Stabilization and Beneficial Use of Contaminated Sediments Applying Mobile Pneumatic Flow Tube Mixing for a Circular Economy

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E.A. Stern, R. Miskewitz, A. Maher[2], A. Kovalik, M. Kitazume[3] , D. Yang [4] and A. Ringen[4]

[2]Rutgers University
[3]Tokyo Institute of Technology
[4]JAFEC USA

Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth

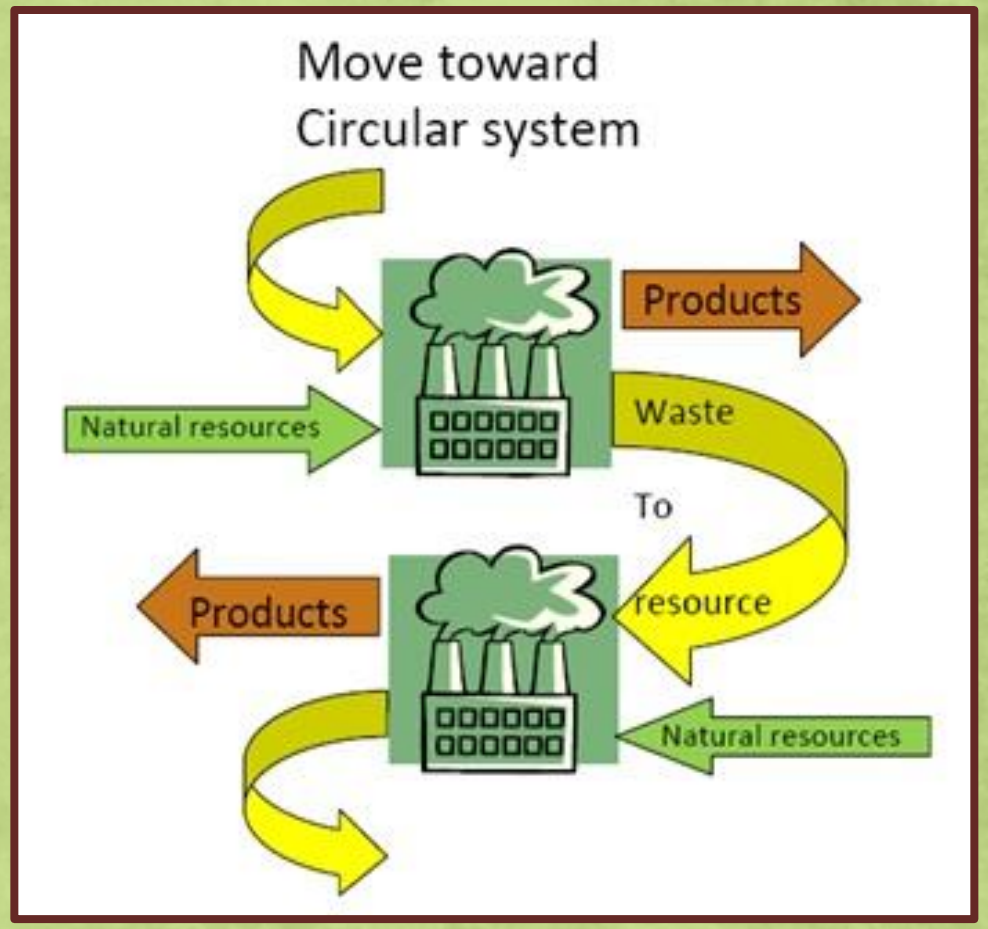
Thesis:

- It's about stabilization of contaminated sediments but more about the Messenger / Delivery System
- Minimizing long distance transport to landfills (unrenewable resources – GHG/LCA)
- Reverse Engineering to the Vision Proposition with an Innovative Process and Outcome
  - Apply Beneficial Use
  - To be integrated into Sustainability Metrics in Remediation Remedy Selection
    - Difficult to do after the remedy is decided
- Barge mounted system that allows project/program flexibility not realized especially in complex urban systems
  - Develop platform / systems engineering to support PFTM

Advancements: Eco-Industrial/Circular Economy Beneficial Use – 1st Generation

- Waste of one process becomes the resource for another: (LCA) / Sustainability Metrics
- End-of-pipe view to a market-led substitution:
  - Zero energy systems
  - Material substitution
  - Reduced Raw Material Consumption
  - Functional Economy (jobs)

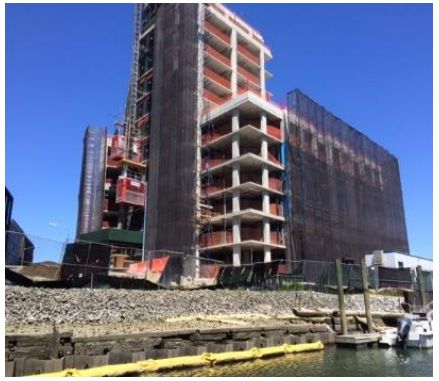
CEAMaS – NL, UK, Ireland, Germany, Belgium, FR
Cement-Lock[tm] – Volcano Partners, LLC
Envisan – Jan Du Nul - France
TREVI/3V Green Eagle Sediment Washing – Italy
SETARMS - France



[Urban] Regional Sediment Management (USM)
Contaminated Sediment Systems

- ***Sustainability / Resilience***

➢ ***Eco-psychology***
  - ➢ *Behavioral understanding of moving forward*
    - ➢ **Open to Change - Innovation**
    - ➢ Urban – City / Port Environment / **infrastructure**
    - ➢ Leadership
    - ➢ Stakeholders / Partners (PRPs)
    - ➢ ***Different brain wiring – short vs. long-term horizons***
      - ➢ *community – political - business interests*



- ***Integrated Sediment Management***
  - **Hybrids – Holistic – Innovative Technology Approaches**
    - Multi Contaminants / Multi Media / Beneficial Use
  - Regional Sediment Management – SOURCE CONTROL
  - Adaptive Management
  - ***Linkage of Engineering with Societal Goals***
- ***Net Environmental Benefit - Vision***
  - Sediments replacing non-renewable resources (economic re-development)
    - Ecosystem – Industrial Approach
      - Local Economy
      - ➢ **Reverse Engineering the Remedy (Sustainability Metrics)**

2nd Generation:

- ✓ Benefits are accrued by mutually realizing the "vision" of the pre and post remediated community as well as the **industrial investor** - achieving revitalization (both environmentally and economically) by strengthening of the built environment

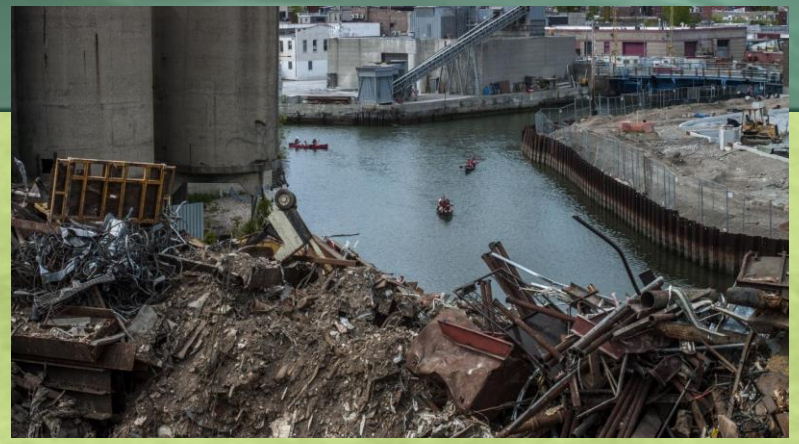
Reverse Engineering = Circular Economy for Beneficial Use of Sediments (technology driven)

HARD STRUCTURE

SOFT STRUCTURE

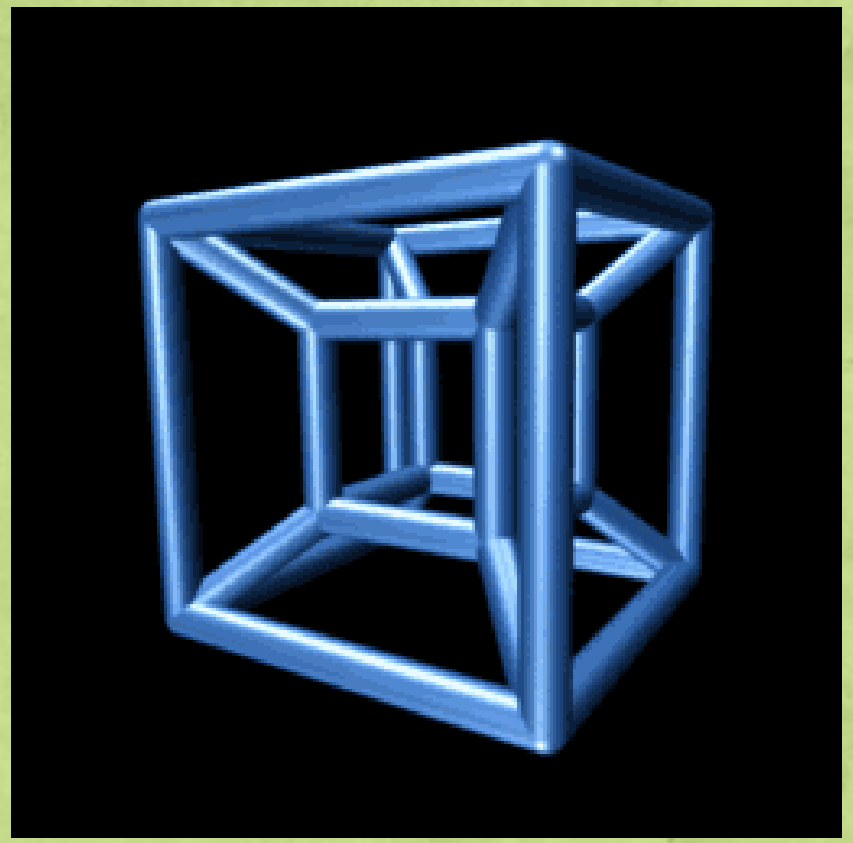
GOWANUS CANAL – Brooklyn, New York

3 km



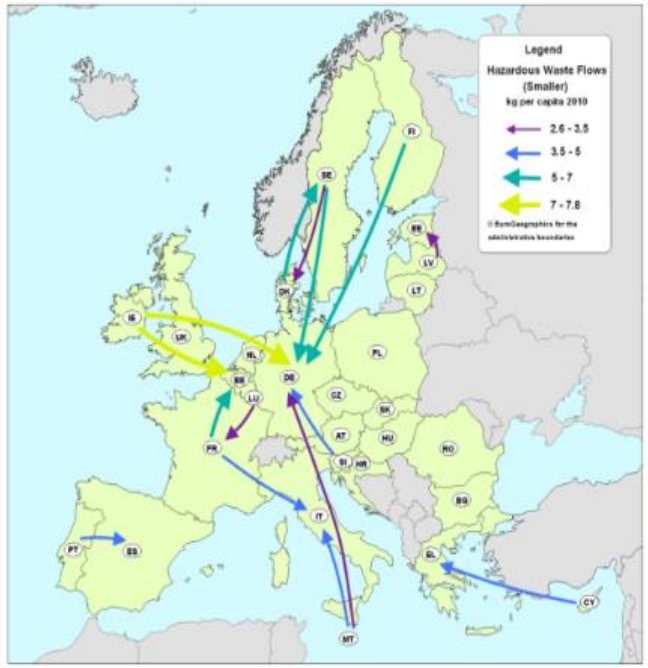
Challenges of Remediation in a Urban Sediment Management
Circular Economy - 4D

- TIME
- SPACE
- DISTANCE
- ➢ *INNOVATION*
  - 0^{th} Dimension
    - PFTM
    - **$$ €€**



Don't do this →

Sediment Disposal Sites (landfills/incineration) – $$ US / €€ EU



CAD
CDF
NIMBY
Environmental Justice

Global Multiple Waste Management

- sediments (Haz) - sewage sludge - MSW

WASTE MANAGEMENT ARLINGTON, OR

WASTE MANAGEMENT MODEL CITY, NY

CLEAN HARBORS ARAGONITE, UT

CLEAN HARBORS KIMBALL, NE

CLEAN HARBORS WAYNOKA, OK

PASSAIC RIVER PHASE I SITE

WASTE MANAGEMENT EMELLE, AL

CLEAN HARBORS LAPORTE, TX

VEOLIA PORT ARTHUR, TX

LEGEND

- INCINERATOR FACILITY
- LANDFILL FACILITY

Sediment Stabilization

- Solidification/stabilization (S/S) is a well-established strategy for the treatment, dewatering and improvement of contaminated sediments, soils and several waste materials
- S/S is a commonly used treatment technology in the US and around the world for a wide range of remediation projects including management of radioactive and hazardous wastes, and contaminated site remediation and Brownfield redevelopment
- The US Environmental Protection Agency has completed several remedial actions using S/S as the primary treatment technology. It has been shown to be effective for a wide variety of organic and inorganic contaminants found in contaminated sediment, soil, and other waste types
- The most successful treatment strategy is the S/S with Portland cement and beneficial use at upland sites and/or efficient trans-loading shipments. To date, approximately 23 million cubic meters of stabilized dredged materials have been applied at a variety of placement sites throughout New Jersey

Treatment and Materials Science Research/Applied Programs Working Towards a Sediment Circular Economy Beneficial Use

- Sedi.Port.Sil
- CEAMaS
- SETARMS
- SEDILAB
- EcoSed
- GeDSET
- Sedimateriaux Approach

➢ New York/New Jersey Harbor Sediment Decontamination Program (USEPA/NJDOT/Brookhaven National Lab)
  - Changing perception of sediments as a waste to a sustainable resource

- 2019 CEDA Position Paper on the Beneficial Use of Contaminated Sediments
- Global Case Studies

Challenges with In-Barge S/S

- Debris
- Uneven Mixing
- One mix for entire barge
- Often over/under design mix
- Dust and Air Emissions

Boskalis – Membrane Dewatering
Lower Passaic River, New Jersey

Pneumatic Flow Tube Mixing Operations (small footprint)

EIS Associates,
NY/NJ Harbor

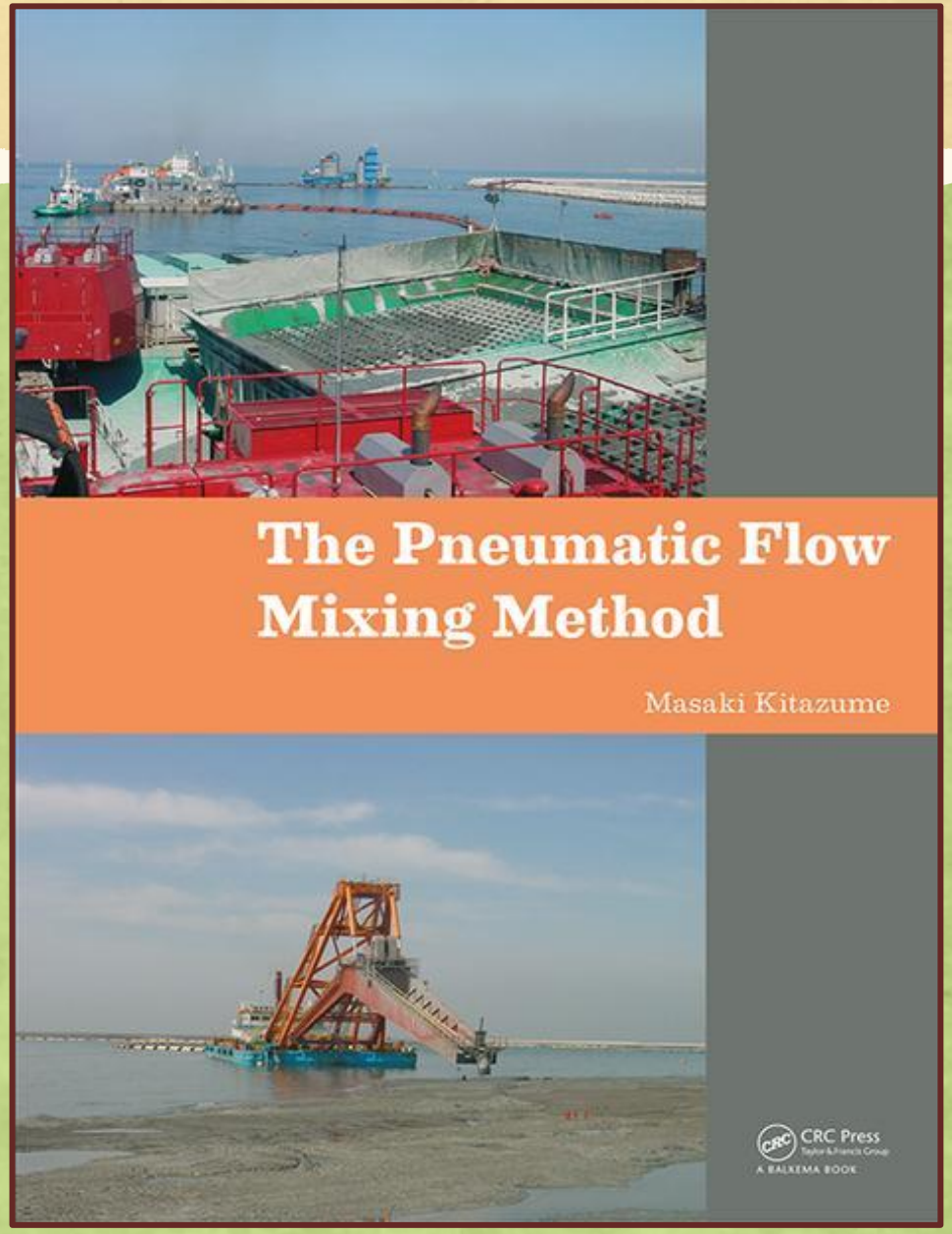
Dredged Material Cement Pug Mill / Geotube Operations (large footprint)

PFTM Background

Pneumatic Flow Tube Mixing (PFTM)

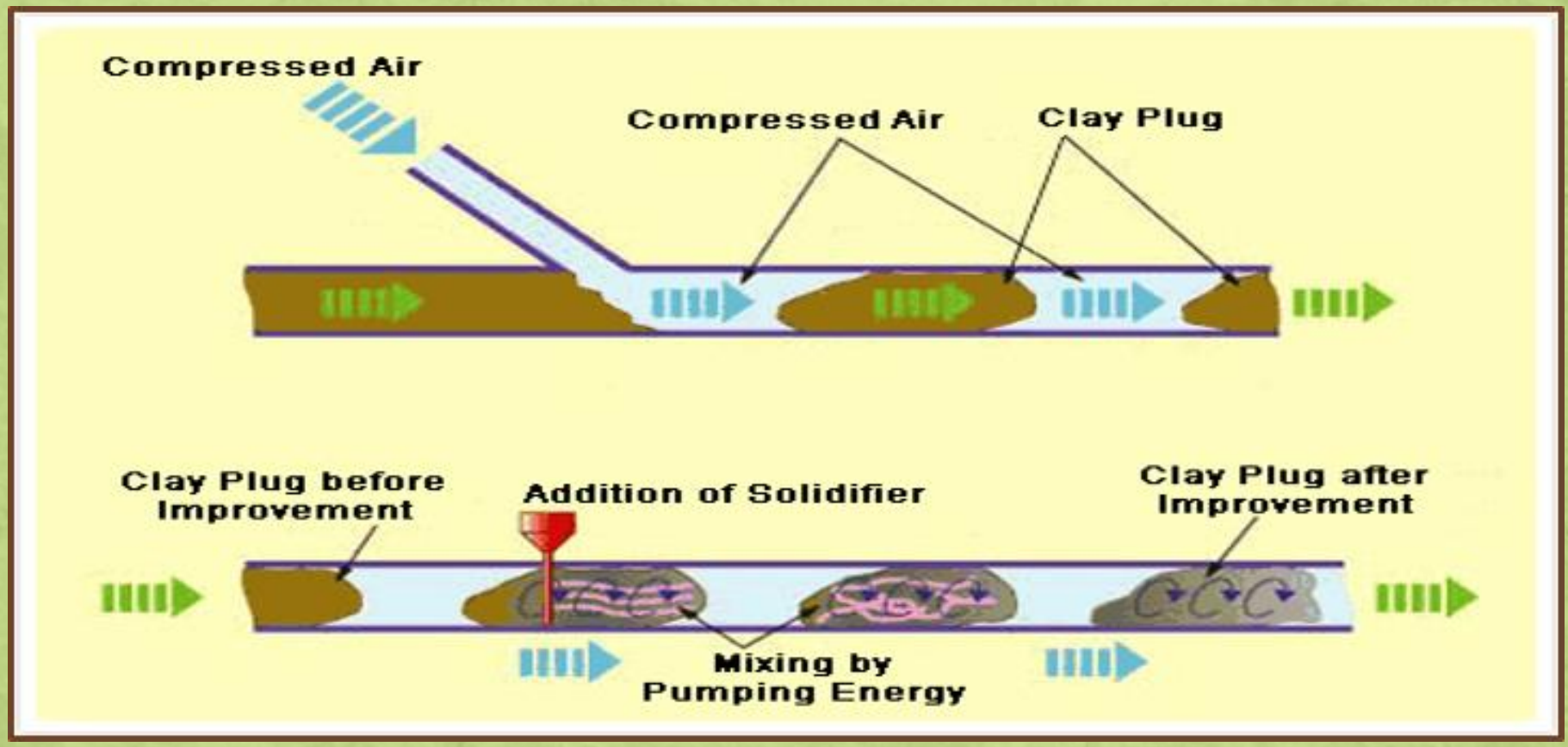
- Developed in Japan in early 2000 for large scale reclamation projects using fine silty clay sediments
- Many successful examples including reclamation works for Tokyo (Haneda-2010) and Central Japan (Chubu-2005) Airport Projects.

Kitazume, 2016 CRC Press, ISBN 9781138029842 - CAT# K30201



Pneumatic Flow Tube Mechanism

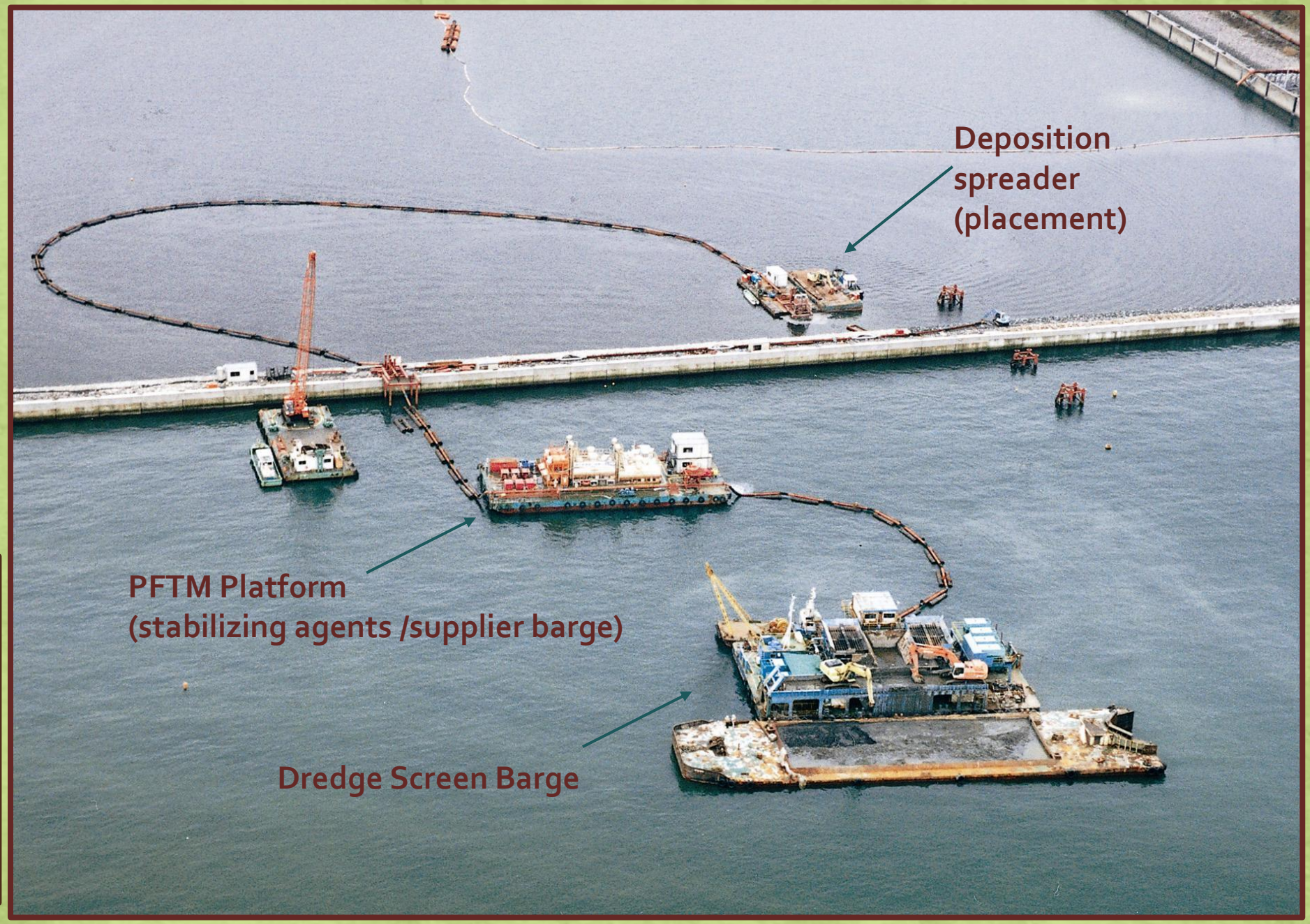
"Soft sediment is broken into "plugs" by compressed air. Plugs reduce pipe surface friction easing flow. During transport cement and clay are mixed by the turbulent flow within the 'plug'." - Kitazume 2002



PFTM Process Flow (Detailed)

Haneda Airport Reclamation 2010

PFTM Process Flow – 7.6K m^3/Day (Japan)



Pneumatic Flow Tube Mixer (PFTM) 1st Generation NY/NJ Harbor (2015)


Pumped up to 1 km
Further with booster


Pneumatic Tube Mixing for
Contaminated Soft Sediments


Amended dredged material
pumped from PFTM
Hardened / cured
dredged material
as structural fill -
one day

PFTM Applications and Placement Options

- **Environmental**
  - Solidification/Stabilization of contaminated soft sediments **(no dewatering or H_2O Treatment)**
    - ➢ Remediation: materials handling transport alternatives – **direct pumping upland or sub-aqueous capping / habitat restoration**
      - *Superfund (complex footprints and infrastructure)*
      - *MGP and Utilities Sites*
  - Brownfields
  - Upland beneficial use of unsuitable dredged materials not meeting aquatic placement criteria (open H2O)
  - Coastal Restoration
  - ➢ Coal Combustion Residues (CCR)
  - ➢ Sediments loads behind Dams
  - Rapid and efficient utilization of stored CDF materials / lagoons
  - Landfill cover

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

- **Allows Project Flexibility in Design and Construction Options**

PFTM Placement Options (continued)

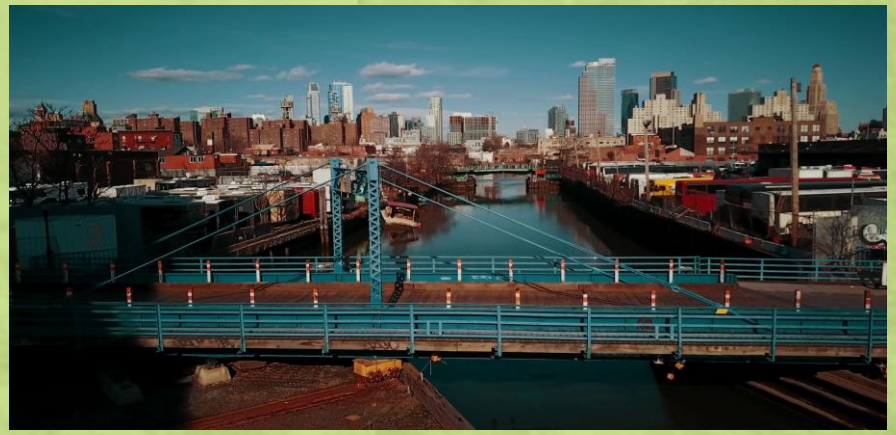
- PFTM system is ***barge mounted*** and can deploy to any coastal site / Can be operated **land side** and work interior (lagoon or dock)
  - Anchored to a Regional Dredged Material Manufacturing Facility (RDMMF)
  - Operating directly adjacent to project site and pump upland for beneficial use / landfill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

- Integrates contaminated sediment placement with fill required at many coastal sites
  - Raising/elevation for flood protection
  - 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 and/or challenging urban infrastructure to a trans-loading facility or used internally for BU / structure - habitat**

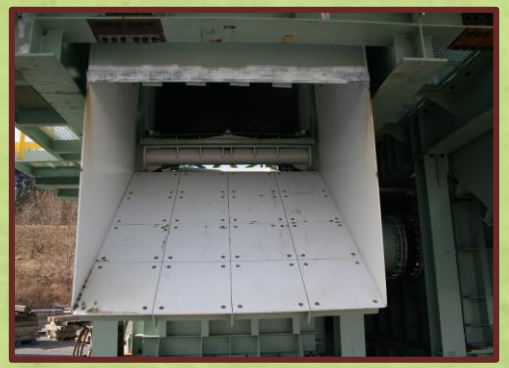


Pneumatic Flow Tube Mixer (PFTM2000) –
MOBILE SEDIMENT ENGINEERING SYSTEM (MOSES)
Port of Coeymans, New York Hudson River Assembly / Carver Marine (2017)

Vibratory Grizzly Screener with Debris Chutes / Collectors into Roll-offs

OLD

NEW



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) – 1530 m^3/day [2000 yd^3]

PFTM Outlet Diffuser

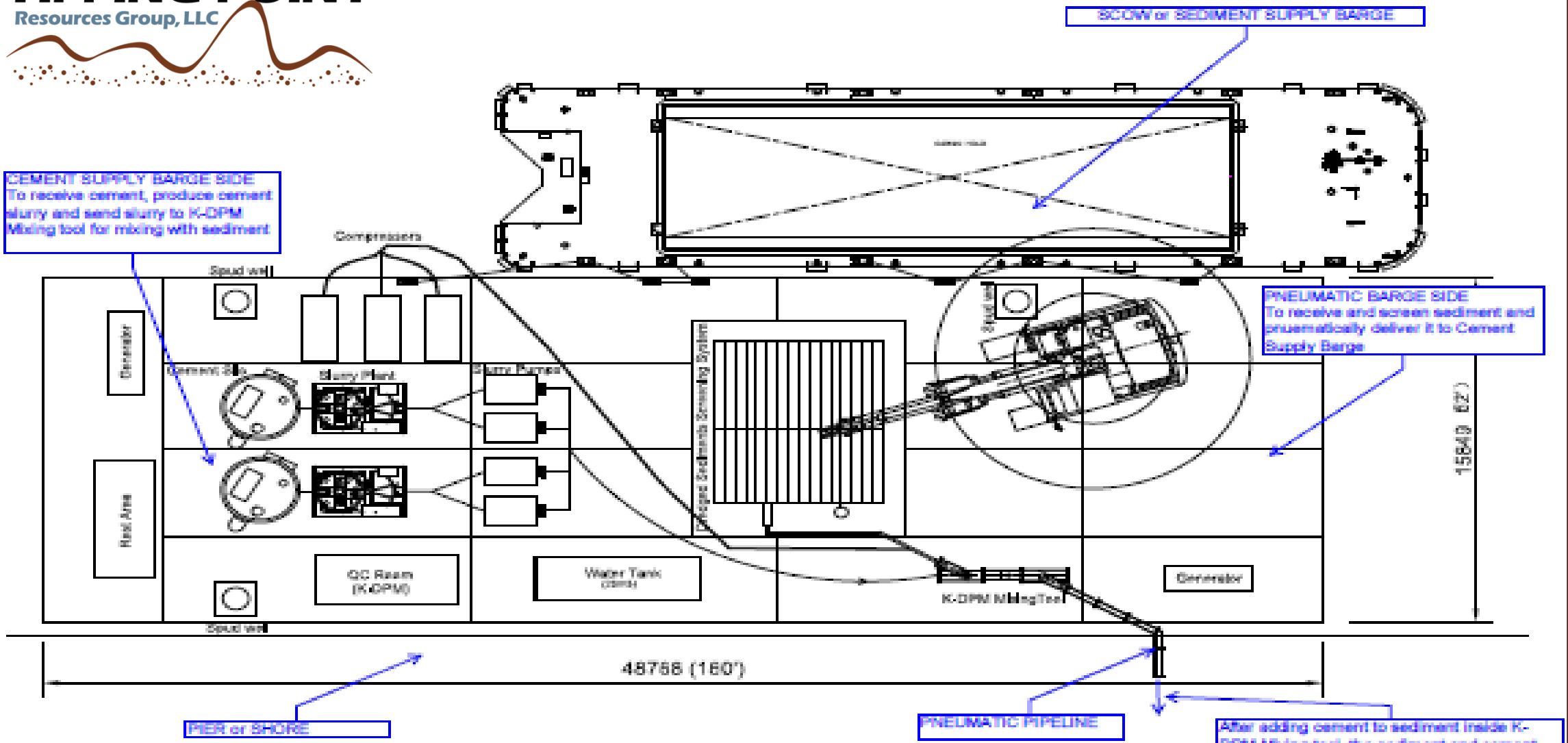
Cement Plant

Water Tank

Grout Pumps

Generators

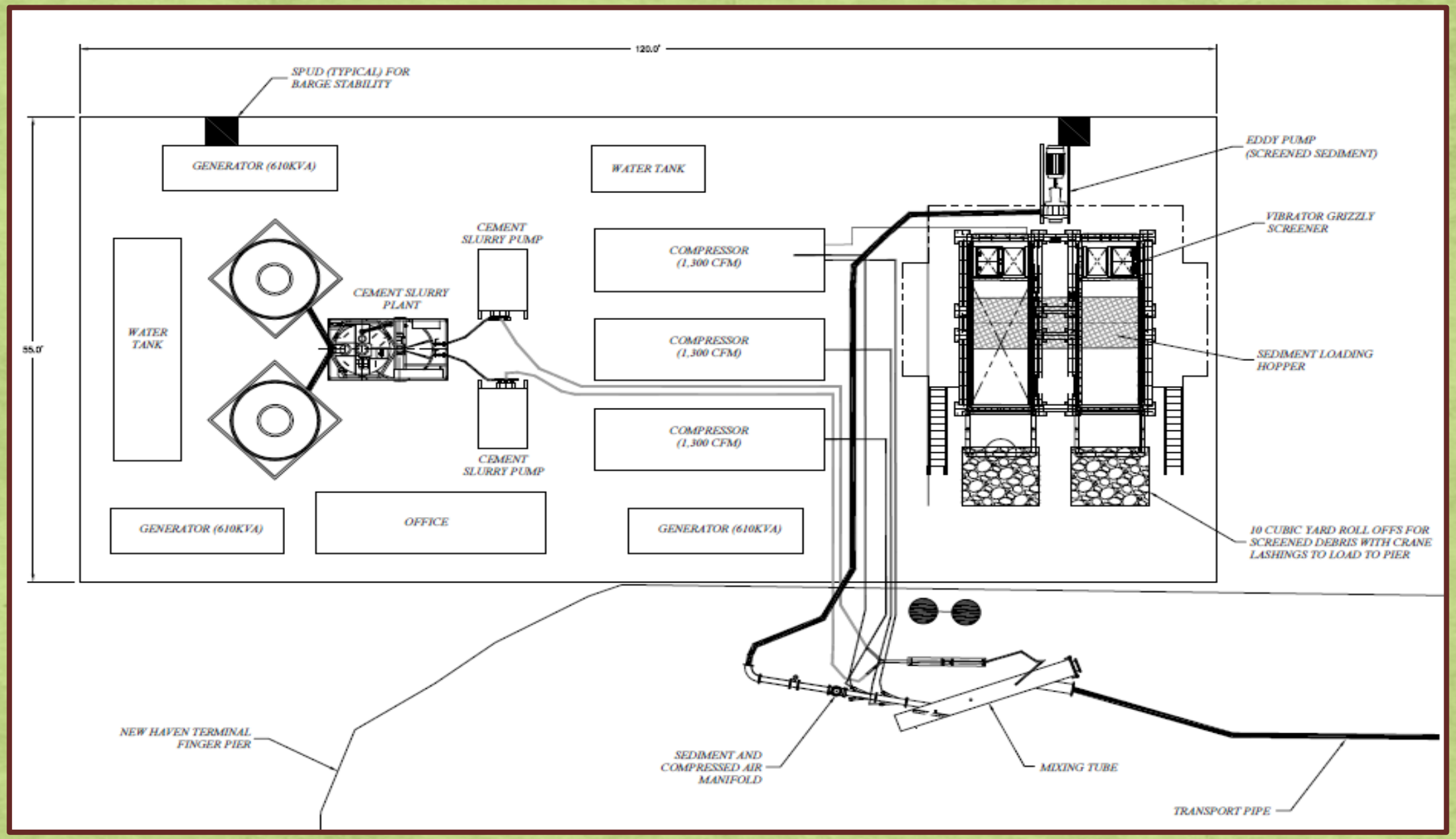
TIPPING POINT
Resources Group, LLC



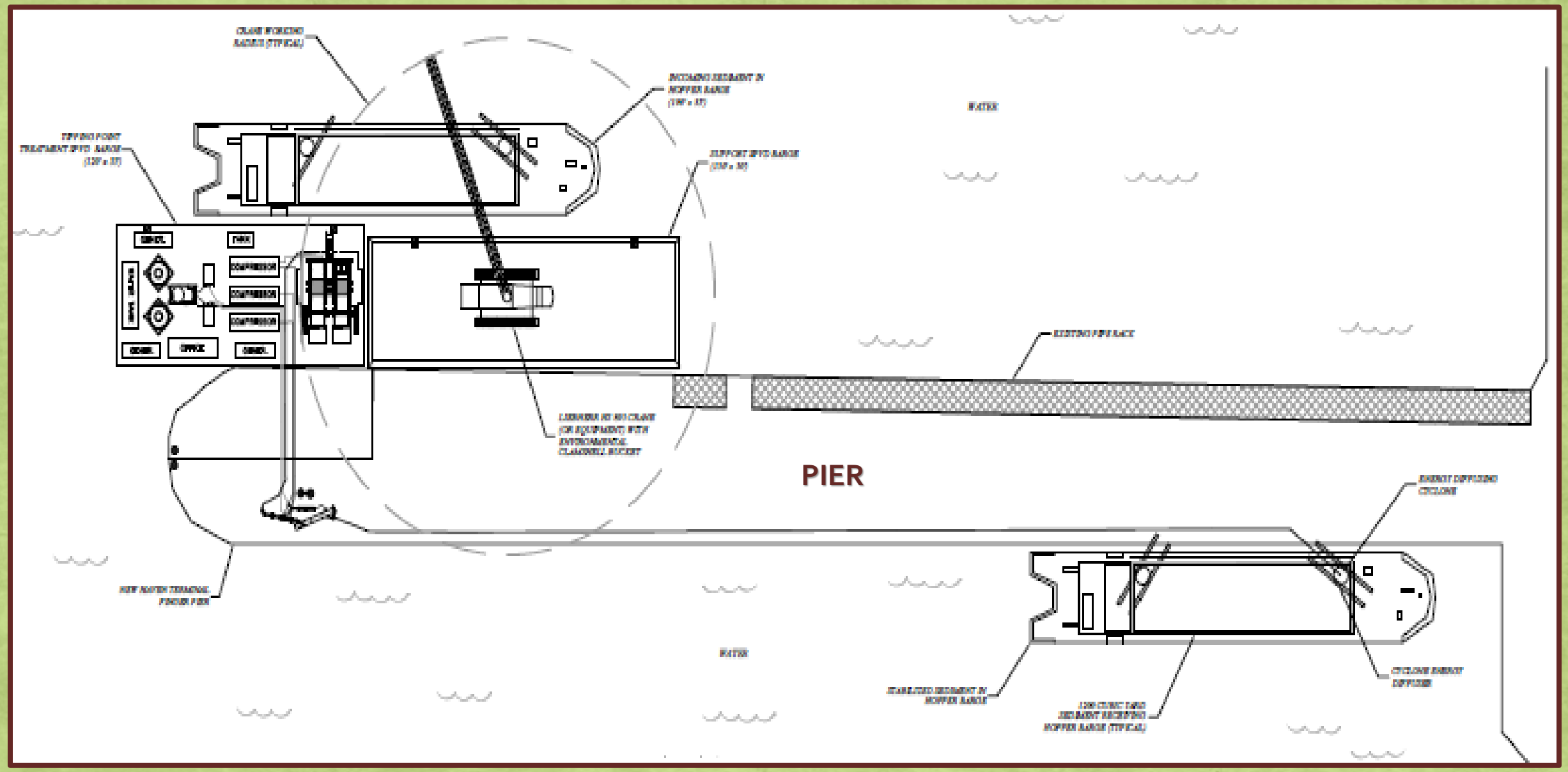
JAFEC USA, Inc.
GEOTECHNICAL CONSTRUCTORS

TUBE MIXING EQUIPMENT LAYOUT ON BARGES (DRAFT)

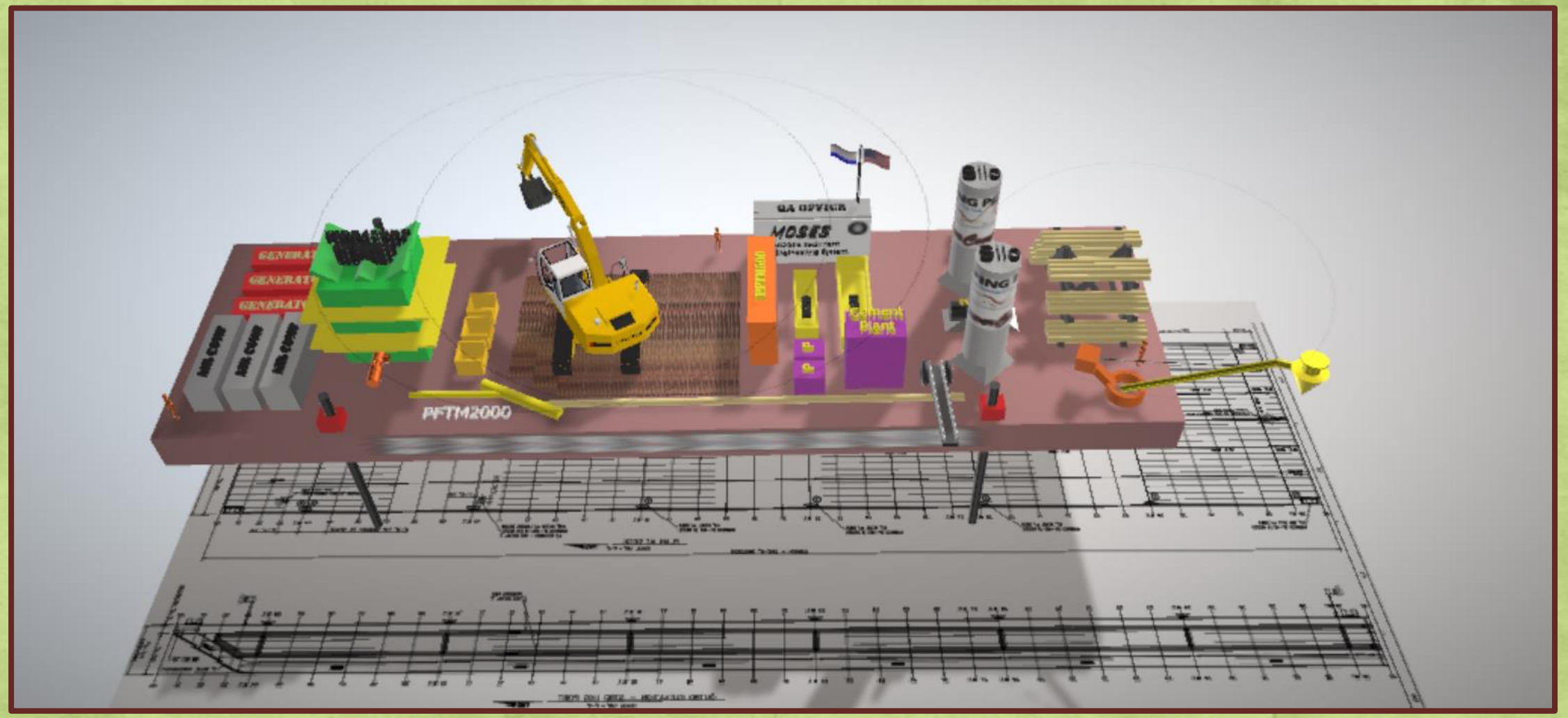
PFTM Equipment Barge Design – off barge



Pier PFTM Layout



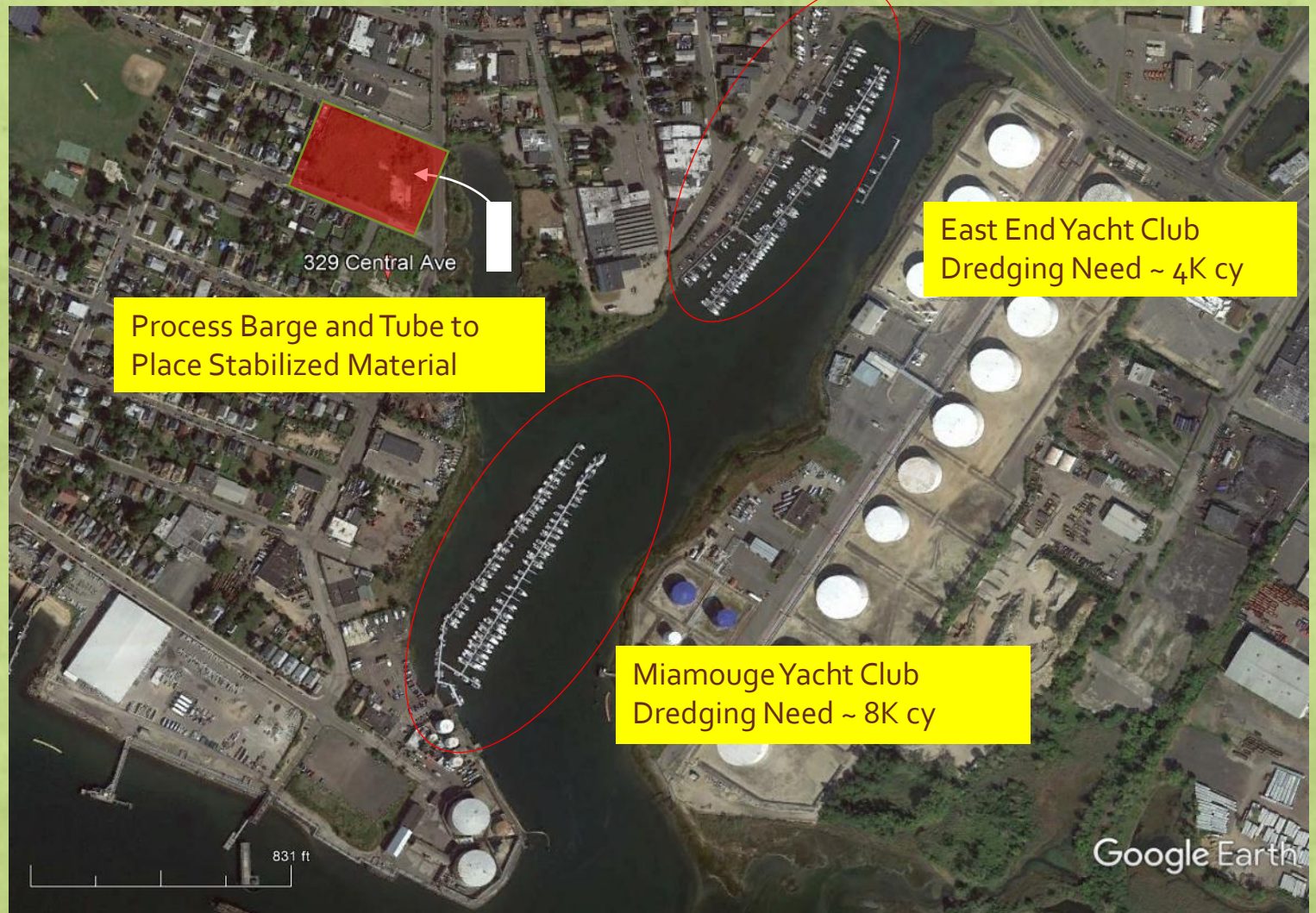
3D PFTM Barge Design – MOSES (MObile Sediment Engineering System



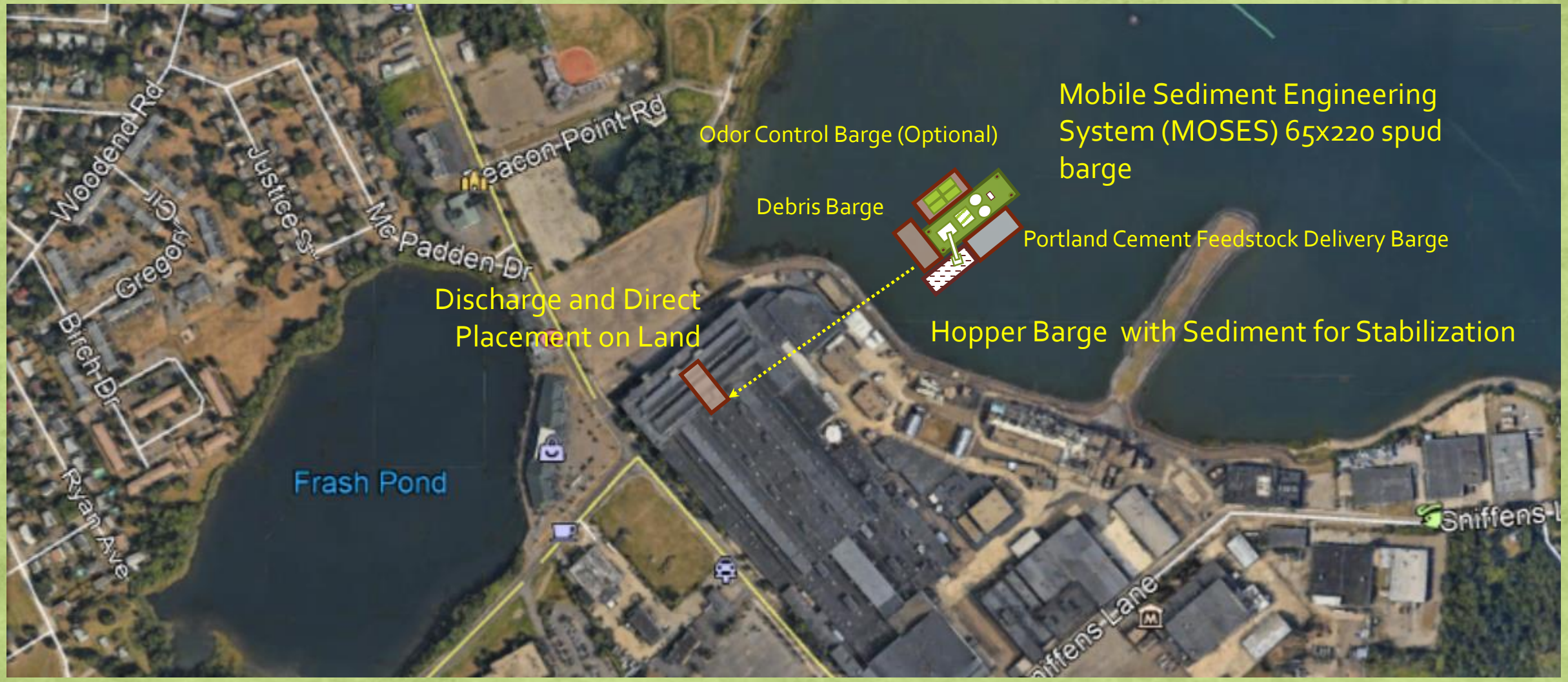
PFTM Attributes to Drive a Circular Economy in Urban Sediment Management Systems

- ➢ Mixing and transport in a closed pipe system
- Transport with air allows pumping amended sediments with up to 1Km / 3000 ft from processing site (simplifies supporting and staging areas needed)
- ➢ No water or air discharge (no dependence on 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 / 46 m^3 (60) CY/hr
  - PFTM 2000 / 190 m^3 (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)

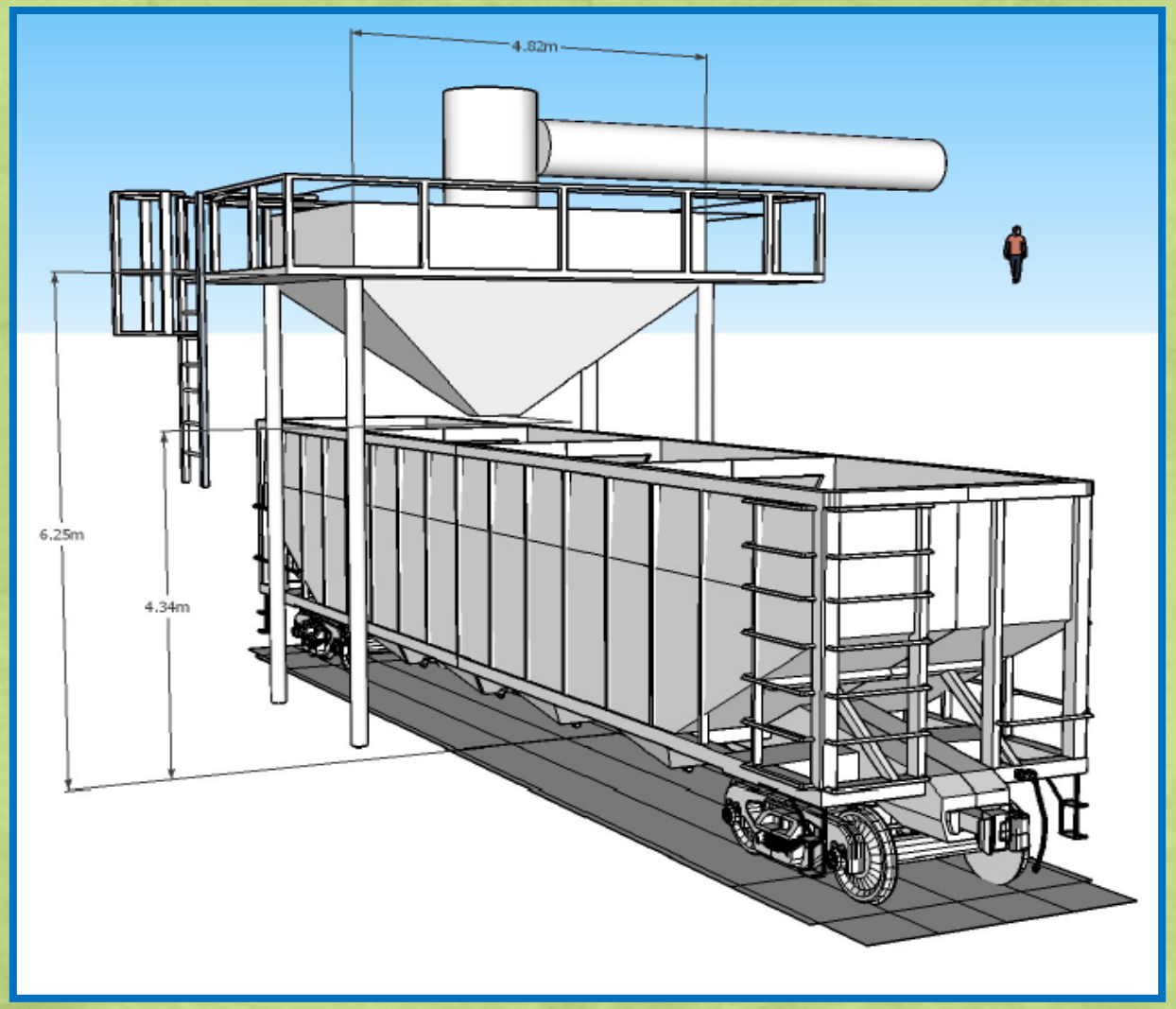
Connecticut Marina Dredging / Upland Remediation Beneficial Use Integration



Conceptual Layout for PFTM Barge Mounted System and Beneficial Use of Sediment at Stratford Connecticut Remediation Site US Army Tank Engine Plant



PFTM Gondola Rail Car Loader (design)



Sediment Immortality

Upland Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth