# Innovative Treatment of Wood-Waste Sediments Using Reactive Amendments and DGT Passive Porewater Sulphide Testing Techniques

Presented by

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# Outline

- Site Setting
- Effects of Wood Waste
- Porewater Sulphides Using DGT
- Bench-Scale Treatability Testing
- Pilot Project
  - Construction
  - Year 1 Monitoring




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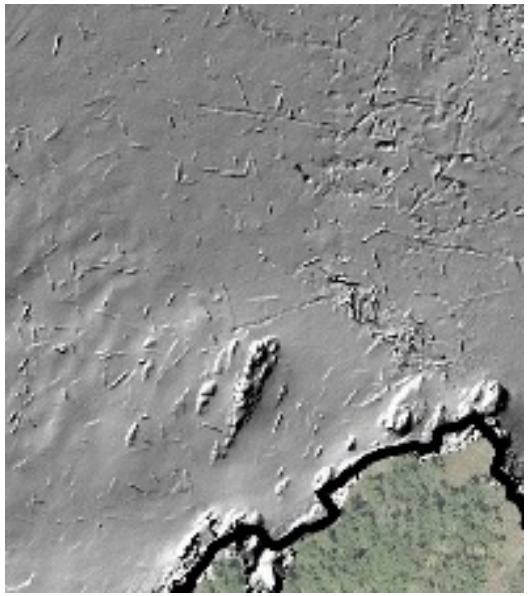
# North Esquimalt Harbour

- Log booming
- Log storage
- Wood mill operations





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# Physical Wood Waste Effects

- Logs, bark, wood chips, processed wood (sawdust), and partially decomposed wood fibers
- Slow to decay
- Can isolate benthic organisms from native sediment
- Can be highly flocculent



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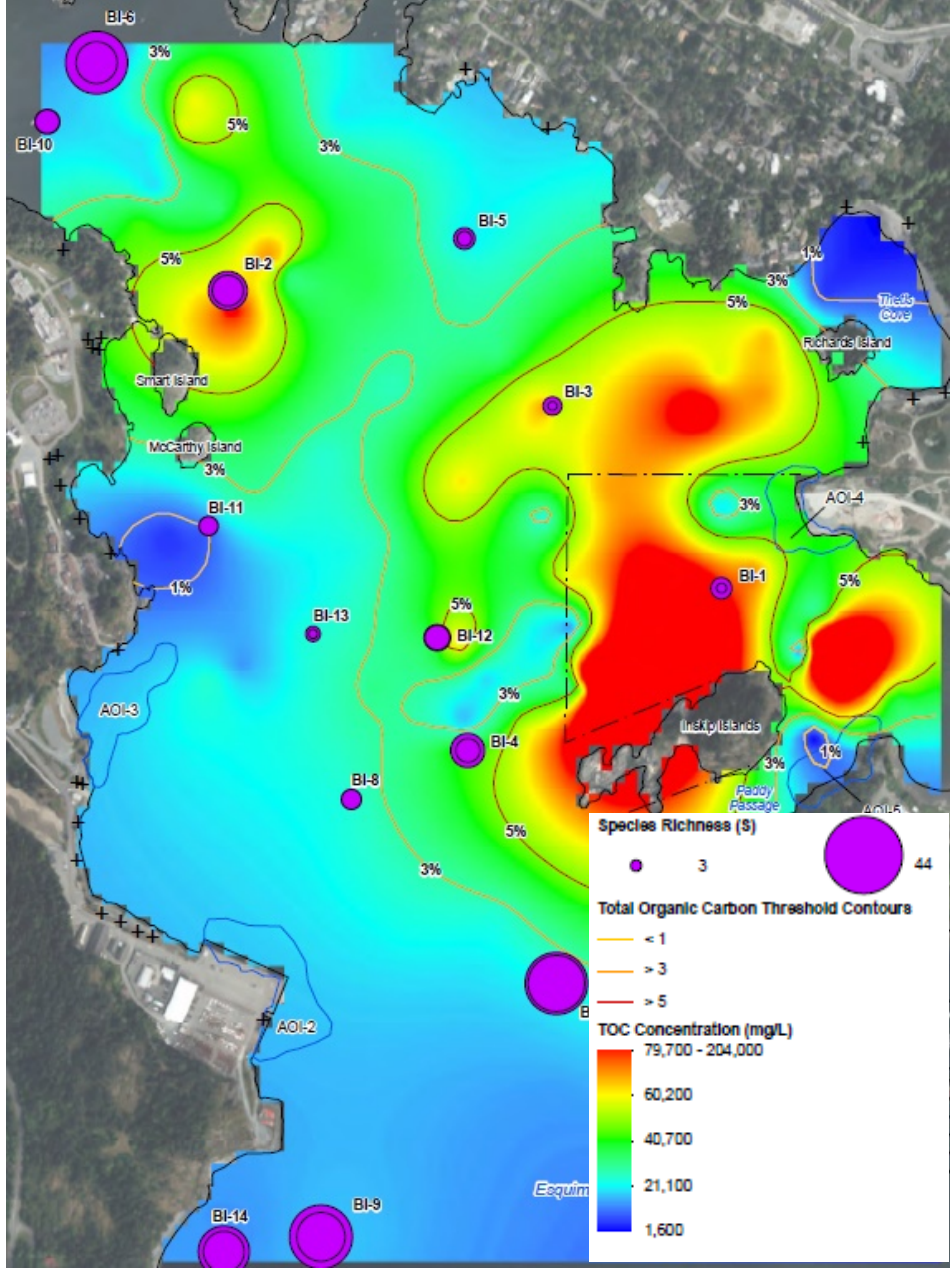
# Chemical and Biological Effects

- Degradation by-products can be toxic to benthic organisms
- Reduced benthic community abundance and diversity
- Reduced survival of bivalves
- *Beggiatoa* spp. bacterial mats



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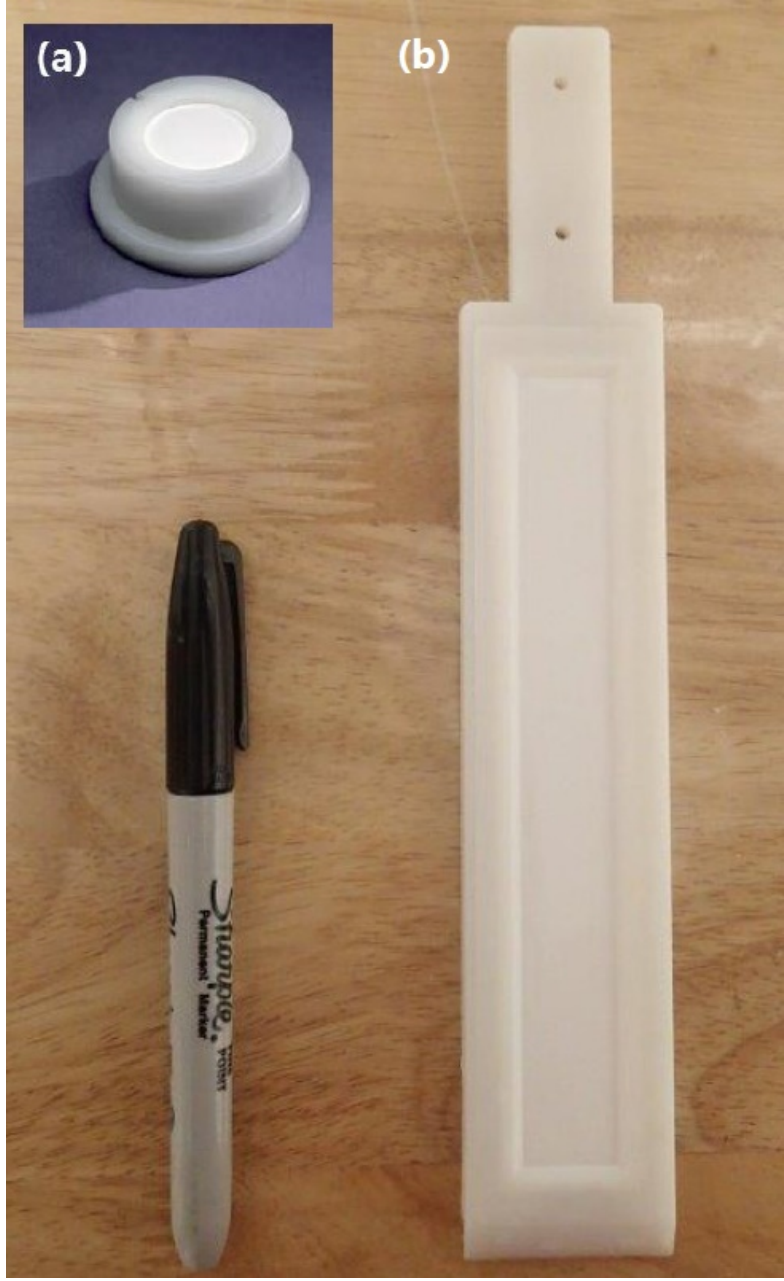
# Porewater Sulphides Using DGT

- Diffusive gradient in thin film (DGT)
  - Reliable in situ measure of porewater sulphide
  - Reaction of sulphide with silver iodide gel (white) to produce silver sulphide (black)
  - Intensity of color is proportional to
    - Sulphide on the gel
    - Exposure duration



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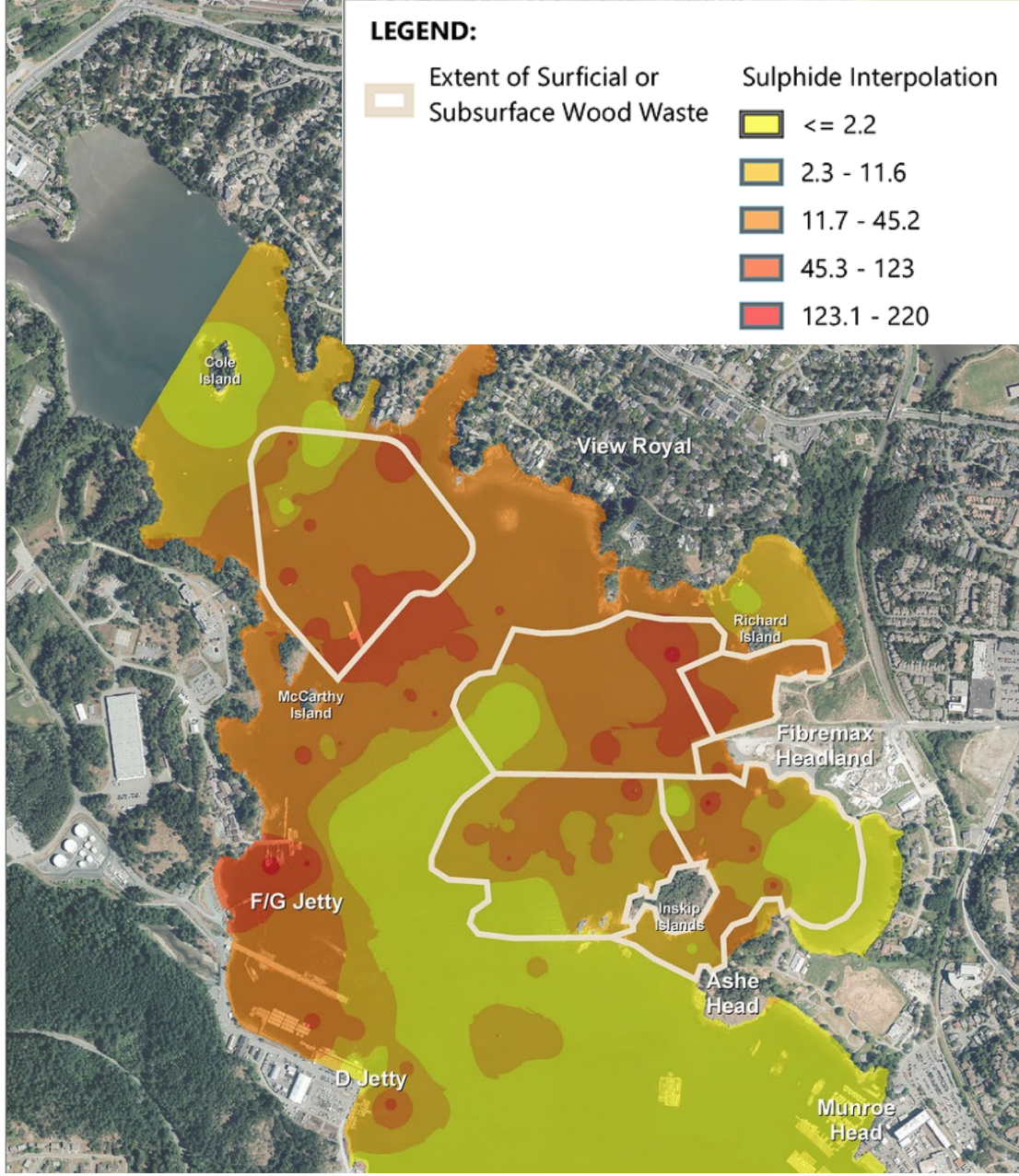
# Porewater Sulphide Concentrations

- Median 25 mg/L
- 2 mg/L can cause toxicity to sensitive species
- Usually but not always colocated with wood waste



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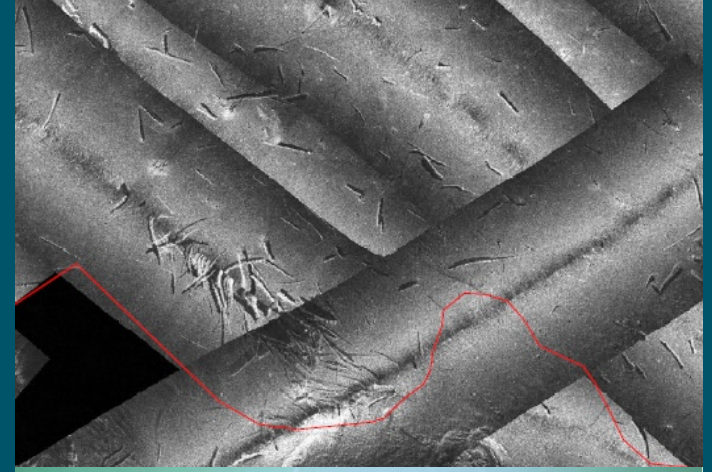
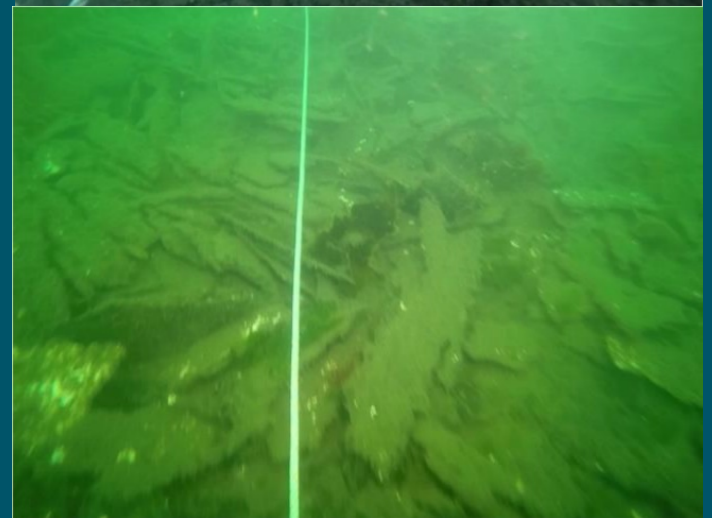
# Wood Waste Remediation Options

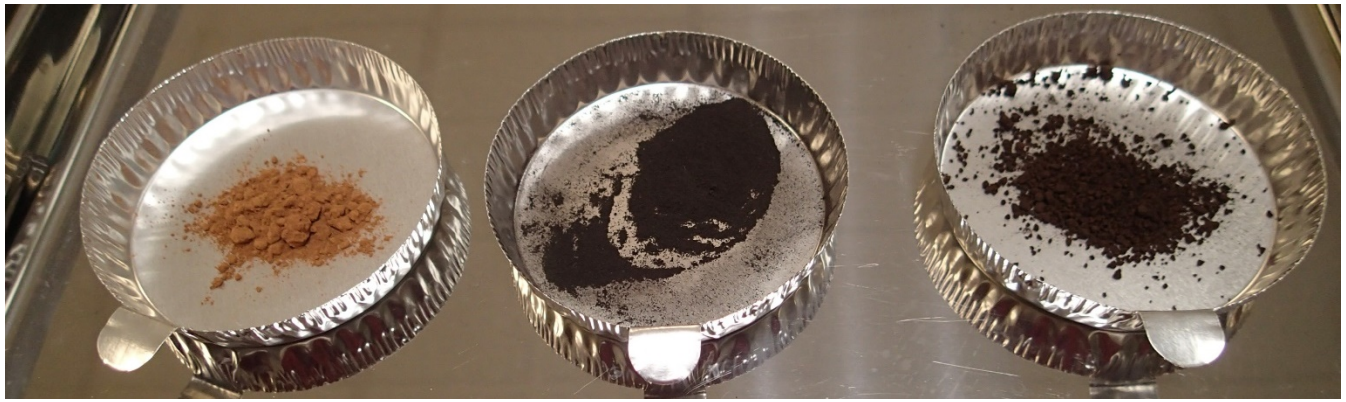
- Monitored natural recovery
- Enhanced natural recovery
- In situ treatment
- Engineered capping
- Dredging





# Bench-Scale Treatability Testing

- Sand cover mixed with treatment amendments to reduce bioavailable porewater sulphide
- Siderite dissolves and precipitates iron sulphides (mackinawite)
- Iron and manganese oxide can oxidize sulphide into sulphate



Siderite $FeCO_3$

Manganese Oxide $MnO_2$

Mixed Metal Oxide (MMO)



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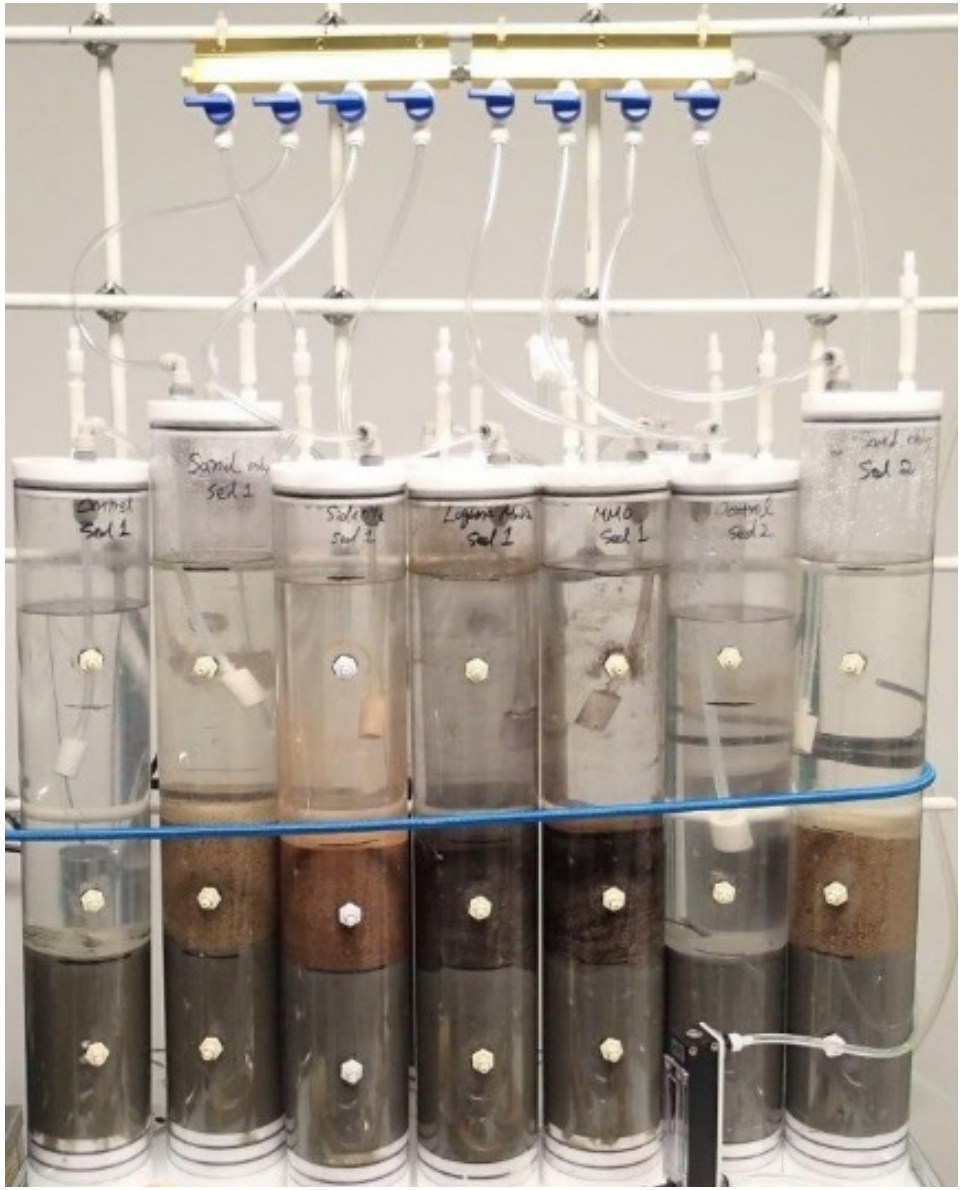
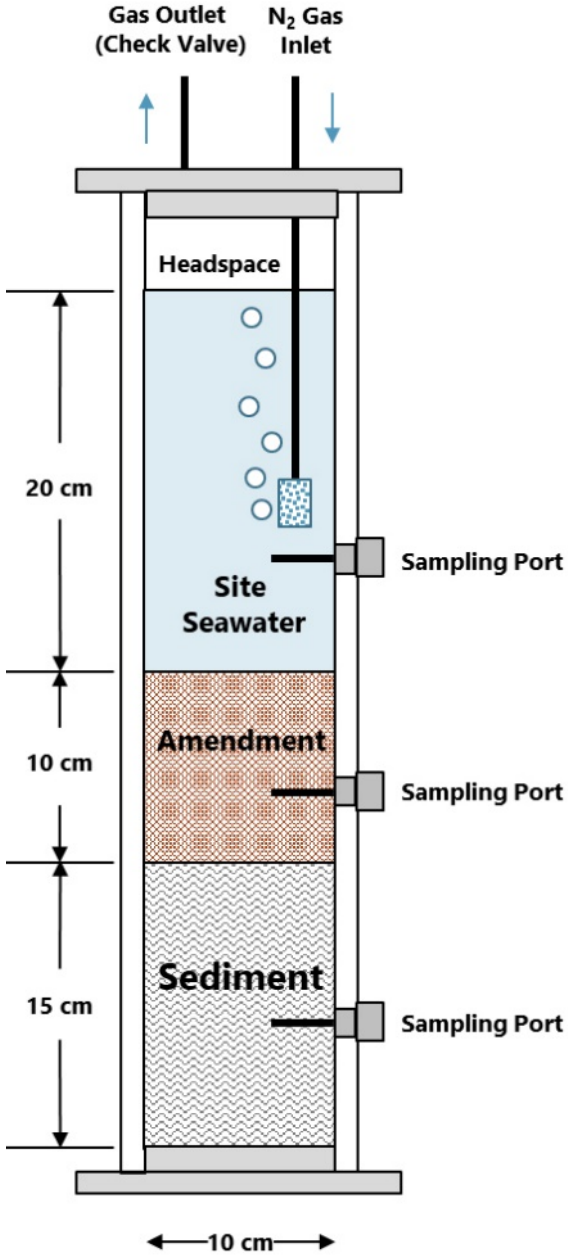
# Treatability Setup

- Sulphides built up in overlying water for sand control but not in treatment amendments
- Iron sulphide precipitate





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# 2020 Pilot Project

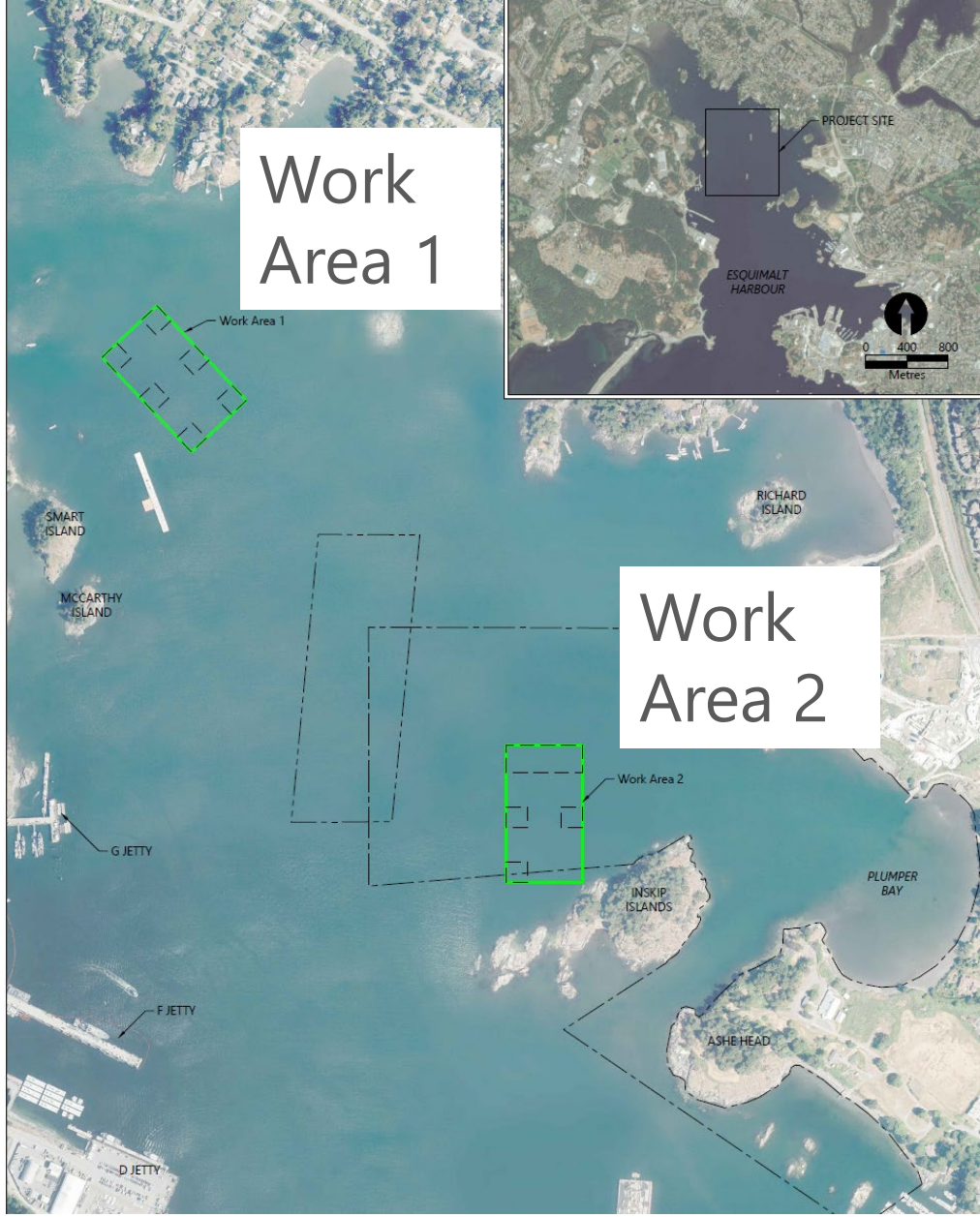
- Evaluate effectiveness
  - Enhanced natural recovery (sand cover)
  - In situ treatment (sand mixed with siderite)
- Evaluate constructability
  - Blend and place amended sand layer in two wood waste areas
  - Practice area
  - Multiple placement methods
- 5% granular siderite by weight at 30-cm nominal thickness

# 2020 Pilot Project Construction

- Placement methods
  - Clamshell from above water
    - 2 to 4 $m^3$/load
    - Cycle time: 1:52
  - Skip box from above water
    - 6 $m^3$/load
    - Cycle time: 2:36
  - Skip box from just above sediment
    - 6 $m^3$/load
    - Cycle time: 3:00
- Daily bathymetry and dive surveys (18 days)

# Pilot Project Work Areas

- Work Area 1
  - Soft wood waste
  - Consolidation and mixing anticipated
- Work Area 2
  - Coarse wood waste
  - Consolidation occurred
- Gas bubbles and sea foam



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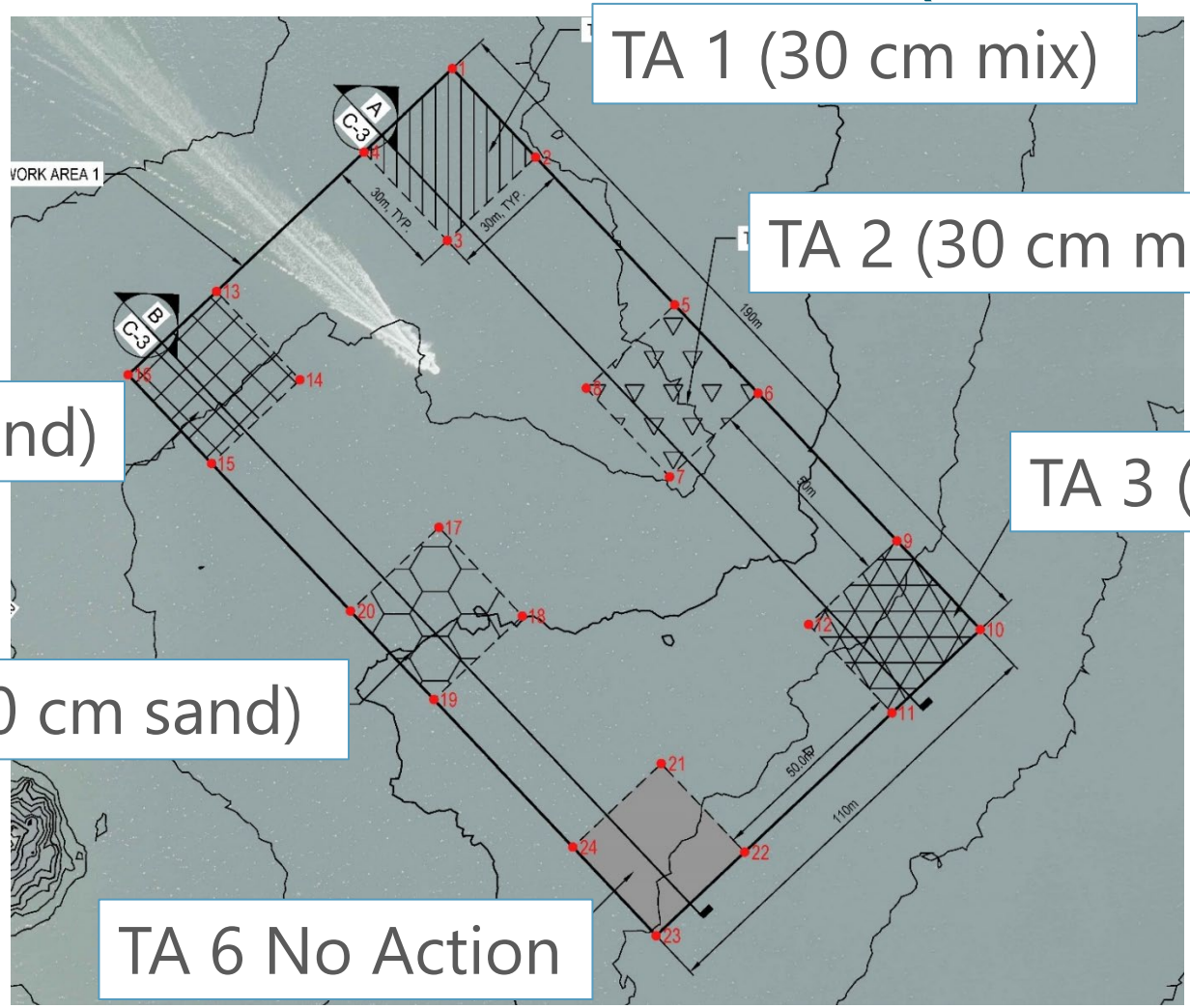
# Pilot Project – Softer Wood Waste (Work Area 1)



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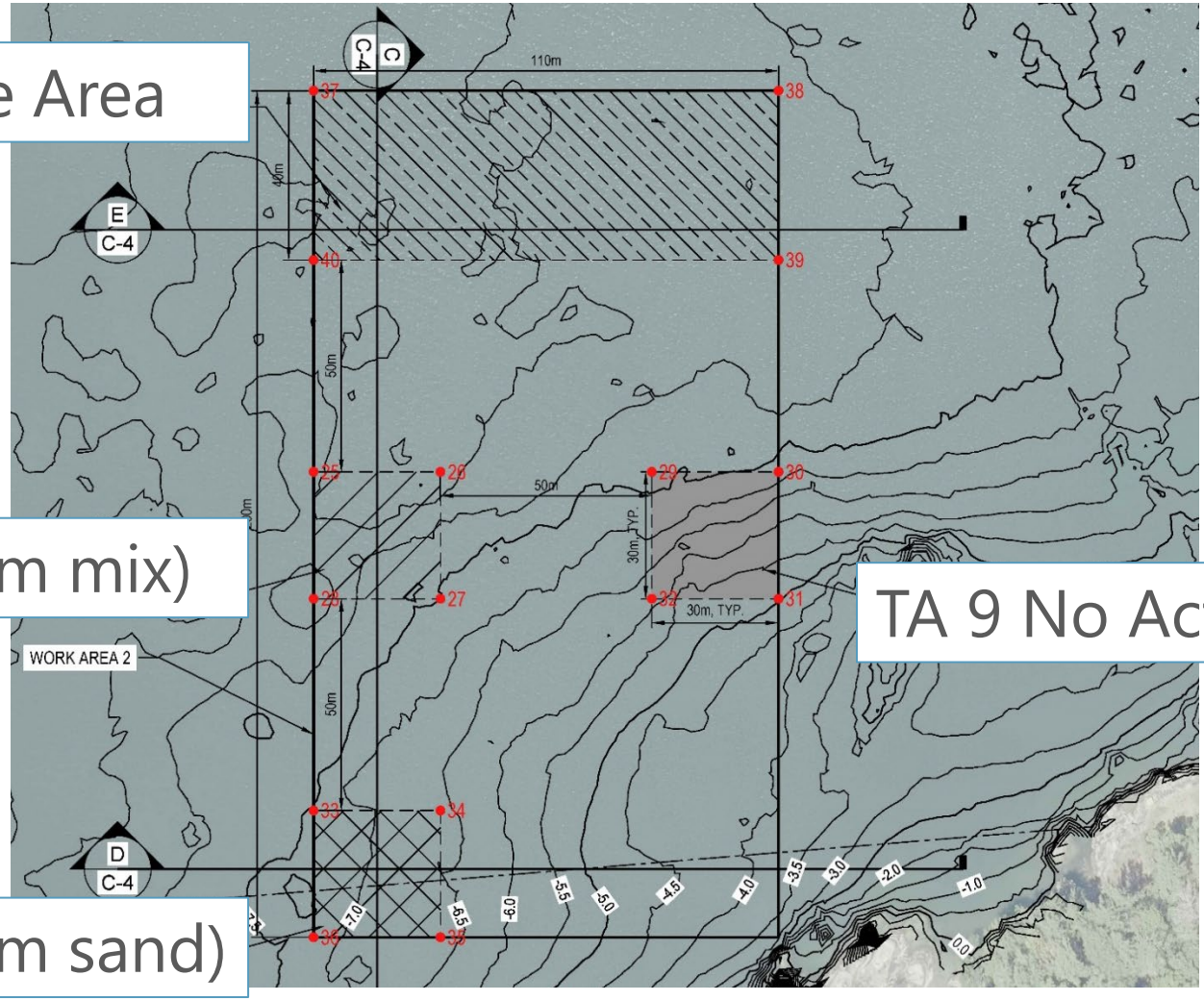
# Pilot Project – Coarse Wood Waste (Work Area 2)

Practice Area

TA 7 (30 cm mix)

TA 8 (30 cm sand)

TA 9 No Action



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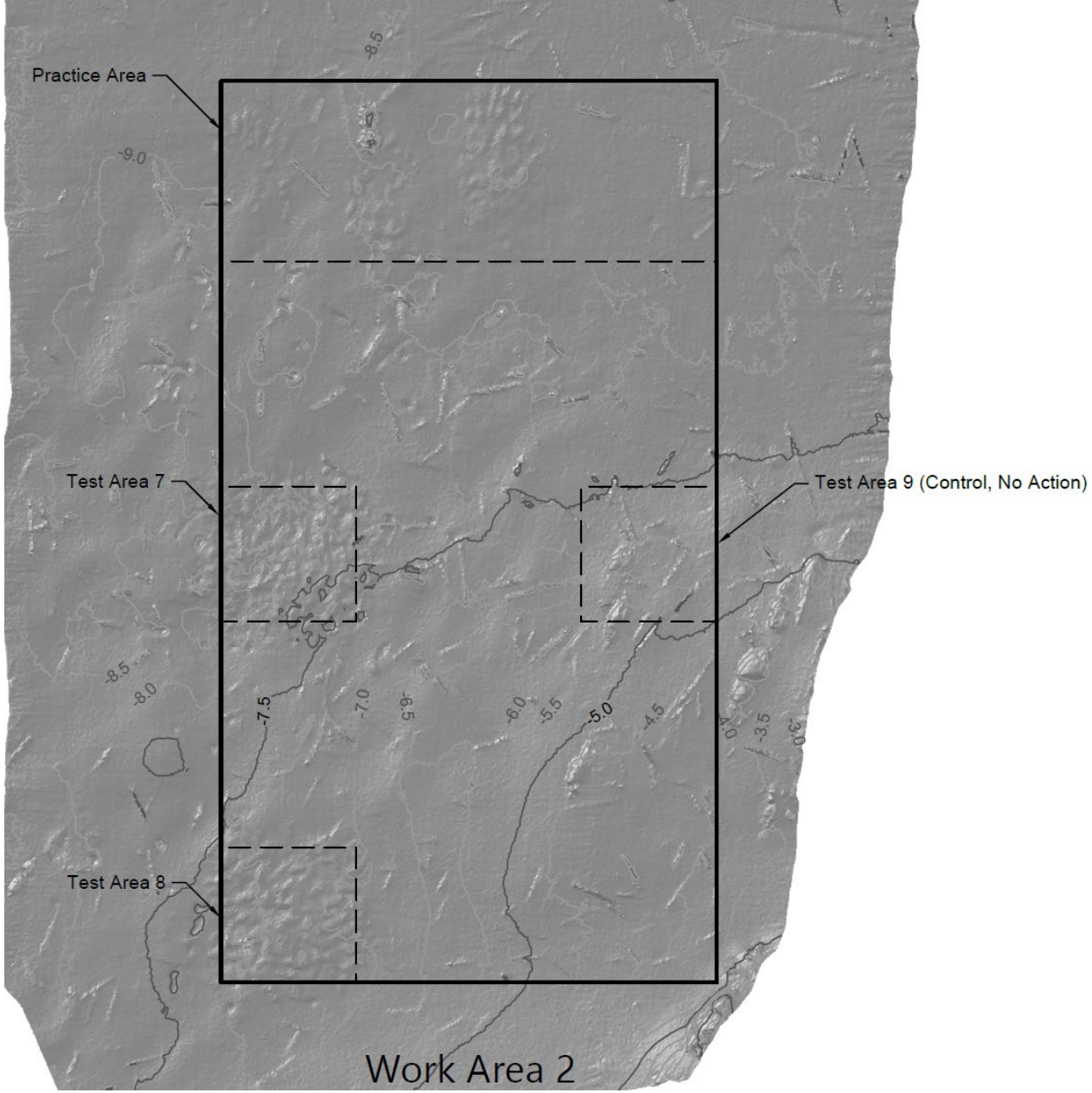
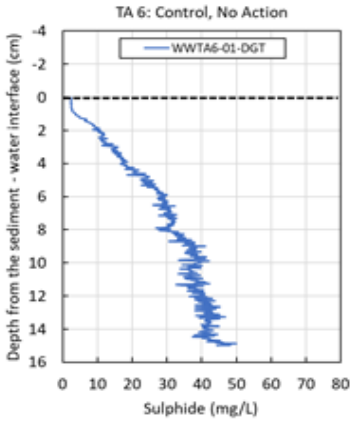
# Bathymetry Changes After 1 Year

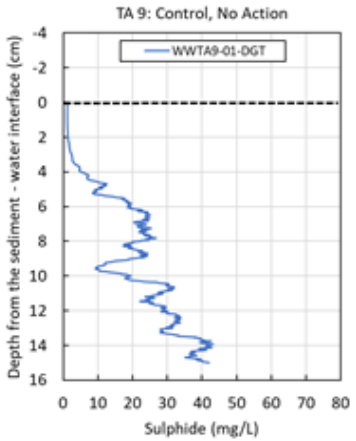
- Approximately 15-cm lower elevation during first 6 months
- No evidence of mixing, major disturbances, or movement of logs
- Sediment Profile Imaging (SPI) photographs suggest differential settling of fine grains, but layering was not observed



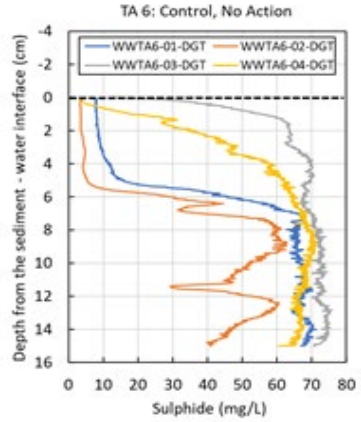
# DGT Monitoring – Control Areas 6 and 9

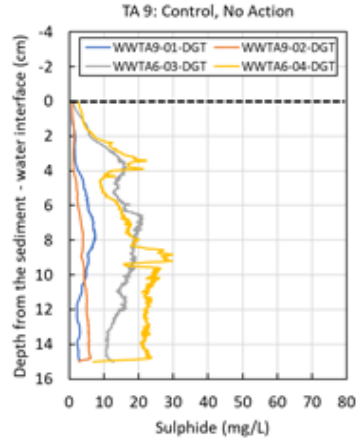
## March 2020



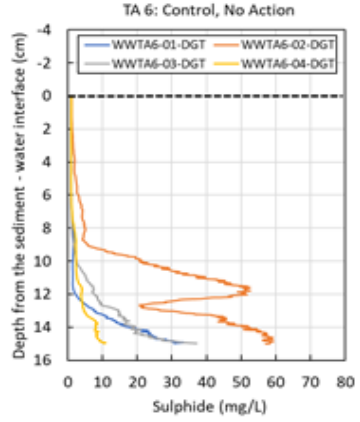



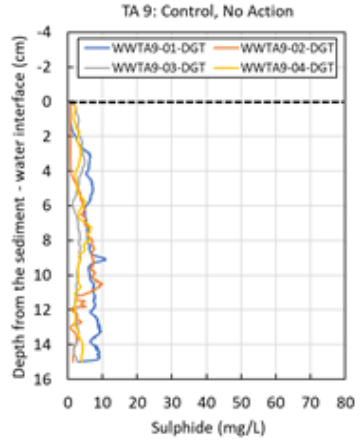

## October 2020



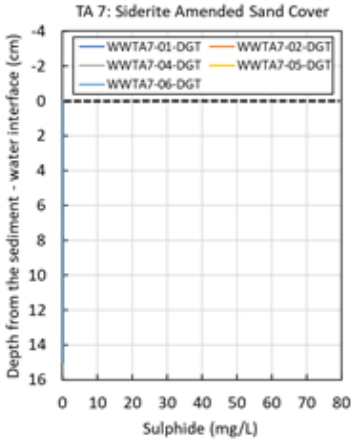

## March 2021

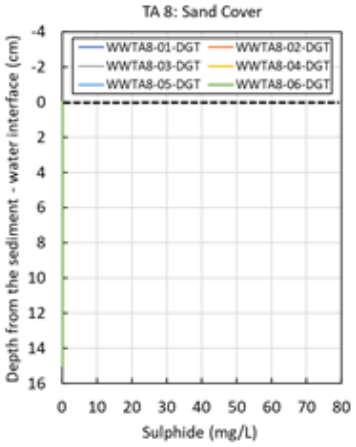


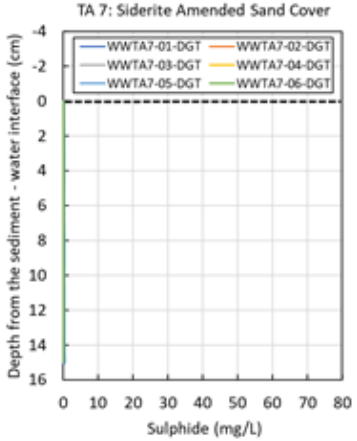
# DGT Monitoring – Test Areas 7 and 8

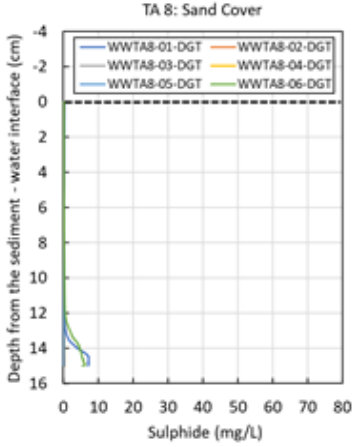
## March 2020



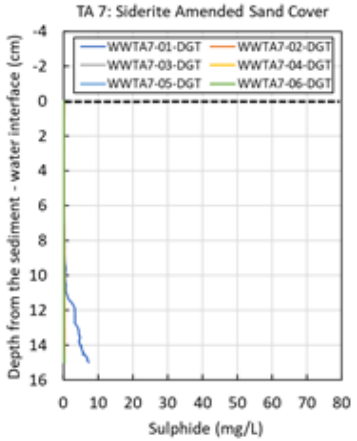



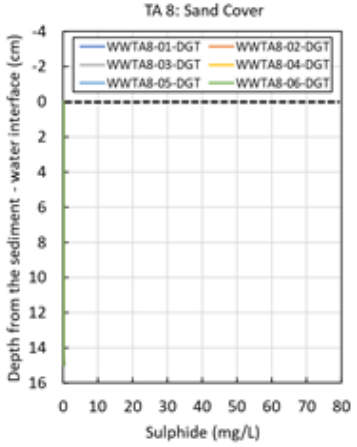

## October 2020




## March 2021



# Sediment Surface: Control – No Action
# Test Area 9



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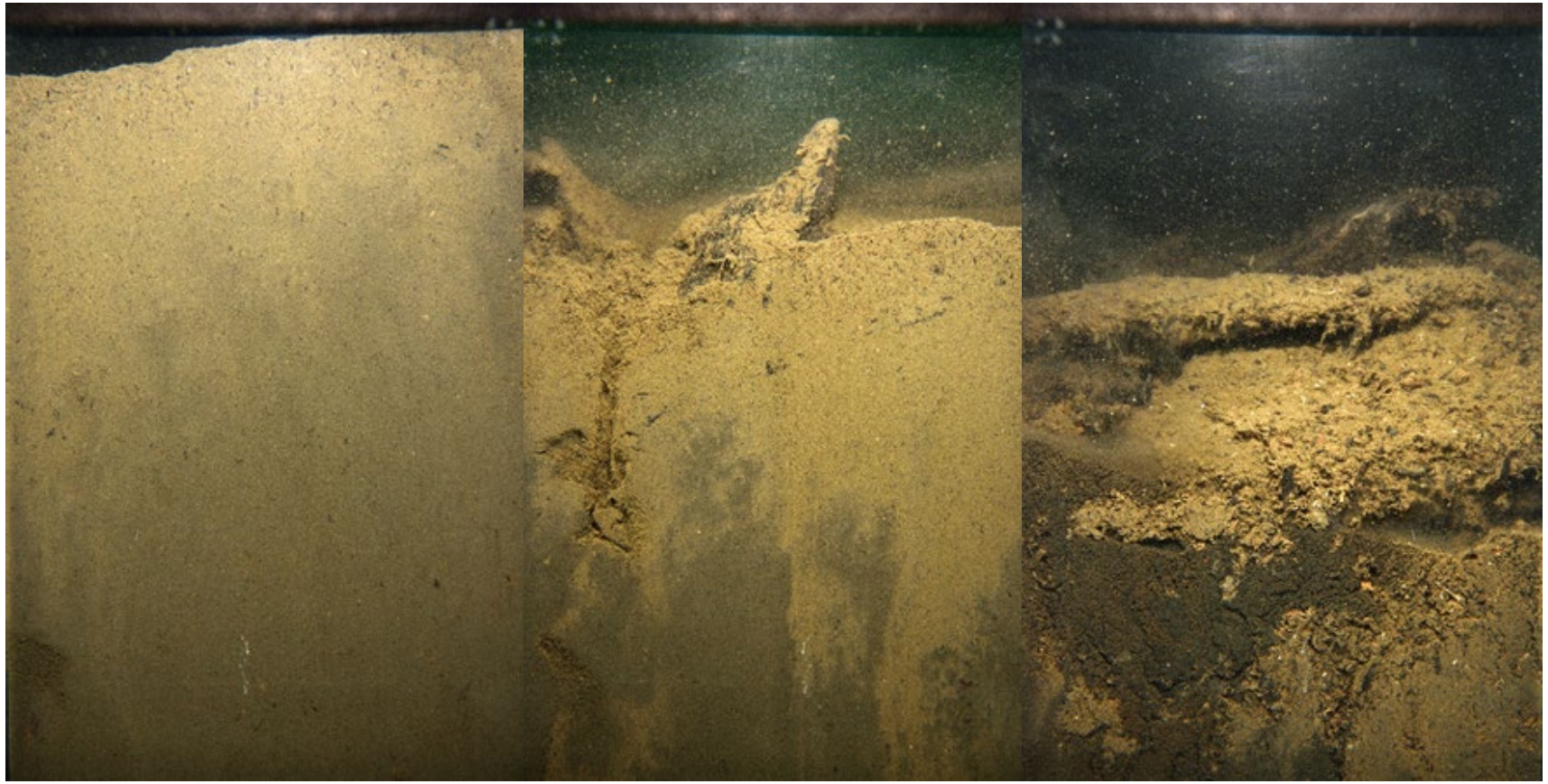
# Sediment Profile: Control – No Action
# Test Area 9





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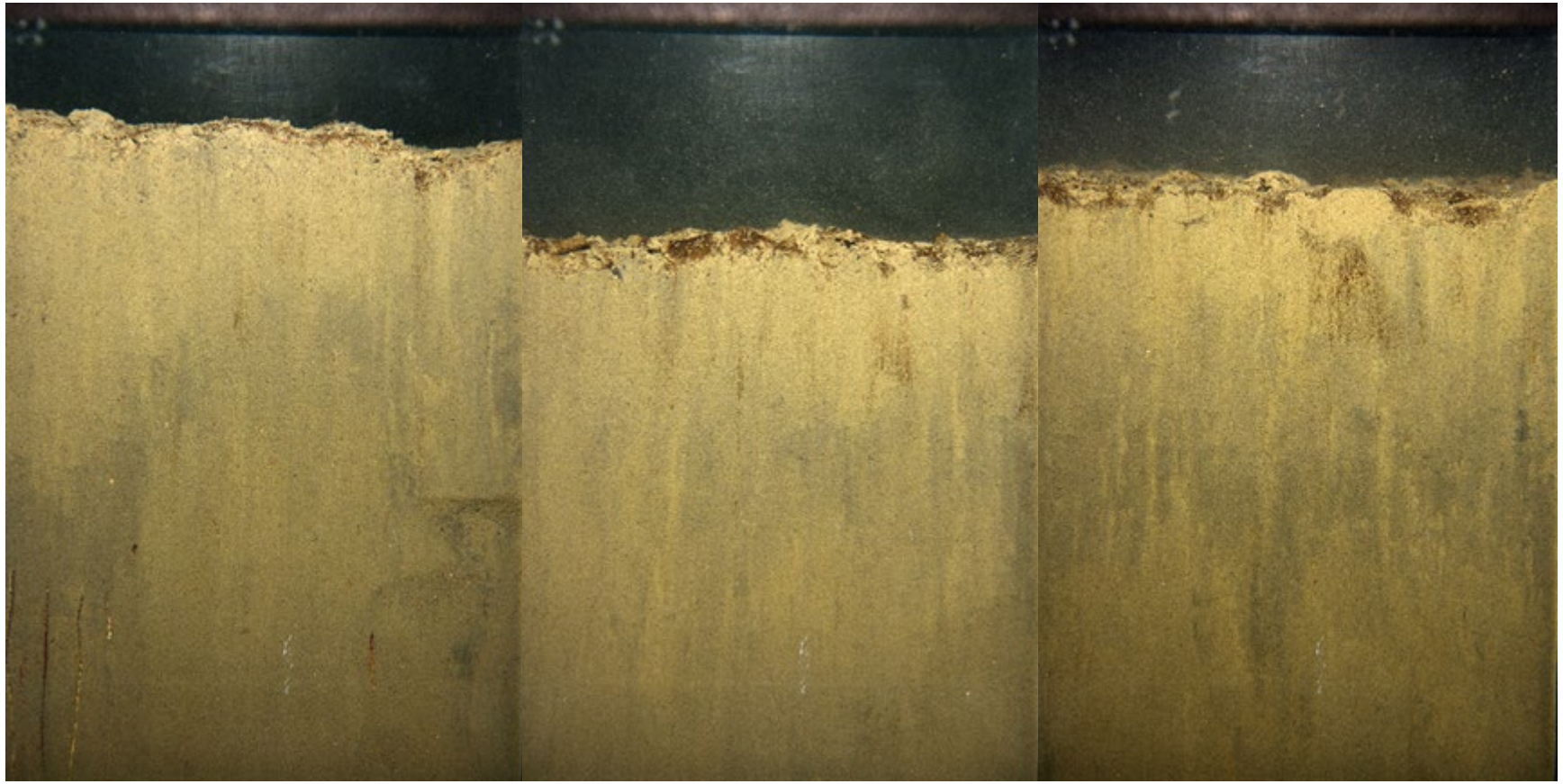
# Sediment Profile: Control – No Action
# Test Area 6





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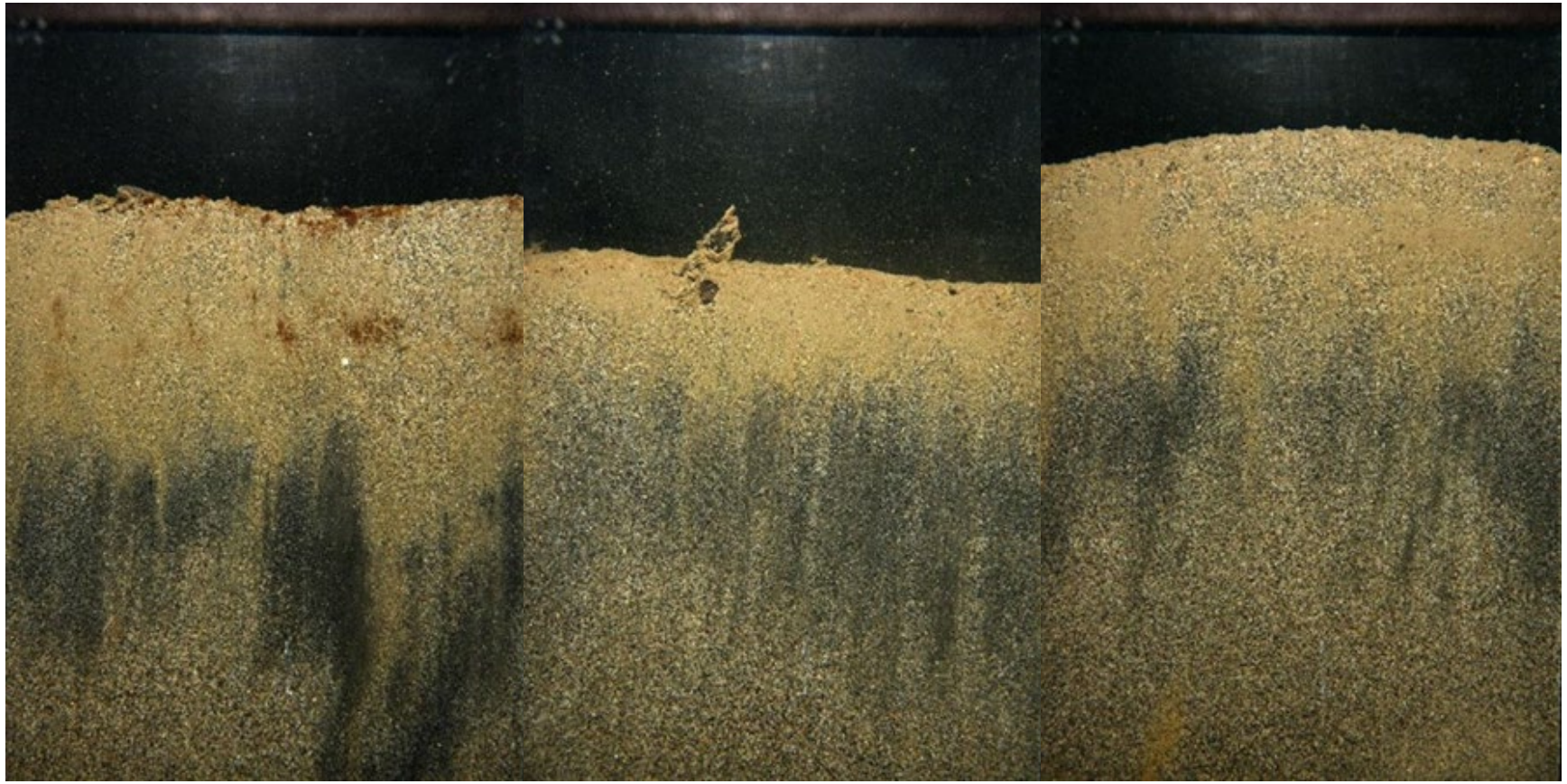
# Sediment Profile: Sand + Siderite, 30-cm Targeted Thickness – Test Area 3





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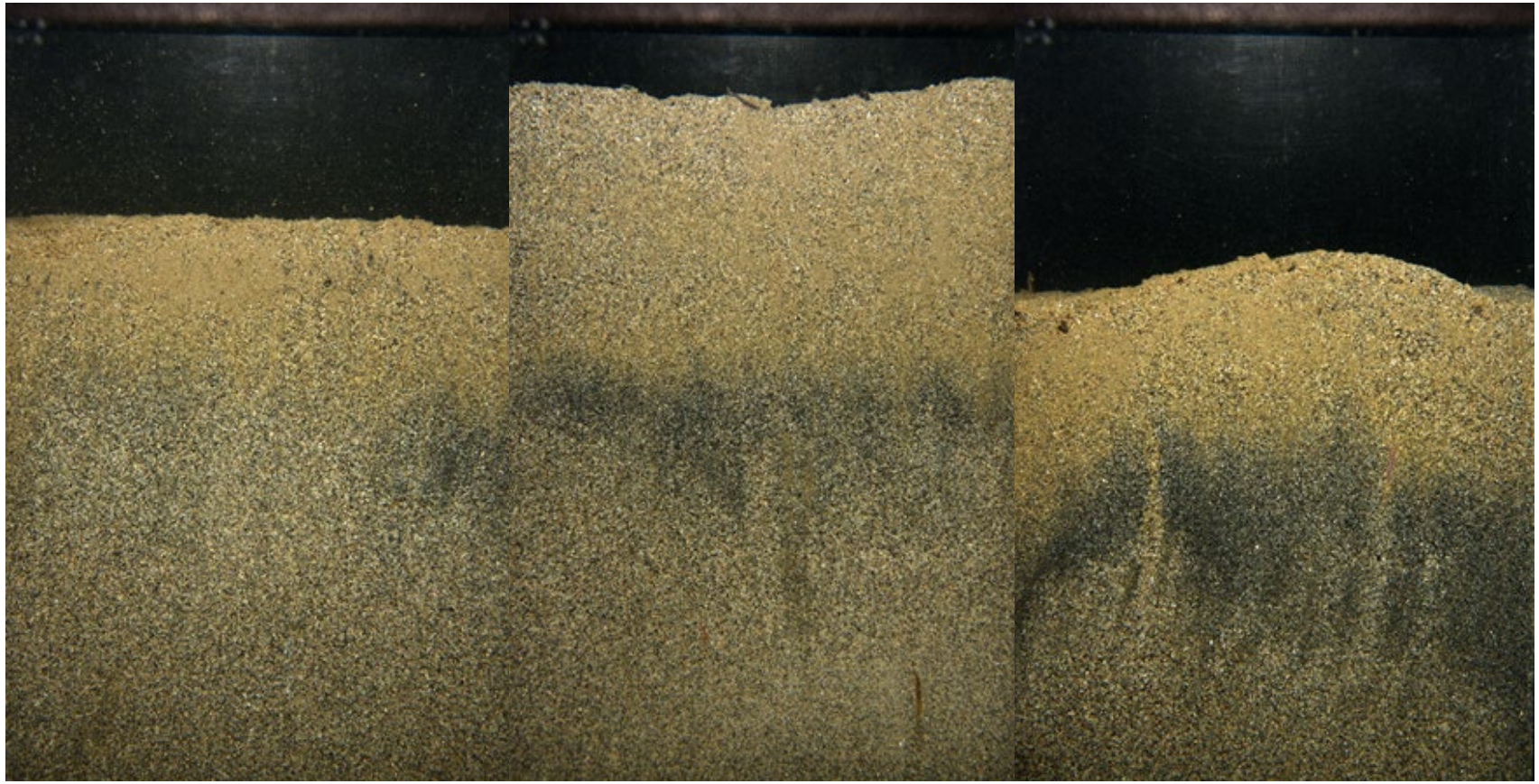
# Sediment Profile: Sand Cover, 30-cm Targeted Thickness – Test Area 4



# Sediment Surface: Sand + Siderite Cover, 30-cm Targeted Thickness – Test Area 2



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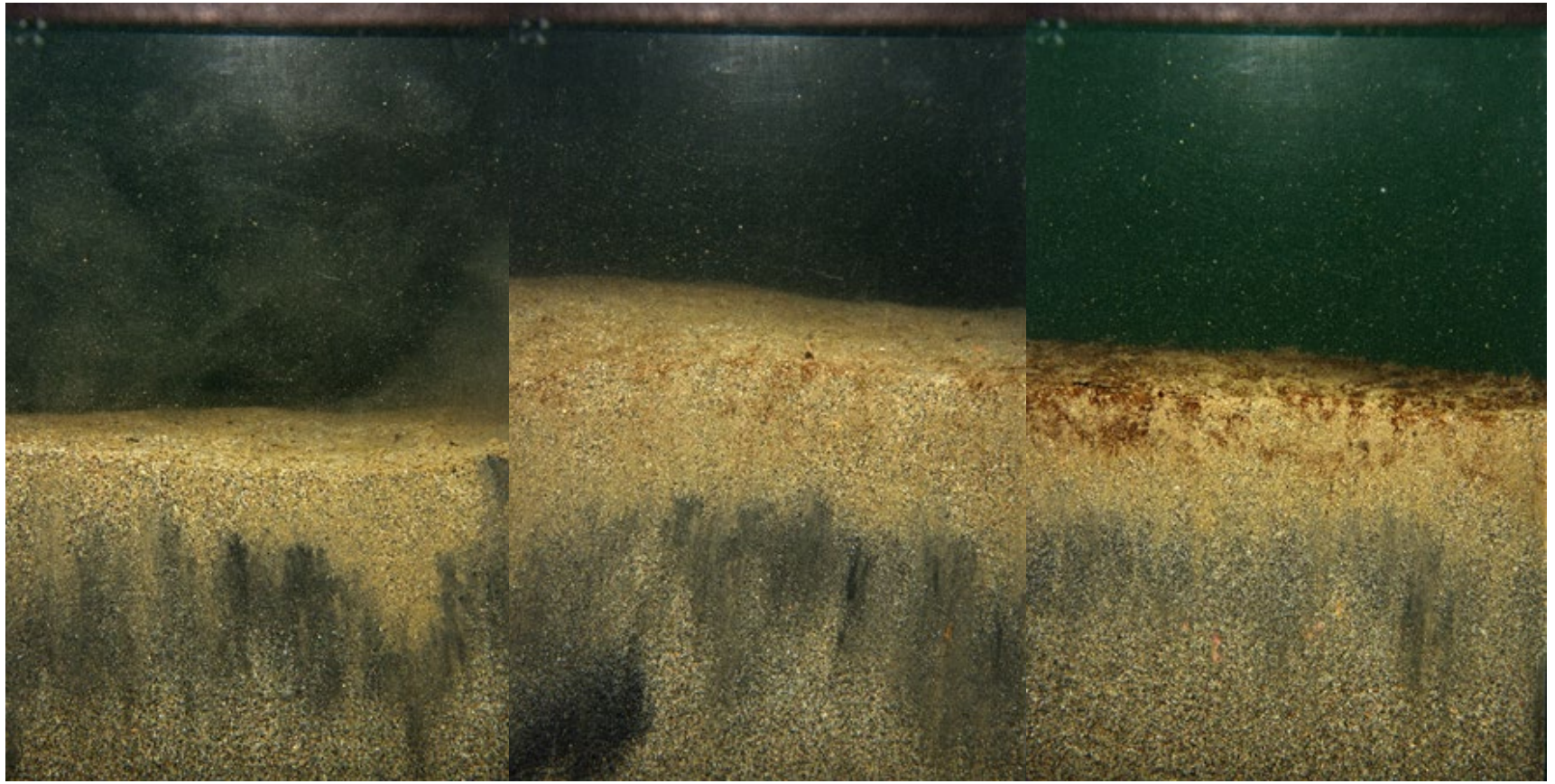
# Sediment Profile: Sand + Siderite, 30-cm Targeted Thickness – Test Area 7





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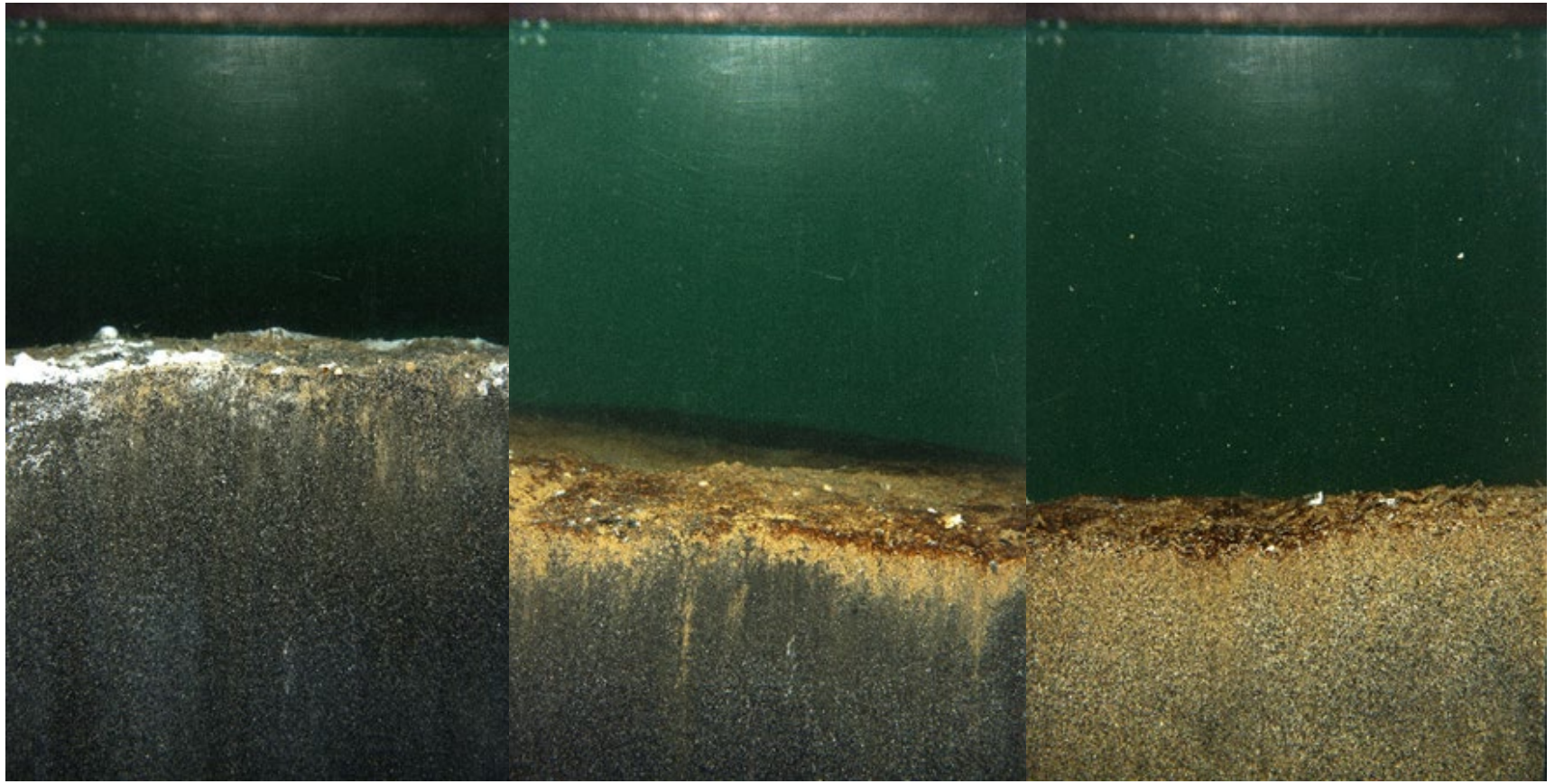
# Sediment Profile: Sand Cover, 30-cm Targeted Thickness – Test Area 8





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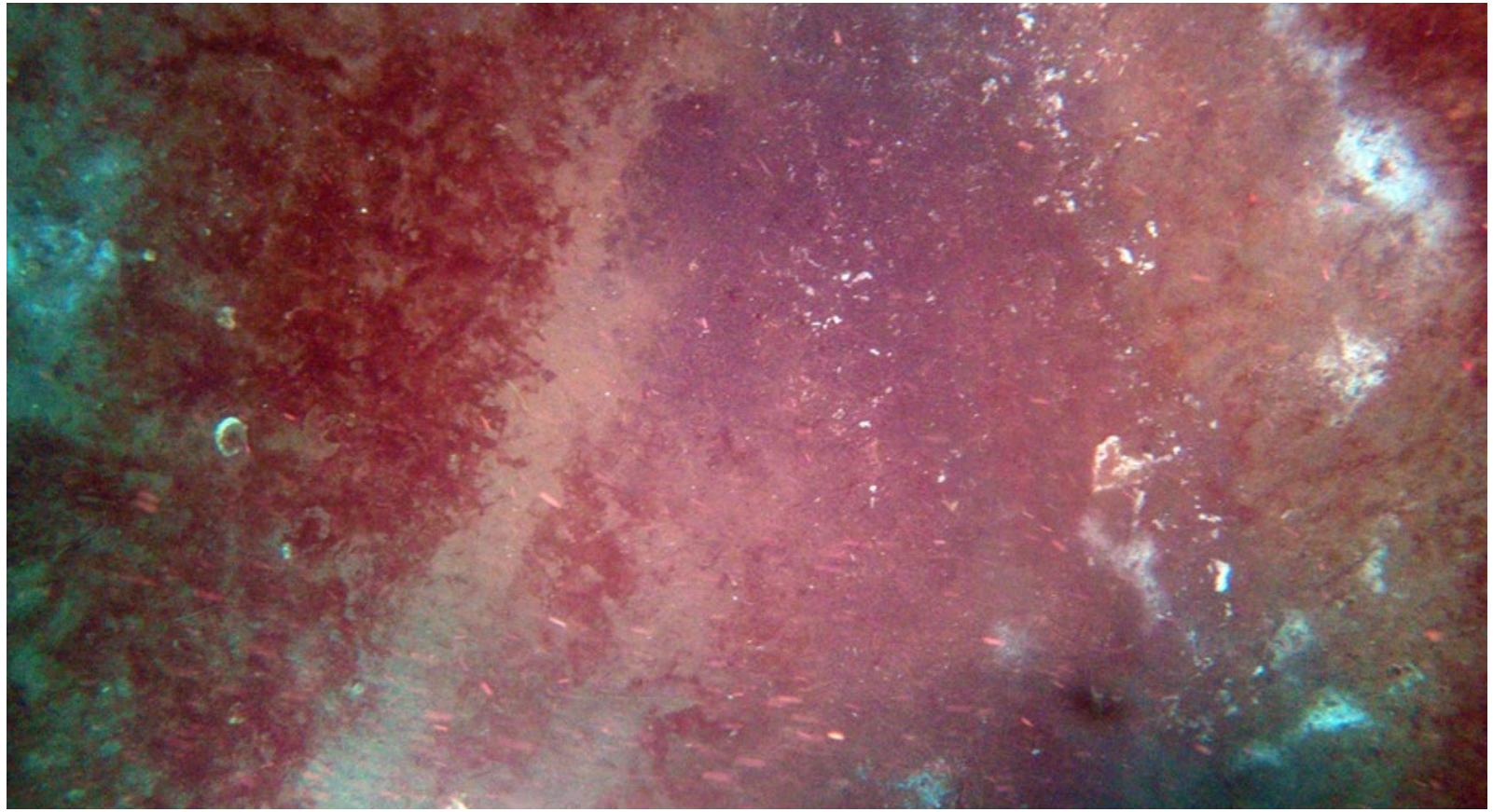
# Sediment Surface: Sand Only, 30-cm Targeted Thickness – Test Area 8



# Year 1 Conclusions

- Similar effectiveness of sand and siderite-amended sand cover
- Slightly elevated sulphide concentrations below 10 cm
  - Sand only in October (8 months)
  - Amended sand in March (12 months)
- Sand only had significant black iron sulphide precipitate and *Beggiatoa*
- Year 2 monitoring to determine longer-term effectiveness of sand cover alone
- Algae and sediment deposition may be contributing to sulphide generation

# Questions/ Discussion