

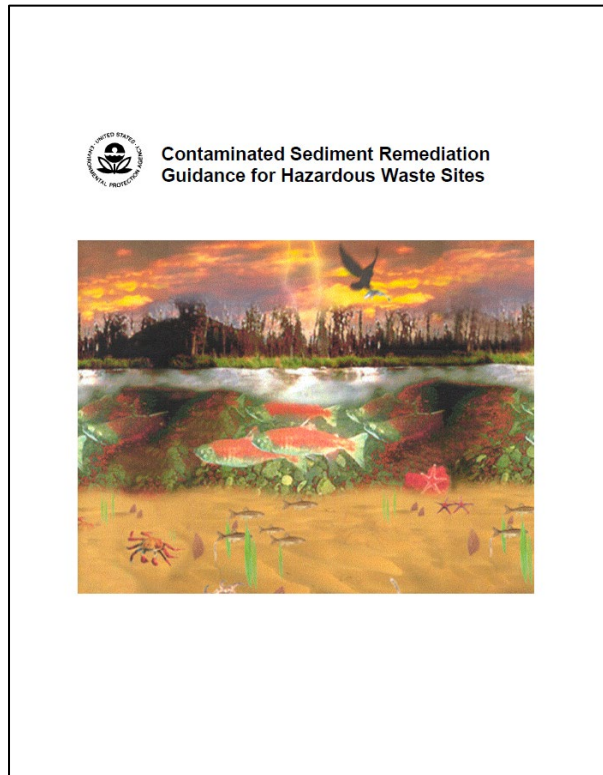
In-situ Isolation of Contaminated Sediments: Case Studies and Best Practice

Karl Gustavson

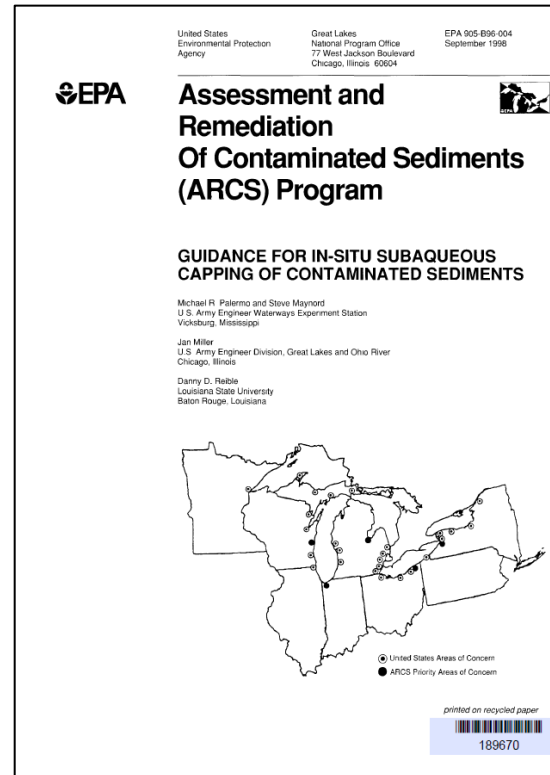
U.S. Environmental Protection Agency

Office of Superfund and Emergency Management, Washington DC

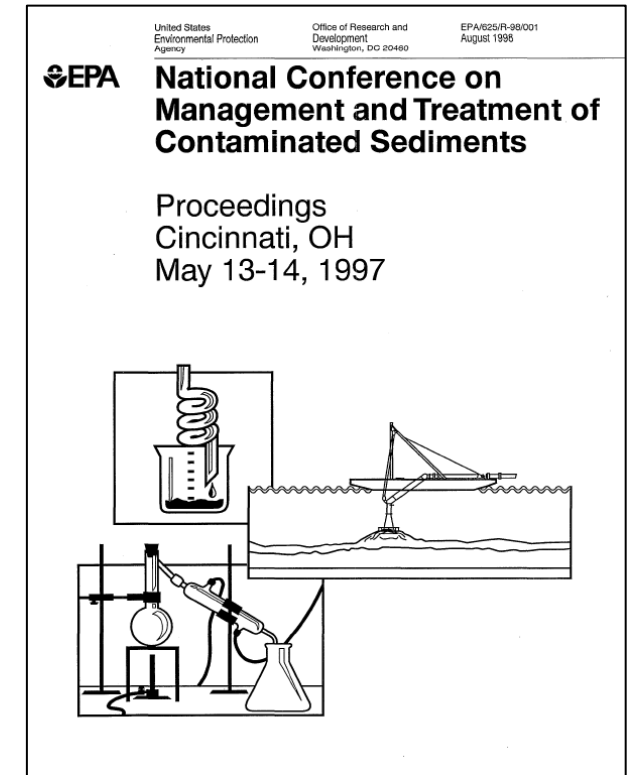
Capping Case Study Compilations



<https://semspub.epa.gov/work/HQ/174471.pdf>



<https://semspub.epa.gov/work/HQ/189670.pdf>



<https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30004S15.TXT>

Using Caps to Limit NAPL Migration: Pine Street Canal (Vermont)

- 38-acre site in Burlington, VT consists of a canal and turning basin, adjacent wetlands, a pond, and land
- 2004 remedy included capping with sand over 8 acres of contaminated sediments
 - Initial cap design did not include an amendment to control NAPL
- Post-construction monitoring identified ongoing release of coal tar in a limited area of the canal
- An amended cap was constructed in 2010 to address releases of oily sheen and coal tar found during monitoring, which included organoclay to address NAPL
- Latest Five Year Review (2021) concluded that the cap remains in place and is functioning as designed

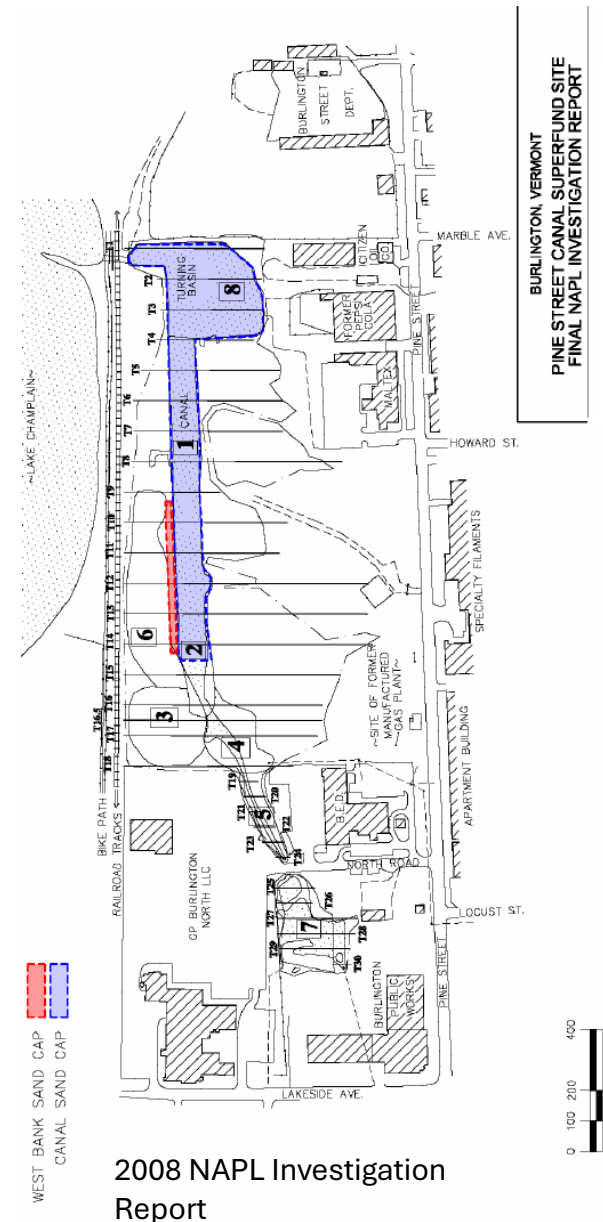


Source: Burlington Free Press: [Pine Street Barge Canal, Burlington VT: A legacy of poison and beauty](#)

Excerpt from “An Overview on Capping” May
2026 Newtown Creek CAG Meeting

Pine Street Canal (Vermont)

- **Canal capping** was completed in March 2003.
- In 2003, a NAPL breakout was discovered in an uncapped area immediately adjacent to, but not in, the canal.
- In 2004, **the sand cap was extended over a portion of the bank** where NAPL was being released.
- Later, NAPL was found on the surface water migration through the sand cap, primarily via gas bubbles.
- In 2010, **an amended cap was constructed** at the southern end of the canal to capture the NAPL before it is released. (“Over time the new cap will fill up and have to be replaced.”)
- To extend the life of the new cap (and prevent contamination from migrating into the canal), several **passive recovery wells were installed** along the banks of the canal.



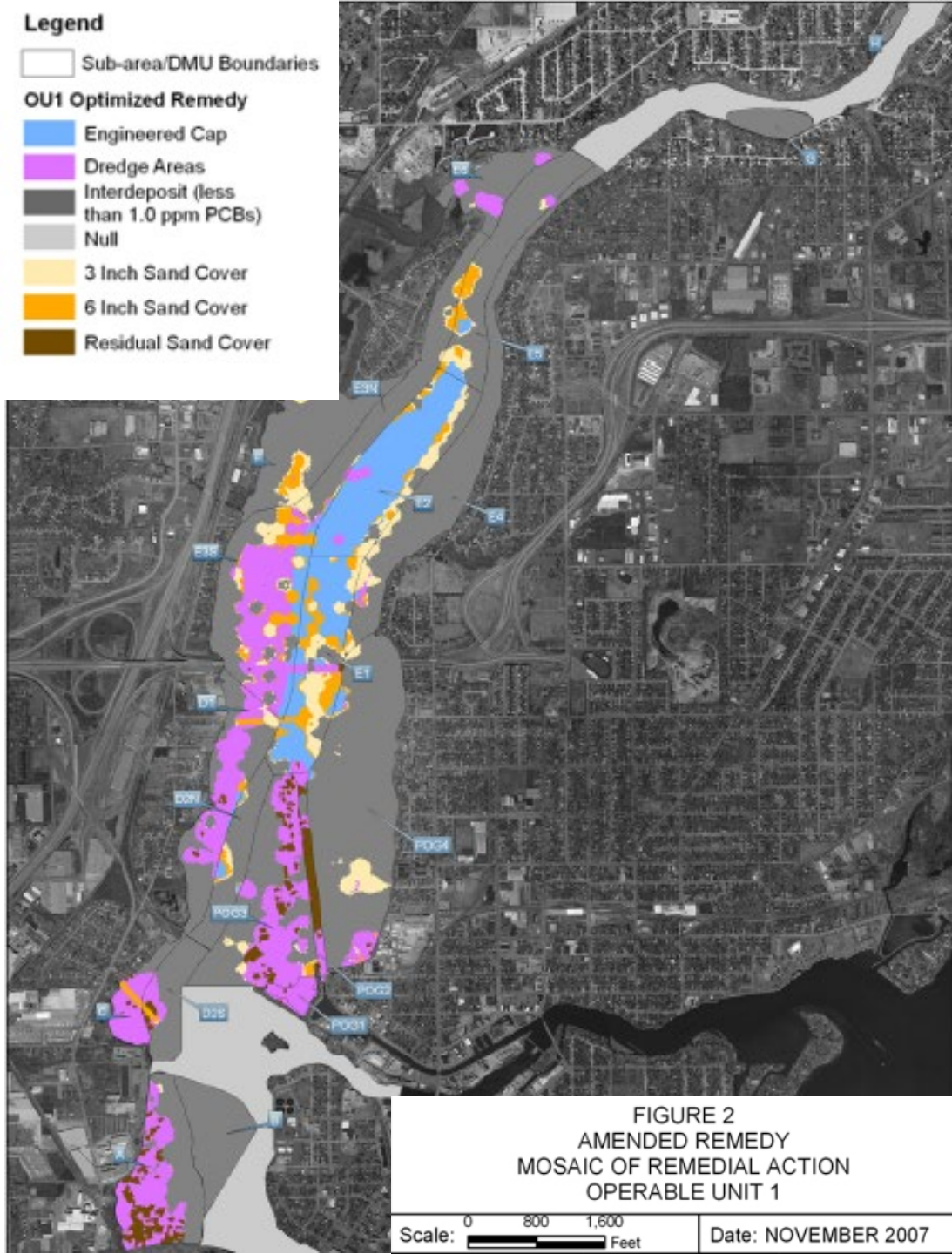
Seaming geocomposite panels



Placement of geocomposite

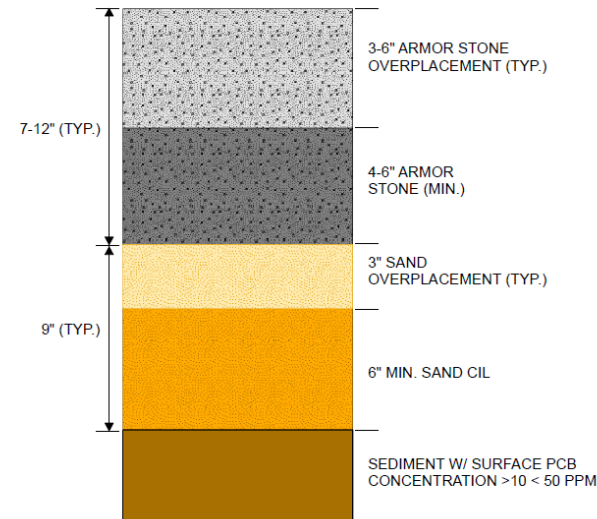


Photograph of barge configuration of geocomposite placement



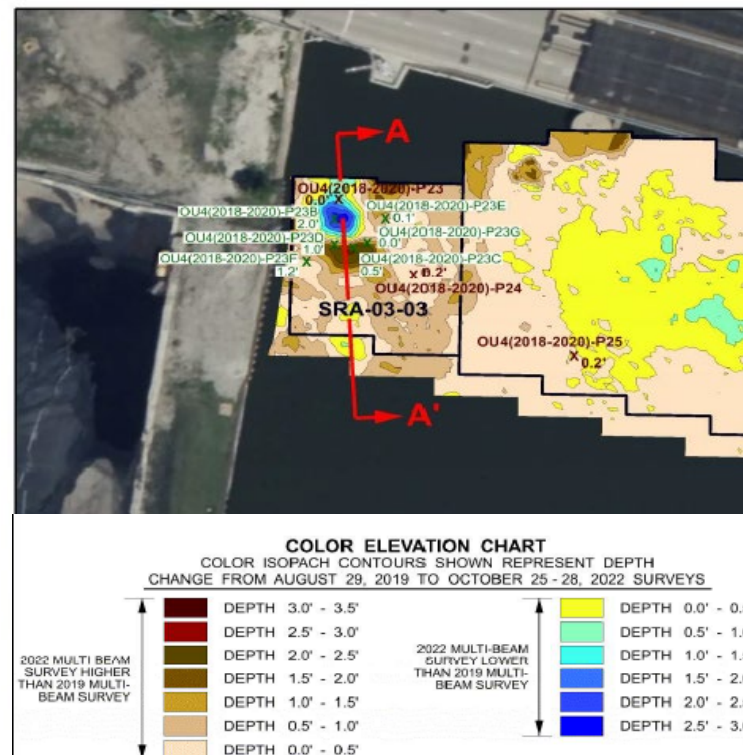
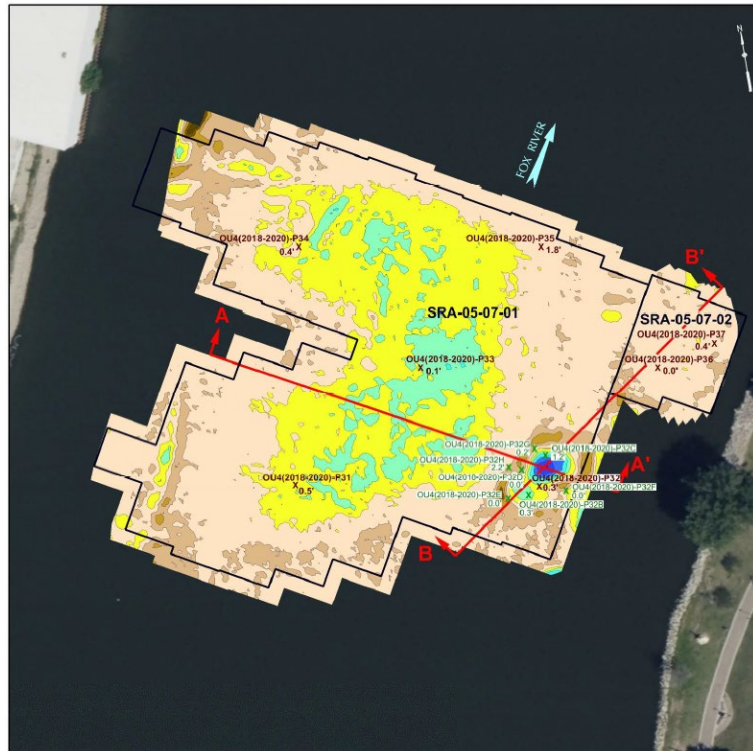
Lower Fox River (Wisconsin)

- PCB releases from historic paper making discharges
- All dredging remedy amended to dredge/cap/cover
- 268 acres of armored sand cap (114 acres in OU1)
- Physical and chemical monitoring



Lower Fox River

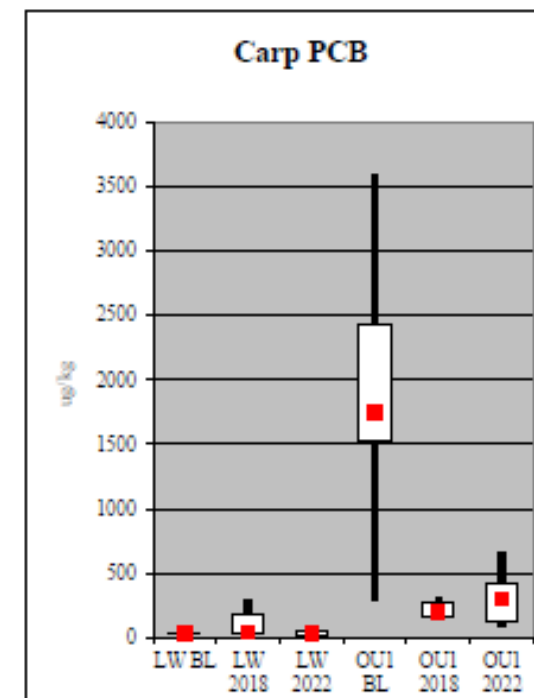
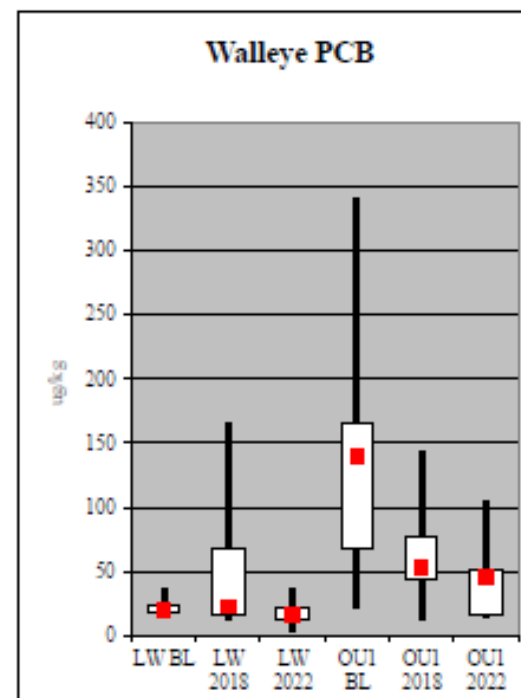
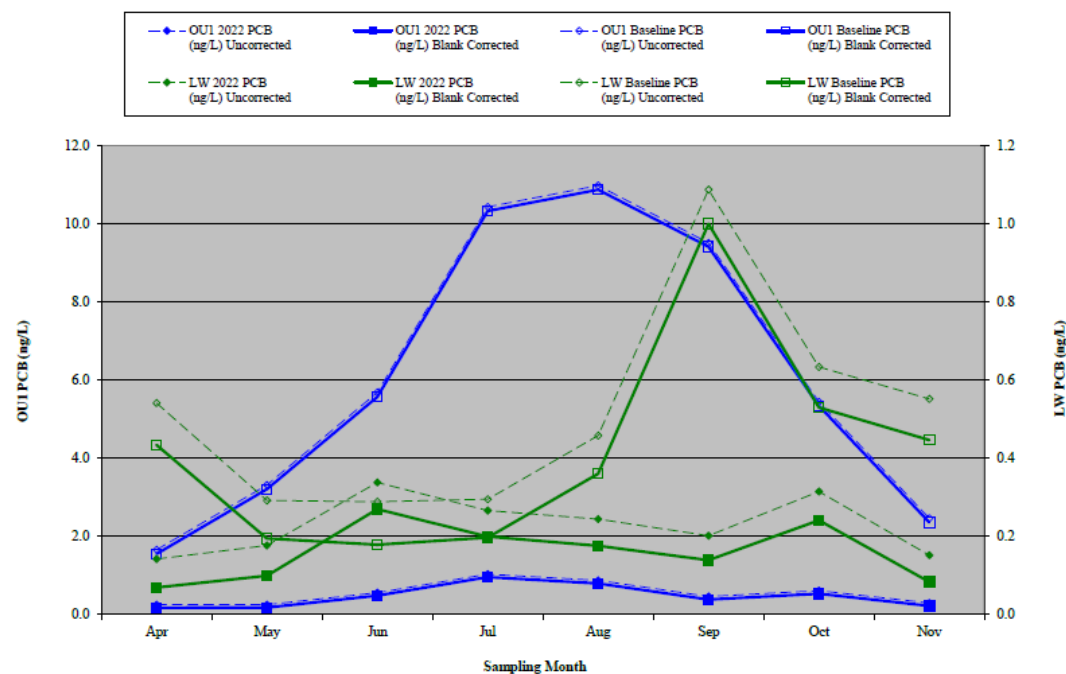
- Routine and flood event-based bathymetry; poling/probing surveys to confirm armor layer and depth of sediment deposition.
- Poling/probing surveys indicate cap armor stone was present at all 490 poling locations providing and that cap armor layer coverage exceeds 95% over the caps.
- Surveys identified some areas of cap-induced settlement and some minor depressions likely primarily due to propwash. The amount of settlement observed in areas of cap-induced settlement did not exceed the range predicted during the design.



Lower Fox River

- Long-term monitoring of surface water and fish tissue is ongoing.

Isolation layer sampling showed “There were no measurable levels of PCBs in the 2-inch segment of the sand CIL analyzed at each location during each sampling event.”

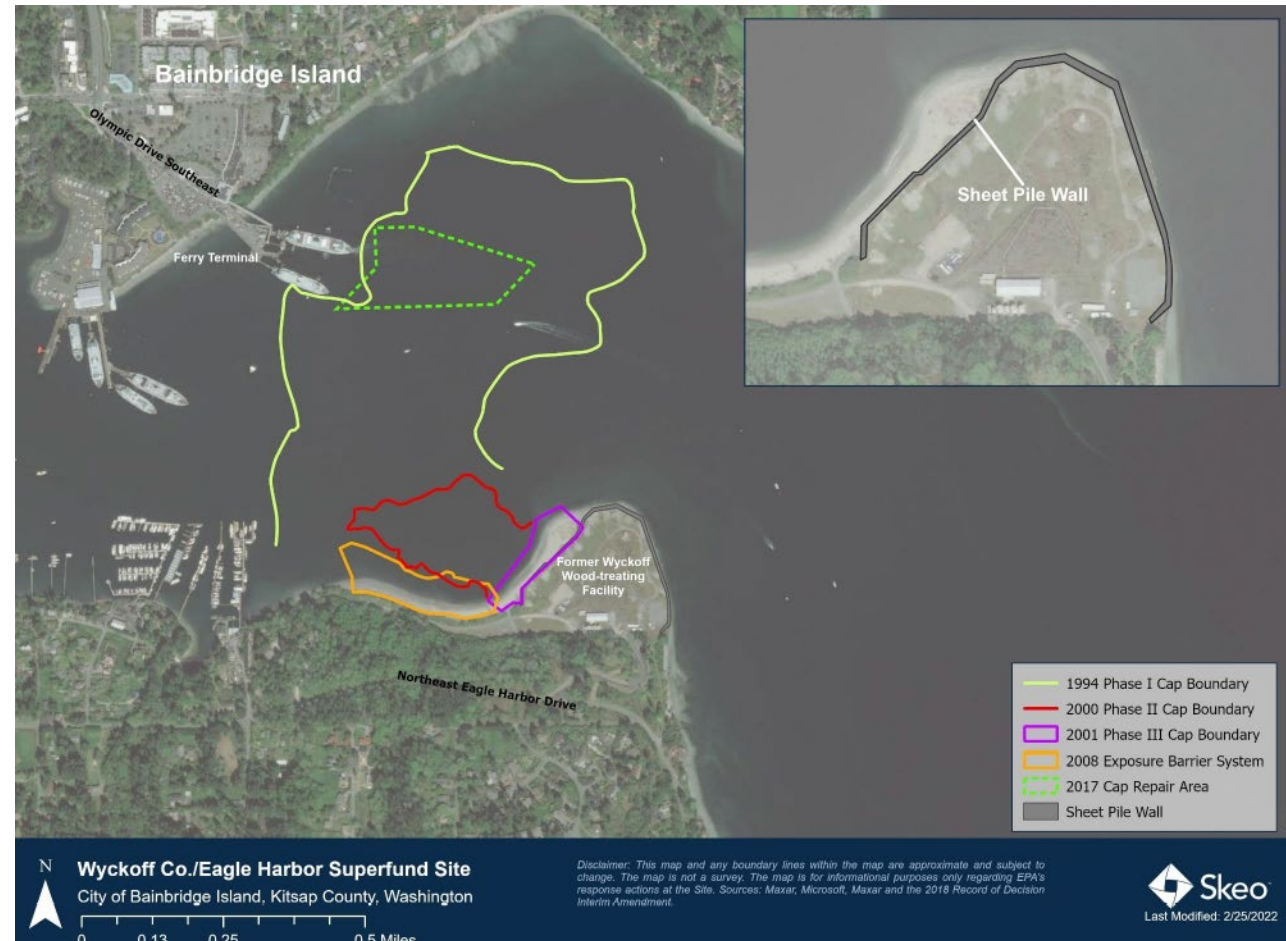


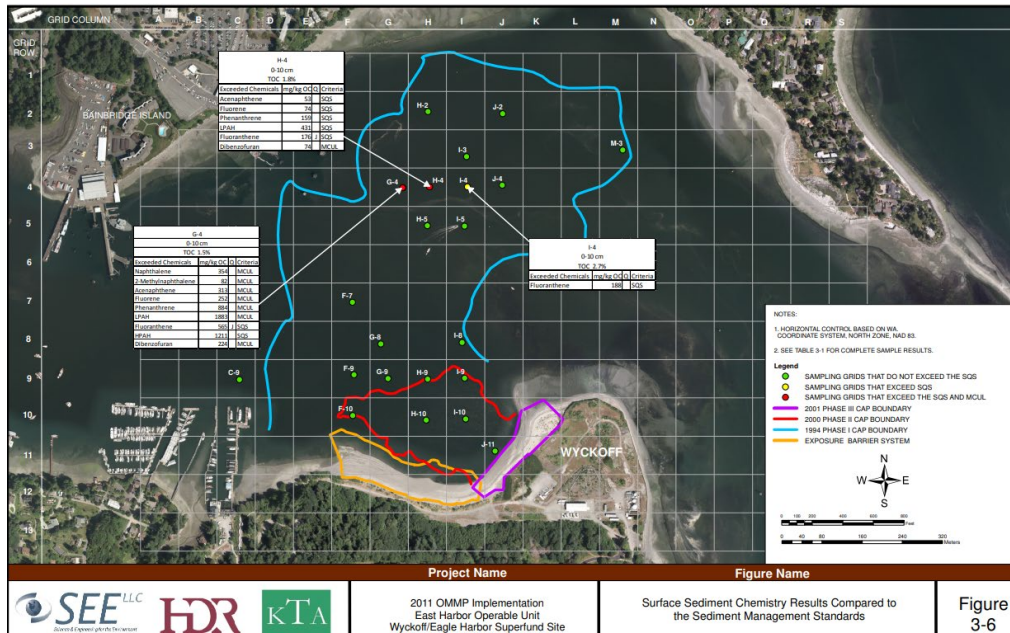
Wyckoff/Eagle Harbor (Puget Sound)

After complaints from citizens in 2005, EPA discovered creosote contamination in beach sediments at the Site.

In 2007, an ESD required an exposure barrier system (EBS) to cover contaminated sediments of the West Beach, and construction of a subtidal cap extension to cover sediments not previously capped.

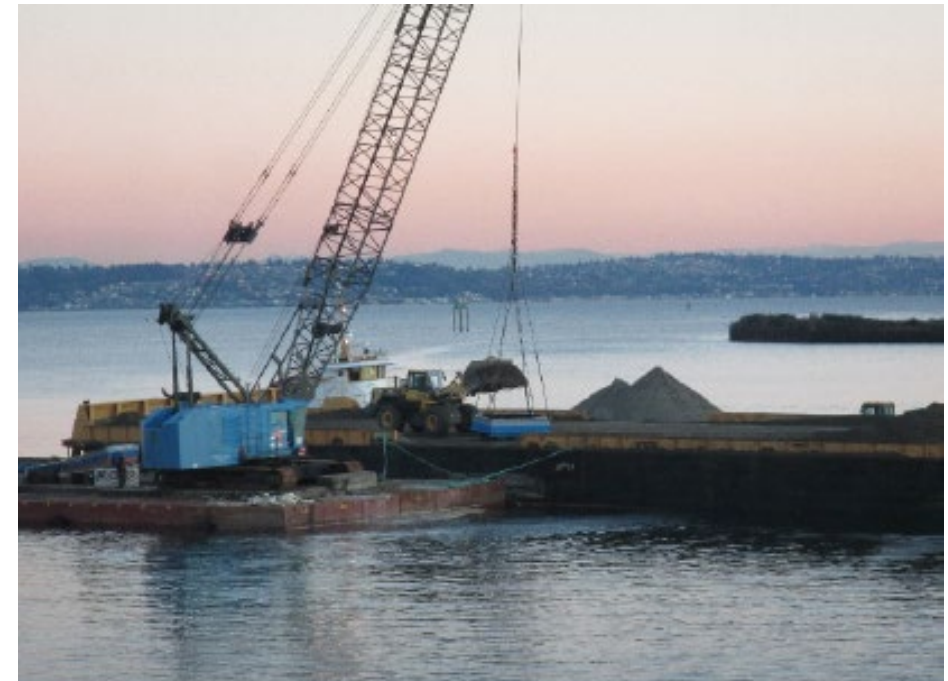
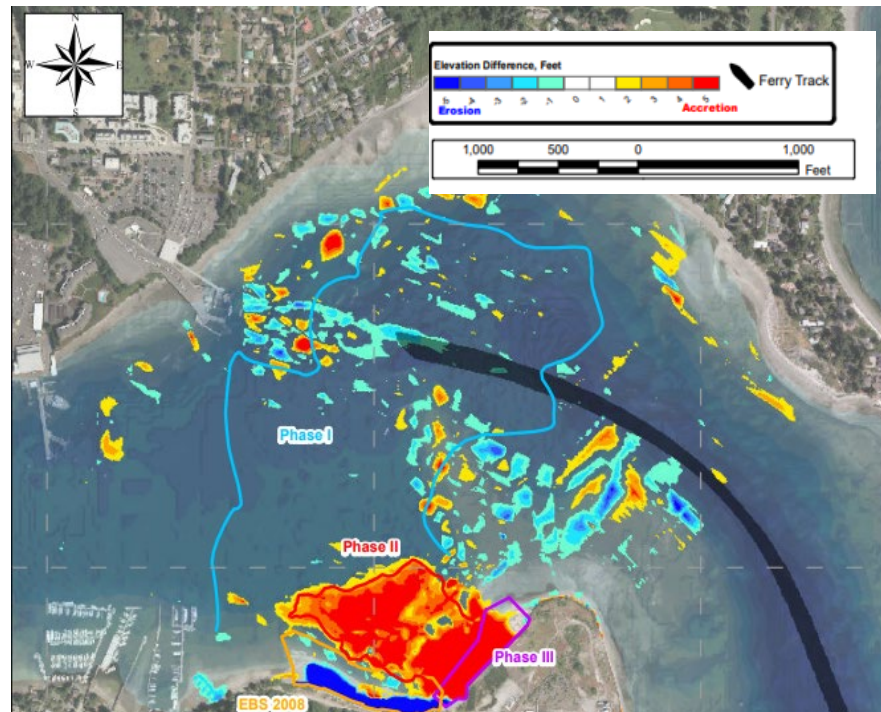
- NAPL/PAH releases from former wood treating
- 54+ acre cap, adjacent upland source control
- Multi-phase 3' sand cap using dredged sediment
- Physical and chemical monitoring

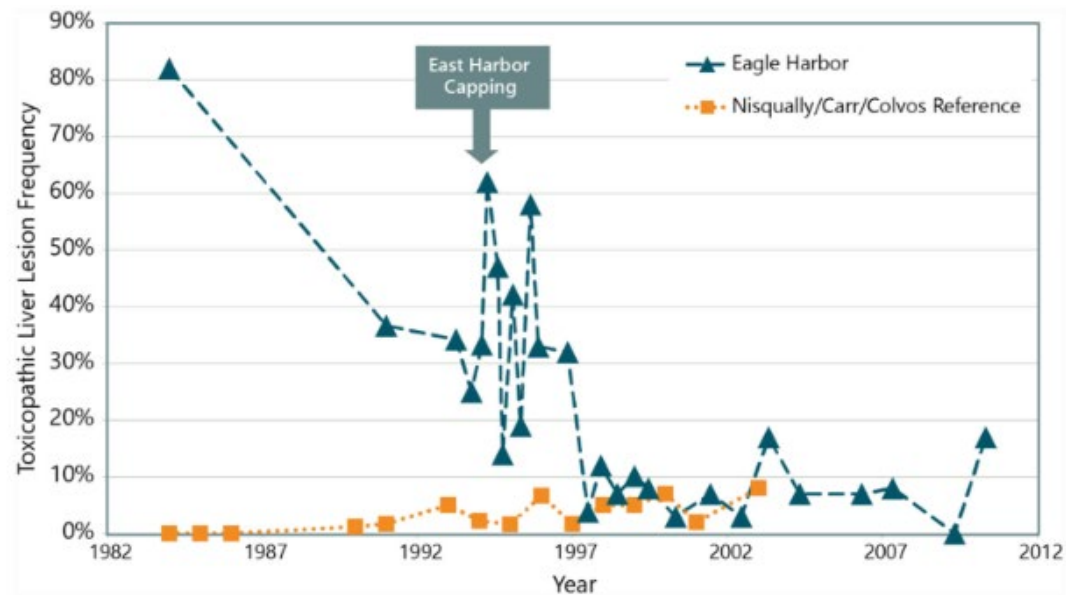




Wyckoff/Eagle Harbor

- Surface sediment monitoring and differential bathymetry indicated that ferry operations led to cap erosion
- Subsequently repaired with erosion resistant materials

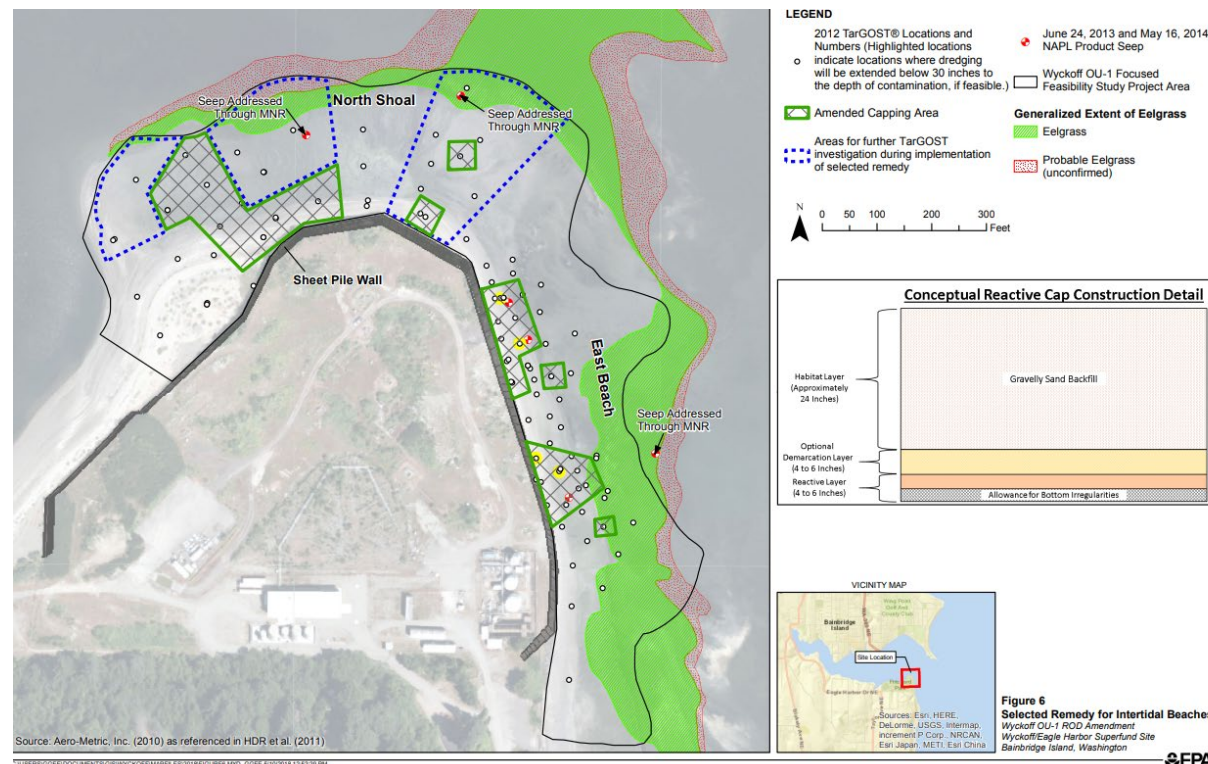
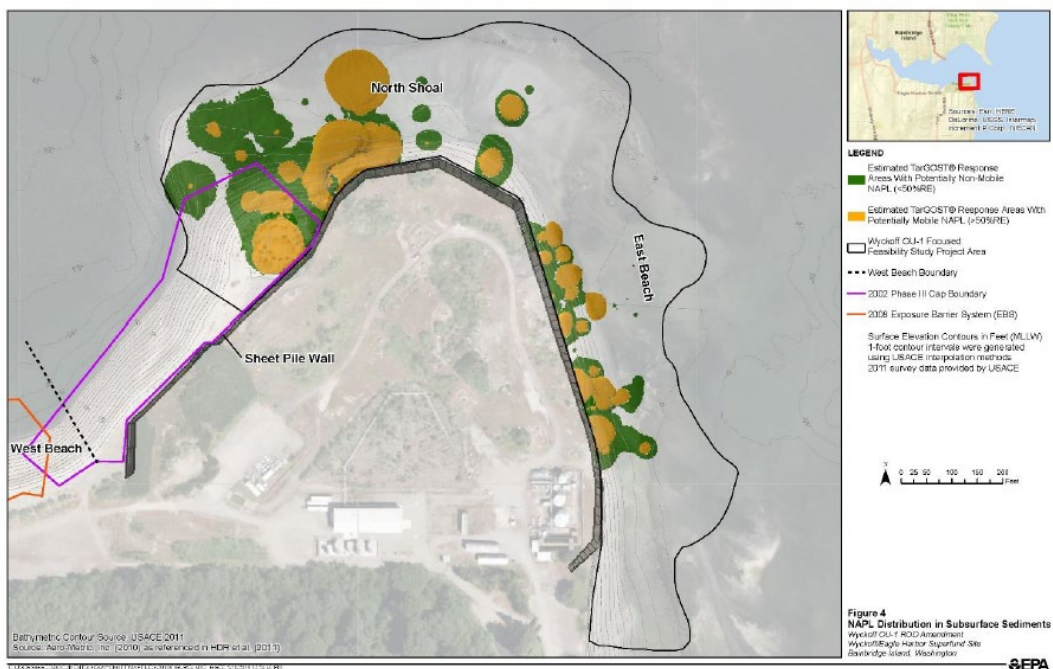




Patmont and Healy, 2024

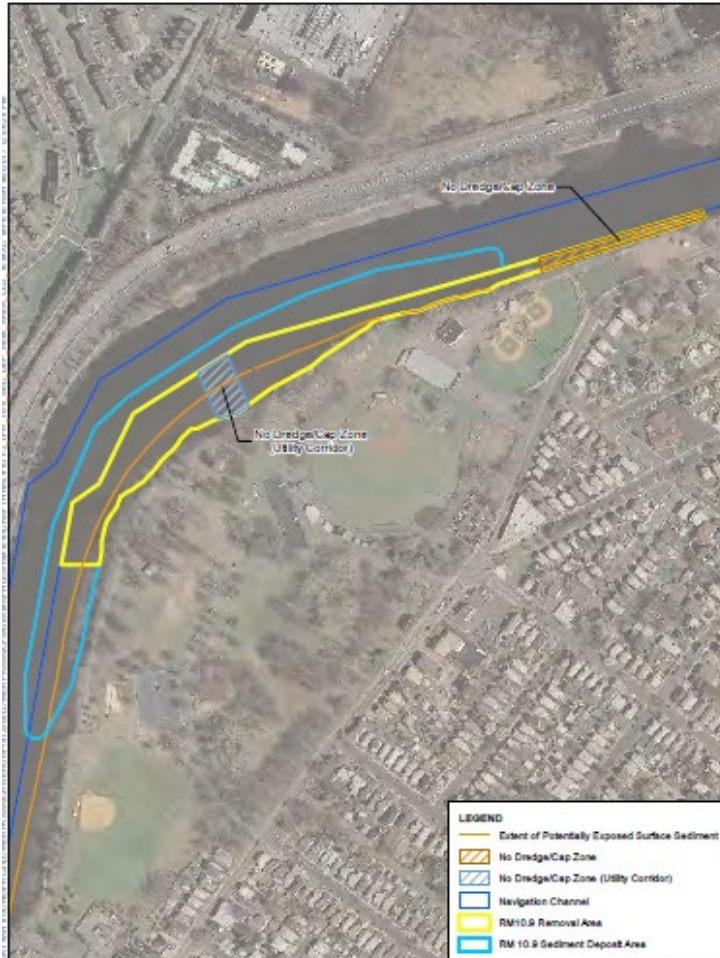
Wyckoff/Eagle Harbor

- Positive outcomes to fish health status
- Subtidal caps O&M responsibilities transferred to State
- Site monitoring indicated ongoing NAPL releases from upland sources to intertidal areas resulting in additional remediation and a ROD amendment



Passaic River, NJ RM 10.9 TCRA Cap

- Industrial river, multiple COCS, incl. TCDD
- Dredge/cap
- 0.5 river mile, 4.3 acre early action
- Physical and chemical monitoring

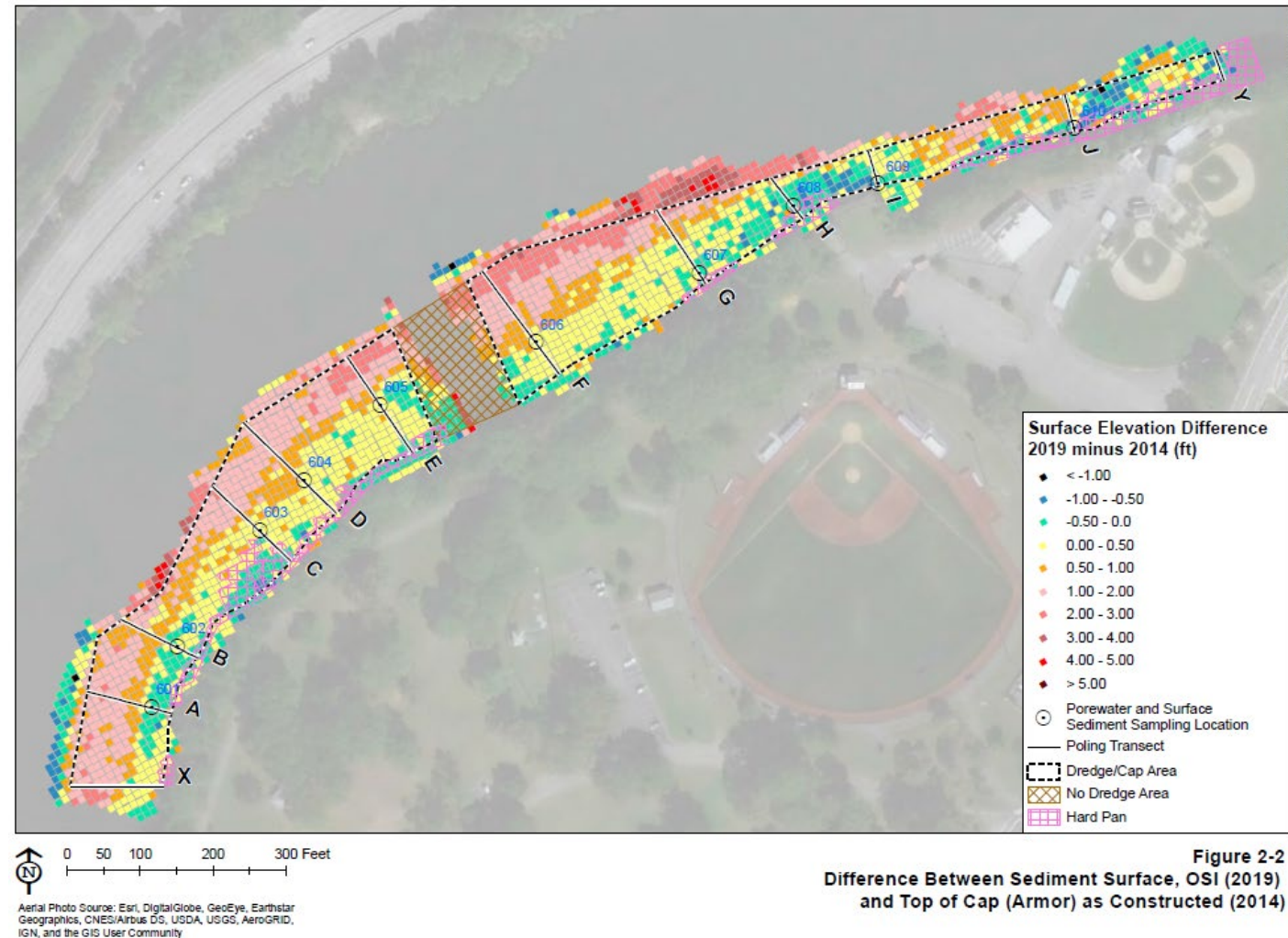


Sand/Habitat Layer
12 inch Type A ($D_{50} = 4.5$ inches)
Armor Layer
Geotextile
10 inch Sand/Active Layer
Underlying Sediment
(Post Dredge)



Passaic River, NJ RM 10.9 TCRA Cap

- Bathymetry, LIDAR, and poling to determine cap elevation
- Deposition on top of cap following placement; some indication of settling



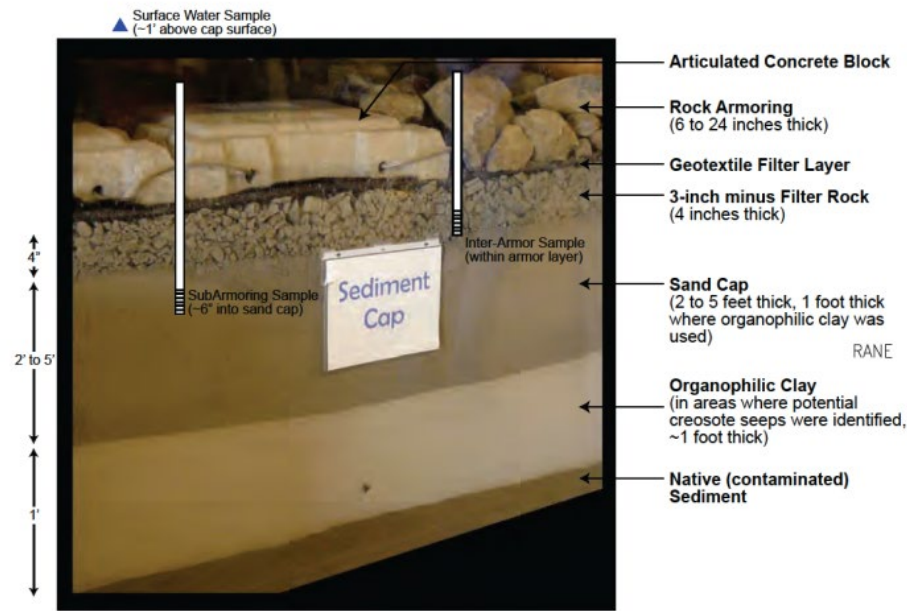
Passaic River (RM 10.9 TCRA Cap)

- “TCDD was not detected in any of the porewater samples and is consistent with modeling.”
- The Removal Action objectives to reduce the potential for receptors to be exposed to underlying contaminated sediment and prevent migration of contamination in the underlying sediments from below the cap are being achieved.



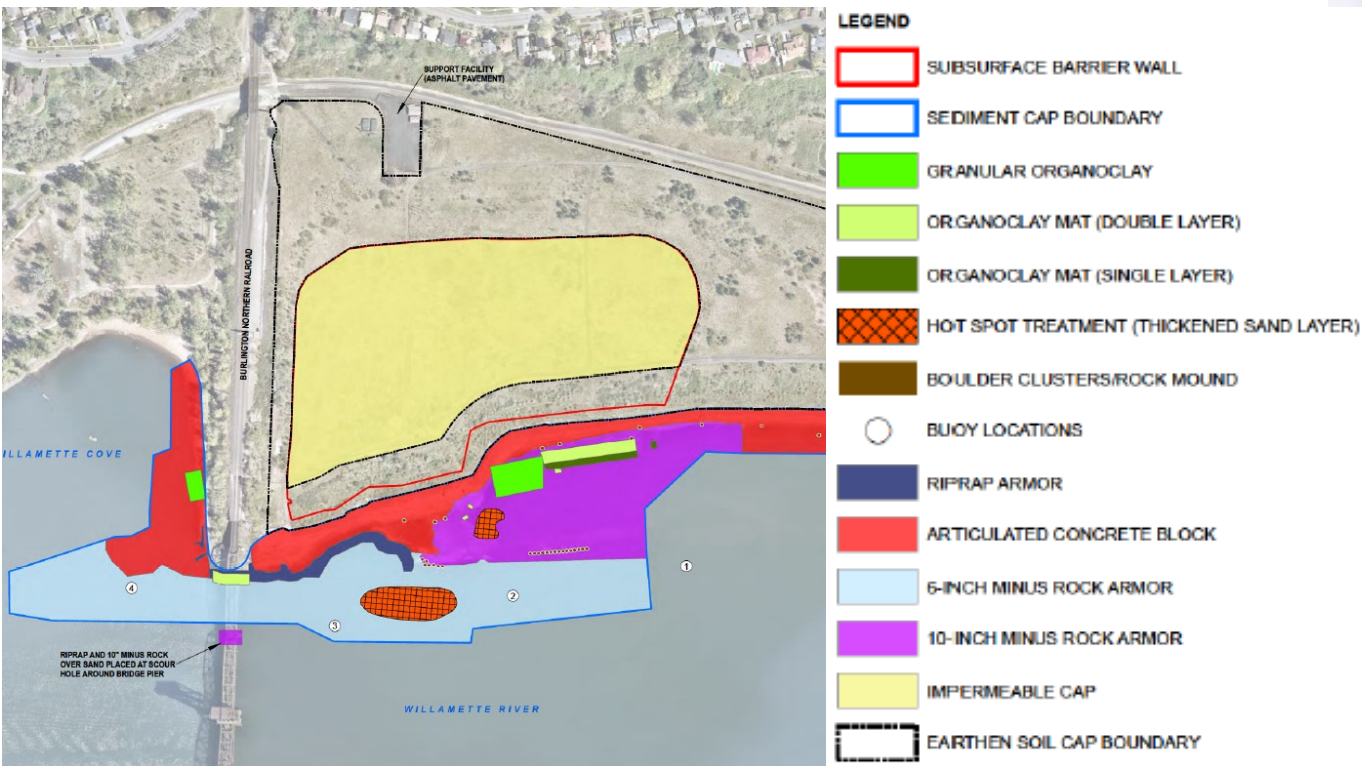
Location	2,3,7,8-TCDD						
	Porewater						Overlying Sediment
	Underlying Sediment		Cap Active Layer		Cap Armor Layer		Sediment
	pg/L	Det?	pg/L	Det?	pg/L	Det?	pg/g
19ZC-0601	0.0639 U	N	0.0728 U	N	0.134 U	N	126
19ZC-0602	0.0726 U	N	0.0771 U	N	0.128 U	N	123
19ZC-0603	0.105 U	N	0.0913 U	N	0.0851 U	N	192
19ZC-0604	0.0472 U	N	0.124 U	N	0.0646 U	N	205
19ZC-0605	0.0579 U	N	0.0494 U	N	0.0499 U	N	225
19ZC-0606	0.209 U	N	0.217 U	N	0.106 U	N	246
19ZC-0606-FD	0.123 U	N	0.183 U	N	0.21 U	N	222
19ZC-0607	0.0987 U	N	0.0604 U	N	0.0749 U	N	120 J
19ZC-0608	0.219 U	N	0.22 U	N	0.195 U	N	41.9
19ZC-0609	0.411 U	N	0.221 U	N	0.113 U	N	12.6
19ZC-0610	0.157 U	N	0.186 U	N	0.213 U	N	114
MIN ^{1,2}		N		N		N	12.6
MAX ^{1,2}		N		N		N	246
Average ^{1,2}		N		N		N	148
Median ^{1,2}		N		N		N	126
STDEV ^{1,2}		N		N		N	77

Location	PCB-52						
	Porewater						Overlying Sediment
	Underlying Sediment		Cap Active Layer		Cap Armor Layer		Sediment
	pg/L	Det?	pg/L	Det?	pg/L	Det?	pg/g
19ZC-0601	3.06 J+	Y	6.16 J+	Y	38	Y	18,400
19ZC-0602	5.11 J+	Y	11.6	Y	28.2	Y	16,700 J
19ZC-0603	17.1	Y	2.52 J+	Y	69.1	Y	20,100 J
19ZC-0604	54	Y	43.4	Y	23.8	Y	24,900 J
19ZC-0605	72.4	Y	4.71 J+	Y	61	Y	21,100 J
19ZC-0606	42 J	Y	6.33 J+	Y	36 J	Y	29,300 J
19ZC-0606-FD	8.39 J	Y	5.75 J+	Y	17 J	Y	24,100 J
19ZC-0607	77.6	Y	6.37 J+	Y	61.8	Y	12,900
19ZC-0608	4.42 J+	Y	8.24 J+	Y	8.51	Y	6,180
19ZC-0609	363	Y	642 ²	Y	14.9	Y	2,190
19ZC-0610	16.4	Y	29.6	Y	31.9	Y	12,200
MIN ^{1,2}	3		3		8.51		2,190
MAX ^{1,2}	363		43		69		29,300
Average ^{1,2}	60		12		35		17,097
Median ^{1,2}	17		6		32		18,400
STDEV ^{1,2}	104		13		20		8,178



McCormick & Baxter (Portland, OR)

- Former wood treating, NAPL and various COCs
- 23 acres, incl. organoclay active cap
- Upland source control
- Physical and chemical monitoring

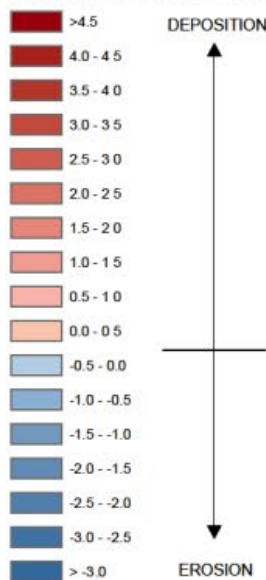


Organoclay RCMs to address releases of NAPL sheens discovered following cap construction in 2004.

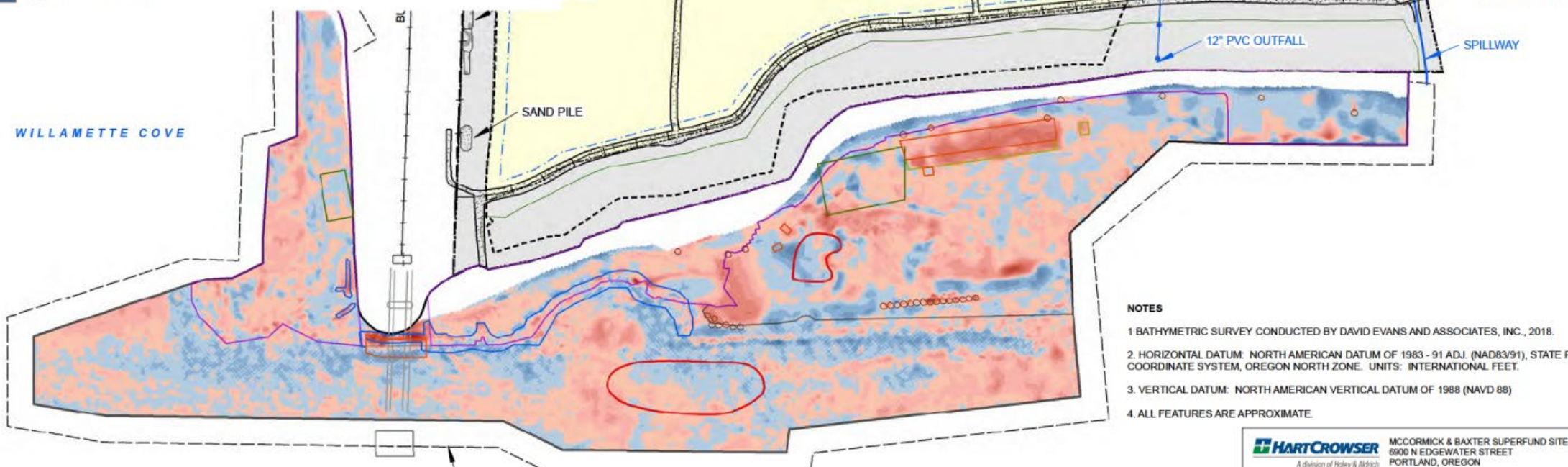


LEGEND

BATHYMETRY DIFFERENCE 2006 VS. 2018 (FEET)



- BOULDER CLUSTERS/ROCK MOUND
- RIPRAP ARMOR
- GRANULAR ORGANOCLAY
- ORGANOCLAY MAT (DOUBLE LAYER)
- ORGANOCLAY MAT (SINGLE LAYER)
- HOT SPOT TREATMENT (THICKENED SAND LAYER)
- ARTICULATED CONCRETE BLOCK
- 6-INCH MINUS ROCK ARMOR
- 10-INCH MINUS ROCK ARMOR
- TURF REINFORCEMENT MAT OVER EARTHEN CAP
- EARTHEN SOIL CAP BOUNDARY
- SUBSURFACE BARRIER WALL
- SEDIMENT CAP BOUNDARY
- IMPERMEABLE CAP

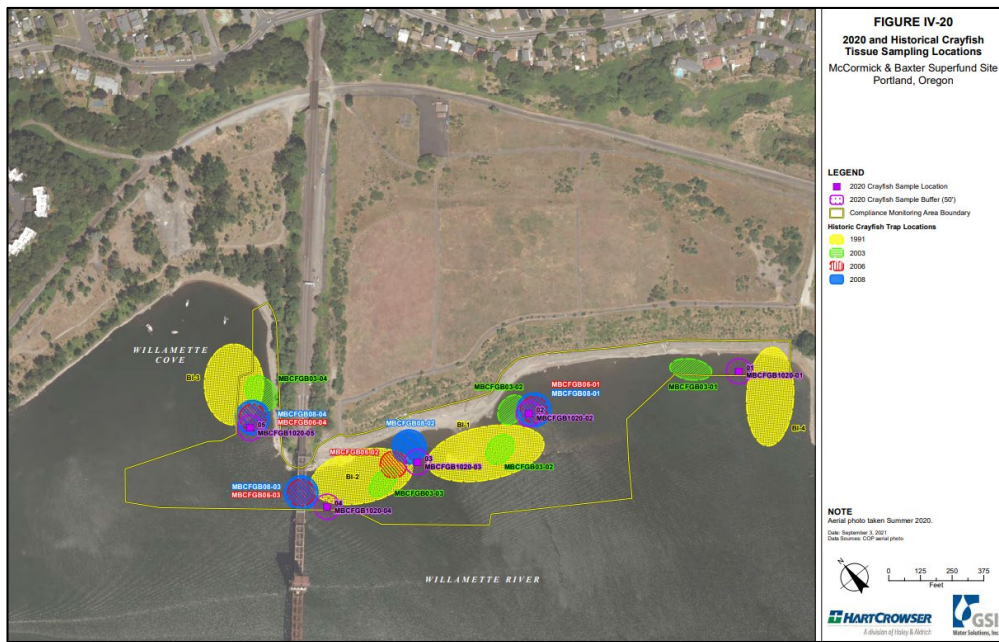


McCormick & Baxter (Portland, OR)

- “Changes in mudline elevations ranged from 3 feet or less of sediment erosion to up to 4.5 feet of deposition.”
- “The bathymetry evaluation indicates that 6-inch, 12-inch, and 24-inch rock armoring layer design thicknesses have been maintained and the sediment cap continues to meet the performance standards of the ROD.”

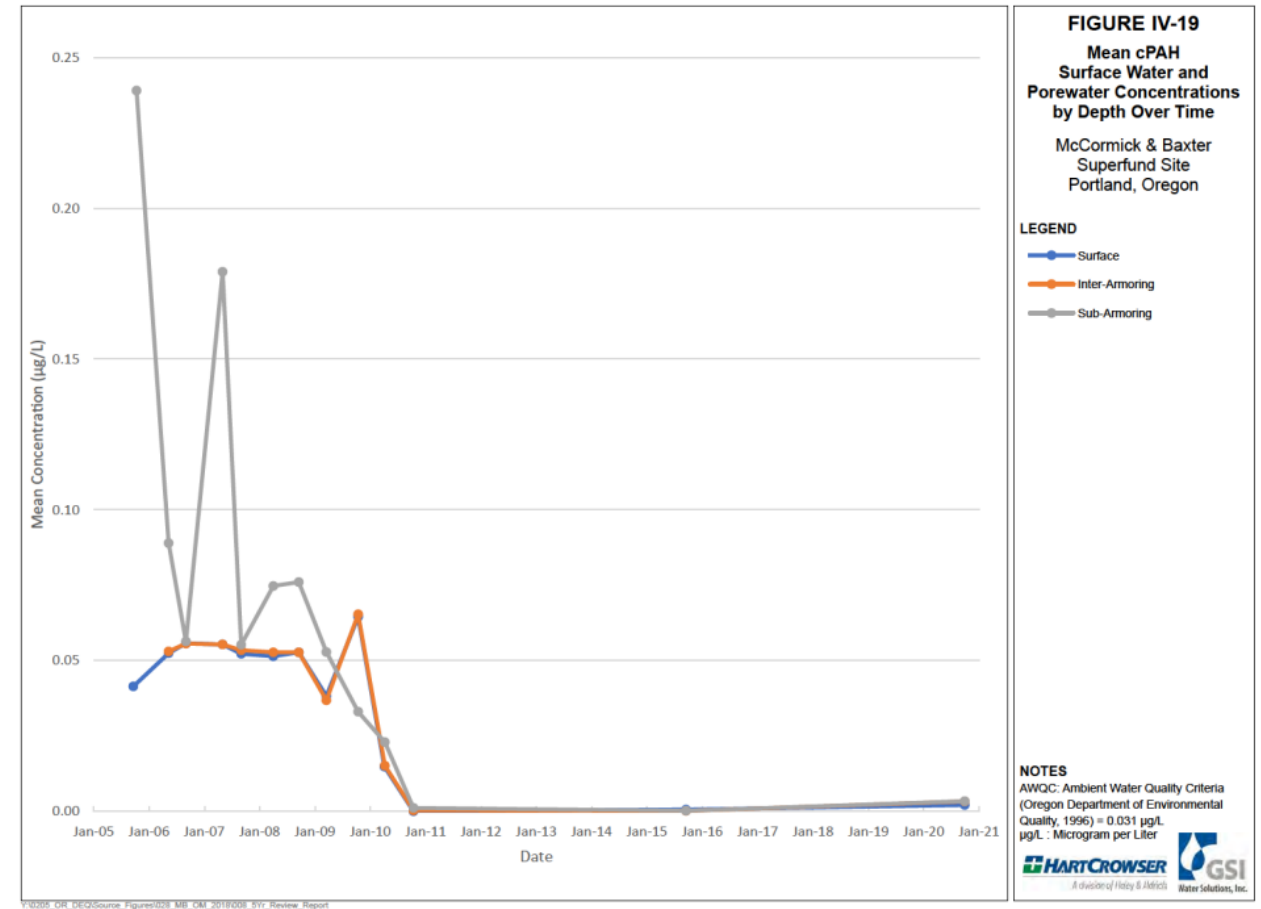
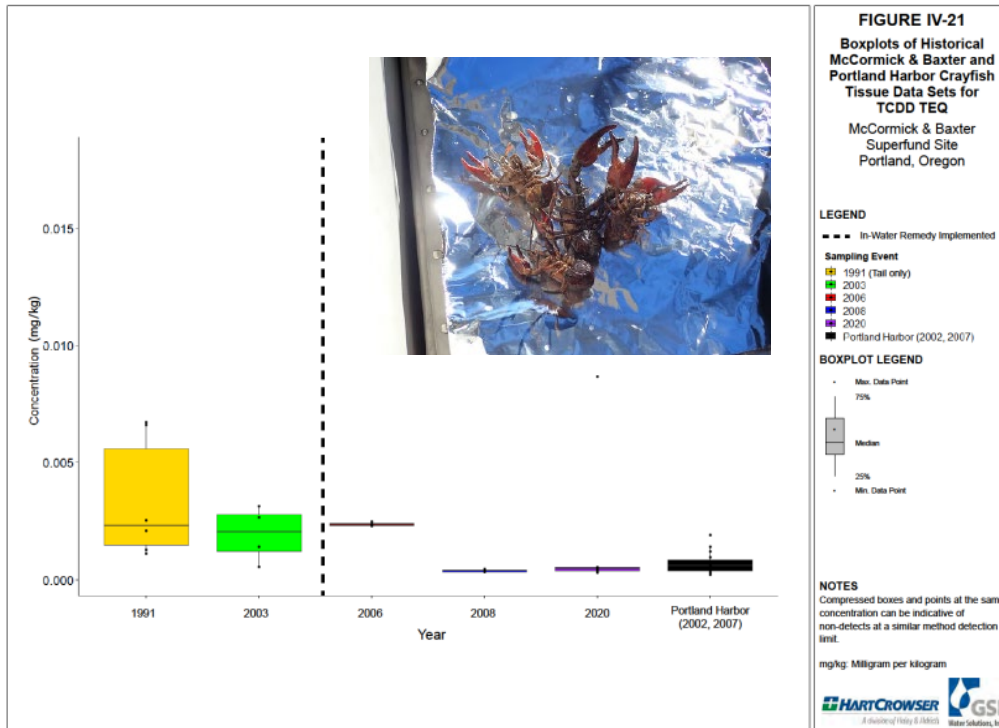
NOTES

- 1 BATHYMETRIC SURVEY CONDUCTED BY DAVID EVANS AND ASSOCIATES, INC., 2018.
2. HORIZONTAL DATUM: NORTH AMERICAN DATUM OF 1983 - 91 ADJ. (NAD83/91), STATE PLANE COORDINATE SYSTEM, OREGON NORTH ZONE. UNITS: INTERNATIONAL FEET.
3. VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88)
4. ALL FEATURES ARE APPROXIMATE.



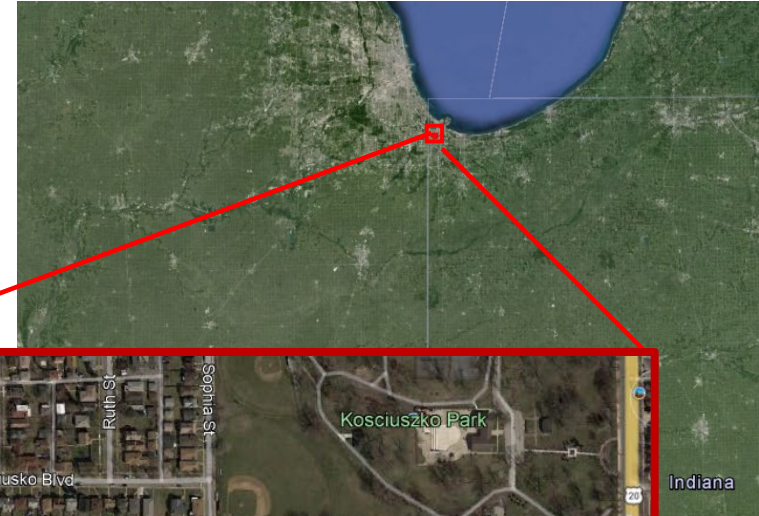
McCormick & Baxter (Portland, OR)

- Porewater/surface water and crayfish sampling
- “These results indicate that the remedy is performing as intended and that there has been no chemical breakthrough at the locations monitored.”



West Branch Grand Calumet River

- 1.2 river miles, relatively shallow and low gradient
- Impacted by NAPL/PAHs from historic industrial discharges



Google Earth

West Branch Grand Calumet River

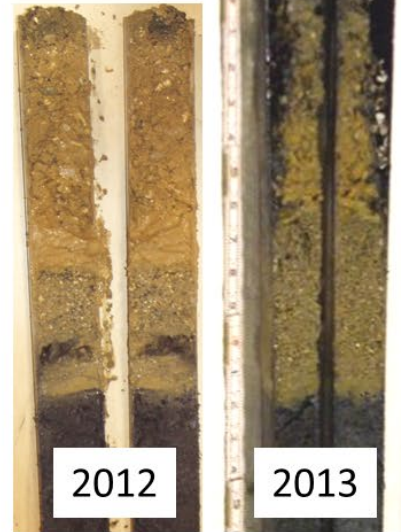
- Hydraulic dredging of top 2-3 ft of sediment
- -Isolation cap: 6 in. of organoclay and granular material below 12 in. of granular material



West Branch Grand Calumet River

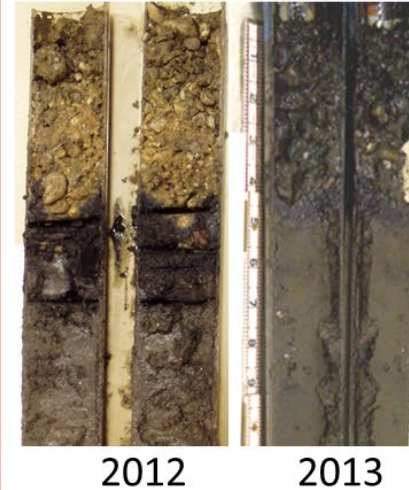
- Pre- and post- capping core evaluation
- Large CSO release after capping
- Considerations of newly deposited material and “as-built” construction

ASBLT-53



Deposition on Top of Cap

ASBLT-70



ASBLT-6



2013 Core Samples

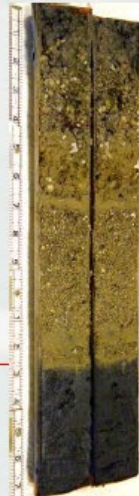
ASBLT 06
(28.8" long)



ASBLT 13
(28.8" long)



ASBLT 24
(24.3" long)



ASBLT 26
(20.4" long)



ASBLT 53
(36" long)



ASBLT 68
(20.4" long)

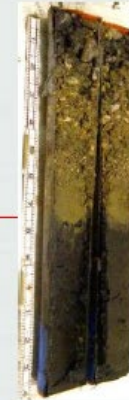
ASBLT 70
(20.4" long)



ASBLT 87A
(20.4" long)



ASBLT 87B
(16.8" long)



ASBLT 88
(18" long)



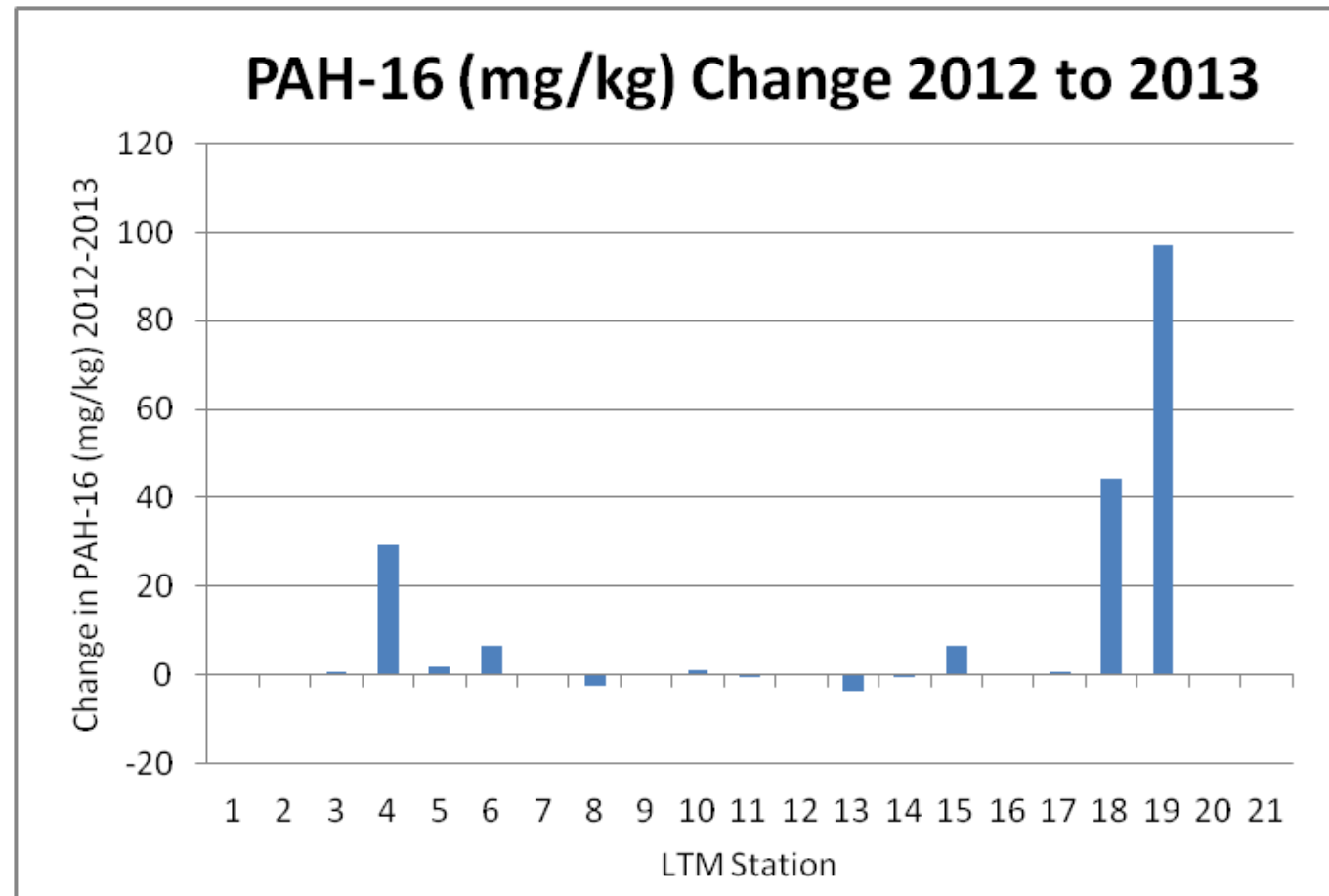
BUILDING STRONG®

ERDC

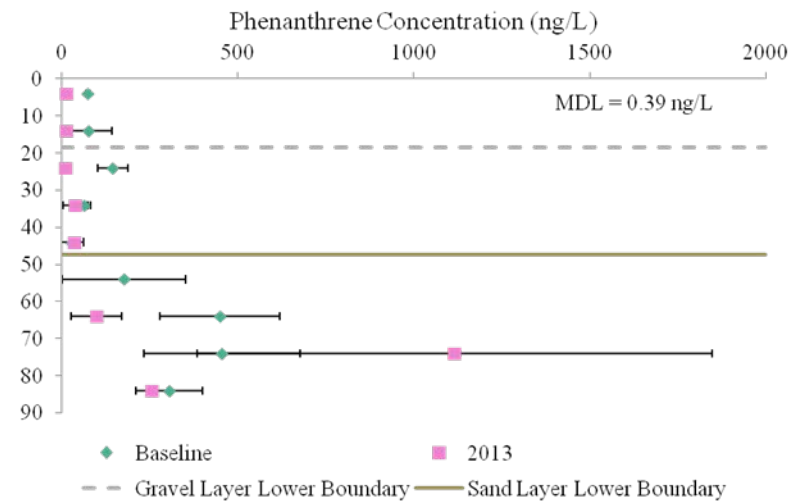
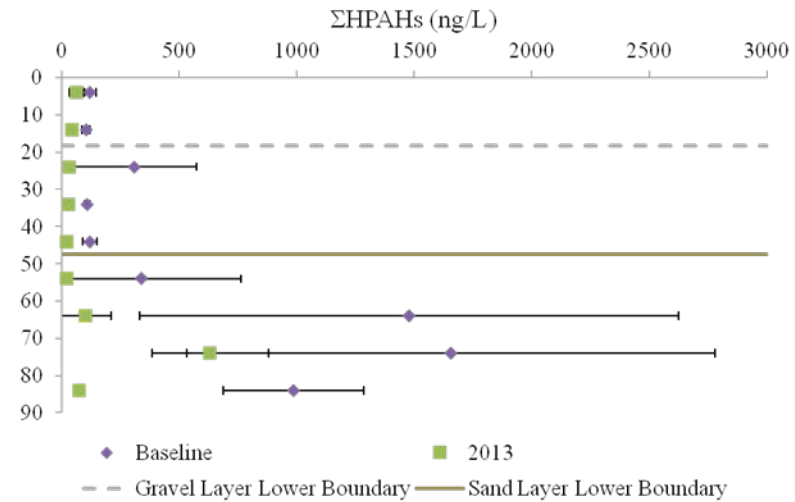
Innovative solutions for a safer, better world

Changes in Surface Sediment Concentration at LTM Stations

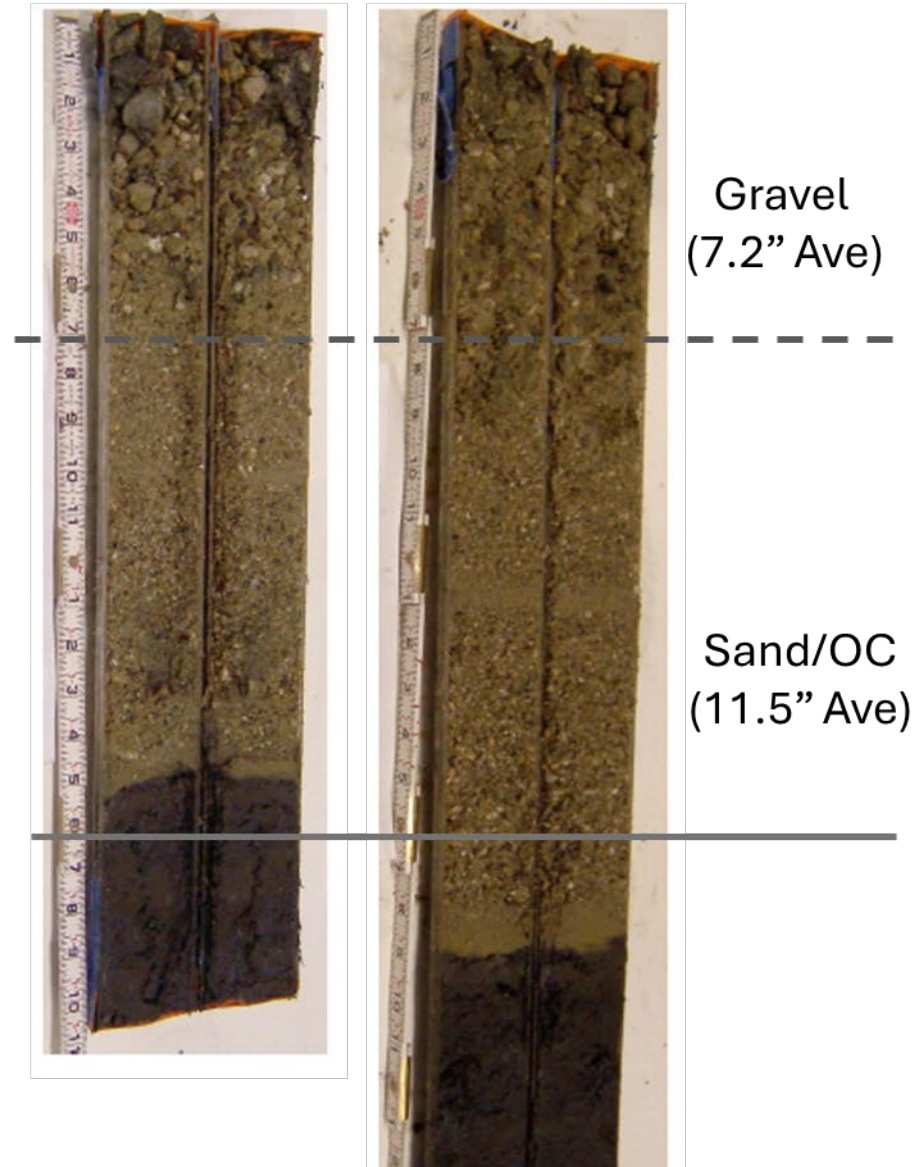
- A couple of stations with relatively large concentration increases.
- Indications that the contaminated material derives from uncapped areas.



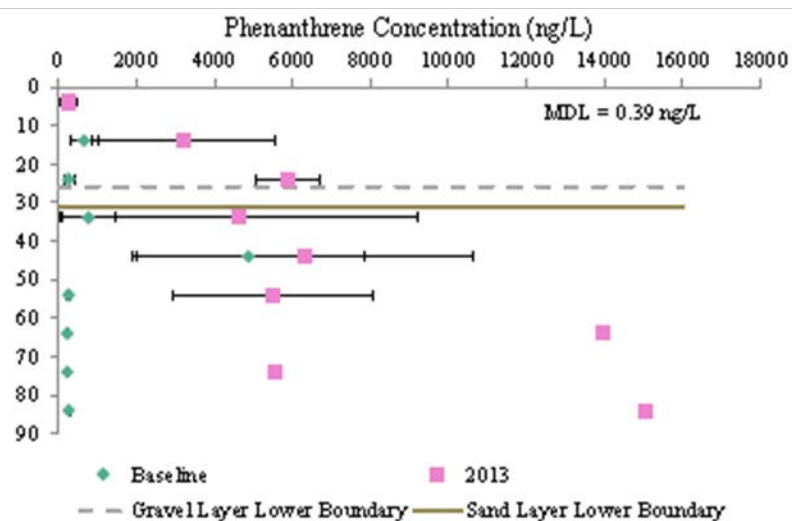
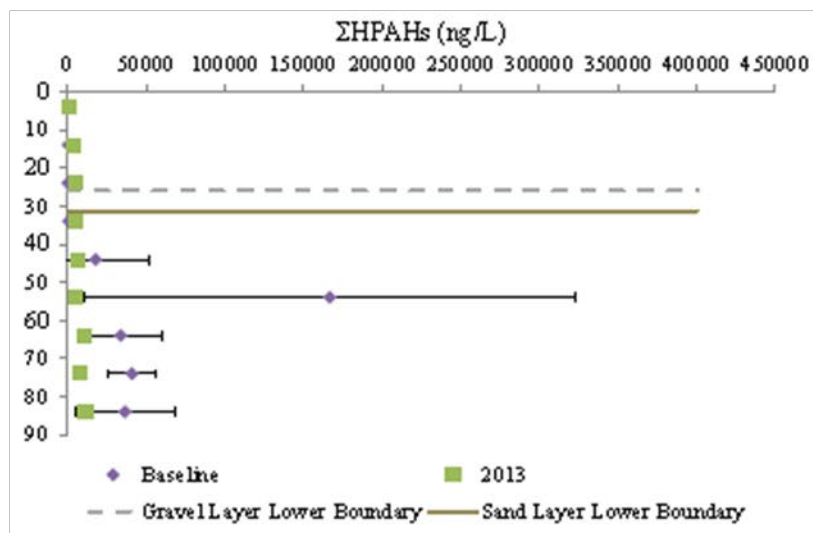
LTM-02 PAH Profiles



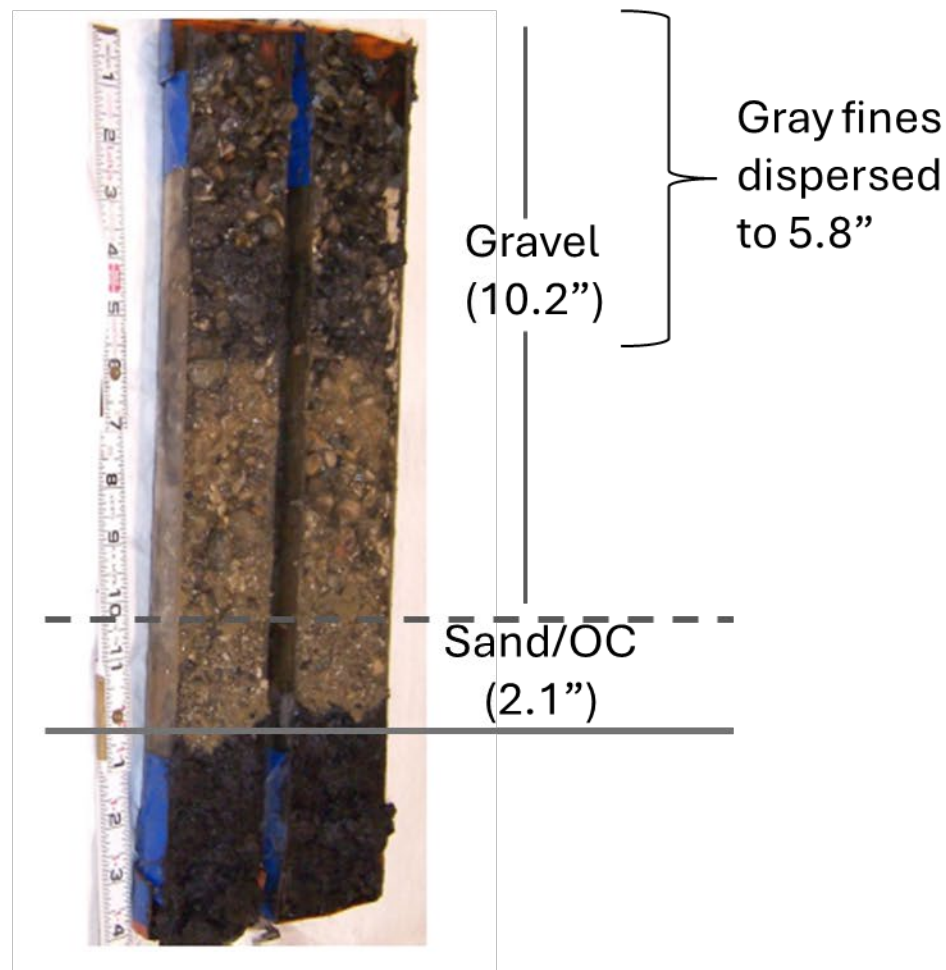
LTM-02 (Dup) Core Description



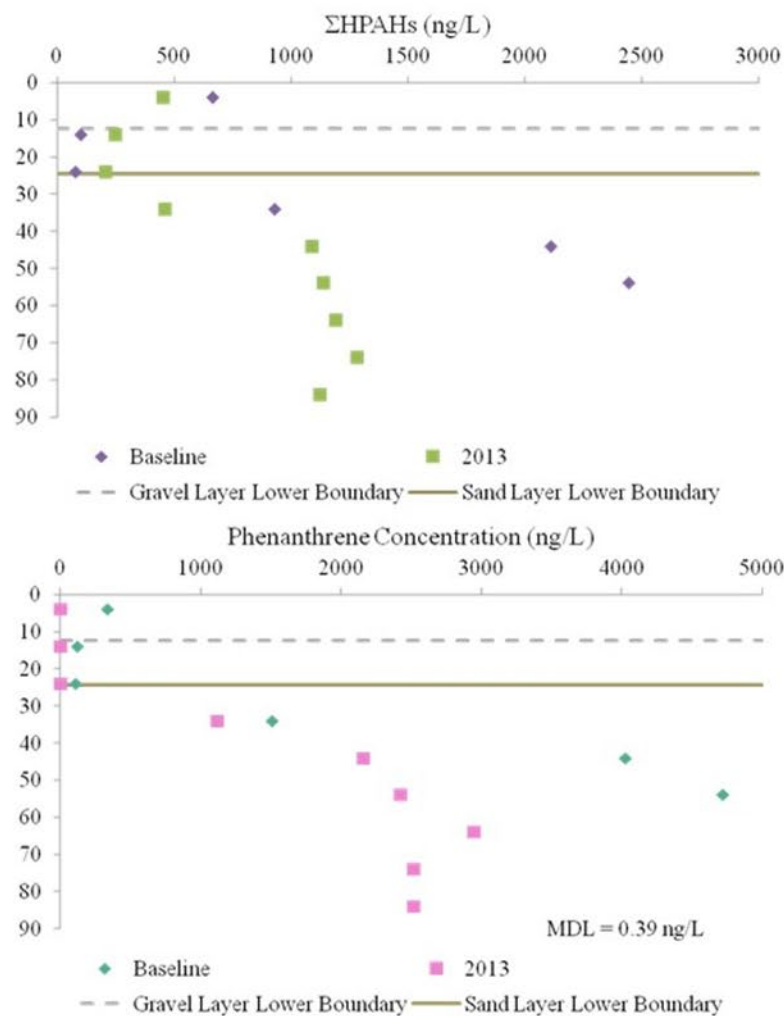
LTM-13 PAH Profiles



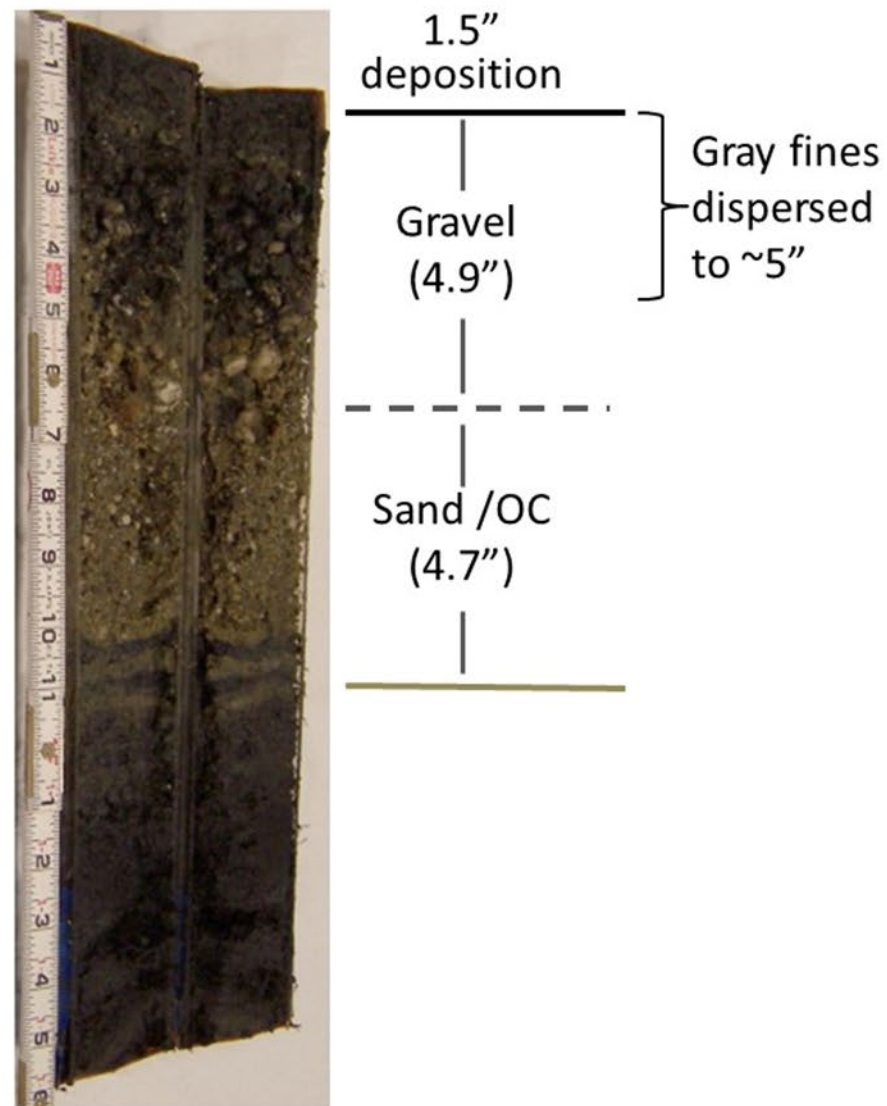
LTM-13 Core Description



LTM-19 PAH Profiles



LTM-19 Core Description



- RIVER CONDITIONS - NASTY!

- STICKY BLACK MUD, METHANE BUBBLES
WHEN STIRRED UP. GRASS GROWTH
THROUGHOUT BOTTOM OF RIVER w/ OIL
AREAS. LOTS OF HUMAN LITTER &
FEMININE PRODUCTS ALL ALONG RIVER

HAZ-MAT SUITS NEEDED?



Conclusions

- Capping (and other) remediation technologies are effective when applied appropriately. Need to consider:
 - Importance of **Characterization**: Much lower potential for impact to the project when sources and contamination are understood before remediation.
 - **Sources**: Characterize and control sources when possible.
 - **Cap design** should consider likely forces impacting its stability and effectiveness.
 - **Construction** control so the “as built” achieves design and remediation objectives.
 - **Monitoring**: Cap performance (physical/chemical stability in capped area) and remedy effectiveness (RAO) monitoring to evaluate performance and inform adaptation as needed.
 - **Maintenance**/repair/expansion when needed.
 - Set realistic **expectations** on post remediation outcomes.

Highlight 5-4: Some Key Points to Remember When Considering In-Situ Capping

- Source control generally should be implemented to prevent recontamination
- In-situ caps generally reduce risk through three primary functions: physical isolation, stabilization, and reduction of contaminant transport
- Caps may be most suitable where water depth is adequate, slopes are moderate, ground water flow gradients are low or contaminants are not mobile, substrates are capable of supporting a cap, and an adequate source of cap material is available
- Evaluation of capping alternatives and design of caps should consider buried infrastructure, such as water, sewer, electric and phone lines, and fuel pipelines
- Alteration of substrate and depth from capping should be evaluated for effects on aquatic biota
- Evaluation of a capping project in natural riverine environments, should include consideration of a fluvial system's inherent dynamics, especially the effects of channel migration, flow variability including extreme events, and ice scour
- Evaluation of capping alternatives should include consideration of cap disruption from human and natural sources, including at a minimum, the 100-year flood and other events such as seismic disturbances with a similar probability of occurrence
- Selection of cap placement methods should minimize the resuspension of contaminated sediment and releases of dissolved contaminants from compacted sediment
- Use of experienced contractors skilled in marine construction techniques is very important to placement of an effective cap
- Monitor in-situ caps during and after placement to evaluate long-term integrity of the cap, recolonization by biota, and evidence of recontamination
- Maintenance of in-situ caps is expected periodically