Sediments (contaminated) behind dams and river restoration - mass stabilization processing, and beneficial use.
Case Study: Gorge Dam, Ohio USA

SedNet Virtual Circular Economy Work Group Meeting (WGCE5)

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Charming City of Nowhere

E.A. Stern, and R. Miskewitz[2]

[2]Rutgers University

TIPPING POINT RESOURCES GROUP

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

MONTCLAIR STATE UNIVERSITY

Clean Energy and Sustainability Analytics Center (CESAC)

Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth

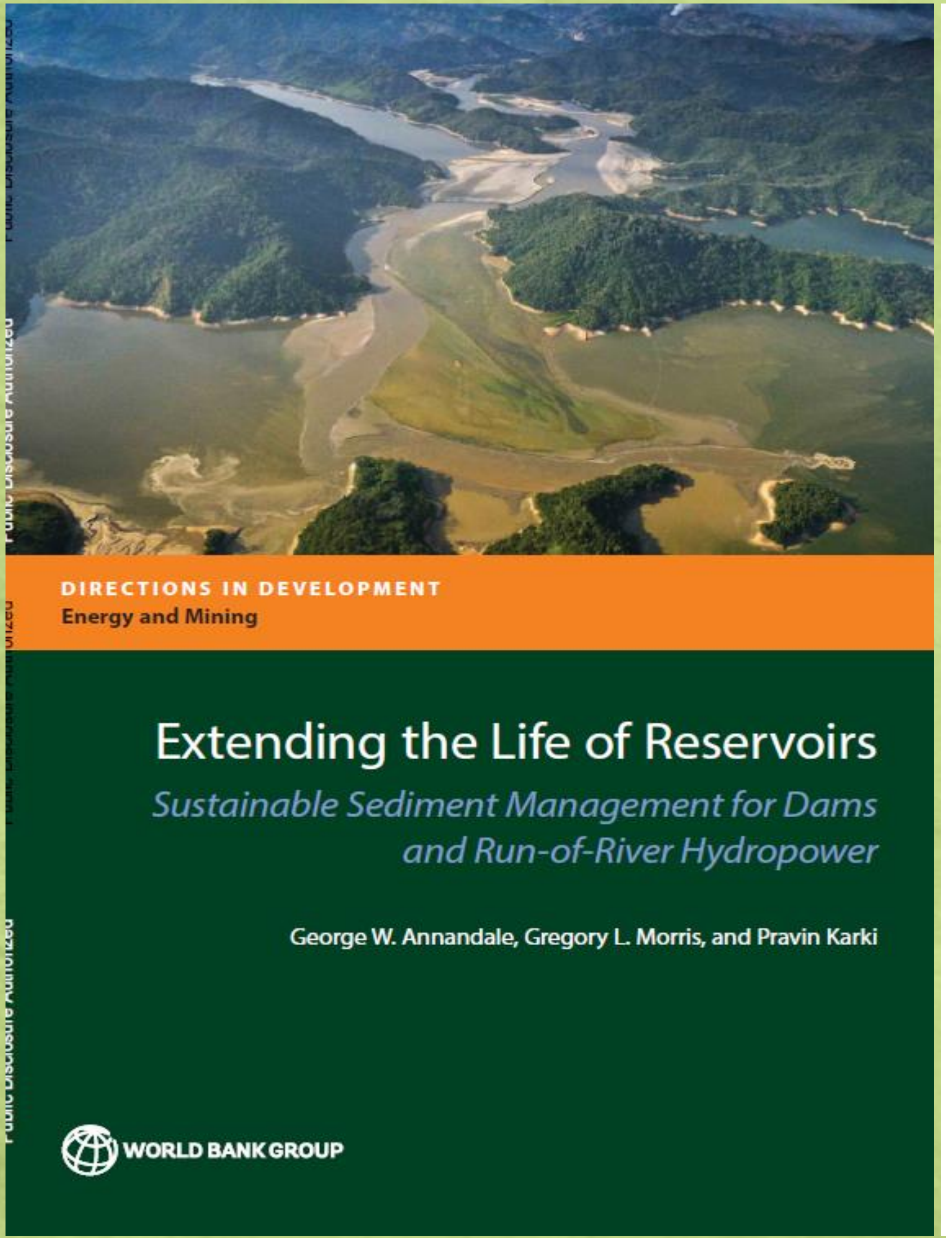
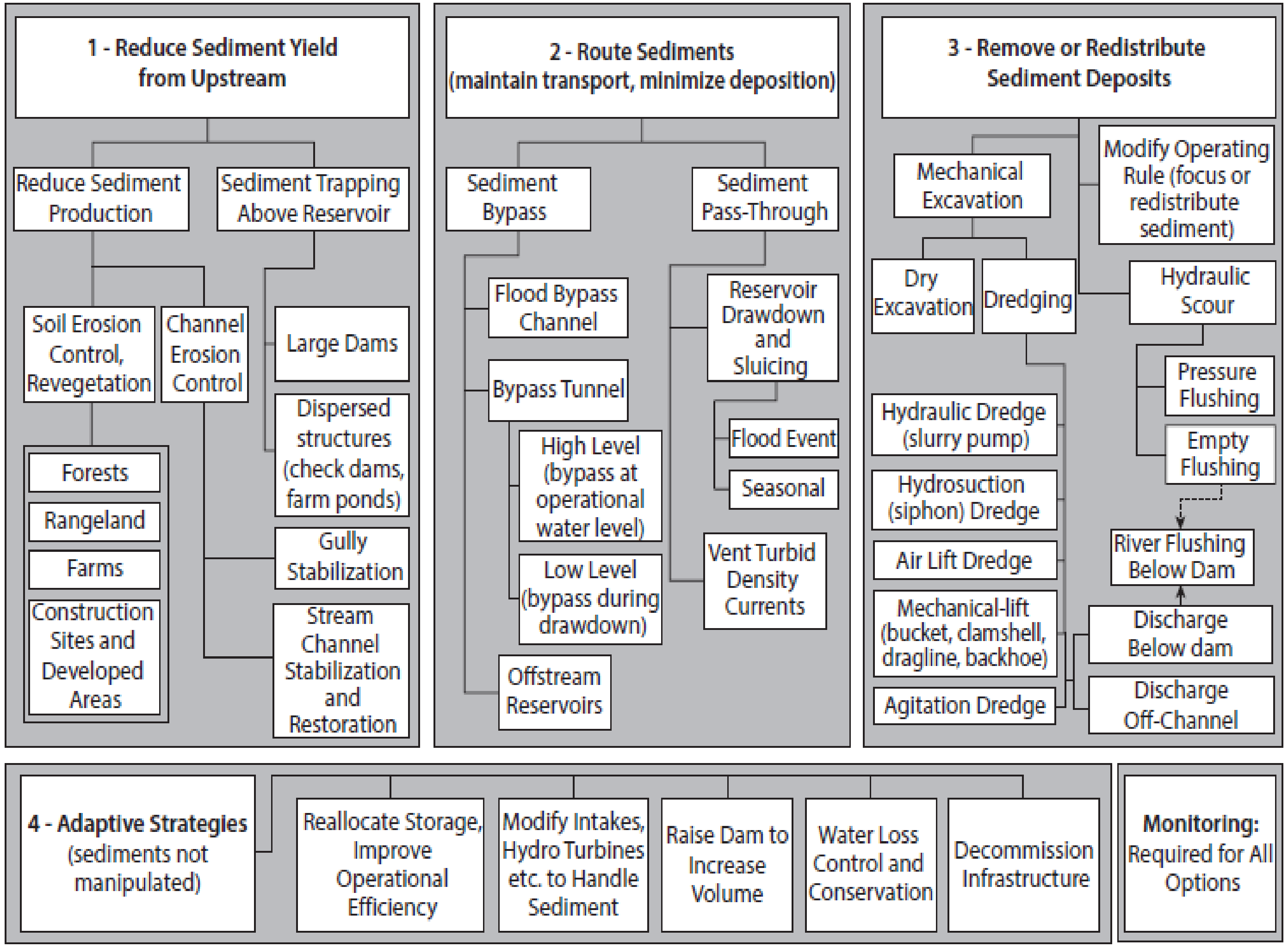
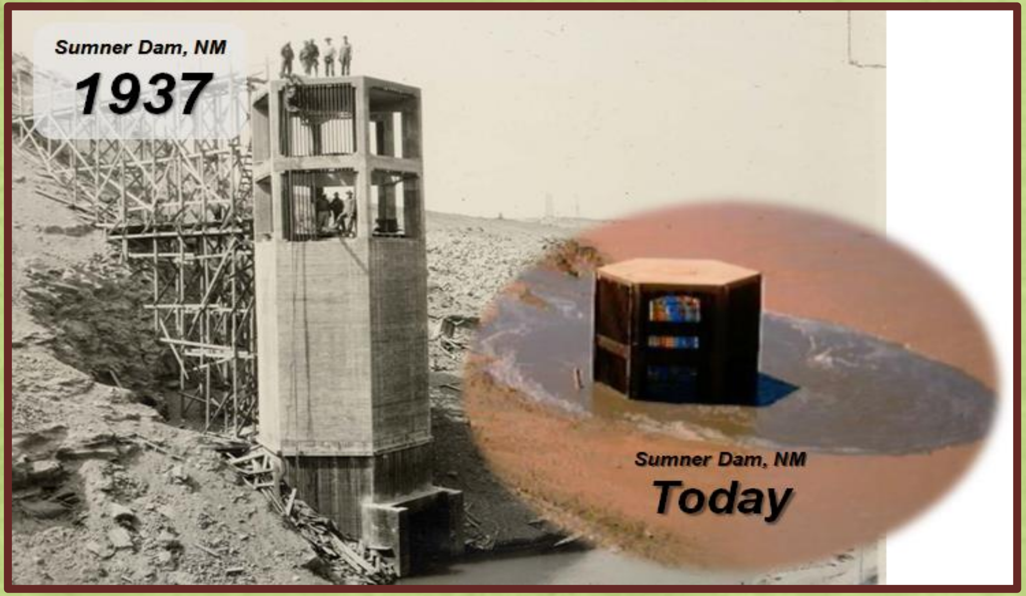


Figure 7.1 Classification of Sediment Management Alternatives



Source: Morris 2015.

Guardians of the Reservoirs



- The US Bureau of Reclamation, in collaboration with the US. Army Corps of Engineers, is sponsoring a competition that seeks **(1) development of more cost-effective sediment removal methods for reservoirs.**

- Competition builds upon the successes of the “Sediment Removal Techniques for Reservoir Sustainability” competition and looks to continue progress in the **(2) development of new processes and technologies that collect and/or transport sediment from reservoirs at a rate that sustains their current capacity.**

  - ✓ **Engineering With Nature**
  - ✓ **EcoShape**

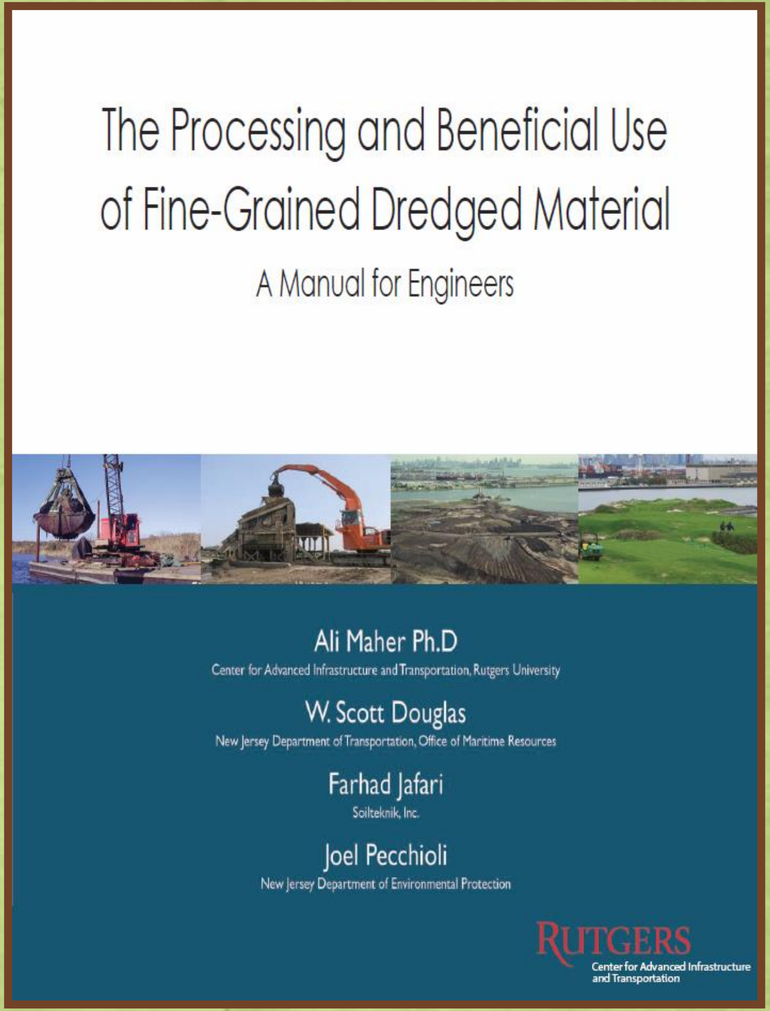
Sediments Behind Dams – Focus Area Examples Mountains to the River to the Sea [SedNet]

- **Contaminated Sediments Behind Dams – sediment transport**
  - Fort Edward Dam (PCBs) Superfund Remediation – Hudson River, New York
- **Sediments at Capacity Behind Dams** (Reservoir Pool)
  - Conowingo Dam (Hydroelectric) - Susquehanna River – Pennsylvania, Maryland, Delaware, New York
- **Dam Removal - Ecosystem Riverine Restoration within an Area of Concern**
  - Great Gorge Dam – Cuyahoga River- Akron, Ohio

Sediment Stabilization

- Solidification/stabilization 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 many remedial actions using sediment stabilization as the primary treatment technology. It has been shown to be effective for a wide variety of organic and inorganic contaminants found in contaminated sediments, soils, and other waste media

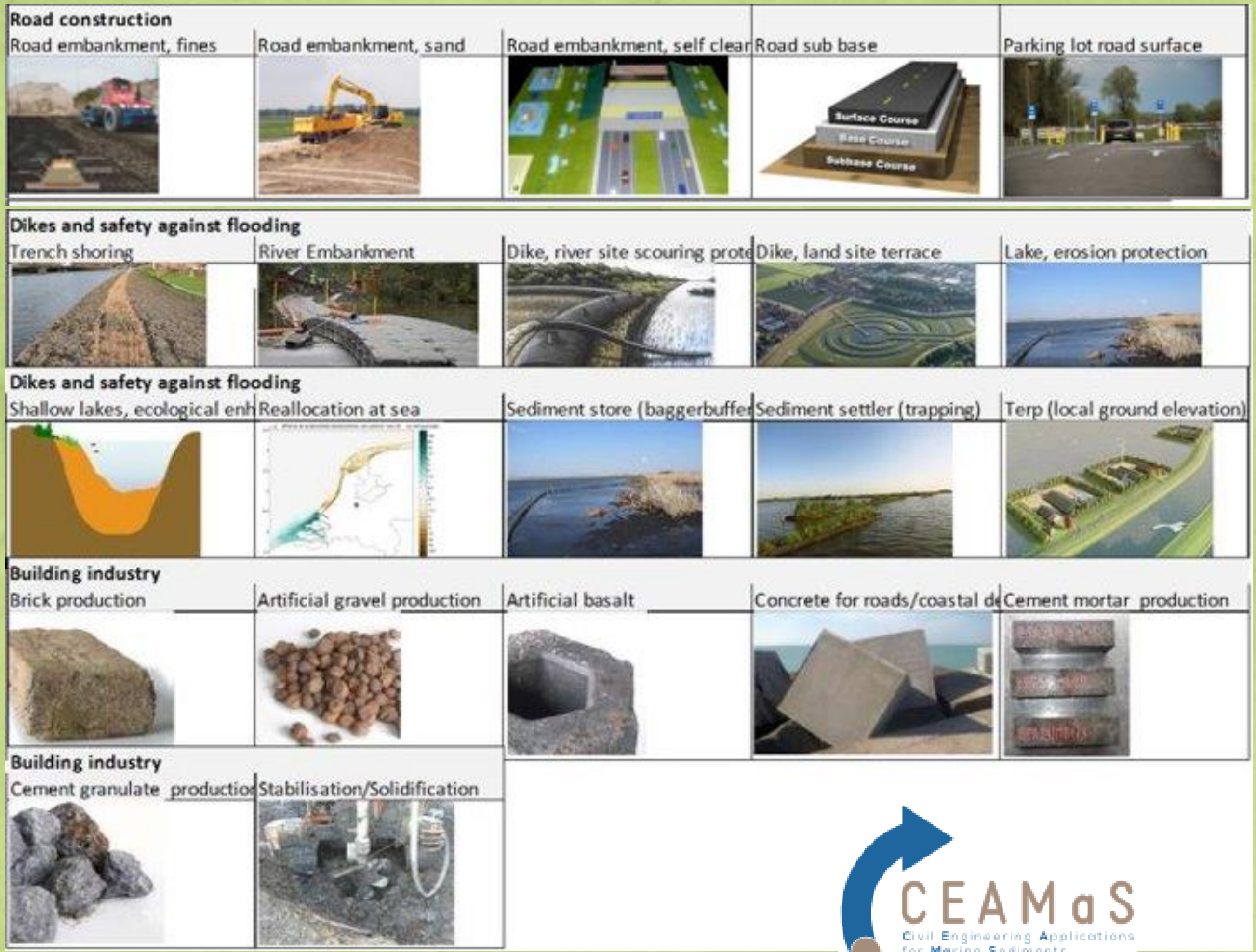
❑ The most successful treatment binder strategy (in US) is with Portland cement and beneficial use at upland sites and/or efficient trans-loading shipments. To date, approximately 23 million cubic meters of stabilized dredged materials have been applied at a variety of placement sites throughout New Jersey



