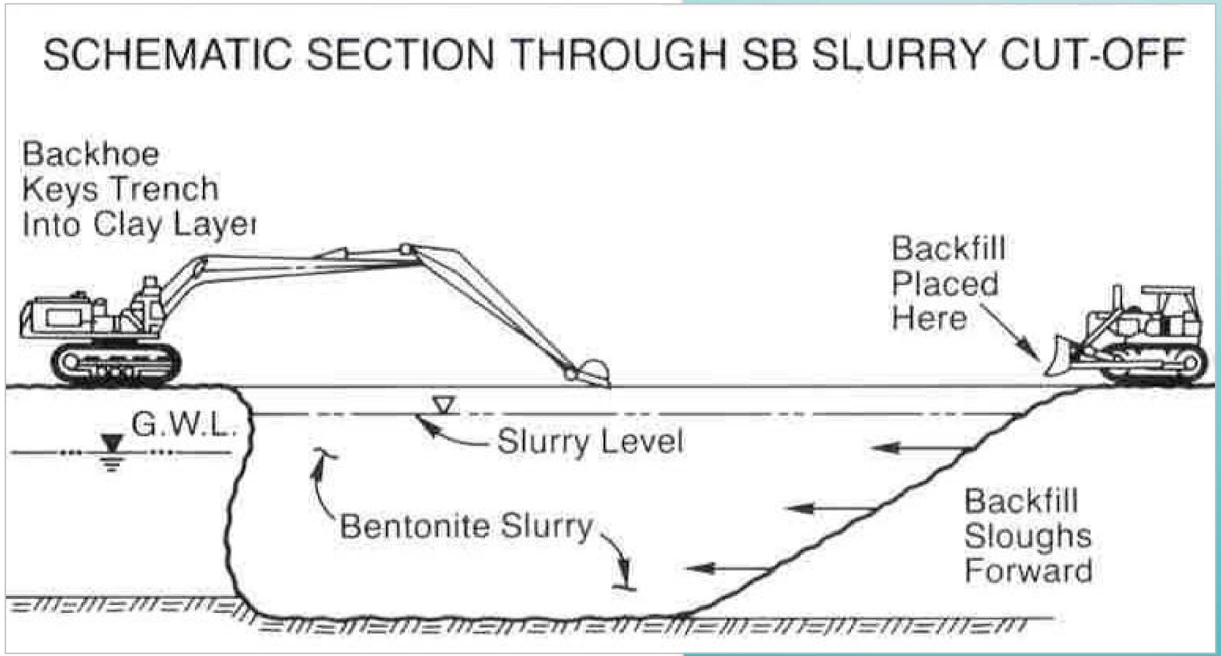
Design Phase - Review Applicable Cutoff Wall and ISS Technologies

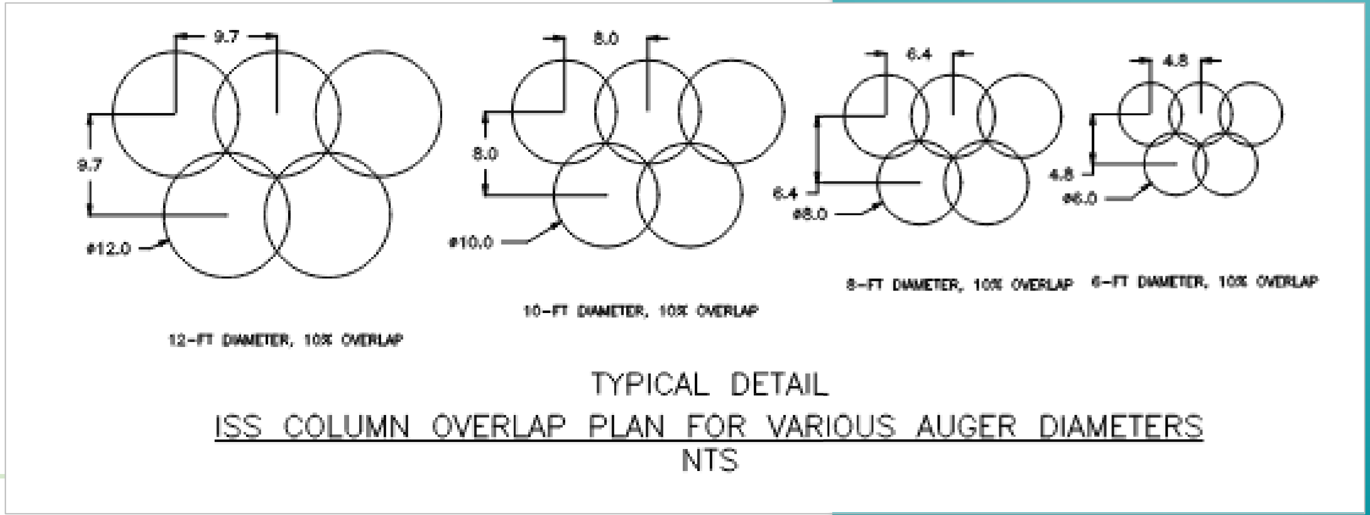
Cutoff Wall Type

- Compacted clay
- Slurry walls
  - Soil-Bentonite (SB)
  - Cement-Bentonite
- Grouted barriers
  - Jet grouting
- Mixed in place
- Steel sheet piles

Cutoff Wall Type

- In-situ mixing
  - Secant pile approach
  - Mixed with excavator bucket
  - Single pass mixing
- Steel sheet piles





Design Phase

Case Study Review

Tobin School Redevelopment

Cambridge, MA

How to account for elements of demolition and redevelopment during the design phase

LCP Chemicals, Inc.

Linden, NJ

Performing an alternatives analysis to determine the best approach for slurry wall design

Tobin School Redevelopment

Cambridge, MA

Site Overview and Background

Contaminants of Concern:

- Metals, specifically Lead
- VOCs
- SVOCs

Alternative Analysis:

- Excavate and Replace
- Excavation Support: Sheet Piles, Slurry Walls, Secant Pile Walls
- ISS

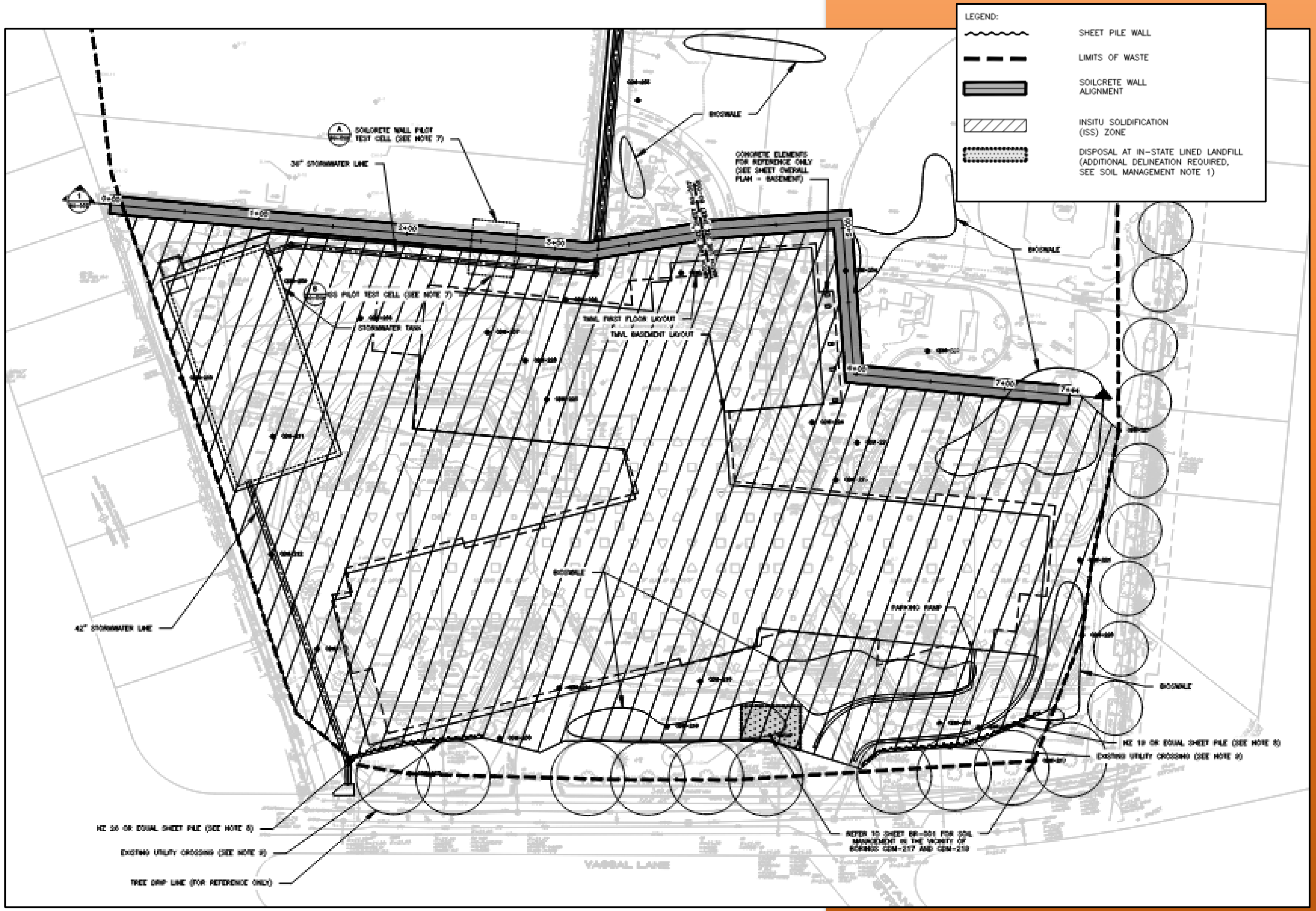
Tobin School Redevelopment

Cambridge, MA

Design Approach & Lessons Learned

Selected Remedial Approach:

- Partial Soilcrete Wall
- ISS of Waste Fill
- Sheetpile Excavation Support



LCP Chemicals, Inc.

Linden, NJ

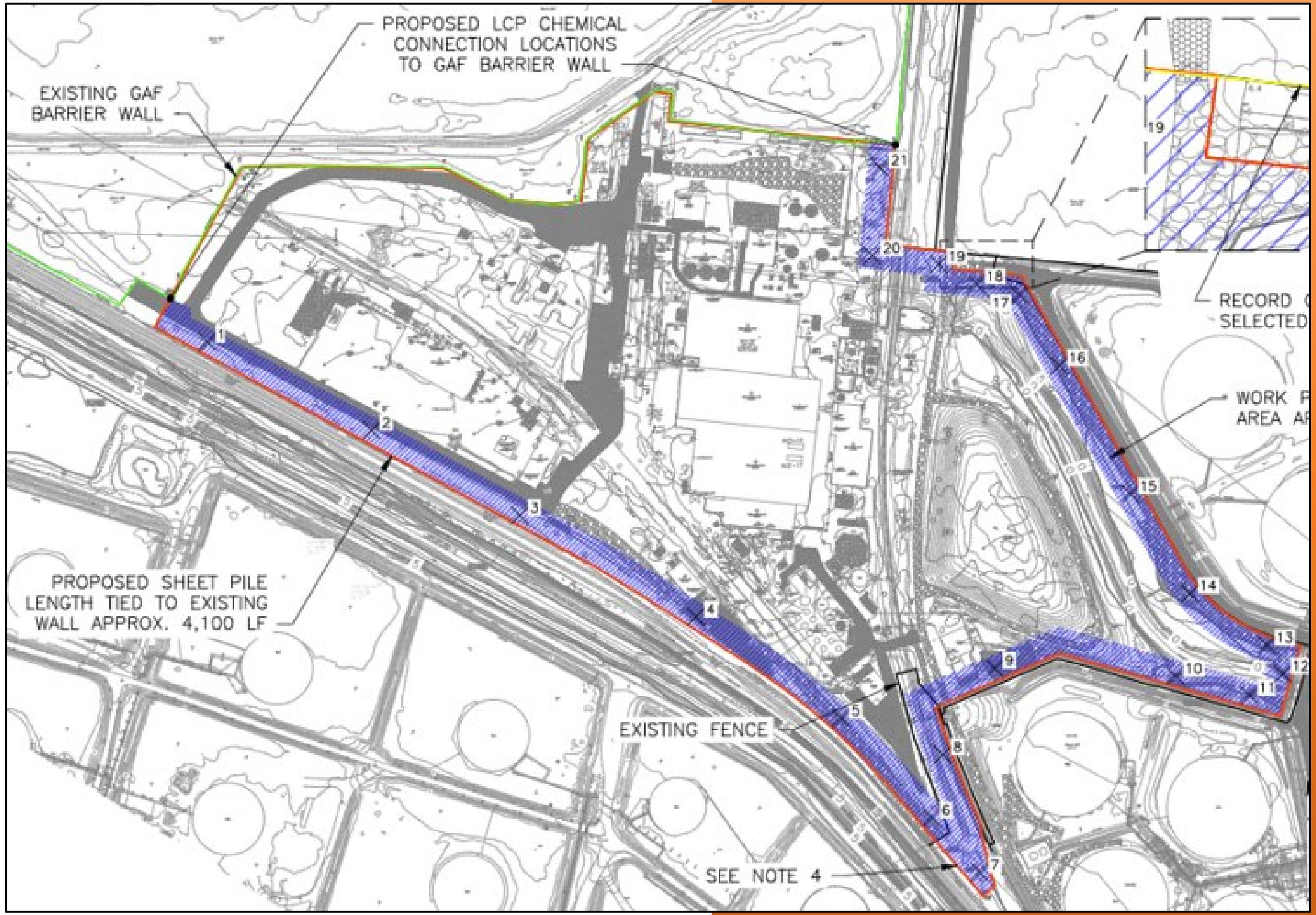
Site Overview & Background

Contaminants of Concern:

- Elemental Mercury and mercuric sulfide hydrocarbons (PAHs))

Alternatives Analysis:

- Steel Sheet Pile Barrier Wall
- Synthetic Sheet Pile Barrier Wall
- Soil-Bentonite Slurry Wall (Clamshell or Long-Arm Excavator)
- Cement-Bentonite Slurry Wall (Clamshell or Long-Arm Excavator)
- Secant Pile Barrier Wall



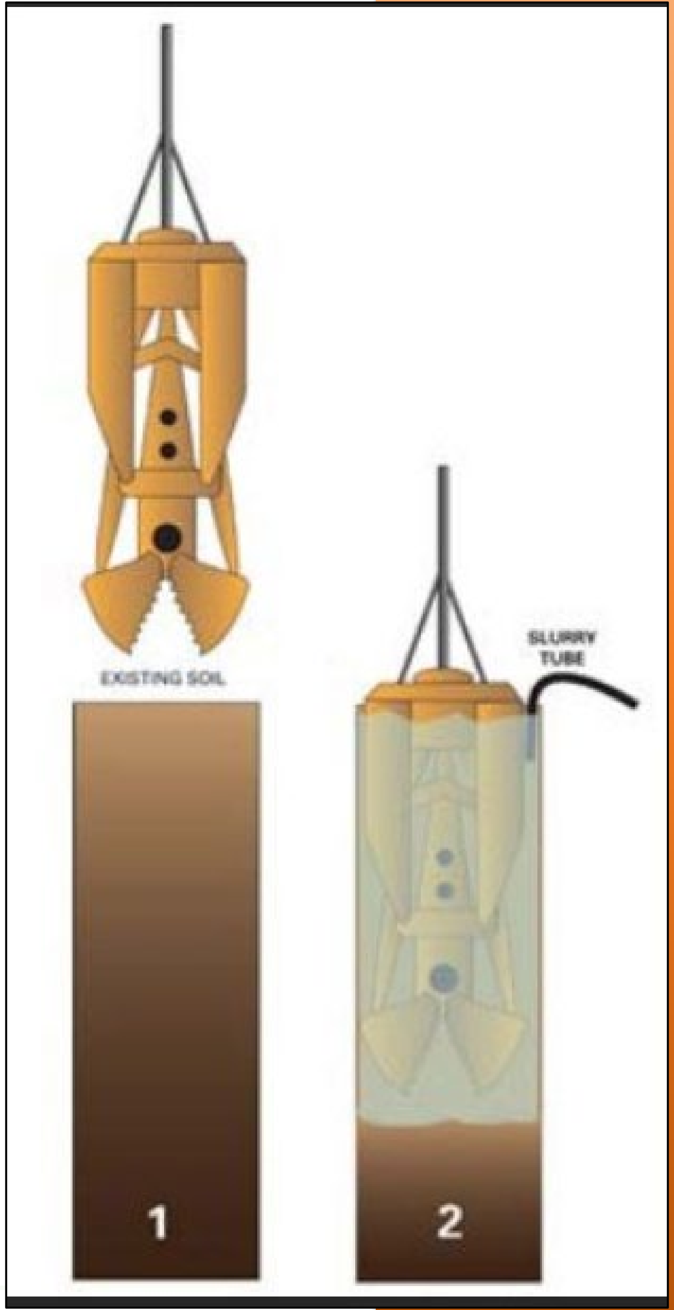
LCP Chemicals, Inc.

Linden, NJ

Design Approach & Lessons Learned

Selected Remedial Approach:

- Cement-Bentonite Slurry Wall Installed by Clamshell Excavator
- Depth: 22 to 28-feet (5 feet into Glacial Till)
- Nominal Thickness: 3-feet



Construction Implementation

Construction Quality Assurance and Quality Control:

- Sampling and testing of the slurry for unit weight, viscosity, and filtrate loss.
- Inspection of Trench Geometry width, depth, key penetration, verticality, continuity, stability, and bottom cleaning
- Sampling and testing of backfill for unit weight, slump, gradation, permeability, leachate, and unconfined compressive strength
- Proper handling and processing of contaminated soils or backfill used during installation

Construction Implementation Phase

Case Study Review

OK Tool Source Area, Savage Well Superfund Site

Milford, NH

How to avoid “windows” in the slurry wall and proper CQC and CQA sampling. Site was successfully closed.

Whitehouse Waste Oil Pits

Jacksonville, FL

Mix design and trench stability issues

OK Tool Source Area

Milford, NH - COC = DNAPL

Site Overview & Lessons Learned

Construction Elements of Concern:

- "Windows" in the slurry wall

Completed Construction:

- Soil-Bentonite Slurry Barrier Wall (Completed 1998) and Groundwater Extraction and Treatment System
- 1500 linear-foot wall, average depth of 80 ft (areas over 100 ft deep)
- Two stage excavation
  - Long stick excavator up to 70 ft bgs
  - Hydraulic clam shell 70 ft to 110 ft bgs

Waste Oil Pits

Jacksonville, Florida; COC = Creosote

Site Overview & Lessons Learned

Construction Elements of Concern:

- Trench Stability

Completed Construction:

- Soil-Bentonite Slurry Barrier Wall (3-foot wide, 3,078 feet long, to an average depth of 70-feet)
- ISS treatment area of approximately 3.9 acres comprised of 8 former waste oil pits

Lessons Learned:

- Bentonite Issues – trench collapse (old fill area), bentonite reacted with the fill material
- Adequate characterization along proposed barrier wall alignment

Trenching Near Station 19+00 Heading North of Site

Long-term Performance and Future Site Use

Case Study Review

Aluminum Manufacturing Plant

Site closure and overview of post closure care

Cambridge Research Park

Cambridge, MA

Future site uses and impacts to design

Aluminum Manufacturing Plant

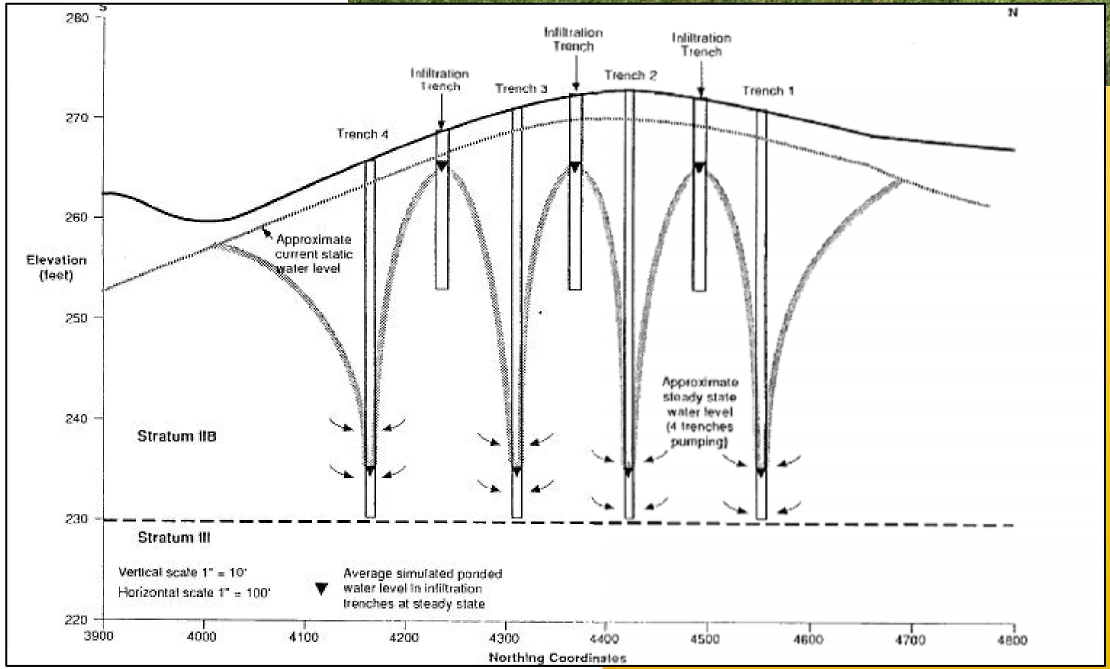
Site Overview & Long-term Performance

Site History and Remediation (1994-1996):

- Phase 1 Remediation – excavation of waste material and contaminated soil, interim grading
- Phase 2 Remediation – installation of biopolymer groundwater collection trenches

Long-term Performance and Closure Care:

- Site closed 20+ years
- Operate leachate collection and removal until no longer detected
- Maintain and monitor groundwater monitoring system
- Capping of trenches



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Site Overview & Background

Proposed Construction:

- 6-story building above grade, 6 levels of below grade parking

- In-situ stabilization with cement slurry
- Wet soil mixing
- Challenges:
  - Subsurface obstructions
  - Odor mitigation
  - Demonstration of compliance with real time monitoring

Cambridge Research Park

Cambridge, MA

Kendall Square Construction

Slurry Wall Design:

- Support perimeter of above grade building
- Temporary Support of excavation system with internal bracing for below grade parking

Cambridge Research Park

Cambridge, MA

Future Site Use

Questions and Answers

Please Remember to Enter Your Question in the “Questions” Tool Bar