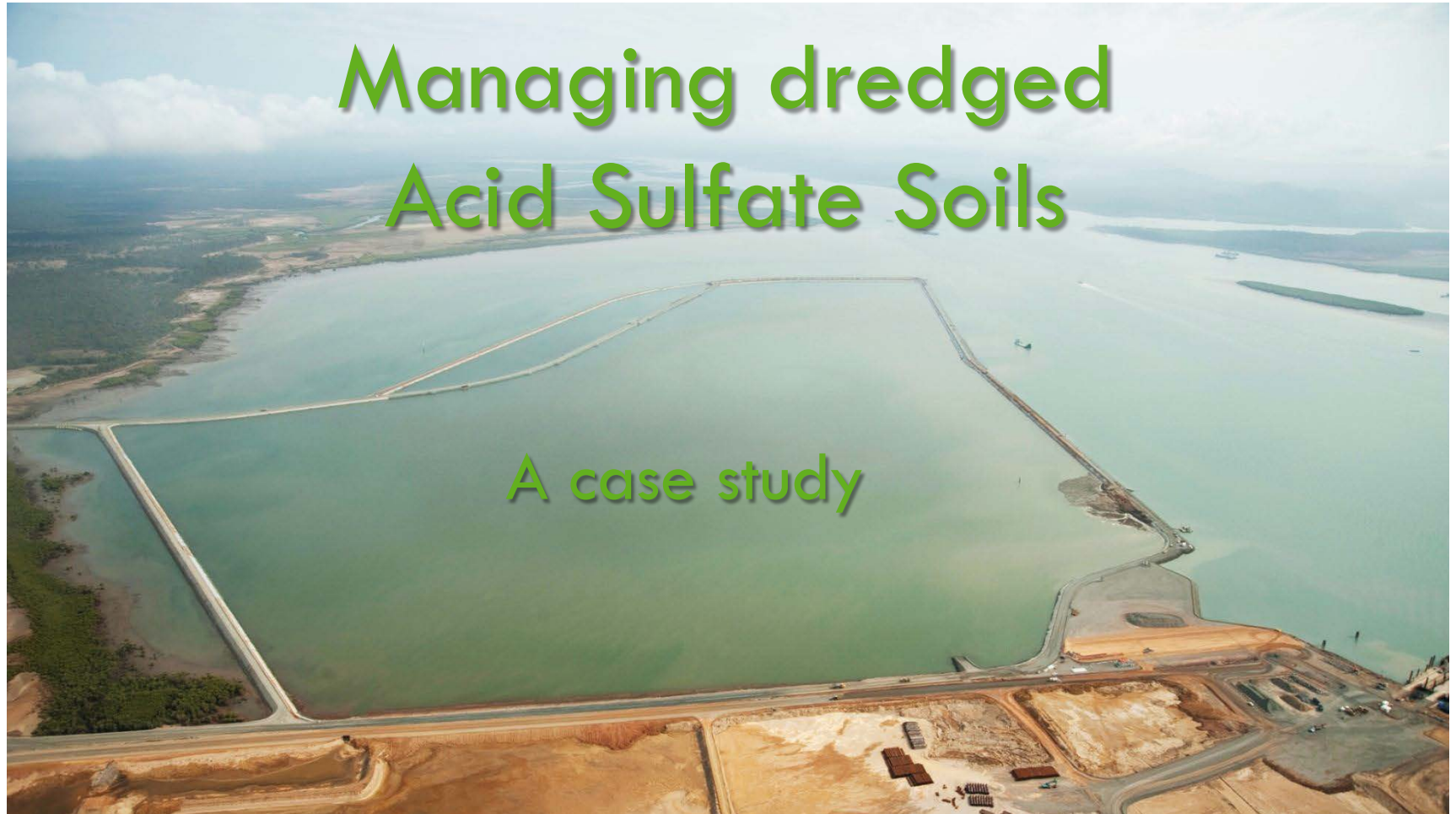




**Dredging  
International**

Marine & Waterway Solutions





# GLADSTONE PORT EXPANSION





# WESTERN BASIN MAIN WORKS DREDGING





# WESTERN BASIN MAIN WORKS DREDGING

- Dredging and Reclamation Works by Joint Venture:

- Van Oord Australia Pty Ltd



- Dredging International Australia Pty Ltd



- Funding parties LNG project Gladstone

- GLNG Operations Pty Ltd



- Australia Pacific LNG Pty Ltd



- QCLNG Operating Company Pty Ltd



- Arrow CSG Australia Pty Ltd





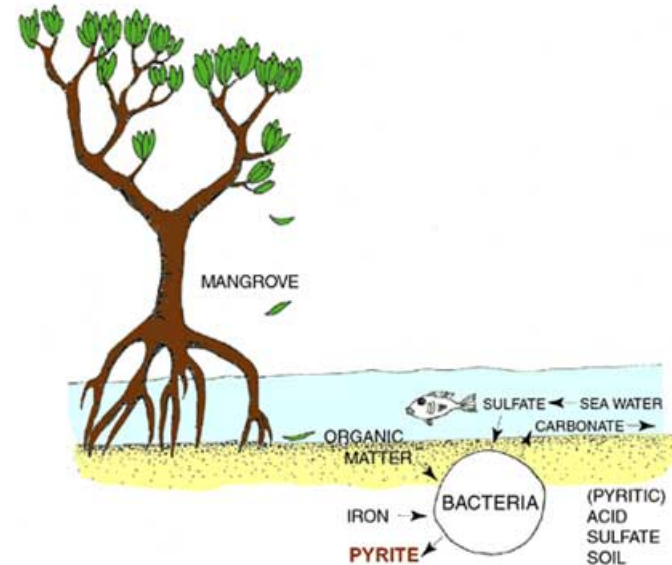
# WESTERN BASIN MAIN WORKS DREDGING

- Dredge Equipment
  - Back Hoe Dredges
  - Trailing Suction Hopper Dredges
  - Cutter Suction Dredges
- 26 Mm<sup>3</sup>
- Destination
  - Offshore Placement
  - Western Basin Reclamation Area
- Acid Sulfate Soils (ASS)
  - 1.5 Mm<sup>3</sup>



# ACID SULFATE SOILS

- Coastal wetlands
- Past 10,000 years (Holocene epoch)
- POTENTIAL ASS (PASS)
  - Iron sulfides (pyrite)
  - waterlogged
  - no oxygen: stable
- (P)ASS in USA





# ACID SULFATE SOILS

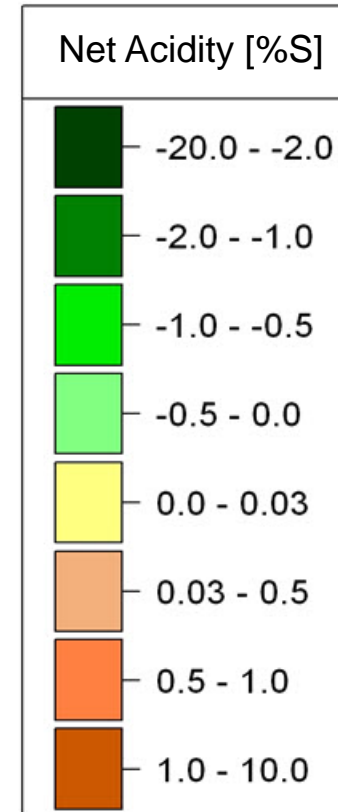
- ACTUAL ASS (AASS)
- Drainage / upland placement
  - Oxidation
  - Sulfates → sulfuric acid
  - pH < 4
  - Leachate (heavy metals)
- Danger
  - Inhibit aquatic life
  - Habitat degradation
  - Degradation of engineered structures





# PASS Definition

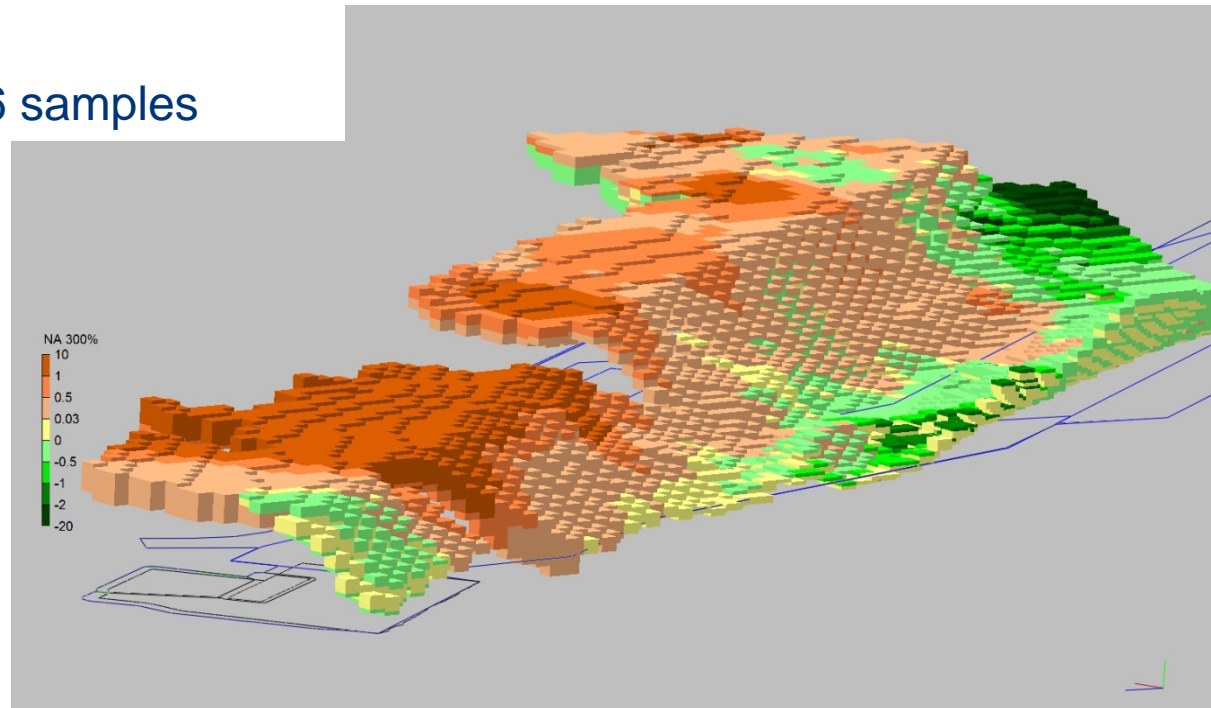
- Potential Sulfidic Acidity (PSA)
- Self-neutralizing PASS
  - Natural carbonate content
  - Acid Neutralizing Capacity (ANC)
- Safety Factor (SF) = 300%
  - Mixing
  - Solubility
  - Fineness
- Net Acidity (NA)
  - $NA = PSA - ANC / SF$
  - PASS:  $NA > 0.03 \%S$





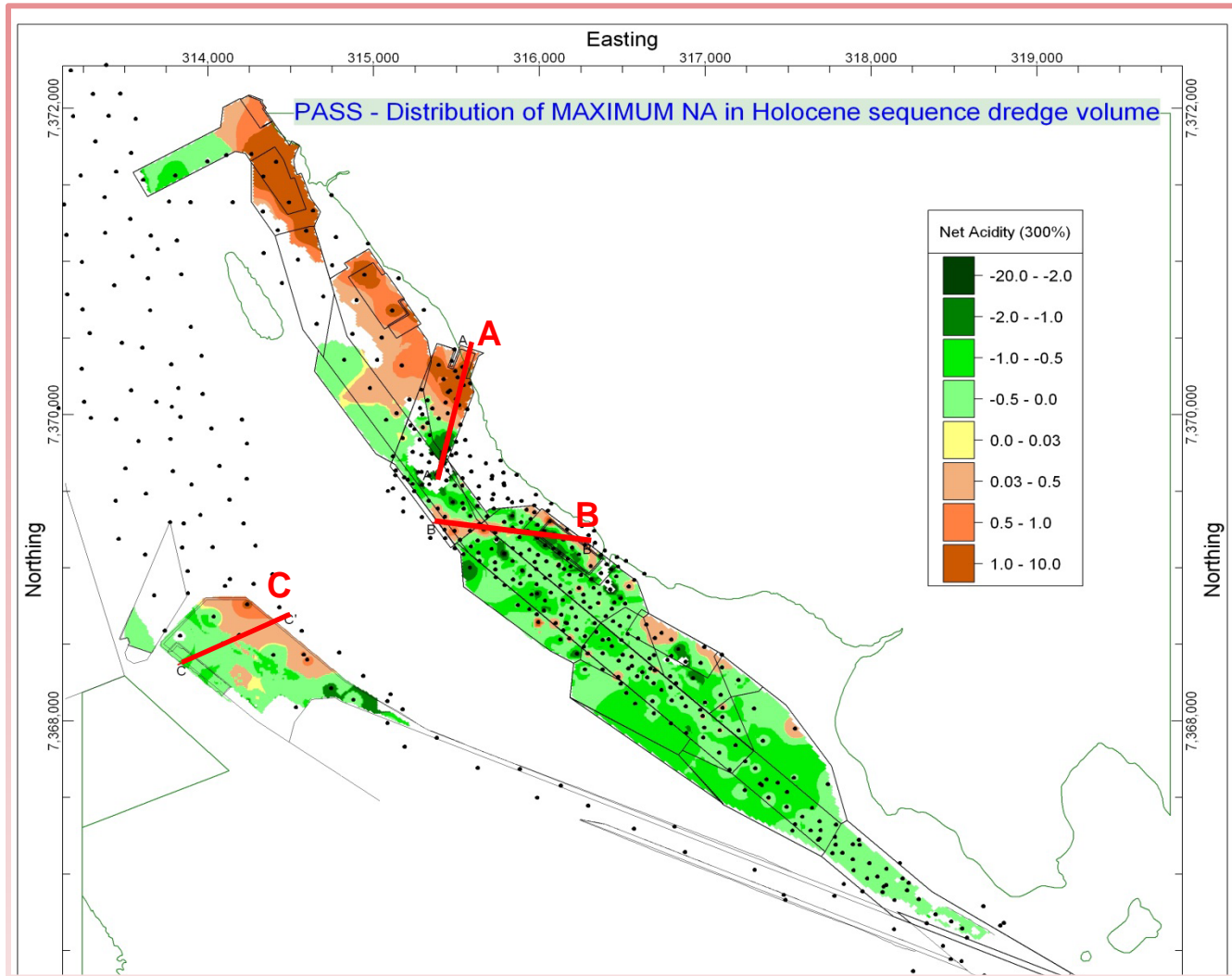
# PASS MODEL

- Outlining the problem
  - Management strategy
- In situ PASS data
  - 561 boreholes, 2246 samples
  - Geochemical data
  - Stratigraphy
- Modeling
  - Net Acidity
  - 3D domain
  - Blocks of 80m<sup>3</sup>
  - IDW algorithm





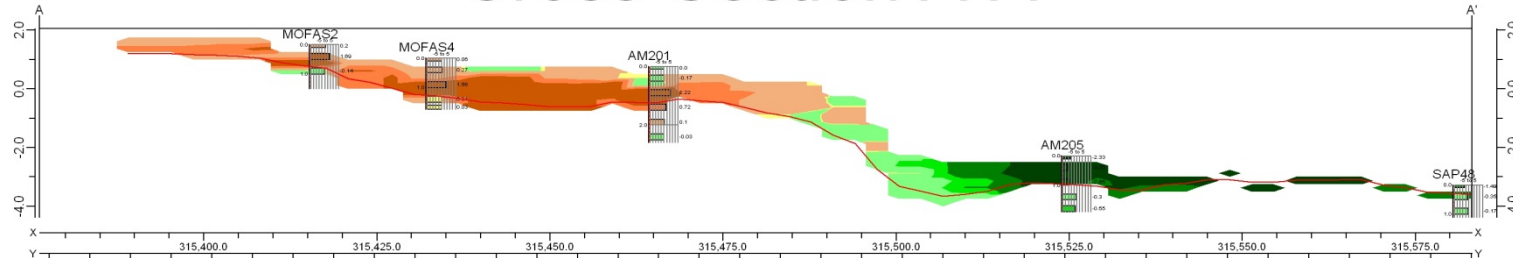
# PASS MODEL



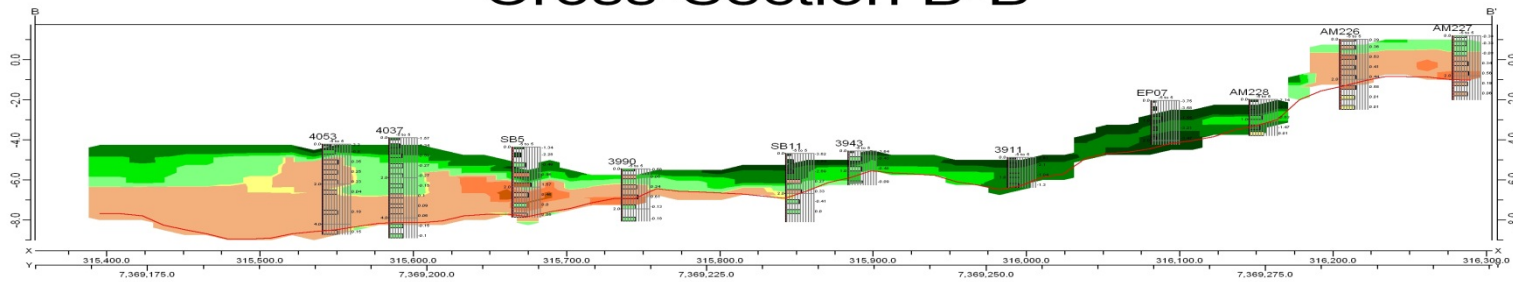


# PASS MODEL

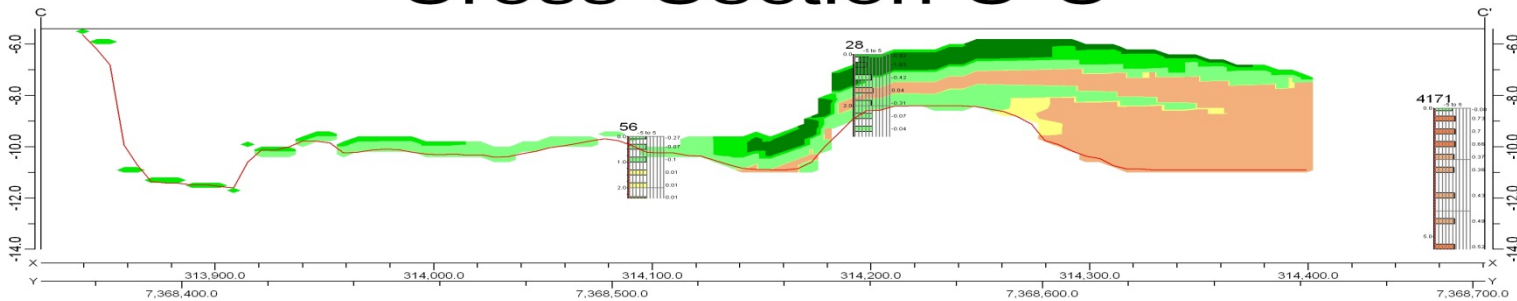
## Cross-Section A-A'



## Cross-Section B-B'



## Cross-Section C-C'

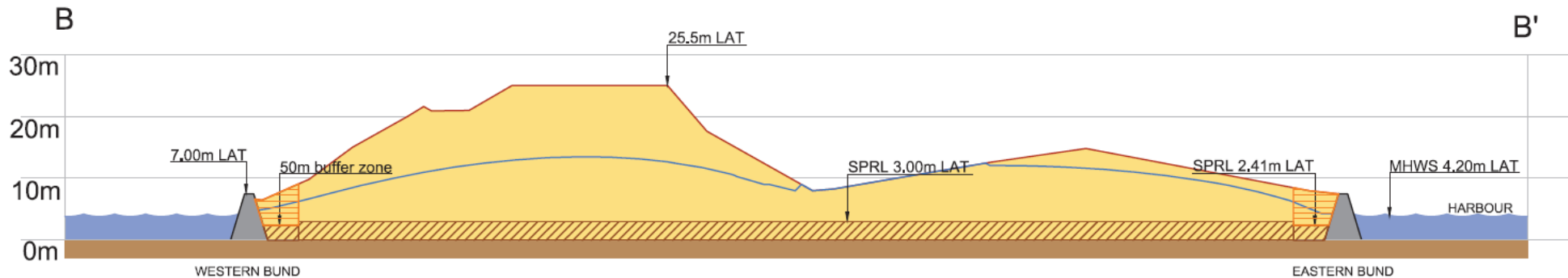






# STRATEGIC REBURIAL

- Underneath permanent water level
  - Anoxic conditions
  - High grade PASS
- Reclamation area
  - Groundwater modeling



- Safe PASS Reinterment Level ~ MSL
- Limited storage capacity



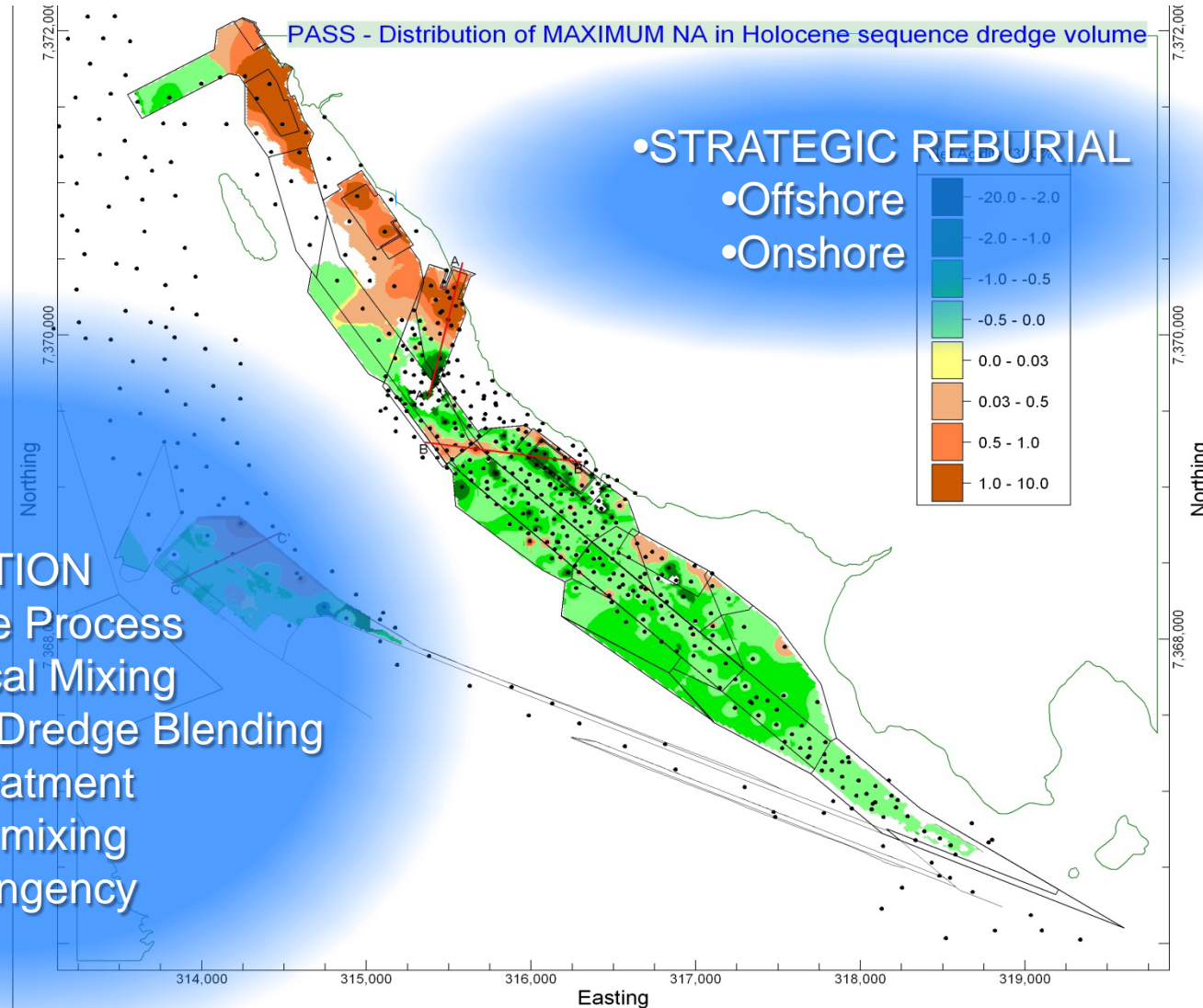
# STRATEGIC REBURIAL

- Offshore placement
  - Minimize bulking
  - Selective dredging
- Back Hoe Dredges + Barges
  
- Keep saturated during transport
- 24h limit
- pH test every 2 hours



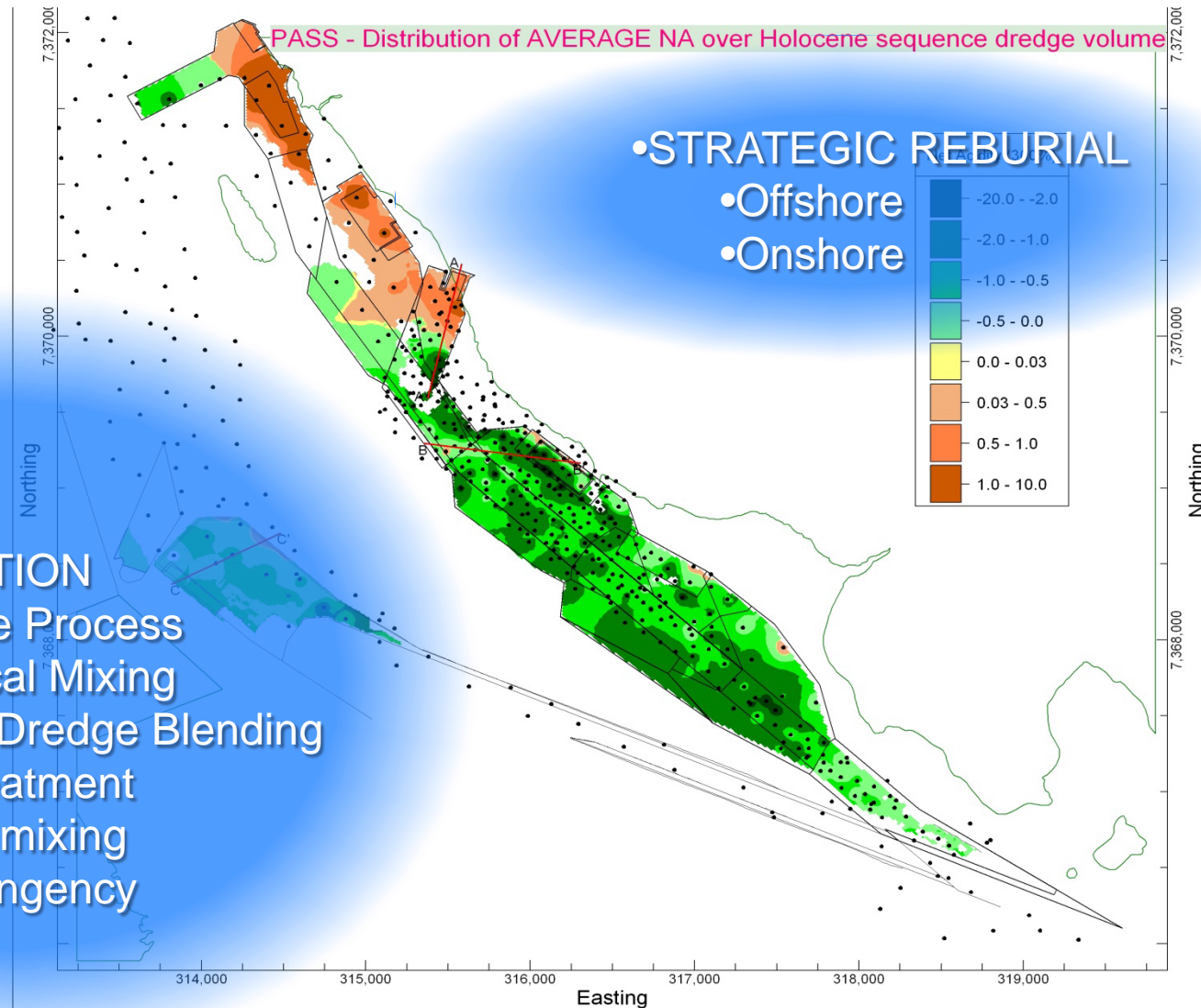


# PASS MANAGEMENT OPTIONS



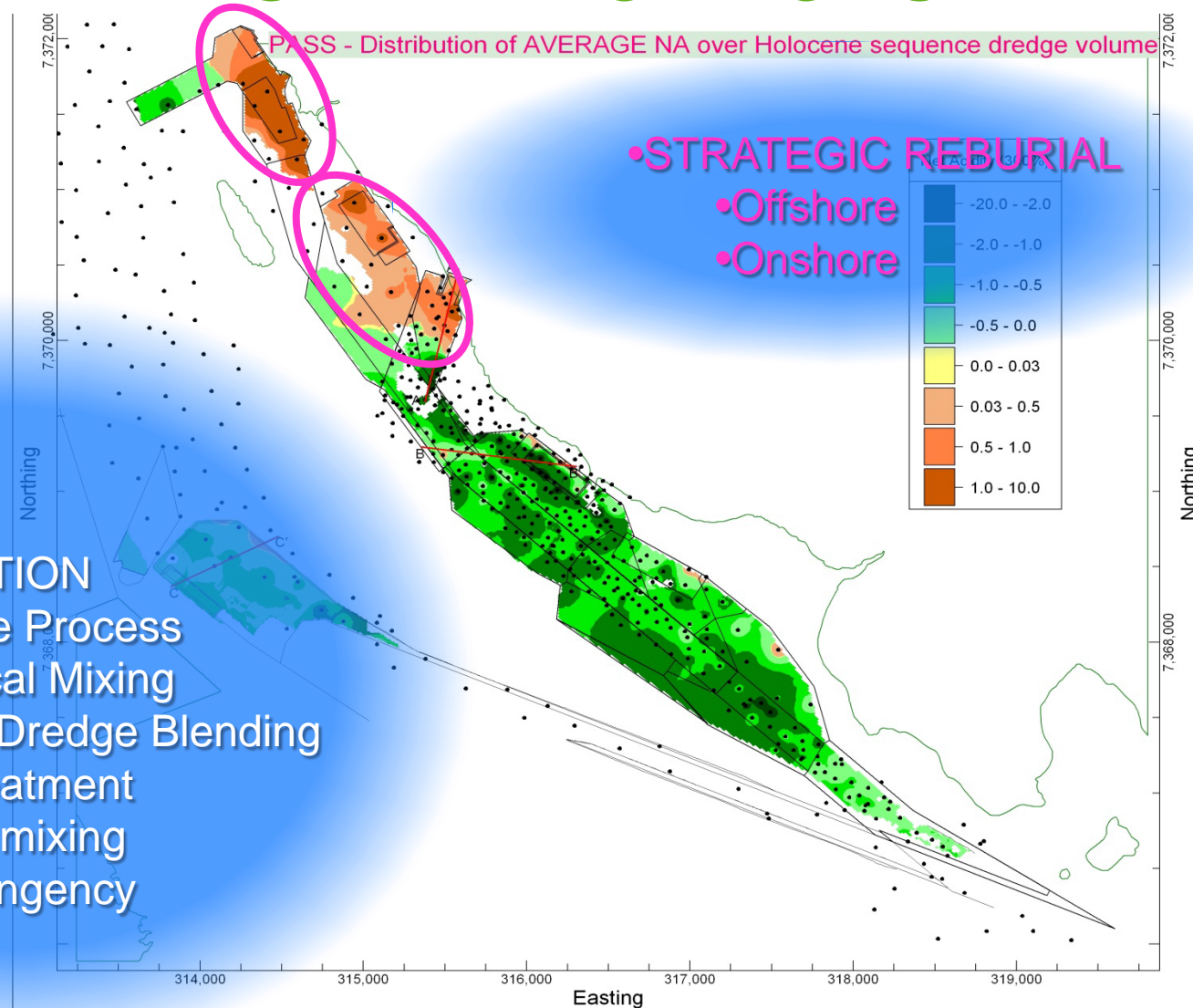


# PASS MANAGEMENT OPTIONS





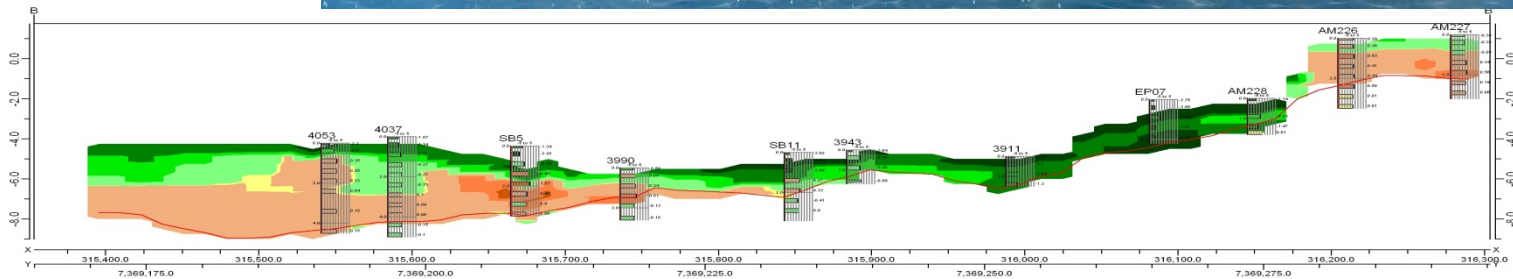
# PASS MANAGEMENT OPTIONS





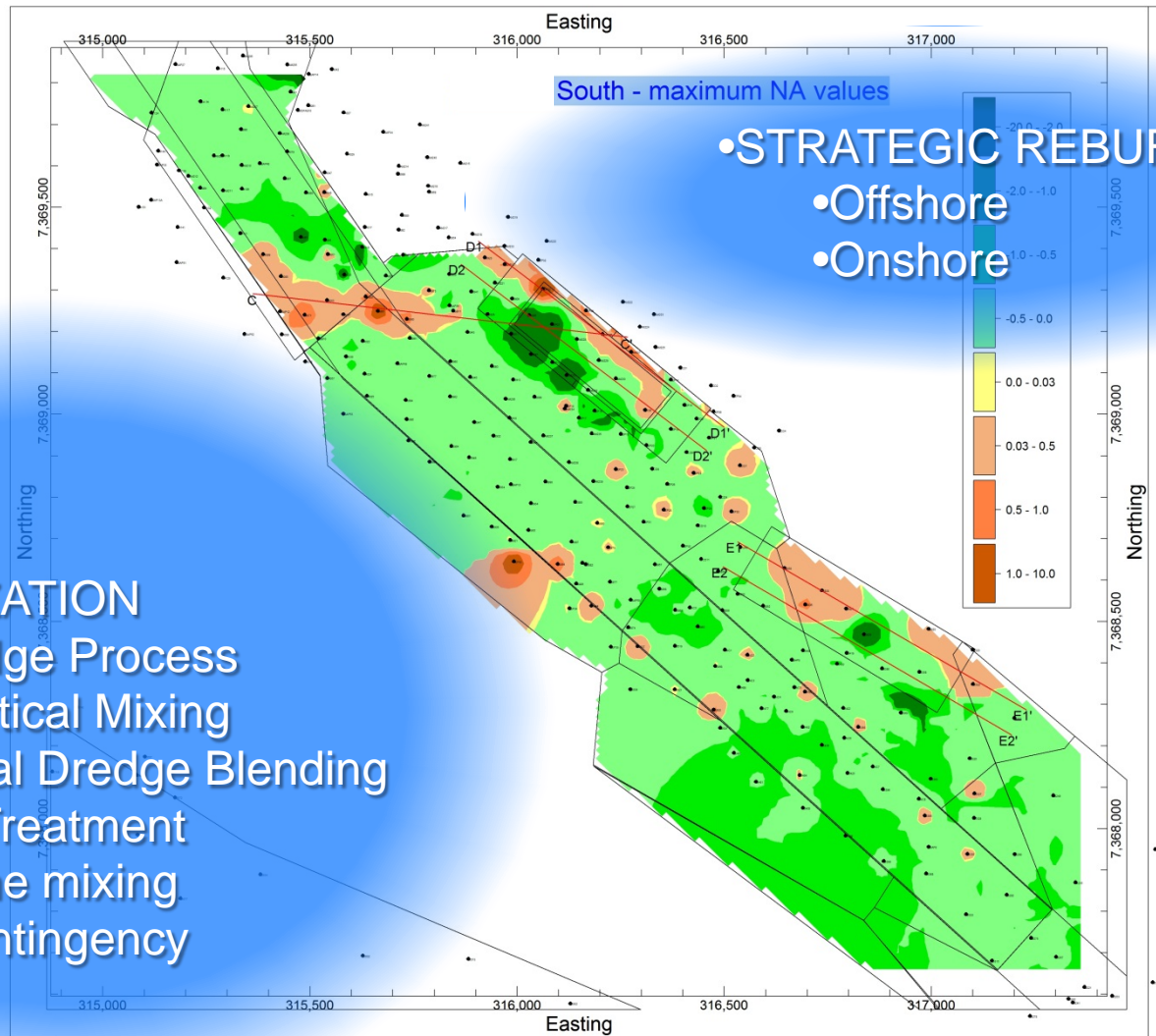
# NEUTRALIZATION BY DREDGE

- Vertical Mixing
- Combined NA
  - Excess ANC
  - CSD
  - Onshore
  - Above SPRL





# PASS MANAGEMENT OPTIONS

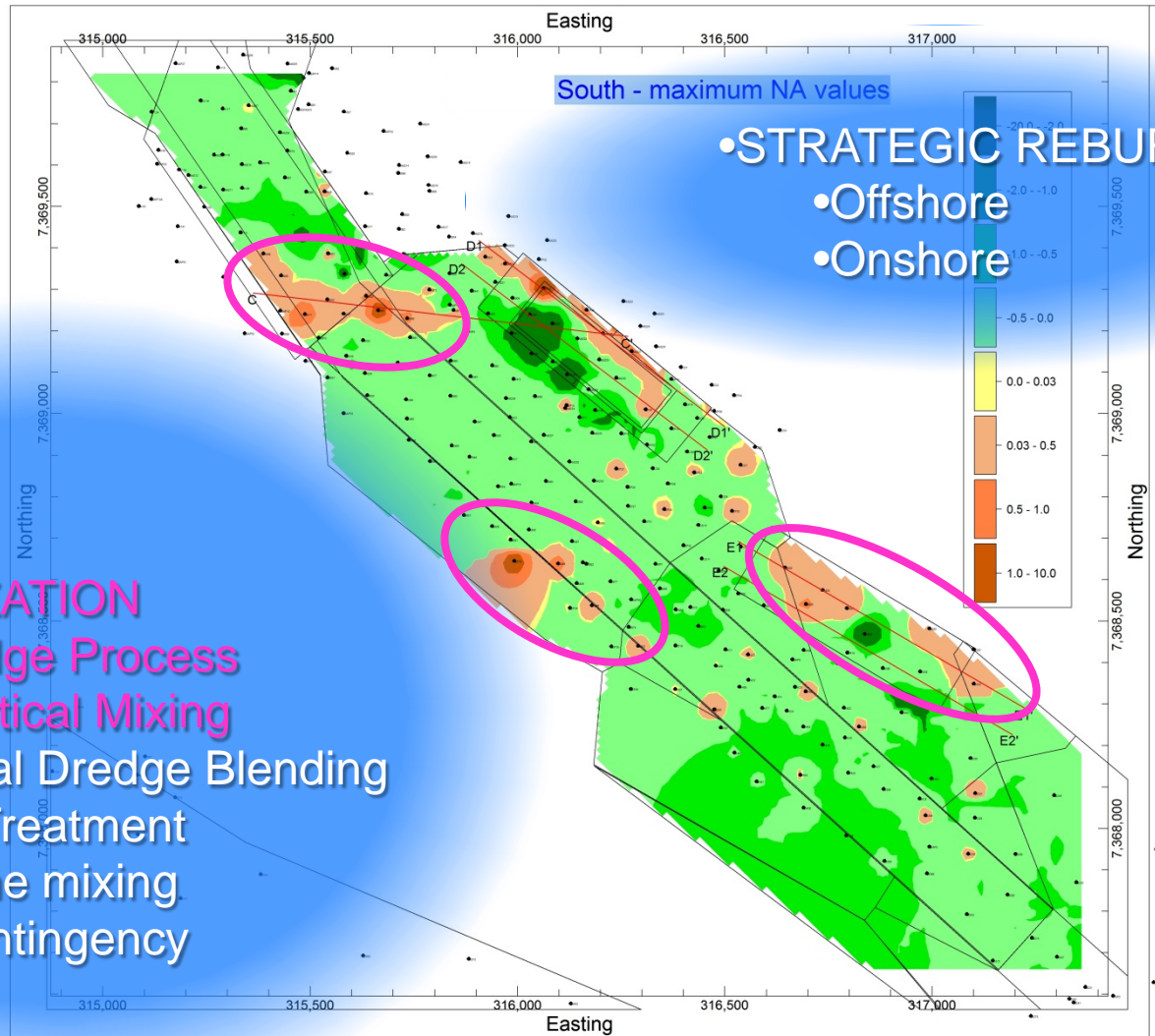


- STRATEGIC REBURIAL
  - Offshore
  - Onshore

- NEUTRALIZATION
  - By Dredge Process
    - Vertical Mixing
    - Dual Dredge Blending
  - Active Treatment
    - Lime mixing
    - Contingency



# PASS MANAGEMENT OPTIONS

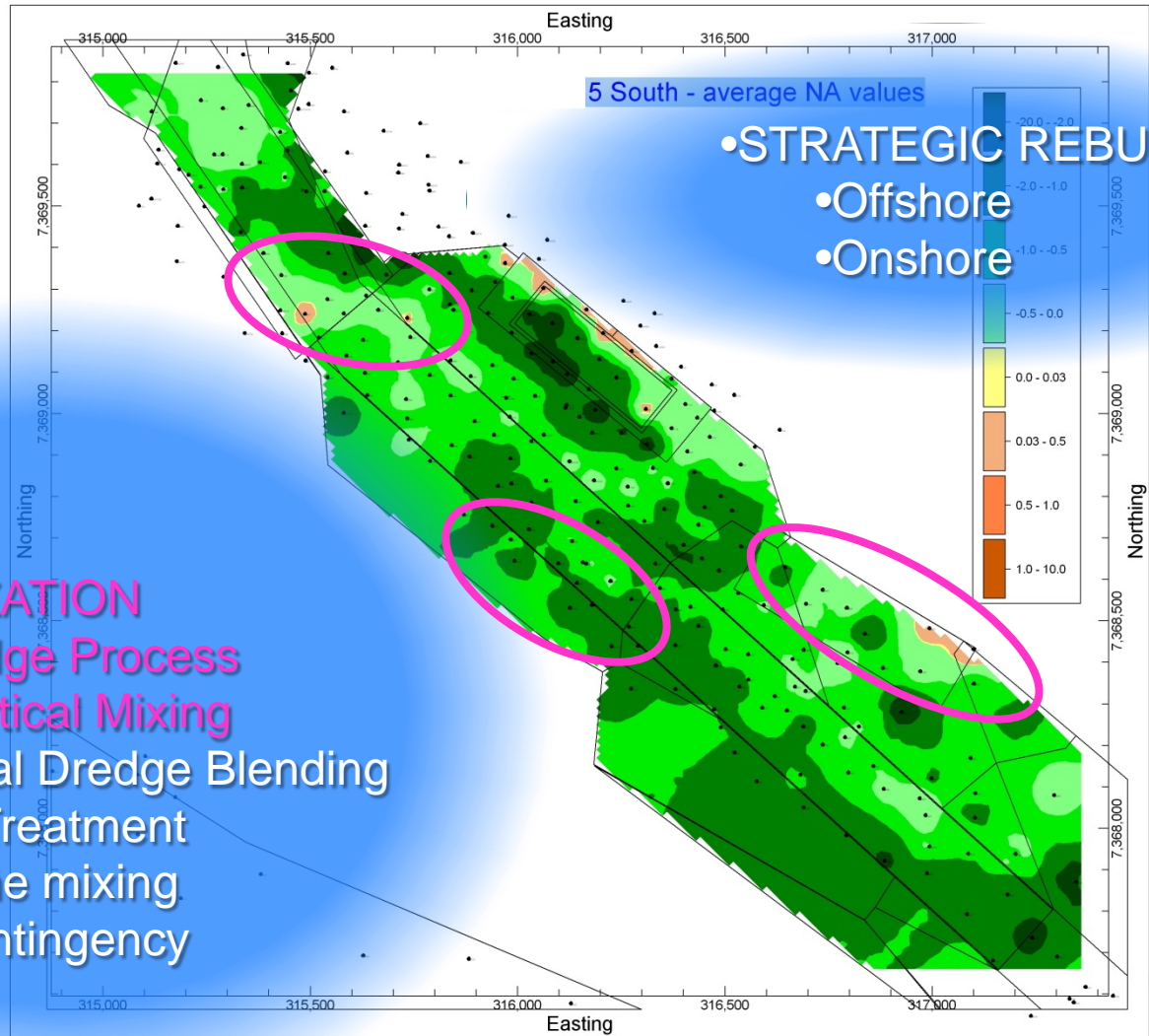


## • NEUTRALIZATION

- By Dredge Process
  - Vertical Mixing
  - Dual Dredge Blending
- Active Treatment
  - Lime mixing
  - Contingency

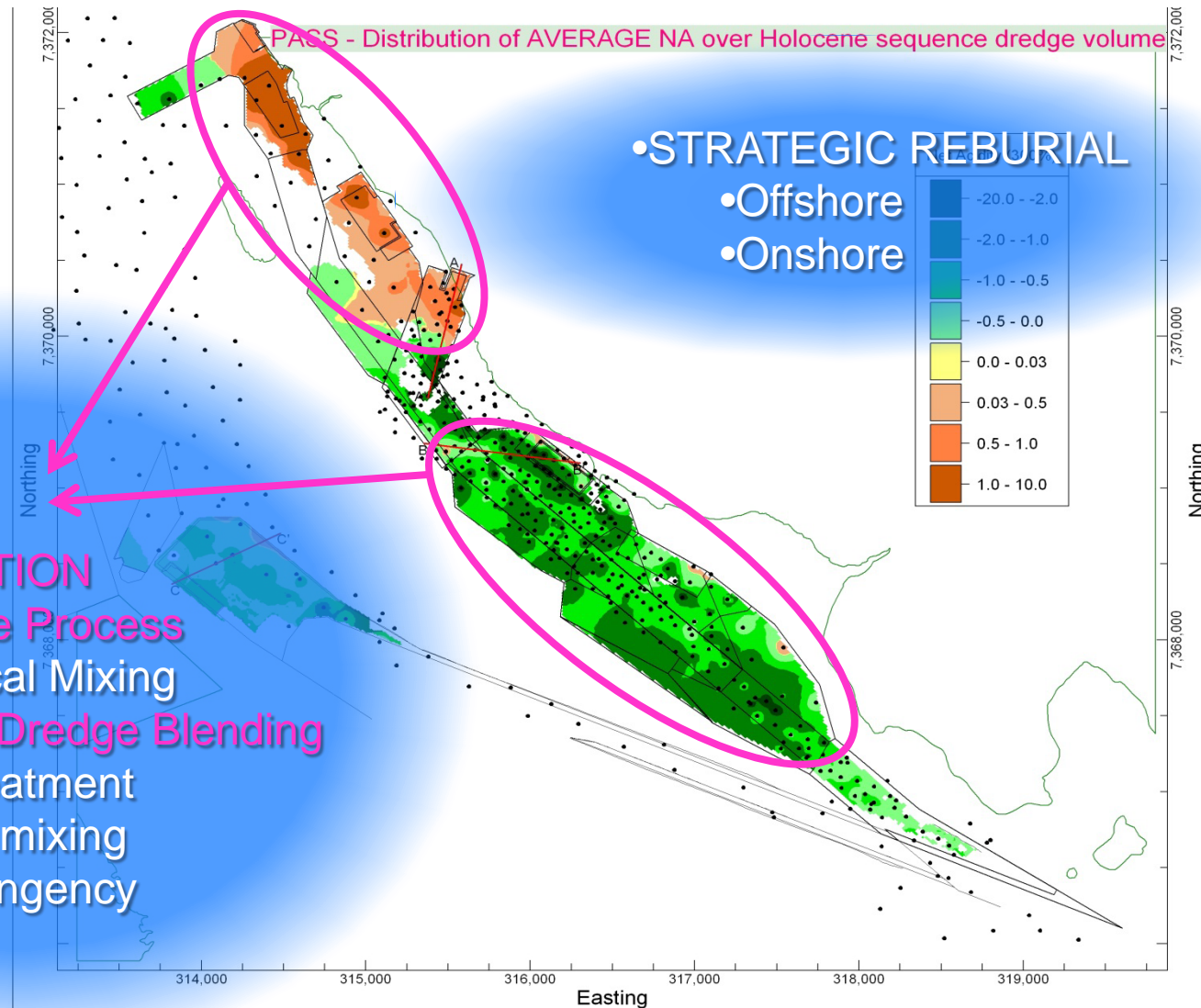


# PASS MANAGEMENT OPTIONS





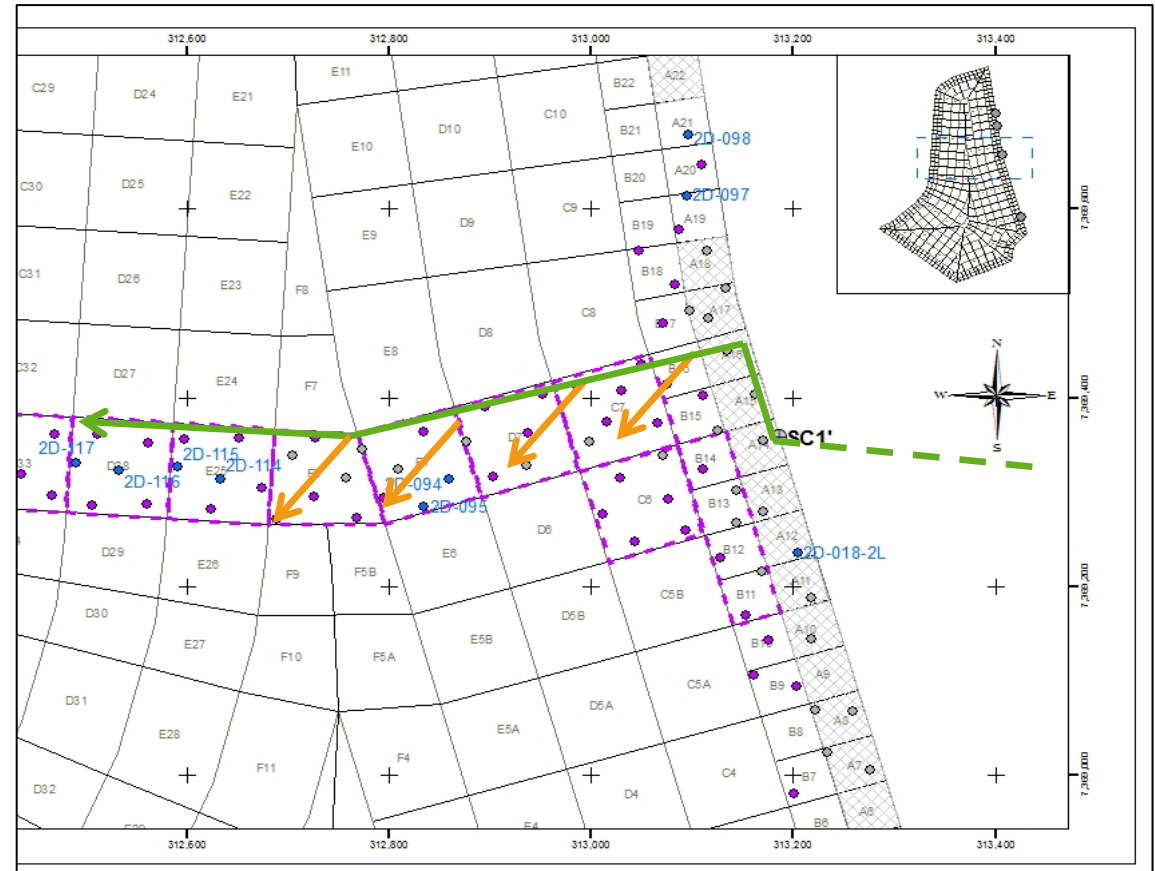
# PASS MANAGEMENT OPTIONS





# (P)ASS TRACKING

- Offshore site
  - 300m x 300m grid
  - Split hopper barges
  - Appointed disposal-cells
- Reclamation site
  - 1 hectare cells
  - Below SPRL
    - Adaptive placement
  - Above SPRL?
    - Testing program





# PASS Sampling Strategy

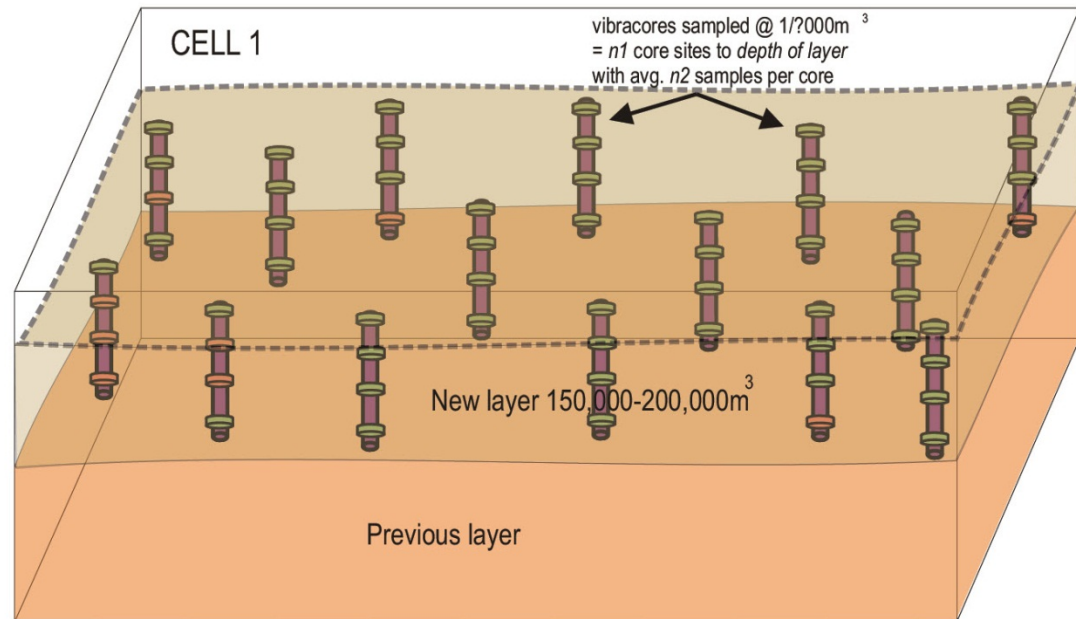
- Above SPRL
- 3m layers
- Continuous coring
- Field tests
  - 0.25m intervals
  - Early indication
    - $\text{pH}_F$
    - $\text{pH}_{\text{Fox}}$
- Validation tests
  - Lab





# PASS Sampling Strategy

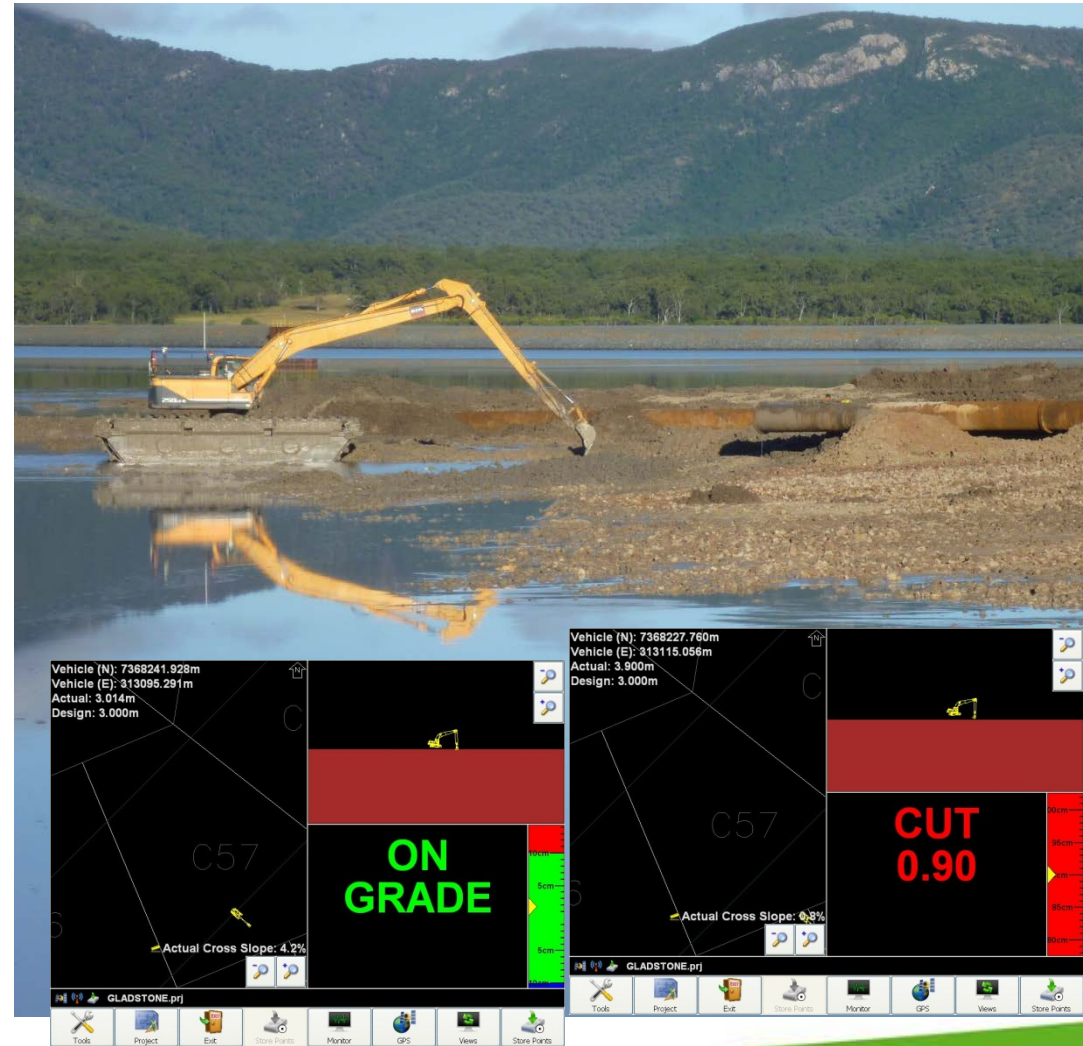
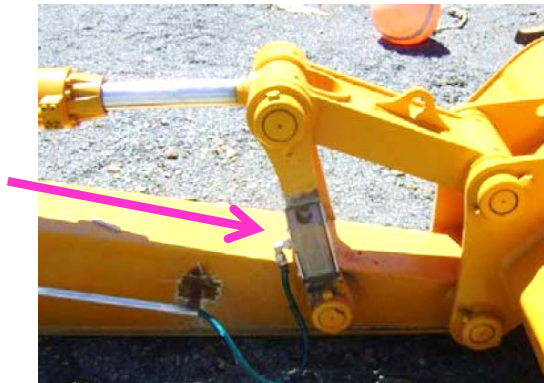
- Composite sample
  - 0.5m intervals
  - every 5,000m<sup>3</sup>
- PASS?
  - adjacent samples
  - 1 ha
  - overall NA
- Fail?
  - secondary sampling
  - 3 sites
  - vertical delineation





# PASS Strategic Reinterment

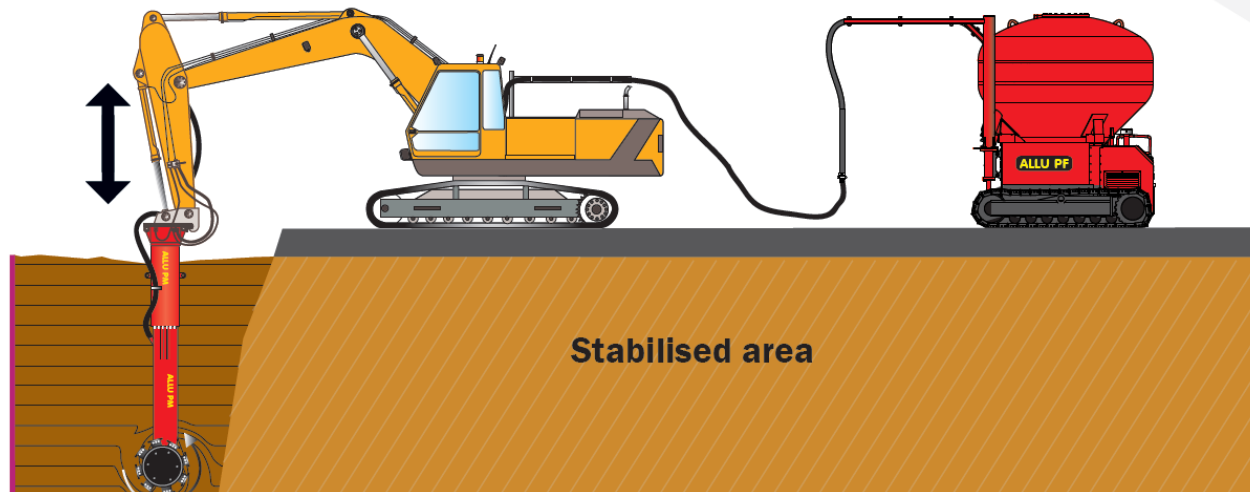
- Relocation
  - Below SPRL
  - Swamp excavator
    - GPS/position sensors
    - vertical control
  - 2m water on top
  - >30 cm capping
    - Stiff clay layer





# (P)ASS Treatment

- Safe storage capacity?
- In situ treatment
  - deep rotary mixing
  - aglime injection
  - binder agent





# (P)ASS Treatment

- Actual ASS
  - no reinterment
  - quick response
  - aglime
  - ripper/spreader/rotary hoe





# ONLINE PASS TRACKING

- **SOILVIEWER**

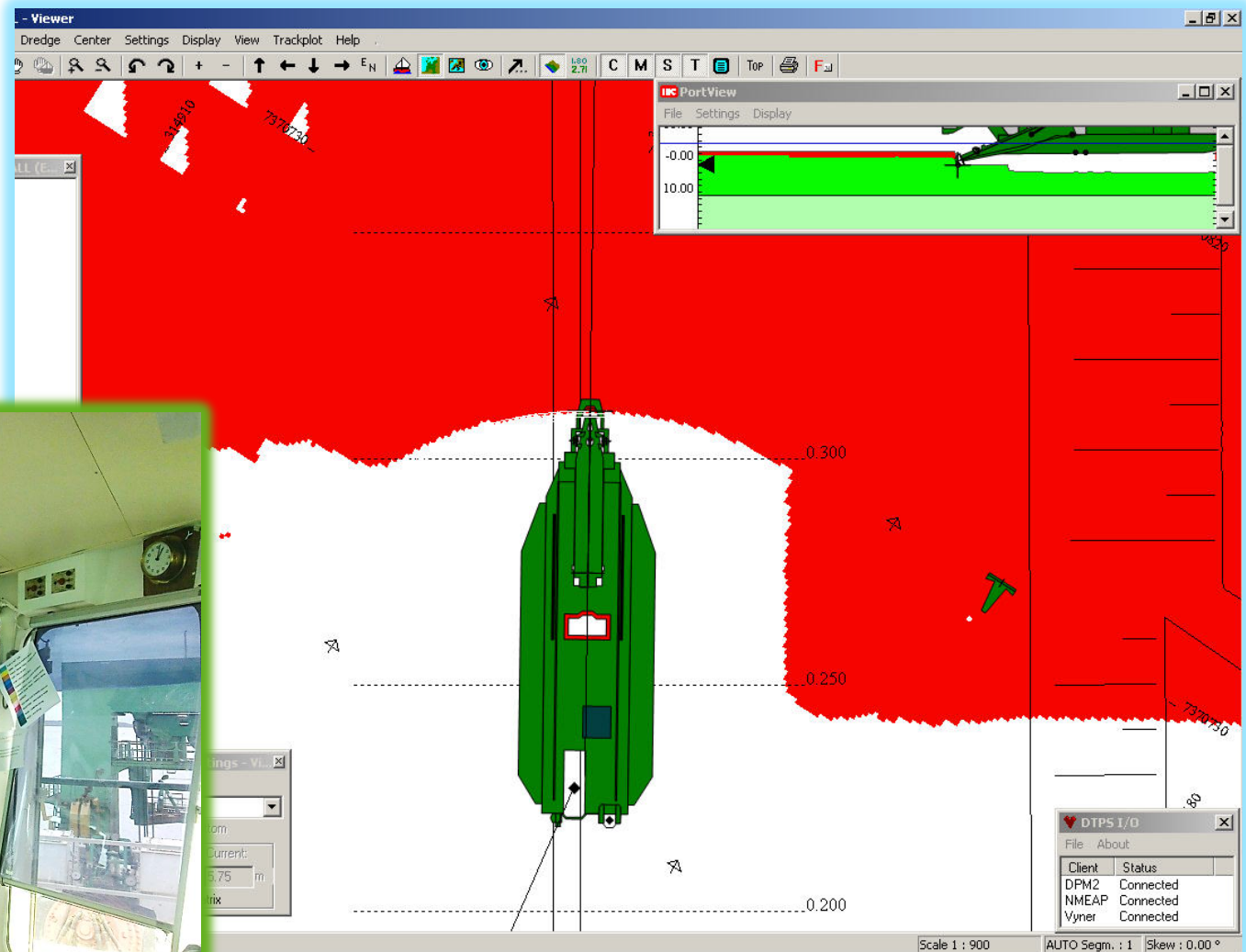
- Real time cutter position
- PASS 4D-model integration





# ONLINE PASS TRACKING

- SOILVIEWER
  - Bridge
  - Relay to shore
  - Client





**Dredging  
International**

Marine & Waterway Solutions



# Managing dredged Acid Sulfate Soils

**Thank you for your attention**