Esquimalt Harbour Pilot Project Treatment of Wood Waste-Impacted Sediments Using Reactive Amendments

Presented by

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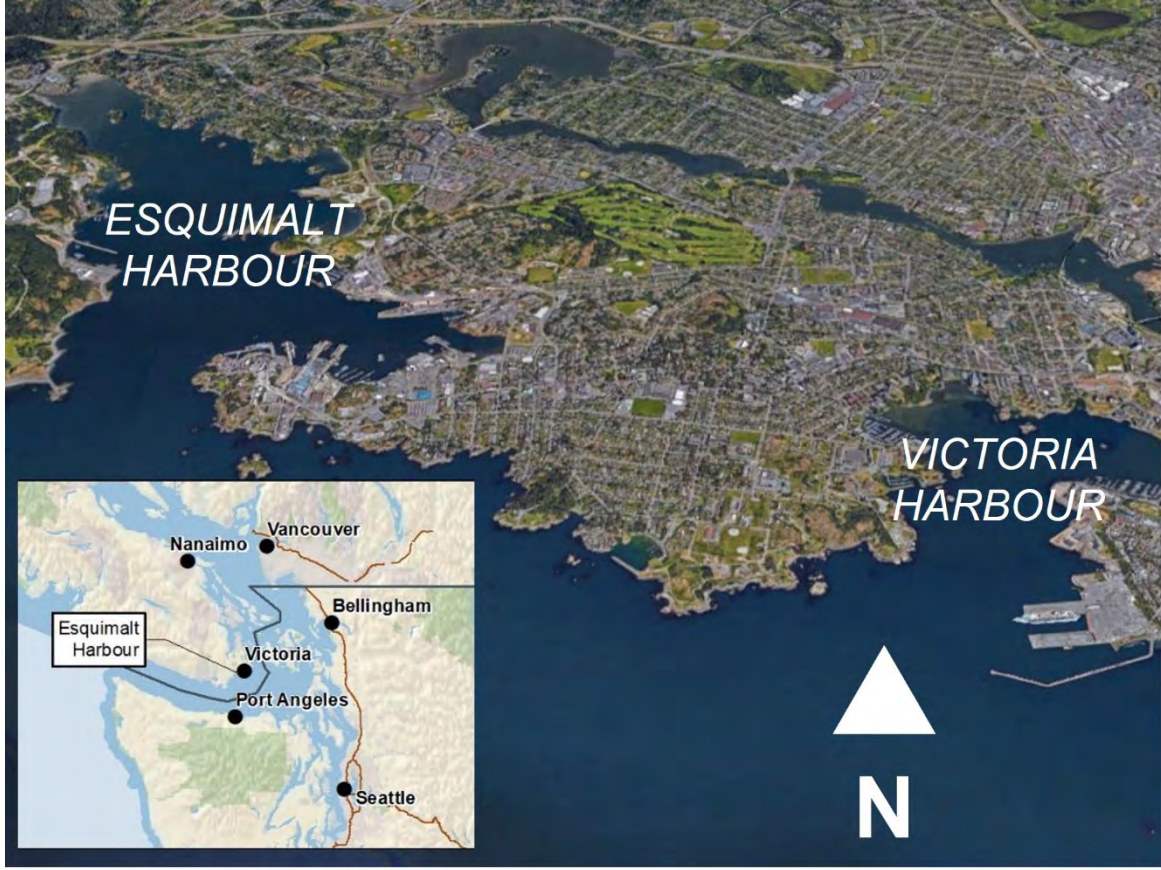
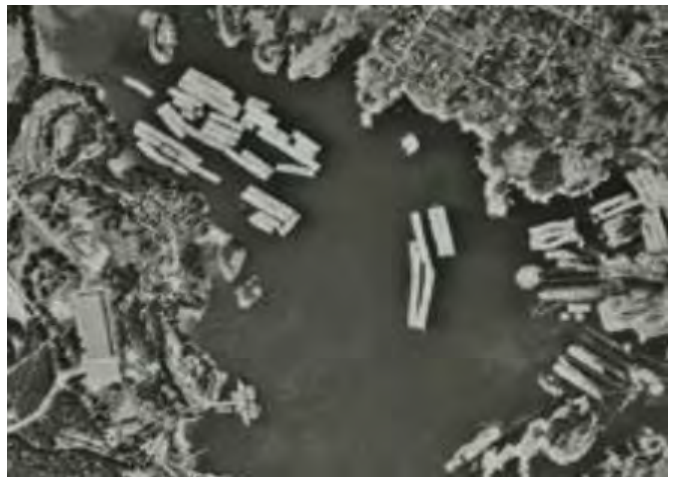
Presentation Outline

- Site Setting
- Effects of Wood Waste
- Porewater Sulphides Using DGT
- Bench-Scale Treatability Testing
- 2020 Pilot Project

North Esquimalt Harbour

- Industrial activities dating back to 1850s (i.e., log booming/storage and wood mill operations)
- Wood waste: logs, bark, wood chips, processed wood (sawdust), and partially decomposed wood fibers





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Effects of Wood Waste

- Wood waste affects both sediment quality and benthic communities
- Physical effects:
  - Slow to decay and persistent over decades
  - Can isolate benthic organisms from native sediment
  - Can be highly flocculent (sawdust and fibers)

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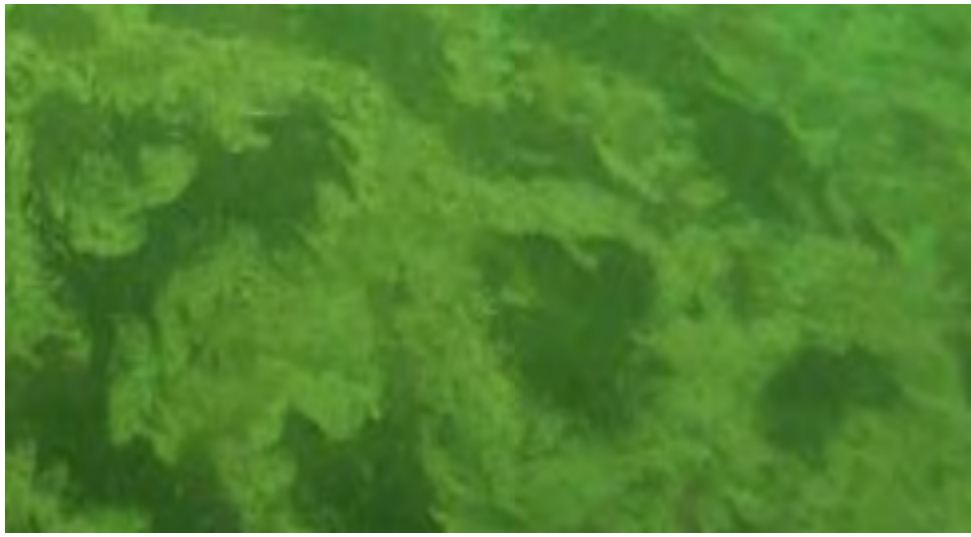
Effects of Wood Waste (cont.)

- Chemical effects
  - High biochemical oxygen demand creates anoxic conditions in surface sediment
  - Degradation by-products (ammonia and sulphide) generated
  - Toxic to benthic organisms (sulphides) and aquatic life
- Biological effects
  - Reduced benthic community diversity
  - Growth of *Beggiatoa* spp. bacterial mats

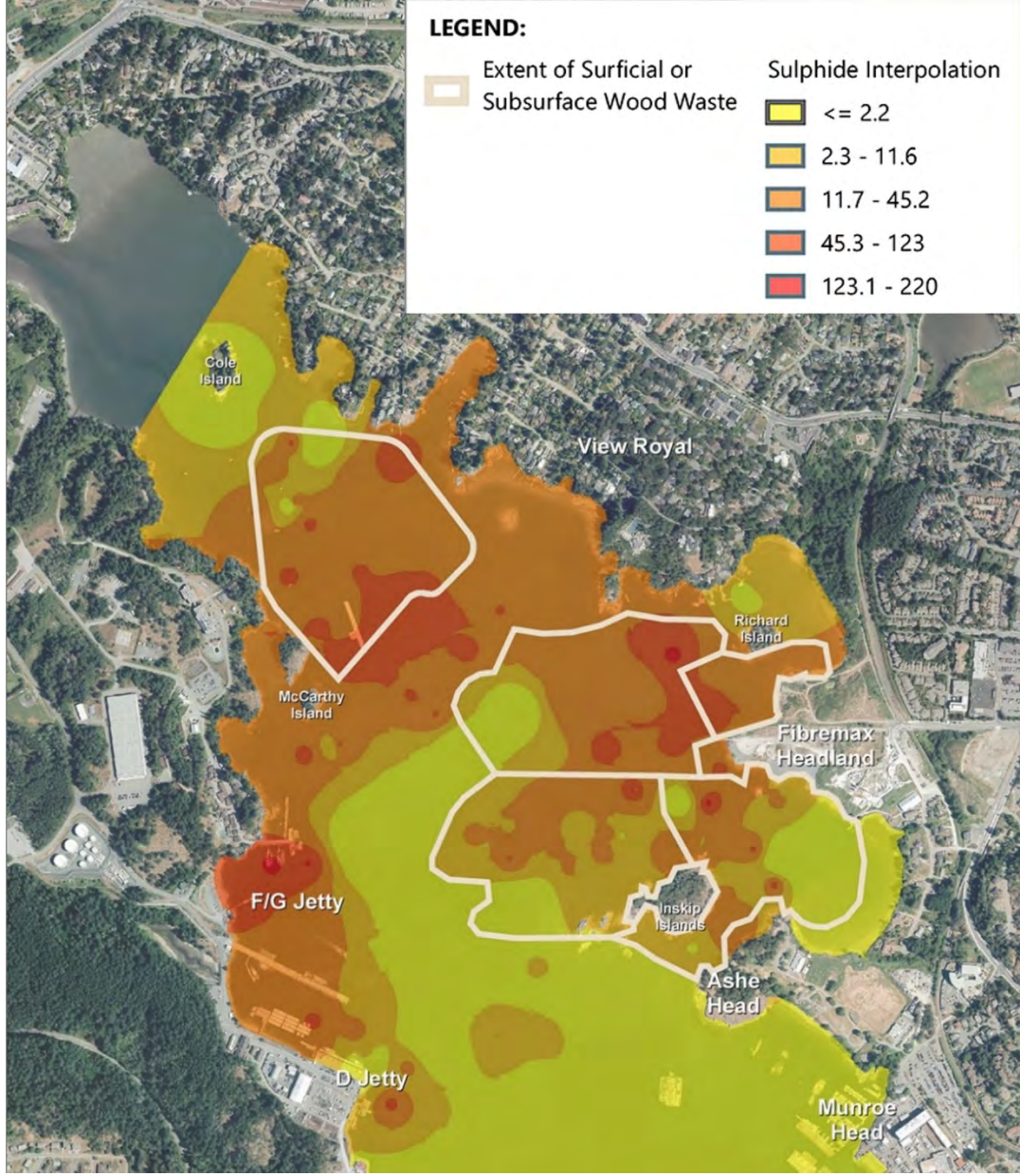


Porewater Sulphide Sampling Using DGT

- Diffusive gradient in thin film (DGT)
  - Passive sampling technique (spear insert into 15-cm sediment)
  - Reliable in situ measure of porewater sulphide
  - Method based on reaction of sulphide with silver iodide gel (white) to produce silver sulphide (black)
  - Intensity of color developed is proportional to:
    - Sulphide accumulated on the gel
    - Exposure duration

Porewater Sulphide Concentrations

- Porewater sulphides were elevated throughout the study area
  - Median: 25 mg/L
  - Range: 0.3 to 200 mg/L
- 2 mg/L can cause toxicity to sensitive species
- Porewater sulphides are usually, but not always, colocated with wood waste



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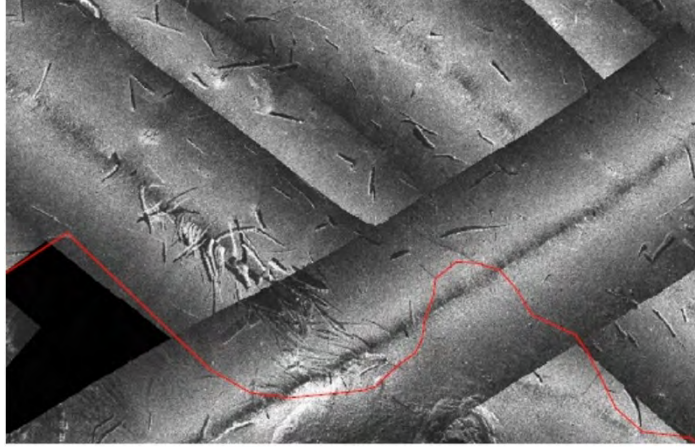
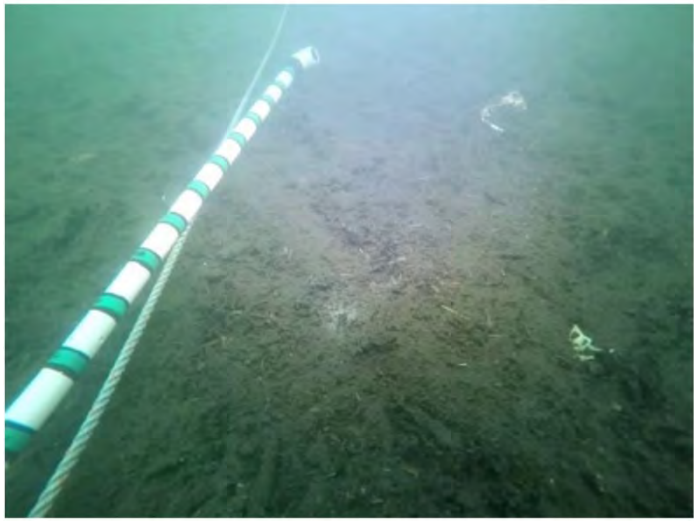
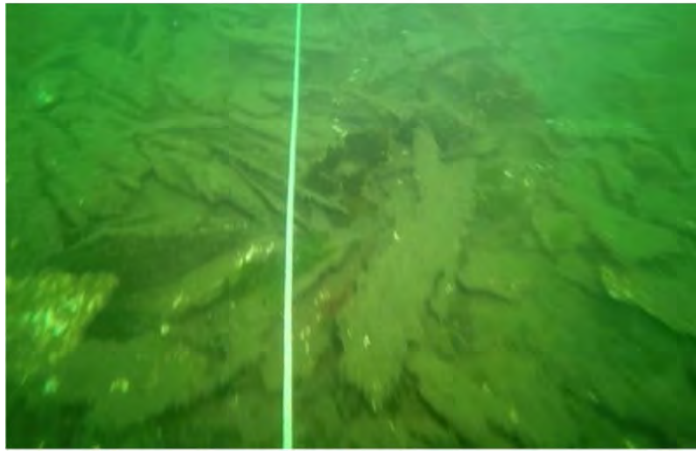
Wood Waste Remediation Options

- Monitored natural recovery
- Dredging
- Engineered capping
- Enhanced natural recovery (ENR)
- In situ treatment







Bench-Scale Treatability Testing

- Tested sand cover (ENR) mixed with three treatment amendments to reduce bioavailable porewater sulphide
- All amendments found effective at binding sulphides in:
  - Overlying water and amended sand porewater
  - Underlying sediment porewater over test duration
- Siderite selected as the preferred amendment

Siderite ($FeCO_3$)

Manganese Oxide (MnO_2)

Mixed Metal Oxide

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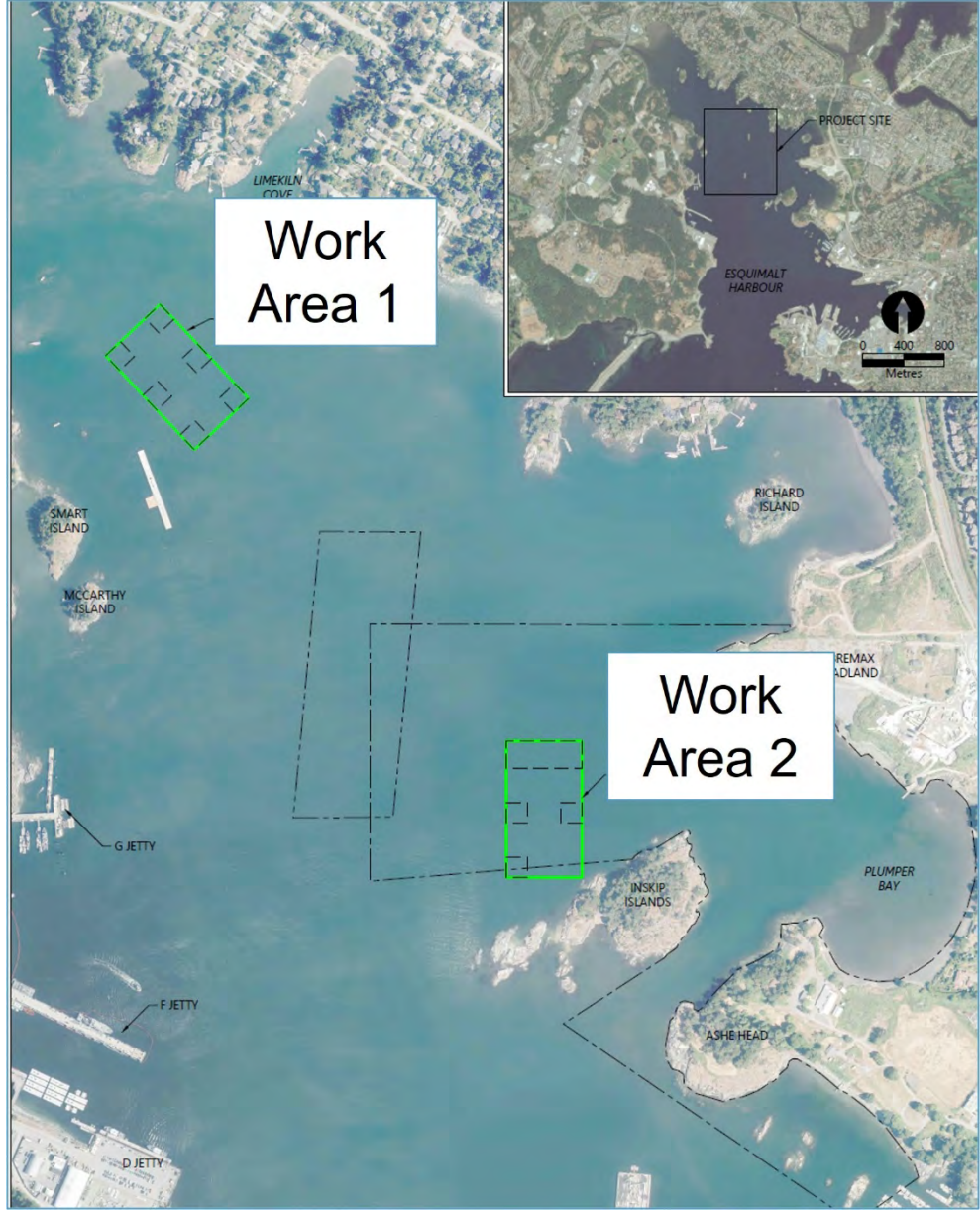
2020 Pilot Project

- Evaluate effectiveness
  - ENR (clean sand cover)
  - In situ treatment (sand mixed with siderite)
- Evaluate constructability
  - Blending of siderite and sand
  - Placement of covers in two different wood waste areas
  - Practice area
  - Multiple placement methods
- Evaluate amendment performance
  - 5% granular siderite by weight at 30-cm nominal thickness
  - Granular form is best for mixing and in situ application

Key Objective
Assess material placement in wood waste areas to reduce sulphide concentrations in porewater

Pilot Project – Work Areas

- Work Area 1
  - Thin, scattered deposits of wood waste (0.4 to 0.6 m thick)
  - Soft, flocculent wood waste
  - Slight consolidation and mixing anticipated
- Work Area 2
  - Thick deposits of wood waste (2 m thick)
  - Coarse, highly porous wood waste
  - Consolidation anticipated



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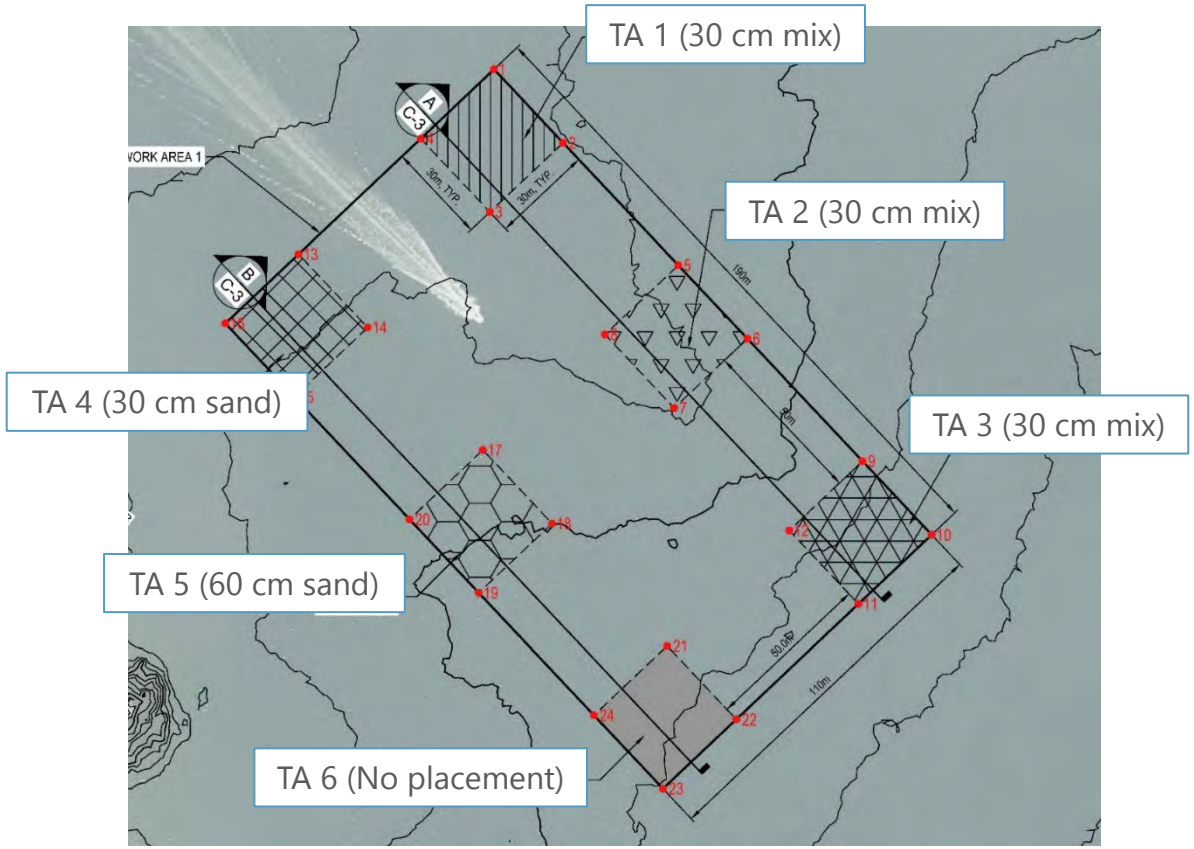
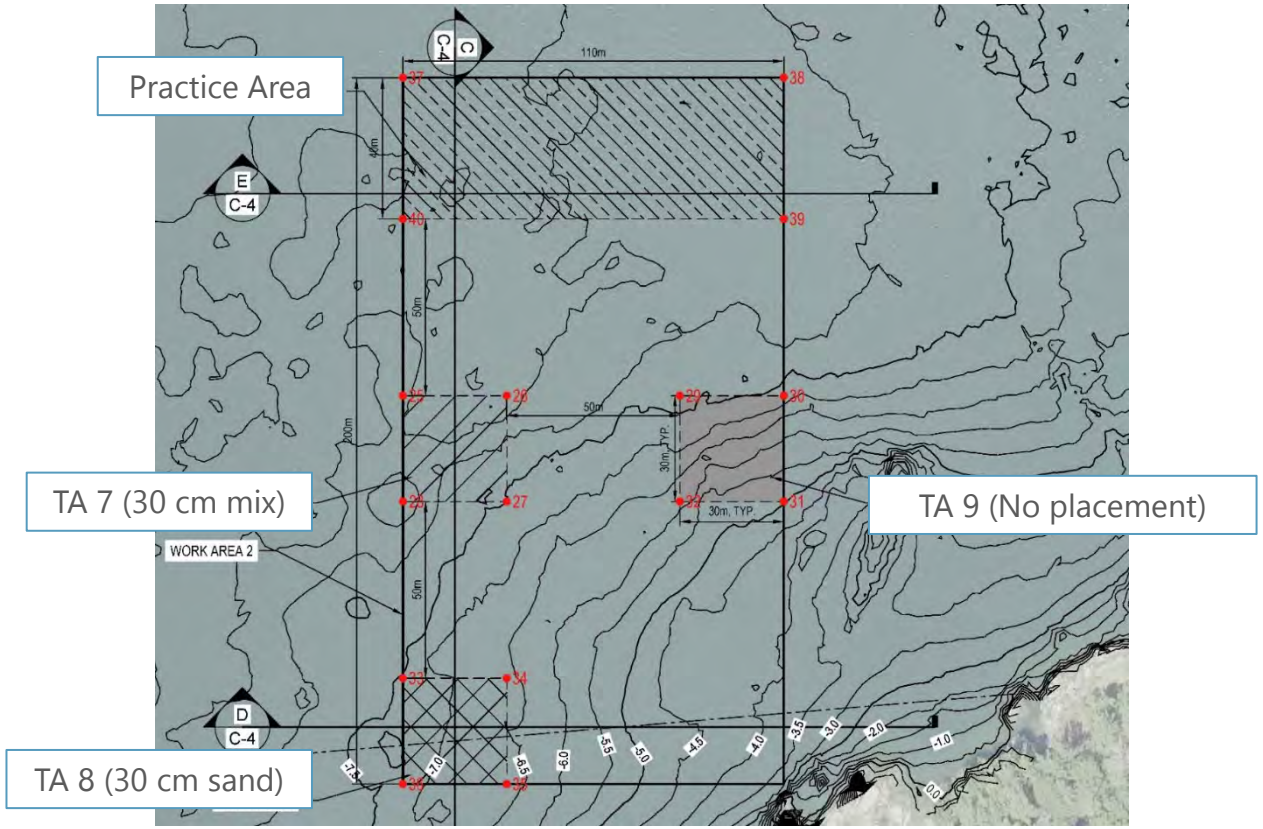
Pilot Project – Work Areas (cont.)



Work Area 1 – Soft Wood Waste



Work Area 2 – Coarse Wood Waste

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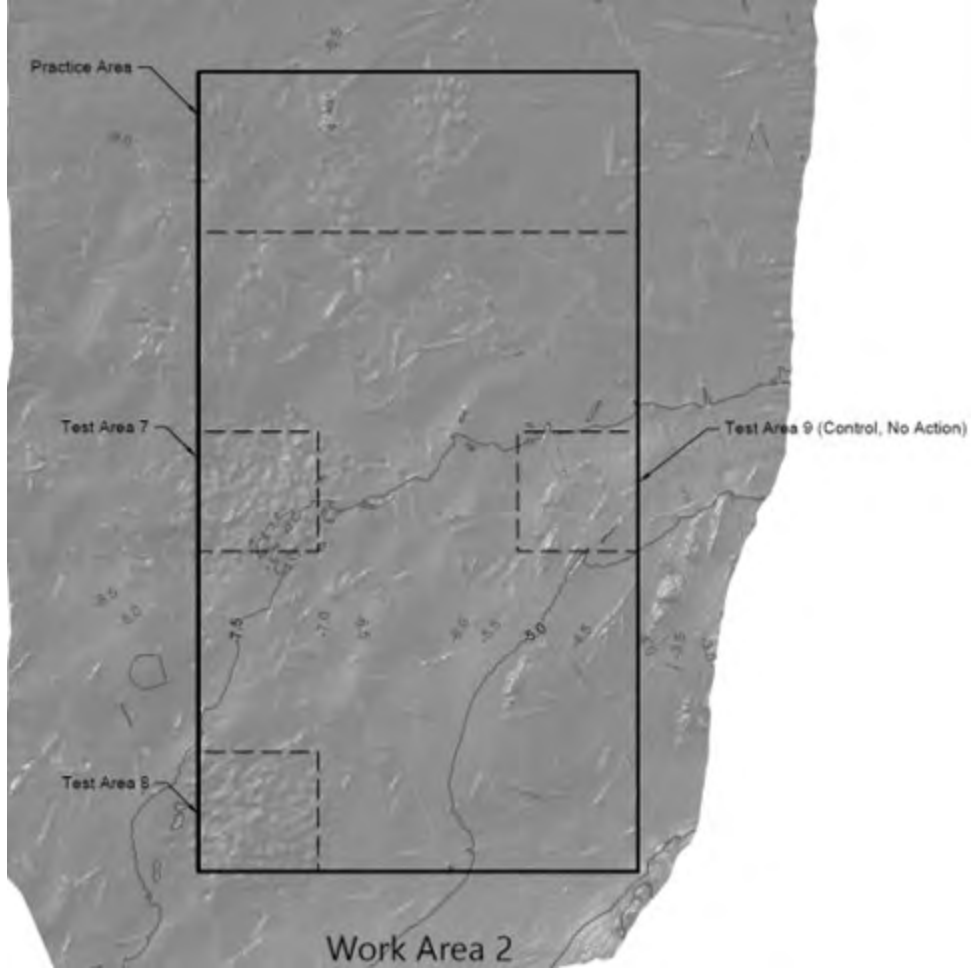
Pilot Project – Construction

- Placement methods
  - Clamshell from above water
    - 2 to 4 m^3/load; cycle time: 1:52 min
  - Skip box from above water (preferred)
    - 6 m^3/load; cycle time: 2:36 min
  - Skip box underwater, just above sediment
    - 6 m^3/load; cycle time: 3:00 min
    - Resulted in mounding
- Daily bathymetry and dive surveys
- Construction duration: 18 days
- Project monitoring so far: 18 months

Bathymetry Changes After 1 Year

- Test Areas (TAs) in Work Area 1 continue to be intact
- TAs in Work Area 2 continue to consolidate/settle
- Approximately 10 to 15 cm elevation decrease during first 12 months
- No evidence of:
  - Mixing during/after placement
  - Major disturbances
  - Movement of logs



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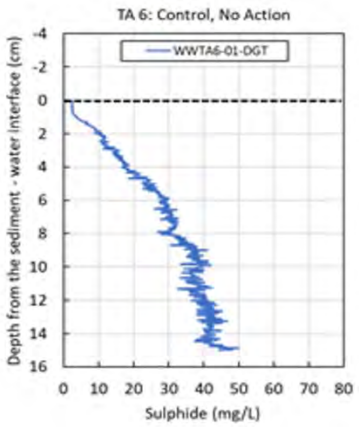
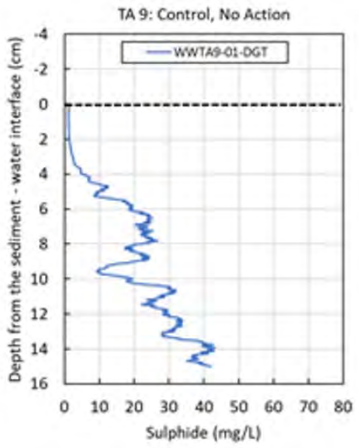
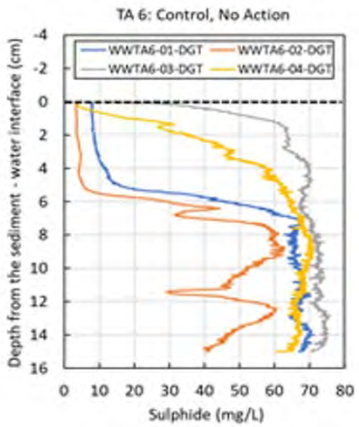
DGT Monitoring – TAs 6 and 9 (Controls – No Placement)

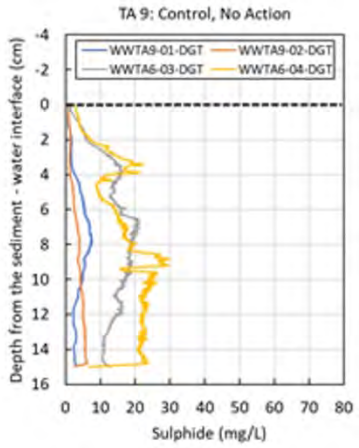
March 2020





October 2020





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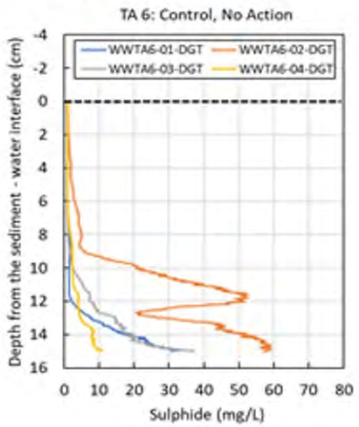
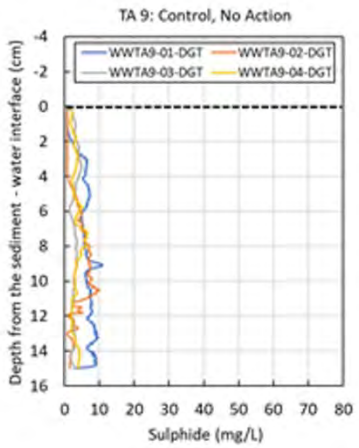
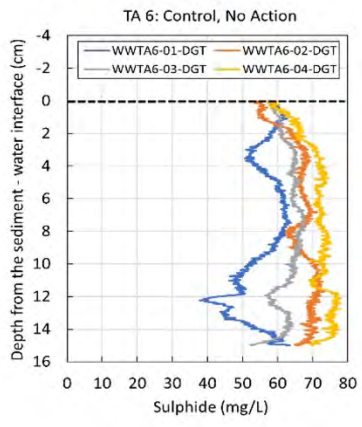
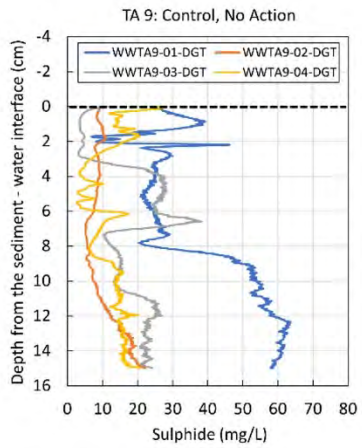




August 2021





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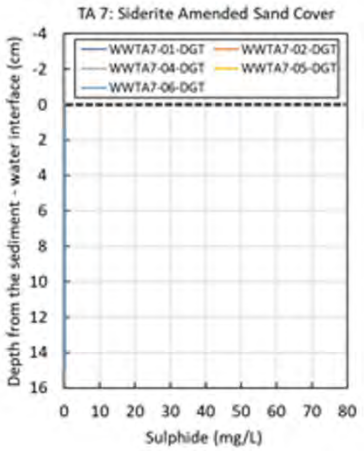
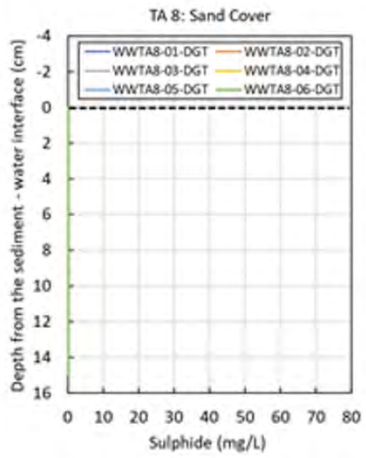
DGT Monitoring – TAs 7 (30 cm mix) and 8 (30 cm sand)

March 2020





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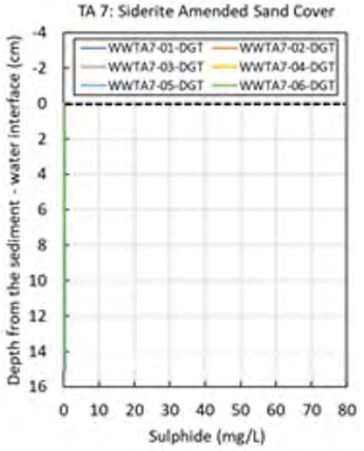

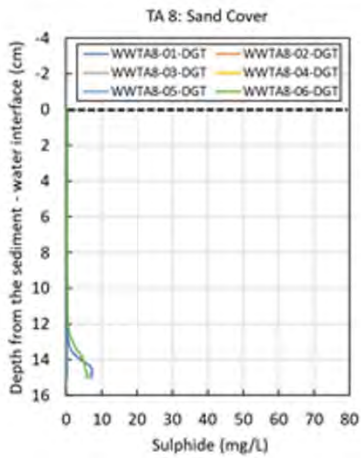

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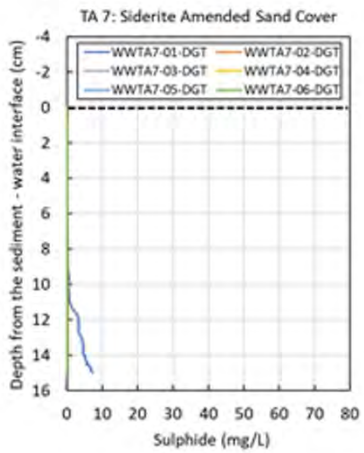

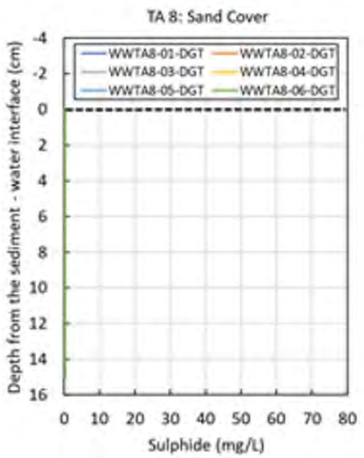

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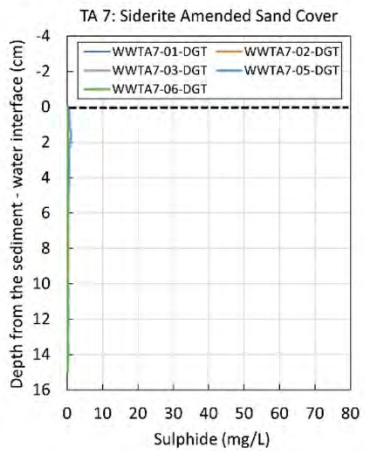
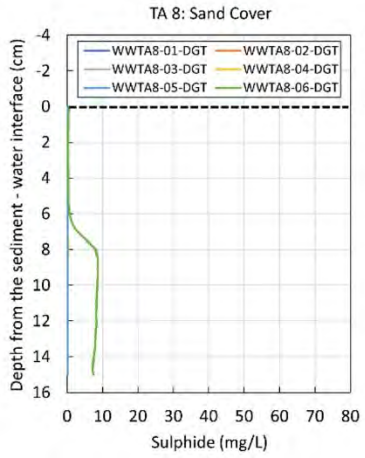
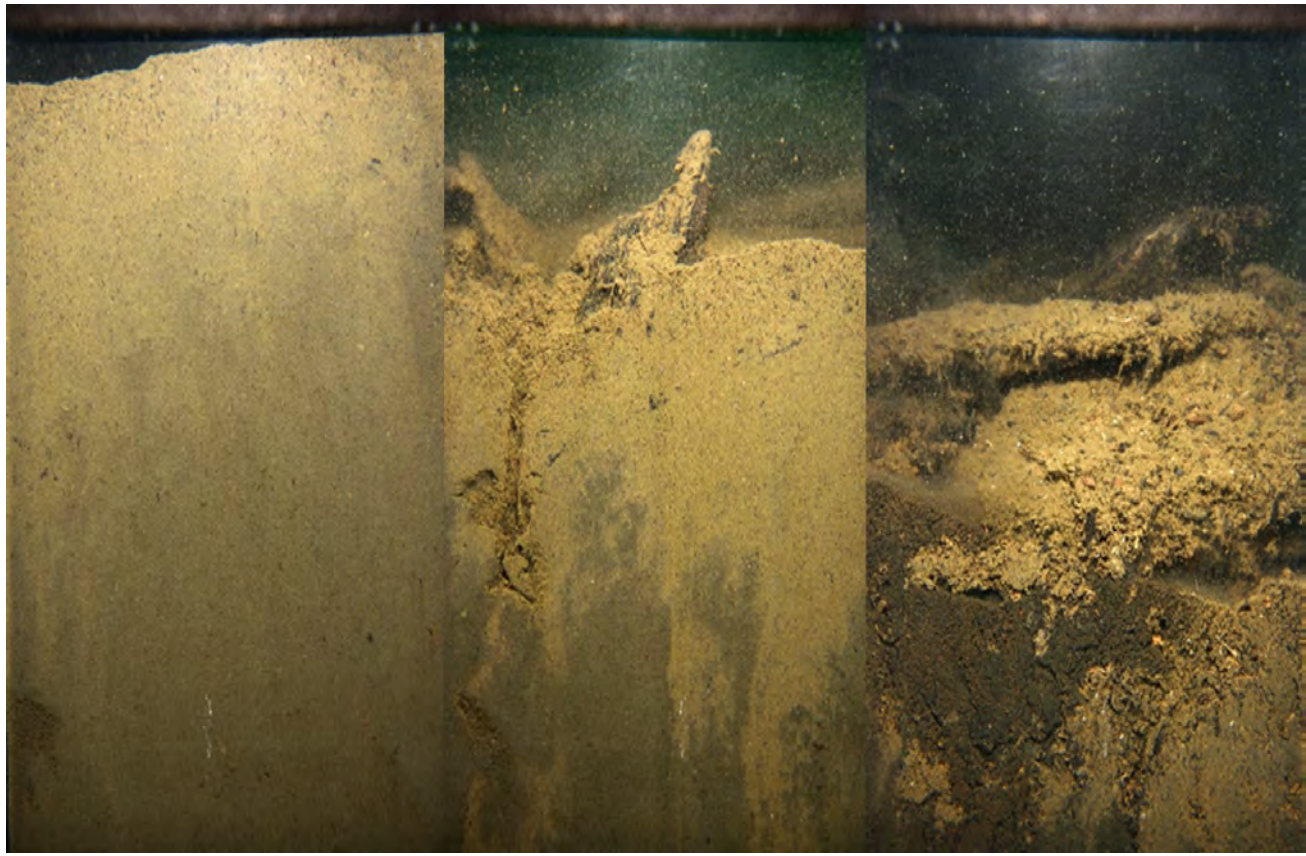




Sediment Surface and Profile – TAs 6 and 9 (Controls – No Placement)



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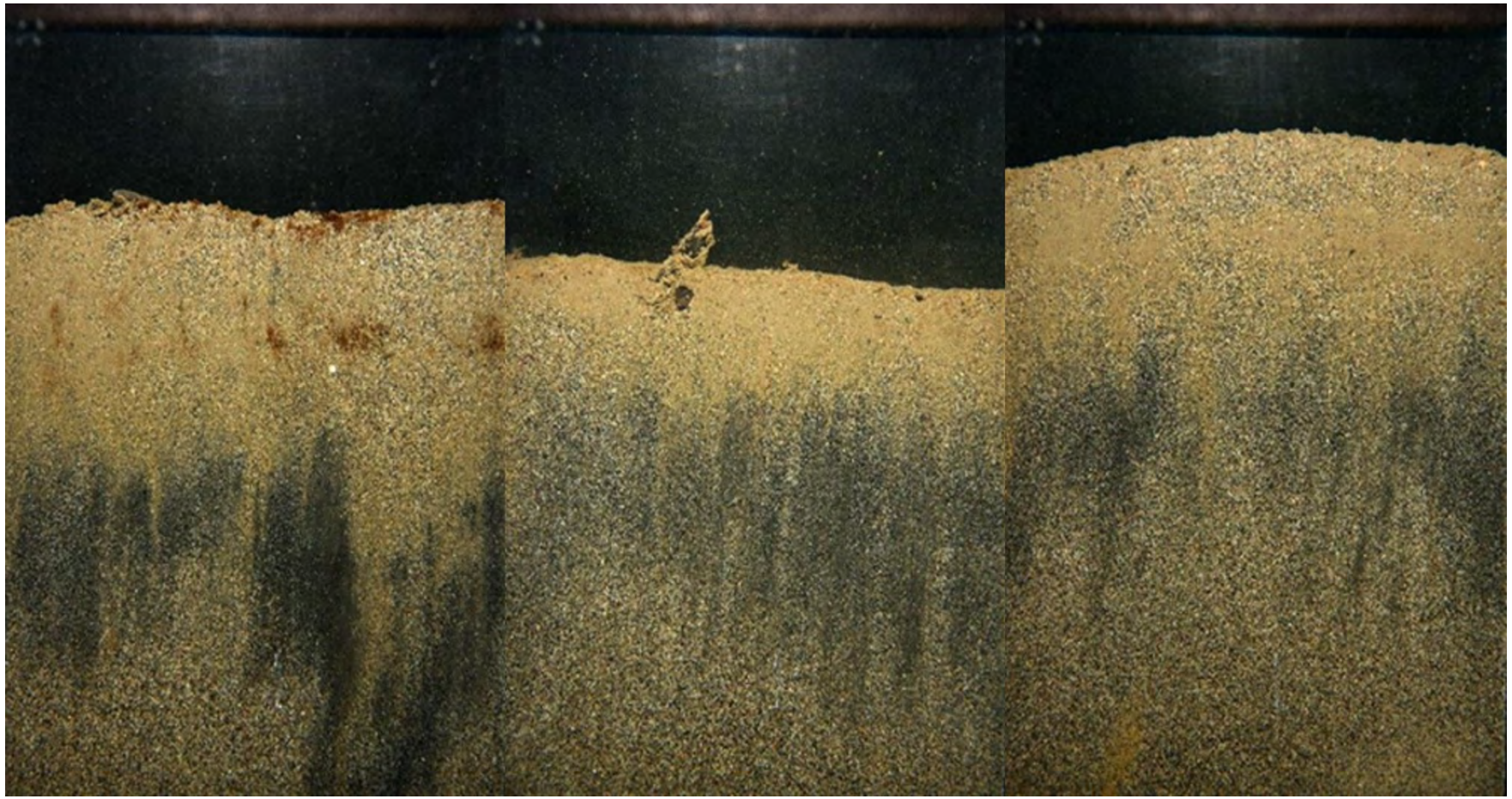
Sediment Surface – TA 2 (30 cm mix) in Work Area 1

Sediment Profile – TA 3 (30 cm mix) in Work Area 1



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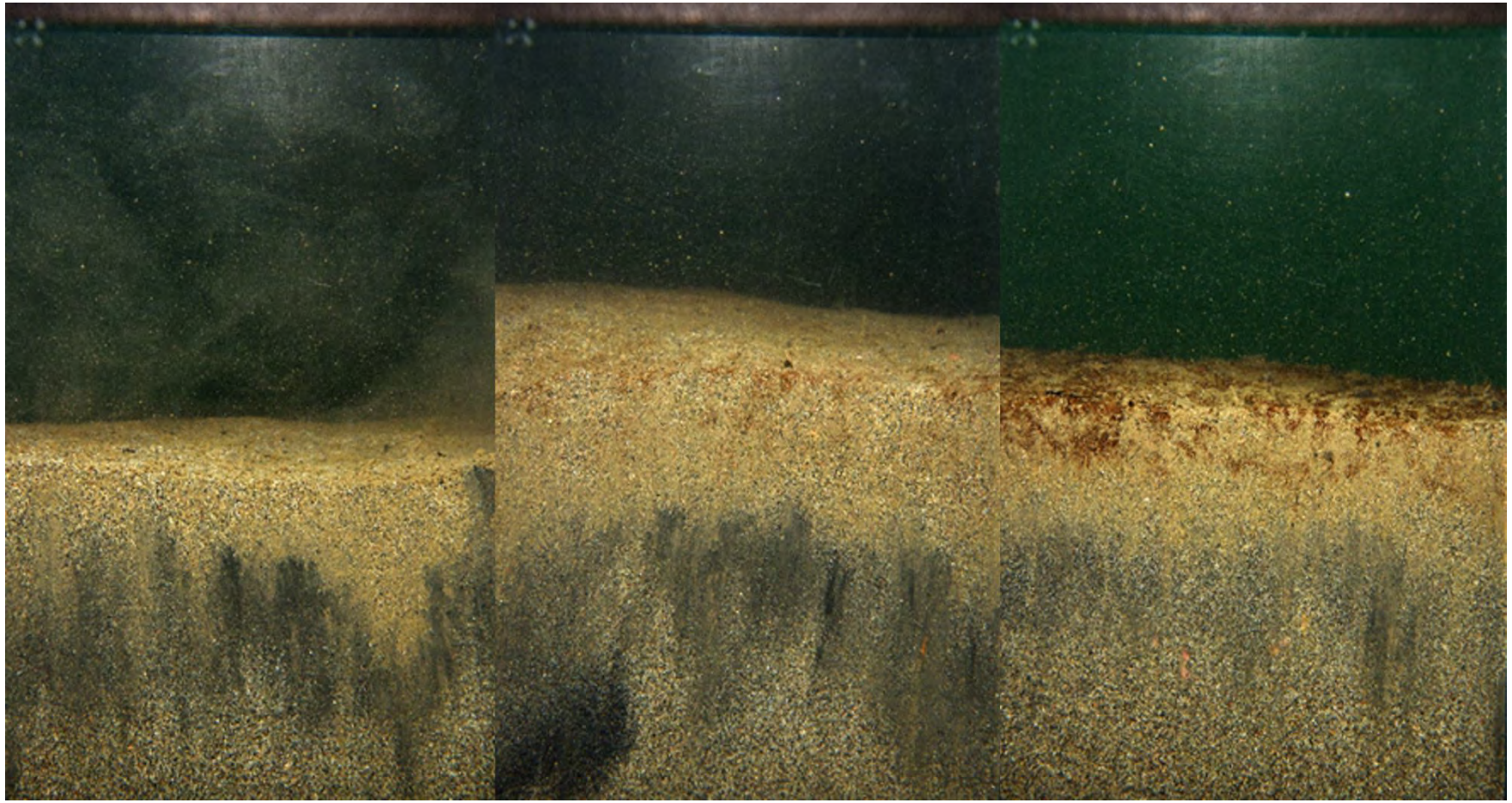
Sediment Profile – TA 7 (30 cm mix) in Work Area 2



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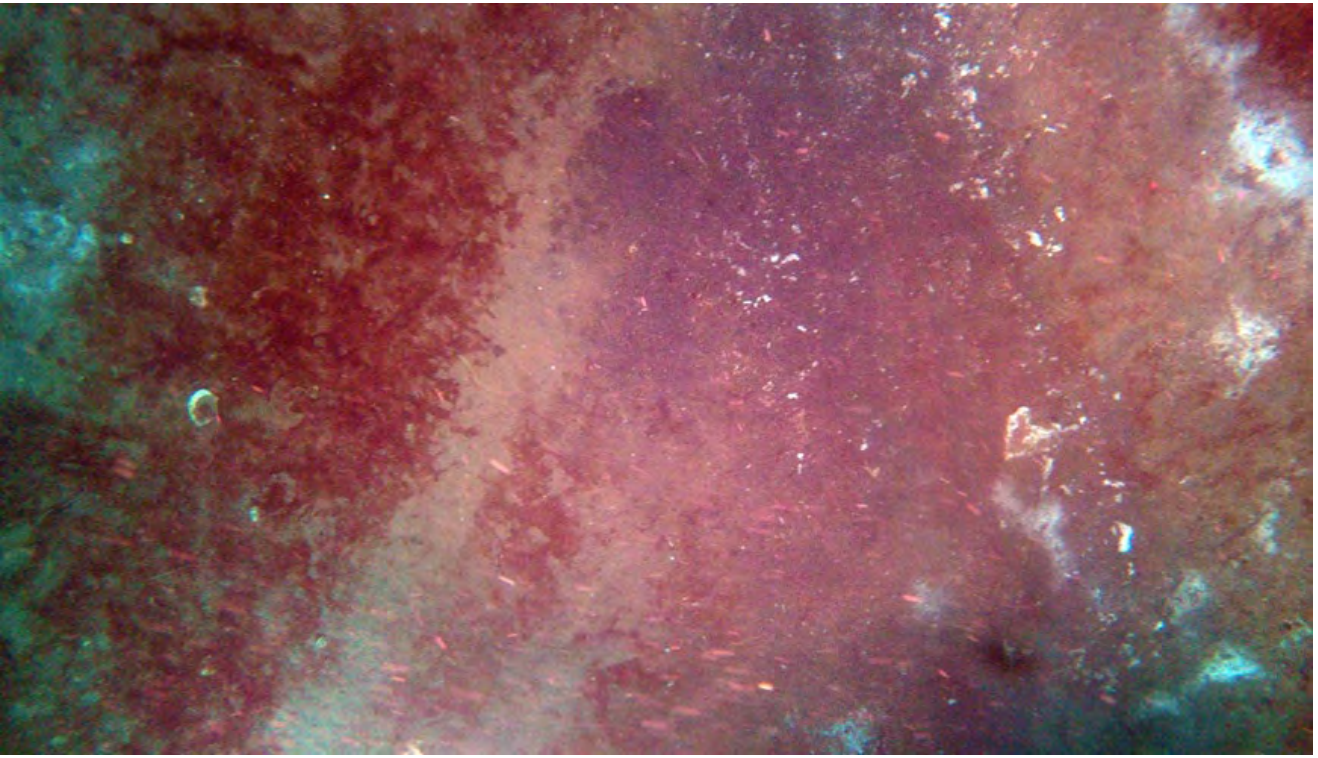
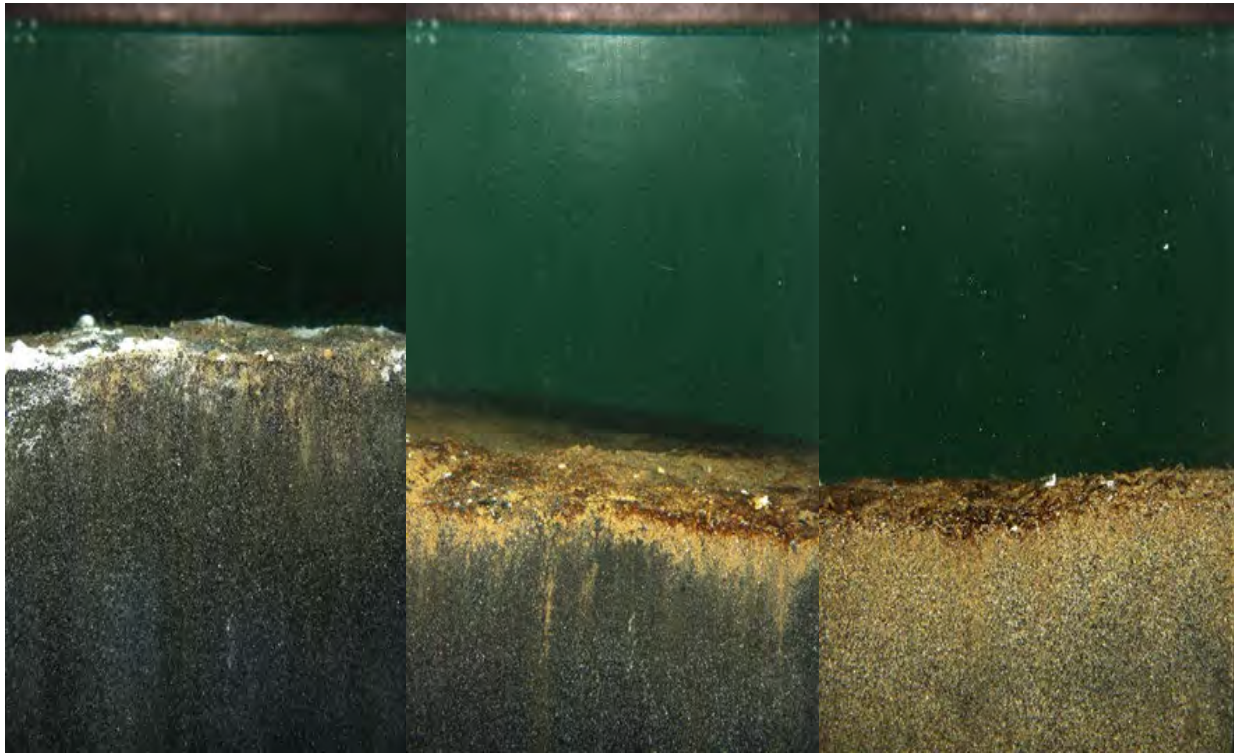
Sediment Surface and Profile – TA 8 (30 cm sand) in Work Area 2





Years 1 and 2 Monitoring Conclusions

- Sand/amended sand covers are constructible and remain stable over time
- Similar effectiveness for all placed covers
  - Continued sulphide generation and diffusion into shallower sediment
  - Slightly elevated sulphide concentrations observed below 7 cm over time
  - Sand-only covers showed sulphide breakthrough and *Beggiatoa* spp. formation
- Benthic community improvement (successful recolonization) in many TAs
- Year 3 monitoring (early 2022)

Questions?

Thanks to:

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