Applications

Environmental

- Brownfield Redevelopment
- **Coastal Restoration**
- Landfill Cover
- Remediation Haz. Waste (Superfund)
- Coal Ash Residual Processing



CEAMaS
Civil Engineering Applications for Marine Sediments

Structural

- Bulkhead / Trench Filling
- **Construction of Berms**
- Structural Caps
- **Elevation for Coastal Resiliency**
- **Port Expansion**

- Expansion in Gothenburg Port, Sweden - stabilize up to 1,000,000 m^3 of contaminated TBT dredged sediments in two phases from 2018 to 2022. The dredged sediments will be mixed with hydraulic binders to provide structural strength to minimize leaching of TBT and for re-use as fill to **expand the surface area of the port by 200,000 m^3**.
- Mixing was carried out in a specialist mixer that mixes the wet sediment with the binder pastes, where mixes are pumped in to a cylindrical drum under high pressure.
- The sediment/binder mix is pumped from the mixing plant to the placement lagoons 600 m distant (bounded by sheet pile walls). **The mix was placed under water.**

CEDA Case Studies, 2019

Quay Construction using Stabilization for Open Space Development

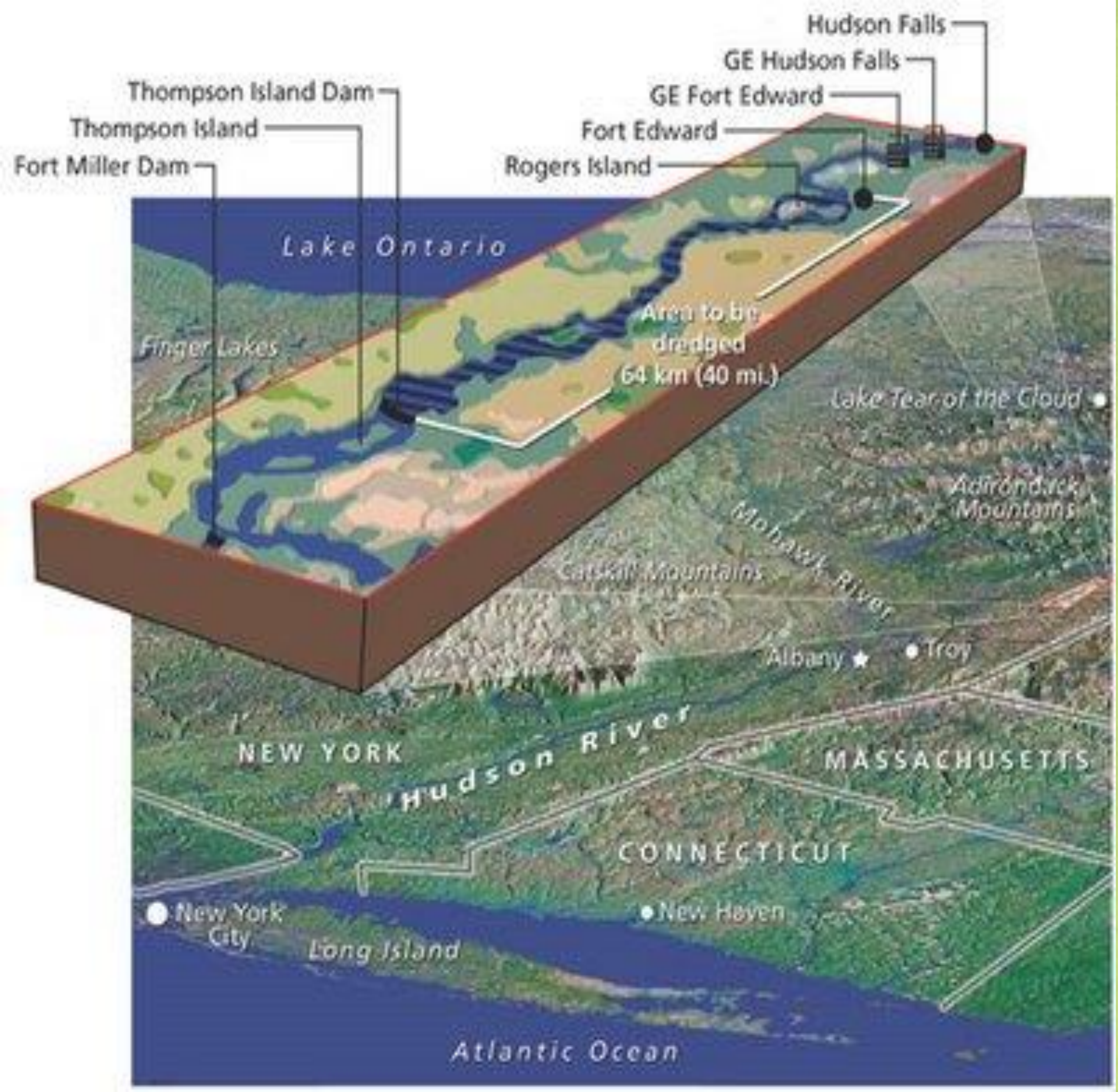
- Contaminated sediment from the seabed at Sandvikselva in the Oslo fjord was removed by dredging and stabilized by mixing with a GGBS (furnace slag) plus cement-based binder
- Used in the **construction of a new quay wall**.
- Approximately 4,000 m^3 of sediments were dredged by a mobile crane and grab, and **placed behind a concrete sheet pile wall, where mass stabilization was carried out by injecting and mixing the GGBS/cement binder with the dredged sediments**.

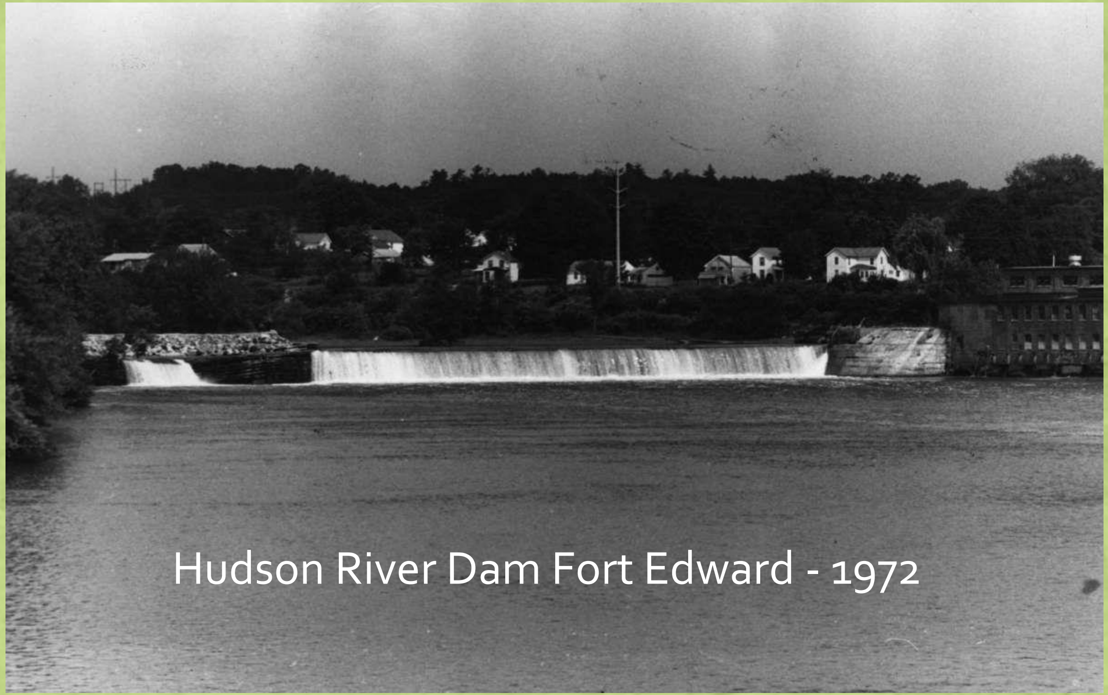
The stabilized sediments were used for construction of a new quay wall, providing an additional 3,000 m^3 of new amenity land.

CEDA Case Studies, 2019

Hudson River General Timeline

- (1947-1977) General Electric using PCBs in manufacturing of electrical capacitators at Fort Edward Plant – New York Hudson River
- (1940-1970's) 90-600,000 kg of mixed PCBs released into Hudson
- (1973) Fort Edward Dam demolished (derelict dam and restoration)
- (1975) Found out that PCBs have affected much of upper Hudson
- (1987) GE Hudson Falls Plant declared Superfund – 321 km (to NYC)
- (2002) USEPA Record of Decision
  - Dredging of 2.06M m^3 (65% of total PCB load)
- (2009-2015) – Mechanical Dredging / dewatering and shipment to Texas
- Is it really done? Steady State? Recovery? Law Suits





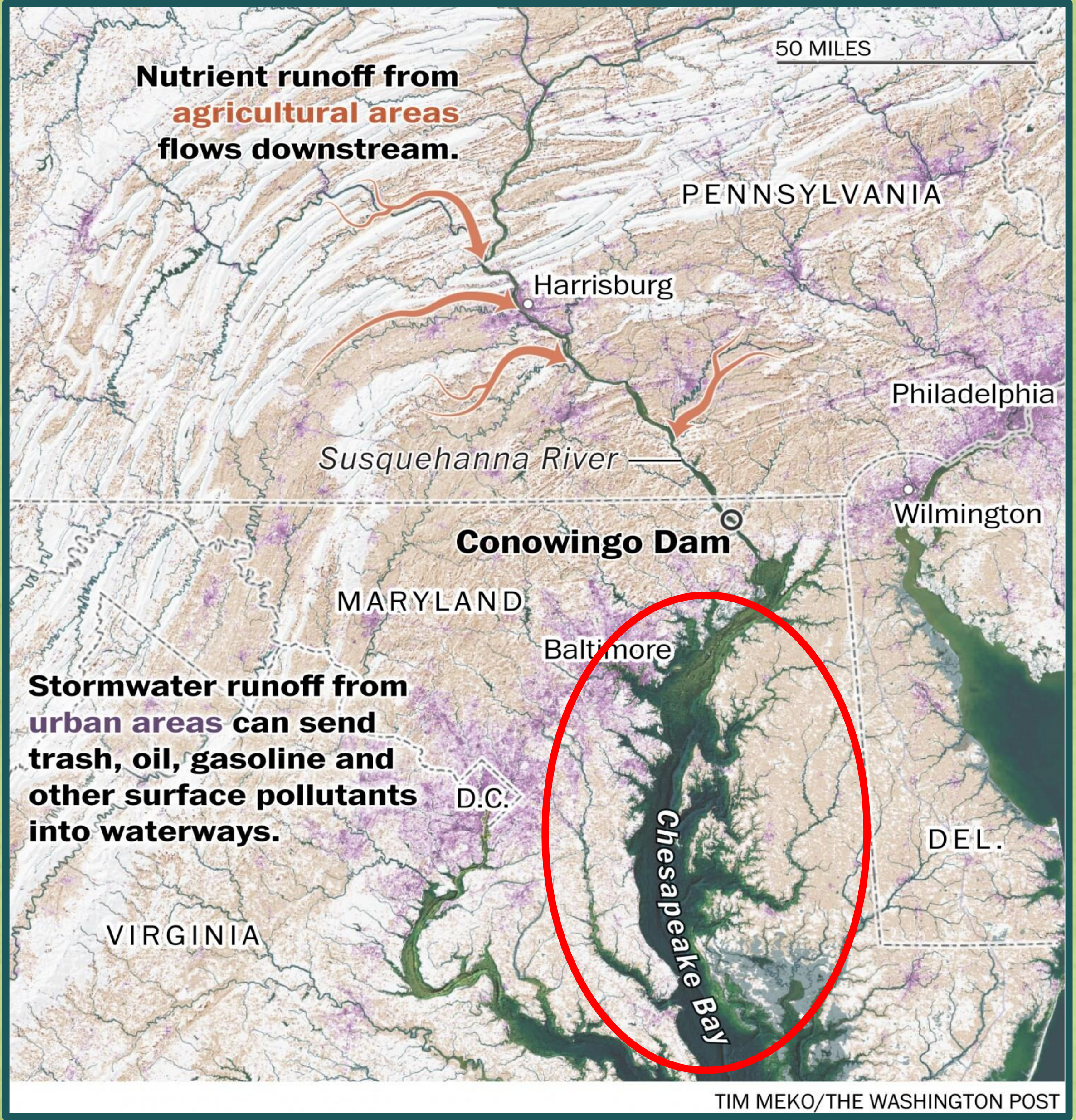
Hudson River Dam Fort Edward - 1972

GE Hudson River Falls Plant

Hudson River Dam Removal – PCBs Contaminated Sediments (The Sunday Gazette, Russ Wege – 2015 October)

- NYS DEC issued a permit to remove a derelict dam a few miles down river from the Hudson Falls/Fort Edward plants in 1973. The DEC regulators thought a dam removal project that would restore the river to natural conditions was good idea
- Natural river conditions no longer existed as sediment had collected in the pool behind the old dam. Unknown at the time, the sediments behind the dam had trapped a great percentage of the PCBs discharged from the GE plants
- The removal of the dam caused the sediment with the PCB contamination to rapidly move down river.
- What to do about it was an unanswered question. GE did nothing illegal. The utility owning the dam, Niagara Mohawk had a state DEC permit to remove the structure. The state had no authority to do anything, and the local municipalities could only complain about the release.

➢ In 1979, a major flood, **Hurricane Floyd** occurred in the Hudson basin. That flood endangered a bridge over the Hudson at Troy and moved a tremendous amount of sediment — spreading the PCB contamination as far south as New York City.



Conowingo Dam – Mountains to the Bay to the Sea
A Whoops Story in Sediment Volume


CONOWINGO DAM CONCERNS
WBAL-TV 11
WEATHER
WBALTV

Conowingo Dam – Susquehanna River
Huge Sediment Volumes in Dam Pool

- Since the dam's construction in 1929, sediment and nutrients have been building up behind it, being released periodically downriver and into the Chesapeake Bay, especially during high flow events
  - Chesapeake Bay Program have spent $$$$ in restoration over 30 years
- Conowingo Dam on the Susquehanna River is at about 92 percent capacity for sediment storage – USGS
  - In 2014, State of Maryland and the US Army Corps of Engineers announced that the reservoir is in a state of "dynamic equilibrium," the point at which a reservoir reaches full capacity and the full volume of sediment and nutrients that are coming down the river will go through the dam and enter Chesapeake Bay
- Conowingo is losing its ability to trap nutrients and sediment from reaching the Chesapeake Bay
  - Significant coal deposits in the sediments

Conowingo- Sediment Restoration to mid 1990's levels

- USACE estimated, 23M m^3 yards of sediment would need to be dredged
  - $3 Billion USD
  - Flow of sediment coming down the river is not curtailed, the dam pond would gradually fill in again – 2.3M m^3/yr, or 1.5 million pickup truck loads, would need to be dredged annually to avoid losing ground
  - USACE estimated that could cost anywhere from $48 million to $267 million USD each year
  - 4 States
  - Who pays?? Maryland? Pennsylvania? Delaware? New York?

- State of Maryland Pilot Study (2020-2021) - Governor Hogan
  - Award Team - Northgate Environmental, Ramboll, Dutra Dredging, Tipping Point, Rutgers University
  - ❖ Our Role: Treatability Testing and development of Beneficial Use Applications for multiple outlets
  - Geotechnical – stabilization
  - Dredging and Transport Logistics – where?

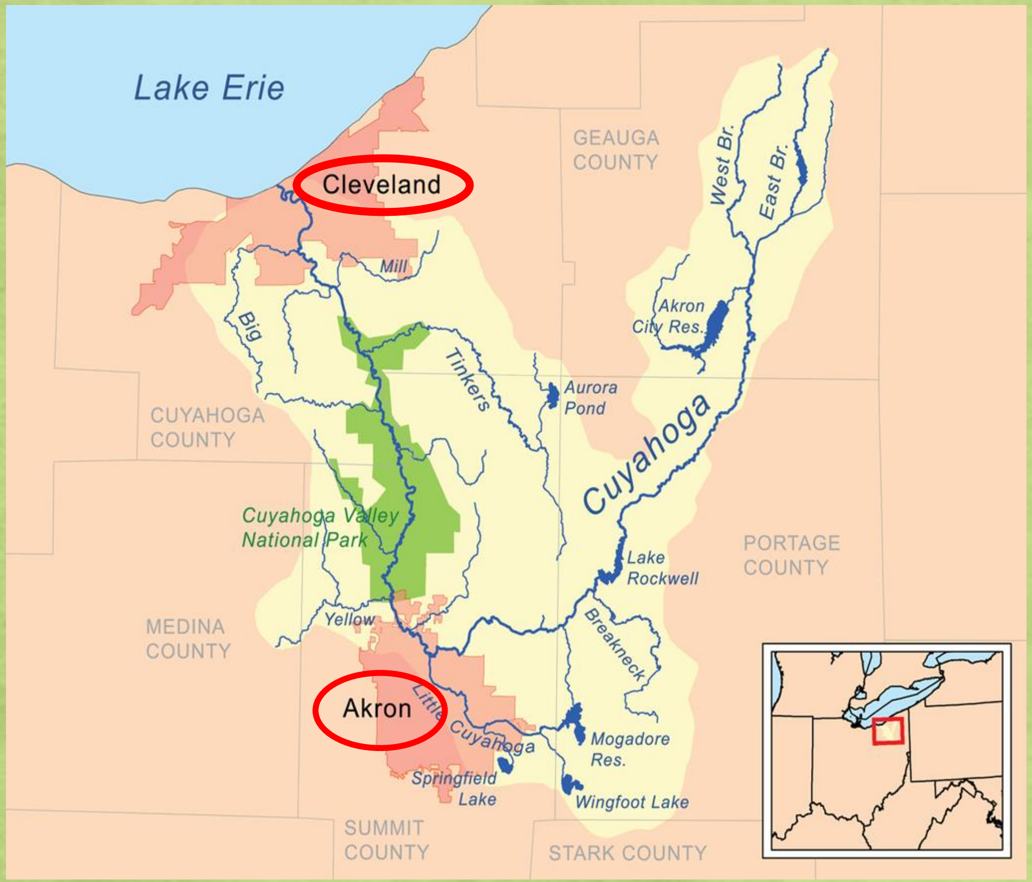
Cuyahoga River, Ohio (Gorge Dam) has caught fire 14 times

22 June 1969 fire helped spur the US Environmental Movement

Launched H_2O pollution control activities

Clean H_2O Act, Great Lakes H_2O Quality Agreement, USEPA and Ohio EPA

- ✓ Randy Newman – "Burn On"
- ✓ REM – "Cuyahoga"
- ✓ Great Lakes Brewing Co. – "Burning River Pale Ale"



Gorge Dam – Cuyahoga River / Akron, Ohio (largest dam)

Designated in 1985 as an Area of Concern in Great Lakes Basin
Authorized in 2010 by the USEPA Great Lakes Legacy Act to Fund Assessment of Sediments in Gorge Dam Pool

- Cost Share 65% Federal USEPA / 35% Sponsors (Partners)
- Goal - Delist Beneficial Use Impairments (BUI)

Action: Dam removal with **habitat restoration** component
Cornerstone of the GLLA – different than Superfund

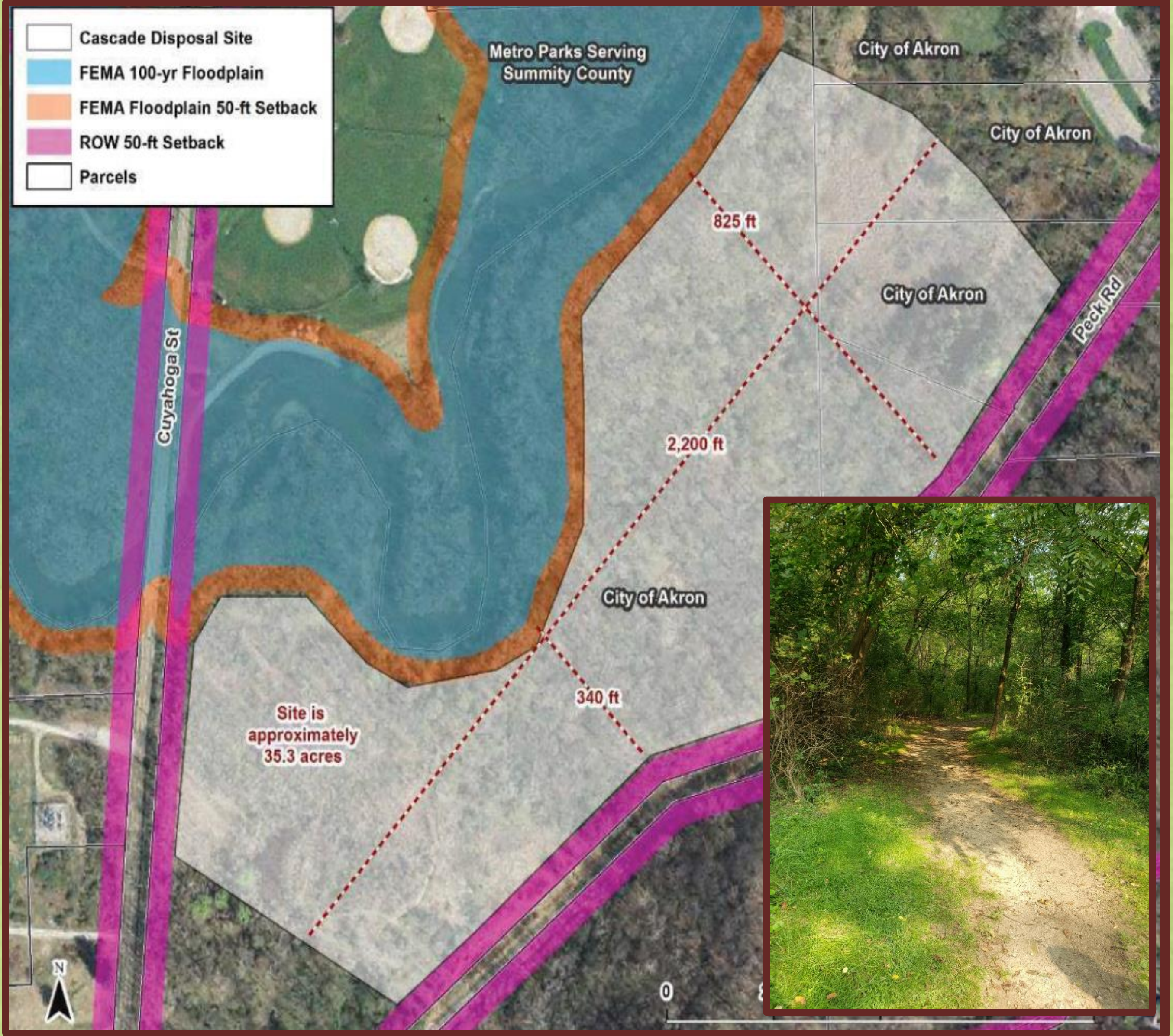
Gorge Dam Removal Logic - BUI

- Impaired habitat loss (fish migration) and benthos
- Flow alteration / hydraulics
- Excessive nutrients levels and low dissolved O_2
- Contaminated sediment load behind the dam pool needs to be dredged before dam is removed
  - Organics/inorganics, oil and grease exceed risk tox thresholds
- In parallel with City of Akron Combined Sewer Overflow long-term control plans
- Recreation (white water kayaking)

❑ **Sediment volume that needs to be dredged before dam removal – 671,000 m^3**

- That's easy……how do you do it? where is it going? No access, No CDF

❖ Beneficial use?



Upland Chuckery Area Placement Site (former 35 acre landfill) along the Cuyahoga River
Need to pump 2.1 km from Gorge Dam Reservoir to Chuckery

Ohio EPA, 21 Sept 2015
Feasibility Report

Bellingham, Washington USA
Squalicum Harbor

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)

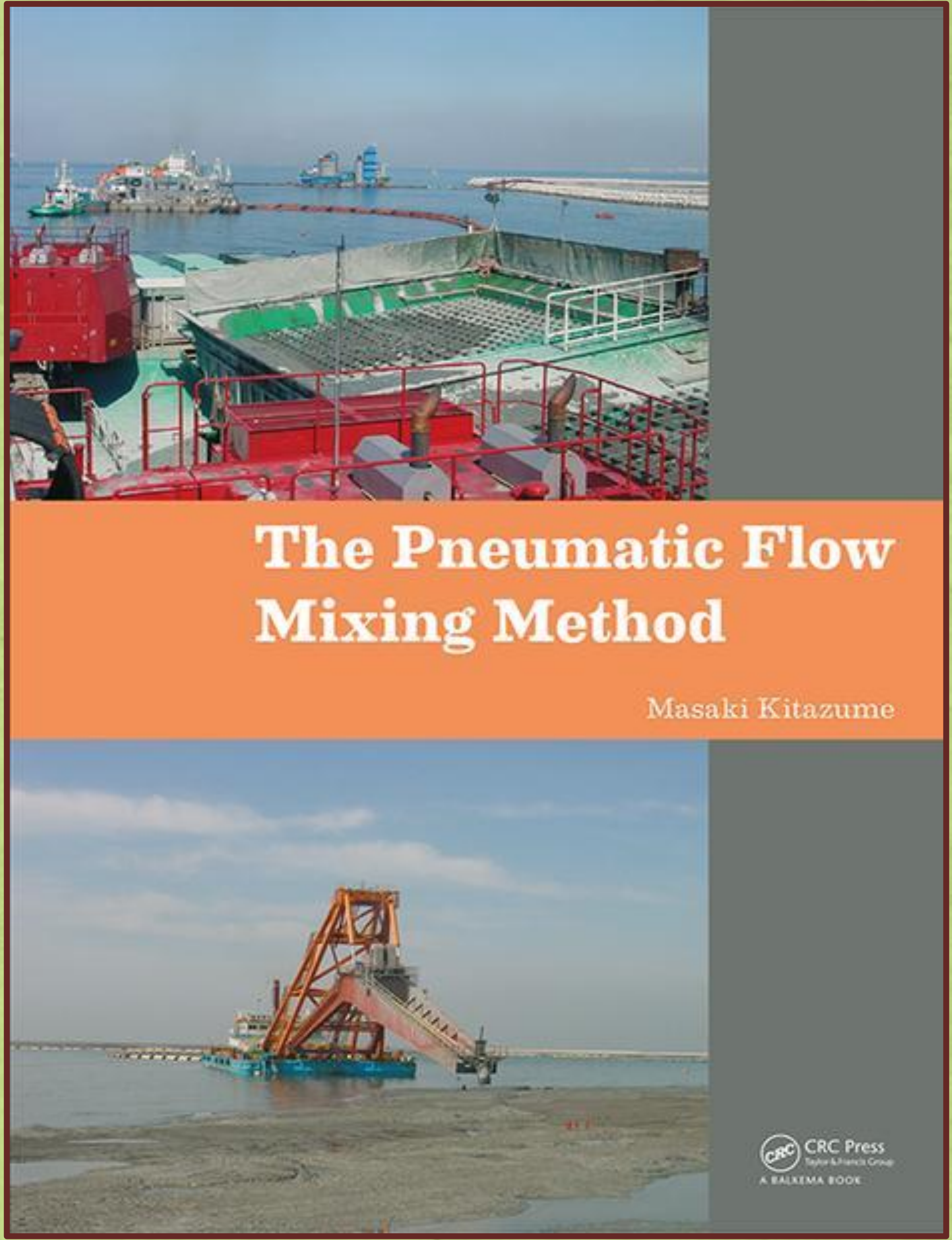
Sediment Dewatering Processes (S/S, Mechanical and Passive)

Removal and Beneficial Use Considerations

- Hydraulic ? Mechanical dredging? – Dam removal and dredging has to take place at different times
- Pumping? Geotubes dewatering /H2O treatment? Then what? How long to dewater? Beneficial use?
- Cost Share Sponsors Responsibility (upland placement):
  - City of Akron, Gorge Dam Stakeholders Committee, First Energy, Summit Metro Park
  - Upland placement of stabilized sediment (35 acre former landfill) adjacent to river
  - Construction of a park and recreation area with trees
    - Wasn't the first consideration until……
- Stabilization of sediments to produce an engineered structural fill
- Pneumatic Flow Tube Mixing for Mass Stabilization
  - Jacobs Engineering – design

Pneumatic Flow Tube Mixing (PFTM)

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

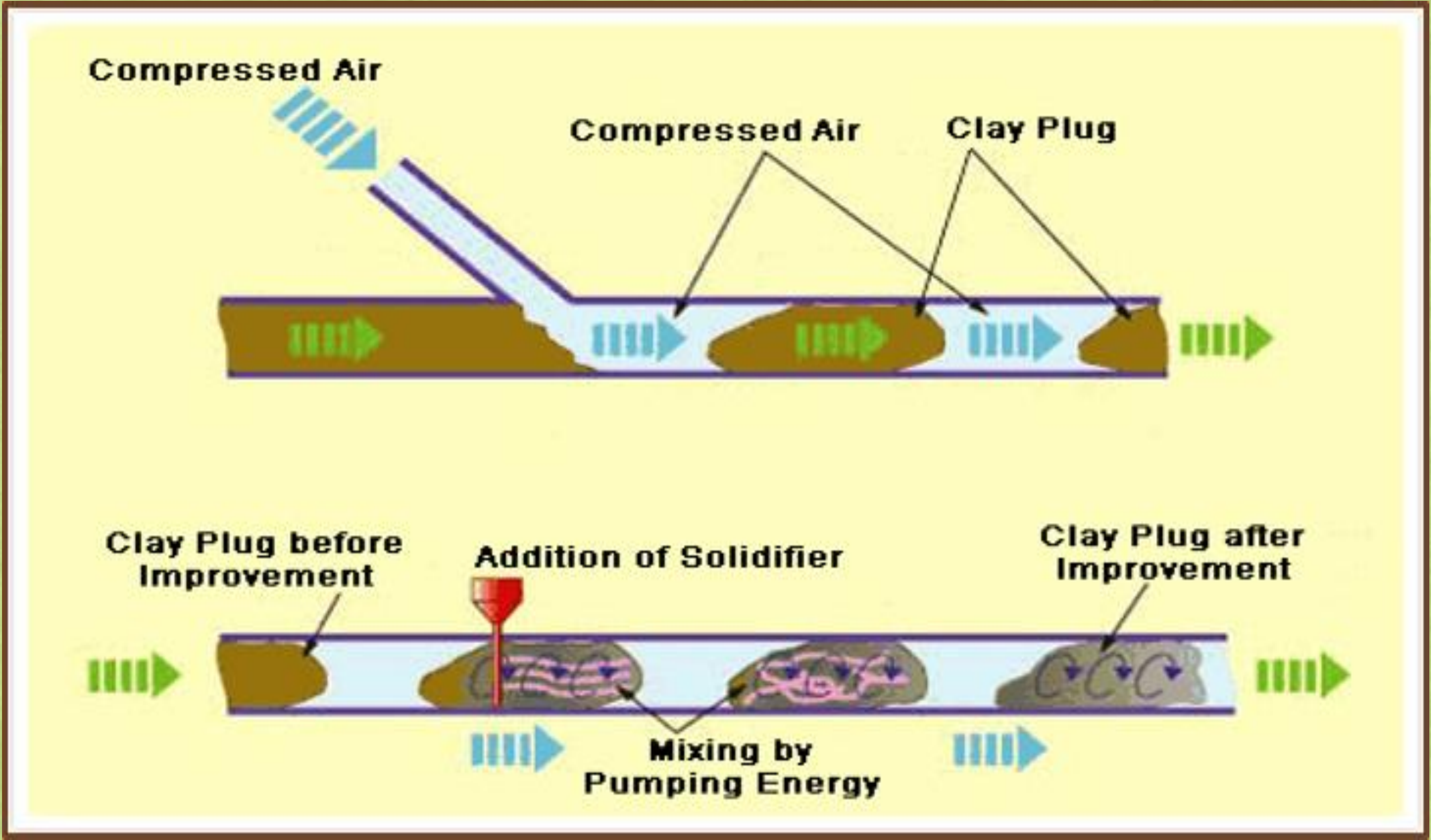


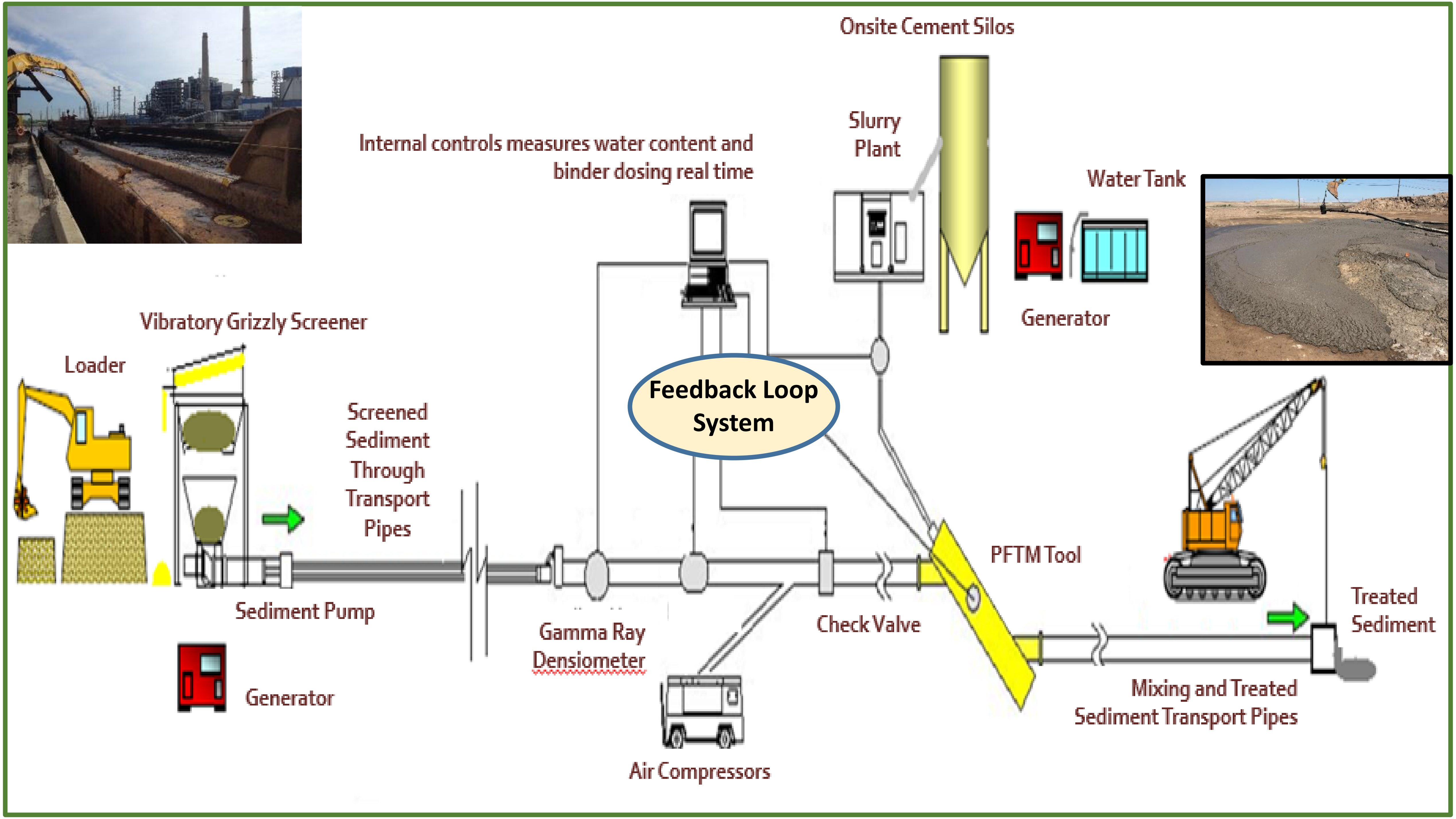
Kitazume, 2016 CRC Press, ISBN 9781138029842 - CAT# K30201

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





Onsite Cement Silos
Slurry Plant
Internal controls measures water content and binder dosing real time
Water Tank
Generator
Vibratory Grizzly Screener
Loader
Feedback Loop System
Screened Sediment Through Transport Pipes
PFTM Tool
Treated Sediment
Sediment Pump
Gamma Ray Densiometer
Check Valve
Generator
Mixing and Treated Sediment Transport Pipes
Air Compressors

PFTM Process Flow – Land Based Option


a) Grizzly/vibrator, screen, and mixing plant

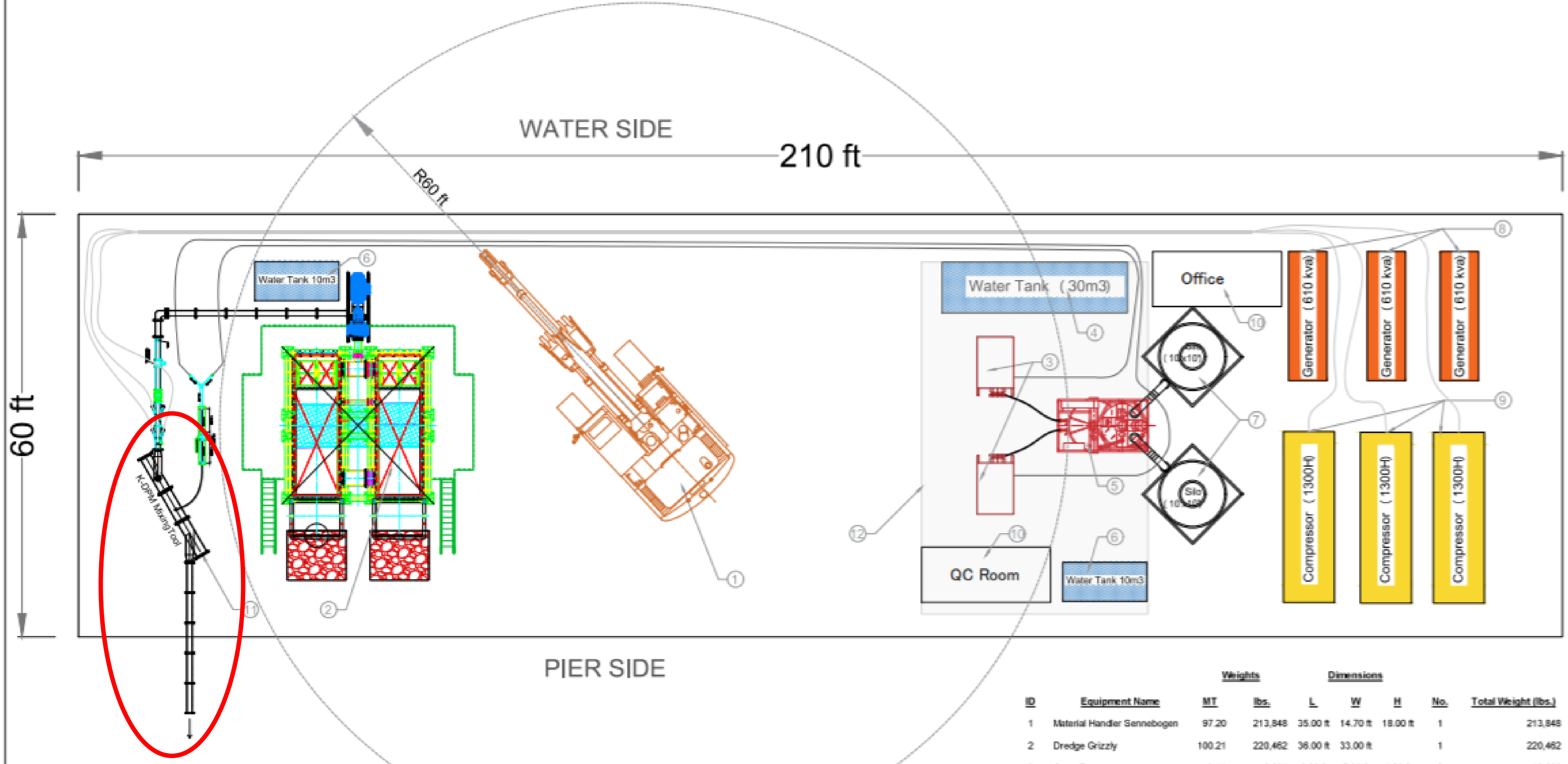

b) Grout Plant


c) Control system / feedback loop

d) PFTM Mixing Tool


e) Transporting pipeline (up to 3000 feet)


f) Discharge

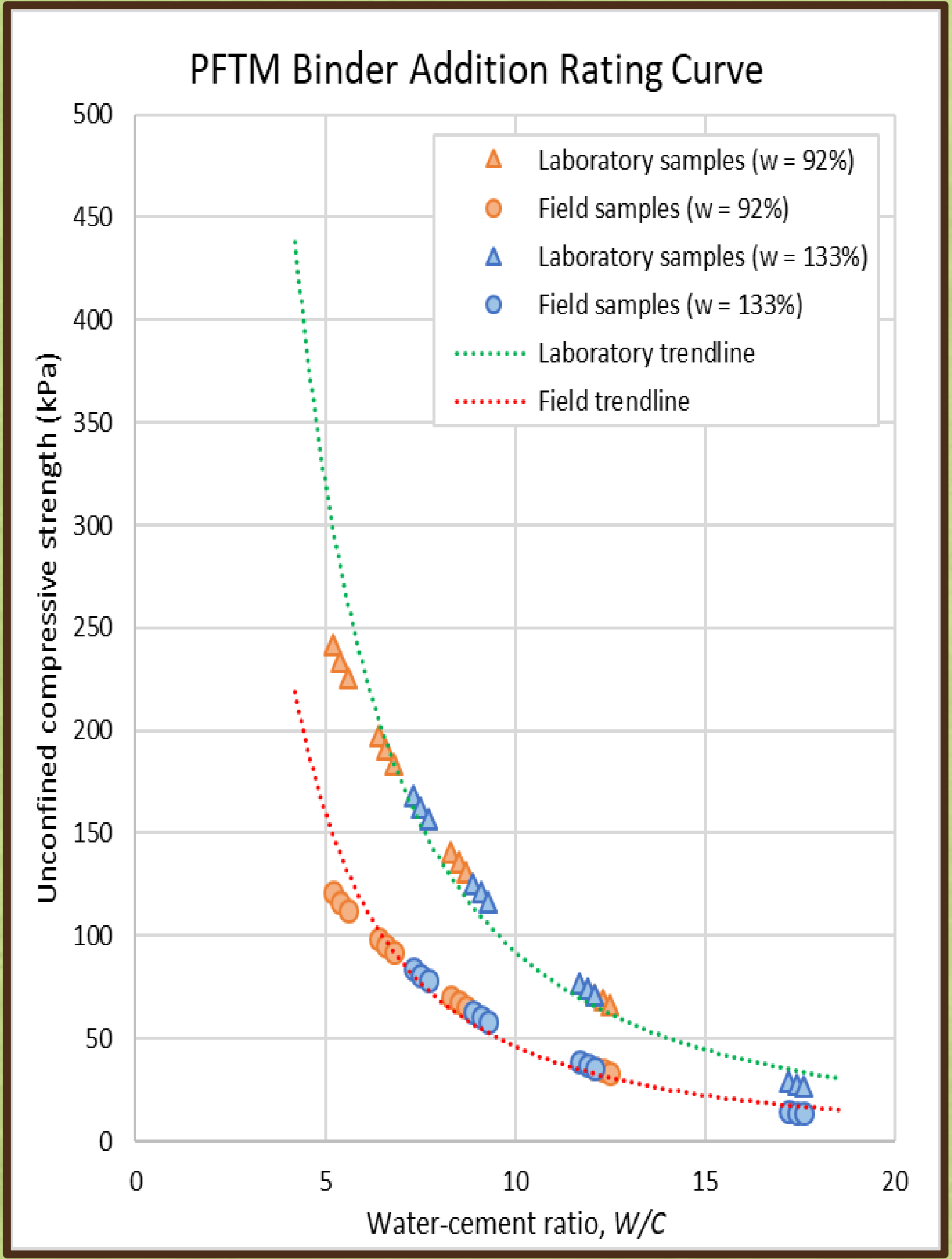


PFTM Mobile Operating Sediment Engineering System (MOSES) / barge platform OPS

		Weights		Dimensions				
ID	Equipment Name	MT	lbs.	L	W	H	No.	Total Weight (lbs.)
1	Material Handler Sennebogen	97.20	213,848	35.00 ft	14.70 ft	18.00 ft	1	213,848
2	Dredge Grizzly	100.21	220,462	36.00 ft	33.00 ft		1	220,462
3	Grout Pump	3.11	6,834	8.20 ft	5.08 ft	4.28 ft	2	13,668
4	Water Tank-30m^3	35.07	77,162	26.37 ft	7.22 ft	5.94 ft	1	77,162
5	Batch Plant	4.10	9,024	11.33 ft	7.25 ft	8.25 ft	1	9,024
6	Water Tank-10m^3	12.53	27,558	11.91 ft	5.51 ft	4.95 ft	2	55,116
7	Silo w/ Full of Cement	54.55	120,000	10.00 ft	10.00 ft	37.00 ft	2	240,000
8	Generator (610 KVA)	9.55	21,010	18.30 ft	5.40 ft	7.87 ft	3	63,030
9	Compressor (1330H)	7.56	16,621	24.24 ft	7.33 ft	8.25 ft	3	49,863
10	Office/QC Trailer	2.73	6,000	20.00 ft	8.00 ft	8.00 ft	2	12,000
11	K-DMP Mixing Tools						1	
12	Sprung Structure			50.00 ft	32.00 ft		1	

- Pneumatic Flow Tube Mixing

Ali Maher, Rutgers University


PFTM Binder Addition Rating Curve
Unconfined compressive strength (kPa)
Water-cement ratio, W/C
Laboratory samples (w = 92%)
Field samples (w = 92%)
Laboratory samples (w = 133%)
Field samples (w = 133%)
Laboratory trendline
Field trendline
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20


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


PFTM Outlet Cyclone Diffuser

Pneumatic Flow Tube Mixer (PFTM) – 2,000 yd^3/day (8hr shift)

Untreated Sediment In

Stabilized Sediment Out

Contact Information:
Tipping Point Resources Group

Eric A. Stern

eric@tprgllc.com
201.247.3281

www.tprgllc.com

Upland Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth