

Mitigating Geological Risks Using Enhanced Geophysical Methods



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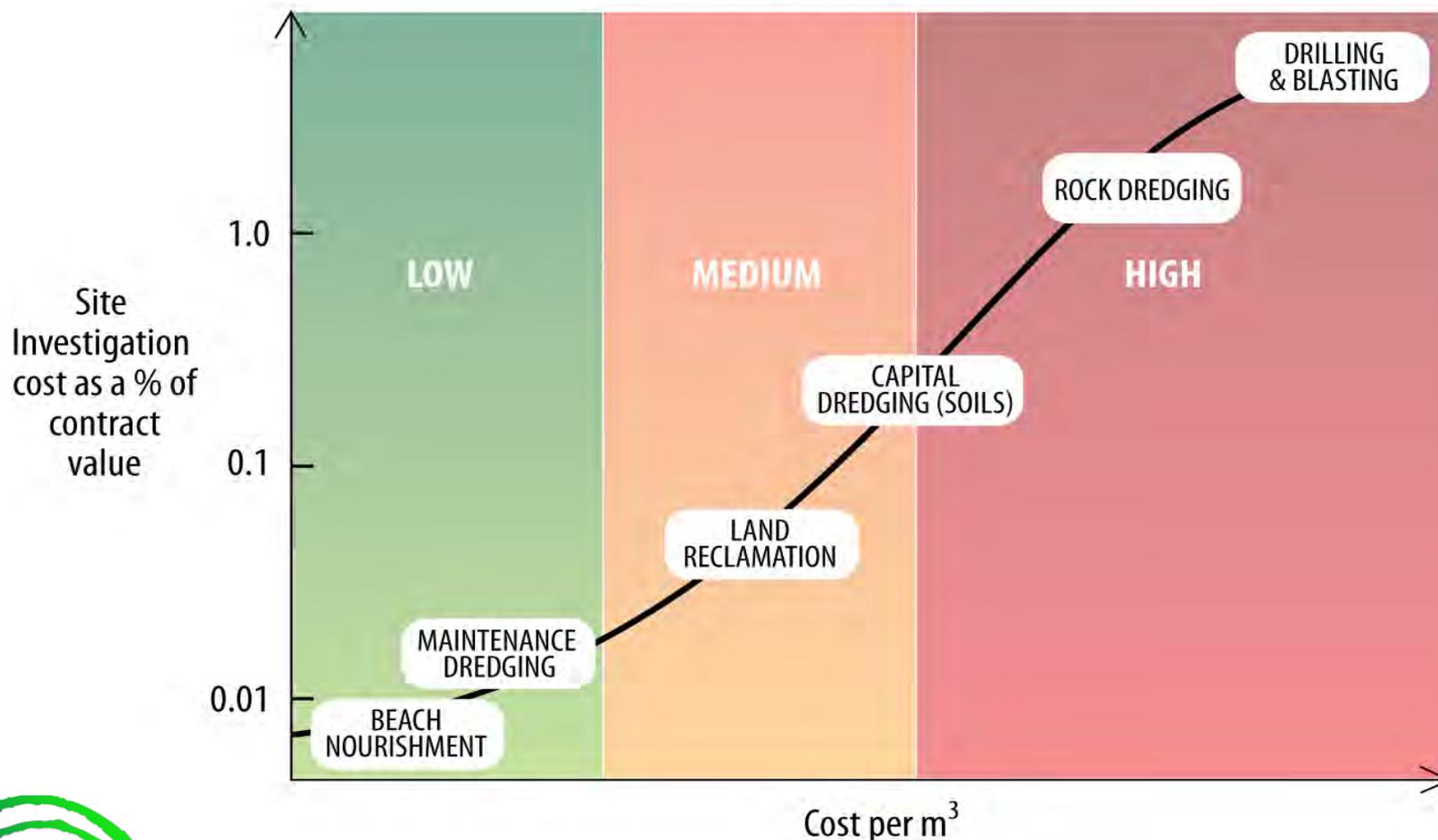
Arc Surveying & Mapping
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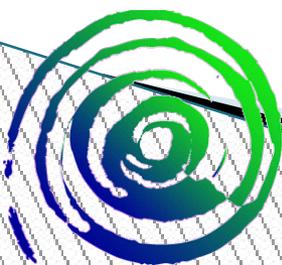
Site Investigation Budget versus Geological Risks



CONTRACT RISK PROFILE



(from: Adverse Physical Conditions and the Experienced Contractor by David Kinlan, 2014)



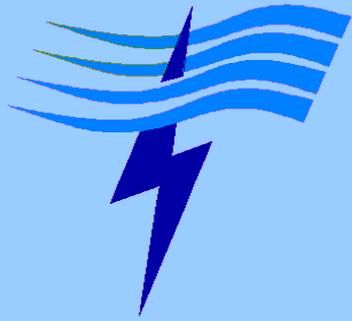
Site investigation quality versus claim value



Type of Information provided to contractors	Average Claim Value / Contract Value
Minimal investigation no samples or test results	15-25%
Sparse information (1980's standard) borelogs with limited interpretative content	10-12%
Comprehensive investigation/design information & test results, no geotechnical model	2 - 2.5%
Comprehensive investigation/design information, detailed geotechnical model	<0.1%

Source : Roads & Traffic Authority, NSW





Site investigation methods



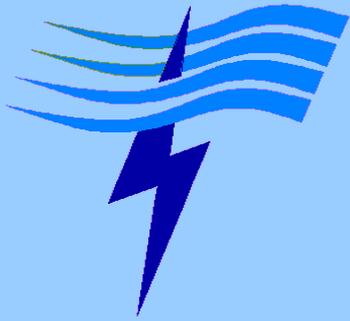
Geophysics

- Defining horizontal and vertical extents of geological structures
- Define dredge volumes
- Relatively fast and economical

Drilling + testing

- Focussed on geophysical structures defined geophysically
- Defining geotechnical parameters
- Expensive and time consuming





Site investigation sequence

- **Define extent of geological structures**
- **Select borehole locations based on geophysical information. Random boreholes are not effective.**
- **Combining geophysical and borehole results in a robust ground truthed 4D model**
- **This 4D model is the base information for:**
 - design**
 - selection of dredging equipment**
 - environmental control**
 - cost estimates**

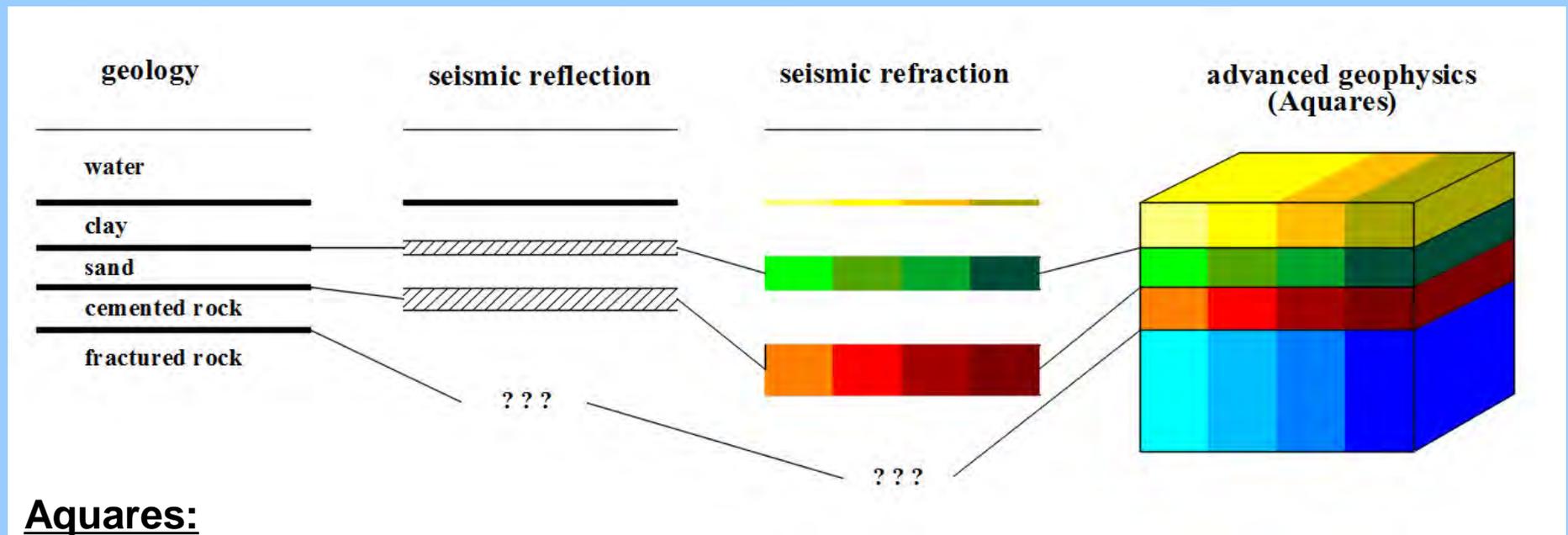




Enhanced (advanced) geophysics



High quality geophysical methods generating **accurate quantitative** as well as **qualitative** information in a **georeferenced 4D model**



Aquares:

Seabed towed cables -> high quality

Accuracy: no acoustic velocity information required

Quantitative: depths and thicknesses

Qualitative: resistivity value distinguishes between different rock and sediment qualities

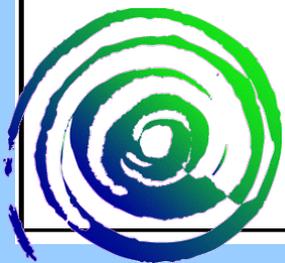
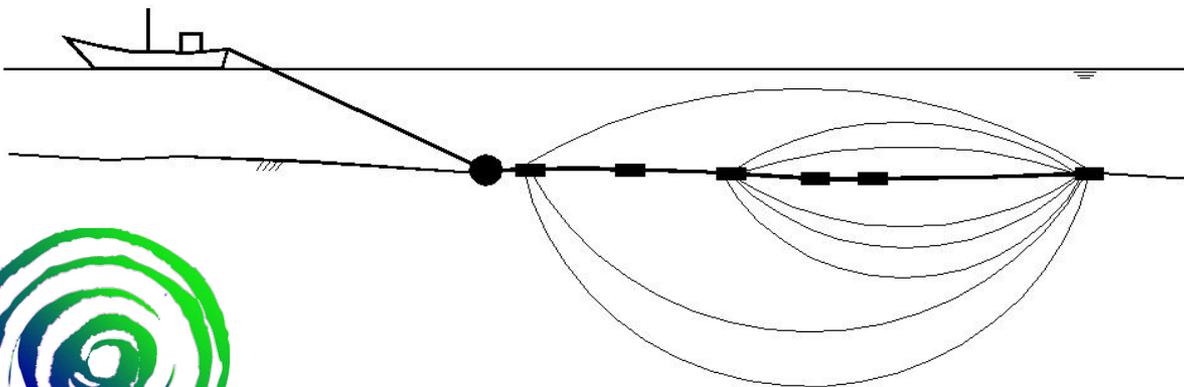
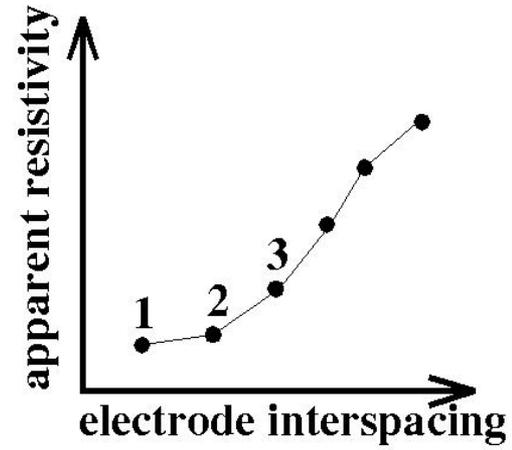
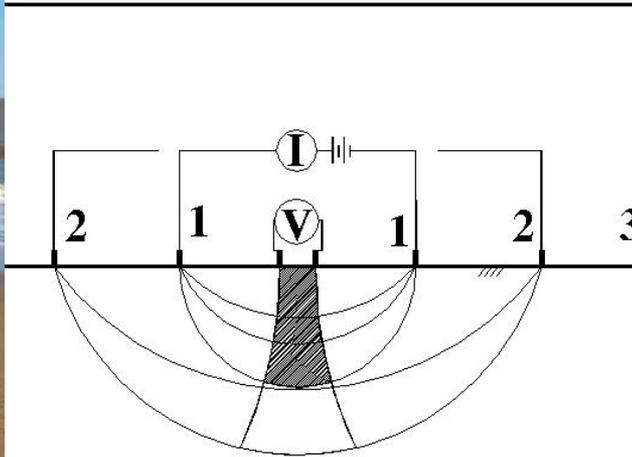
4D model: every point in space has a resistivity value attached to it





Aquares

Principles of electrical sounding

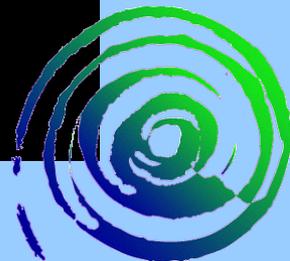
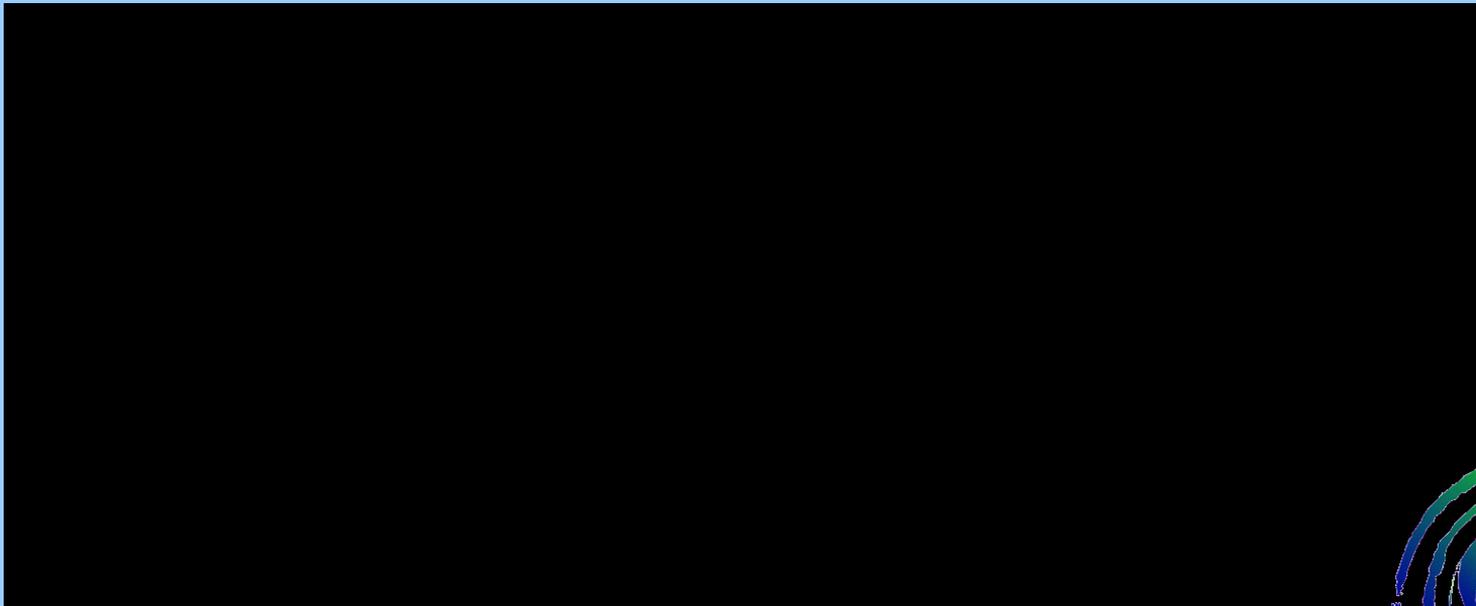




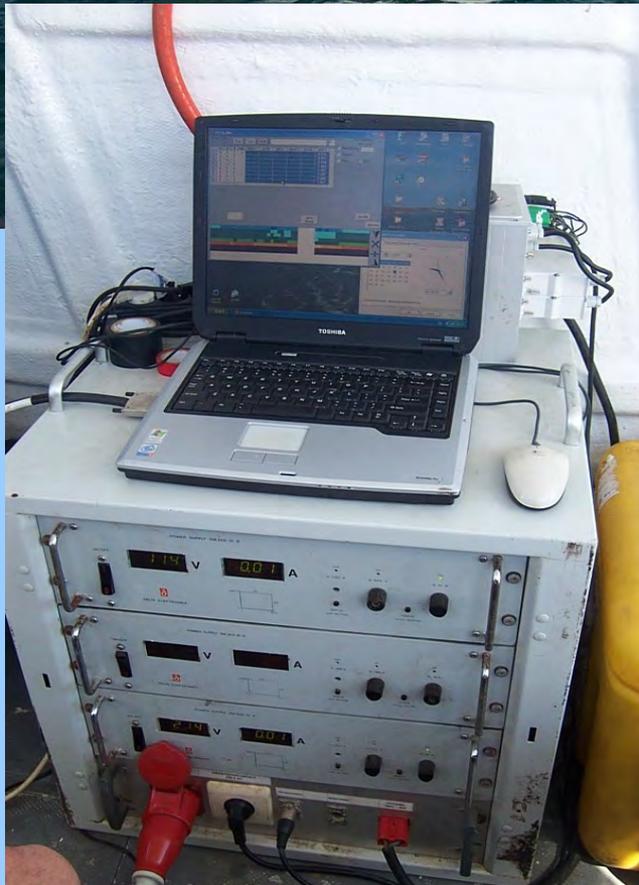
Applications



- Dredging projects
- Port design
- Alluvial mining exploration (gravel / sand / gold / diamonds)
- Pipe / cable route surveys



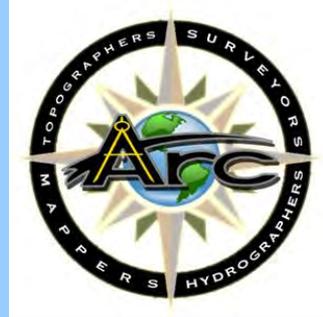
Geophysical Equipment



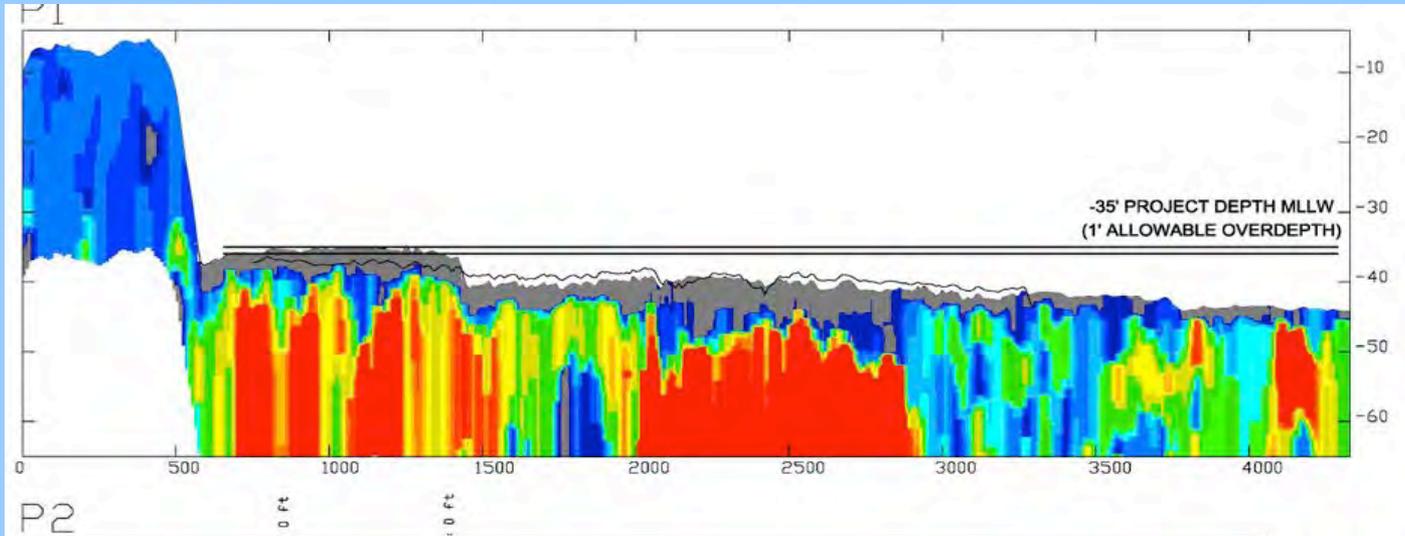
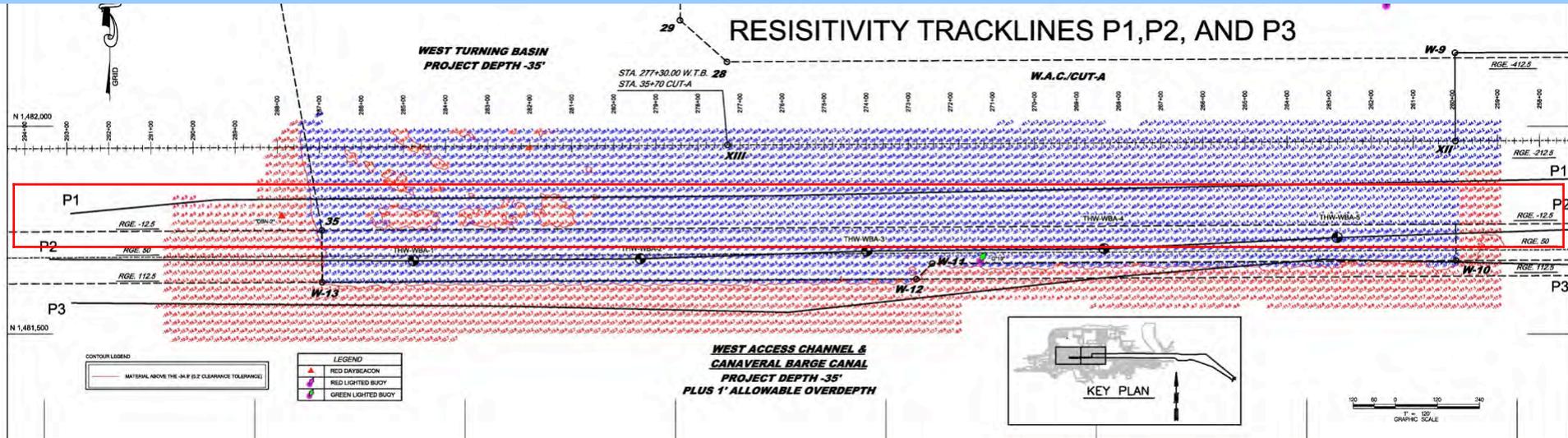
DREDGING SUMMIT & EXPO '17



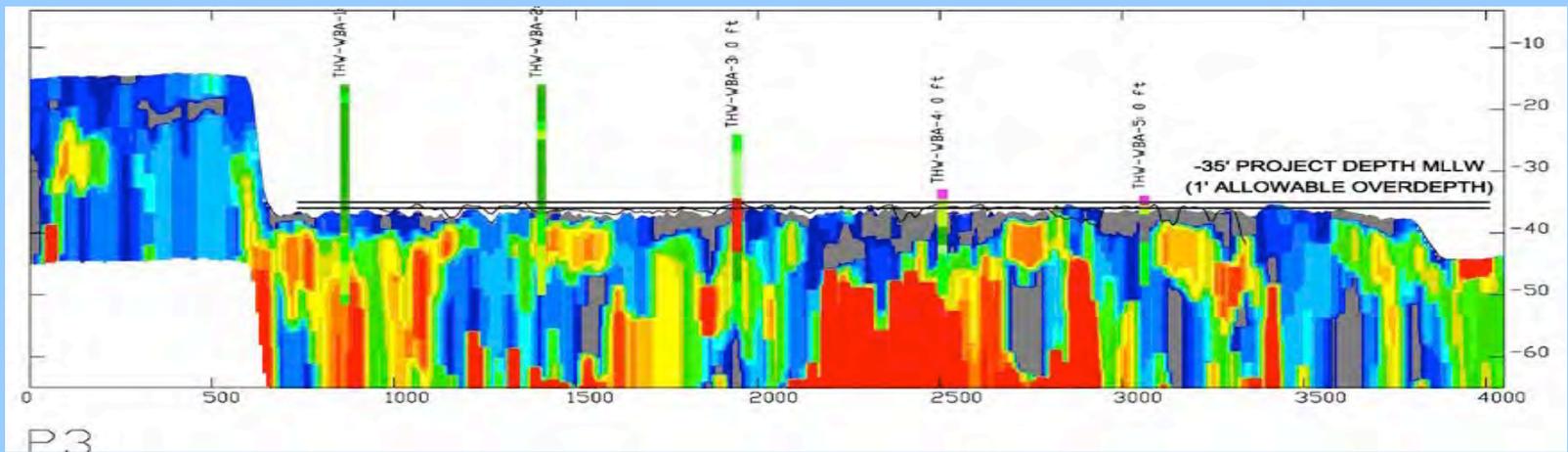
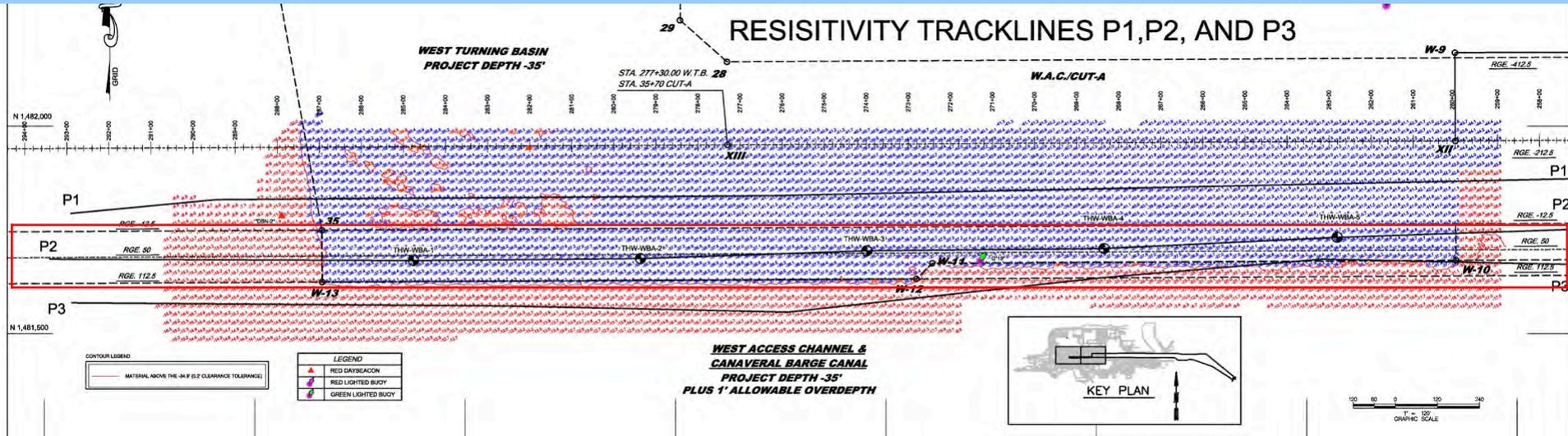
Port Canaveral



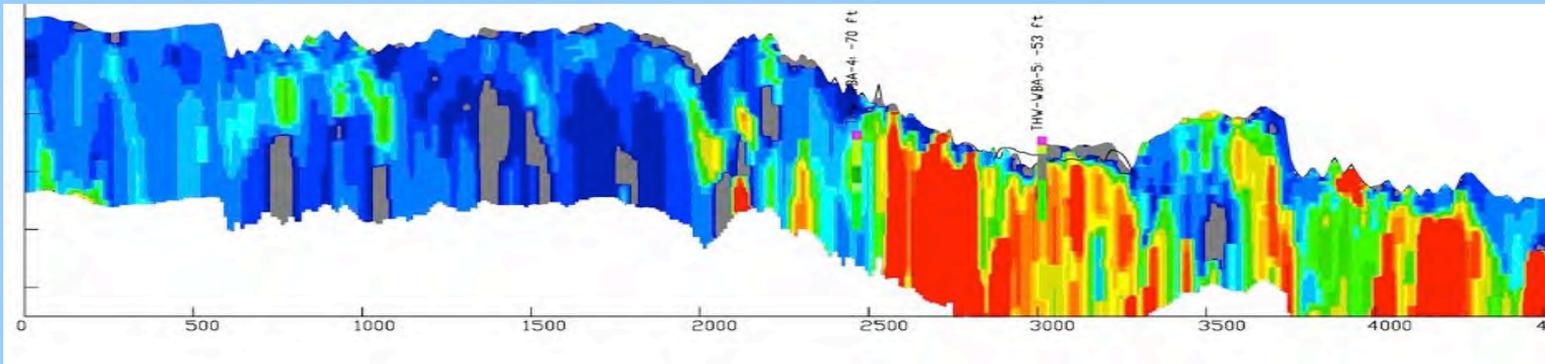
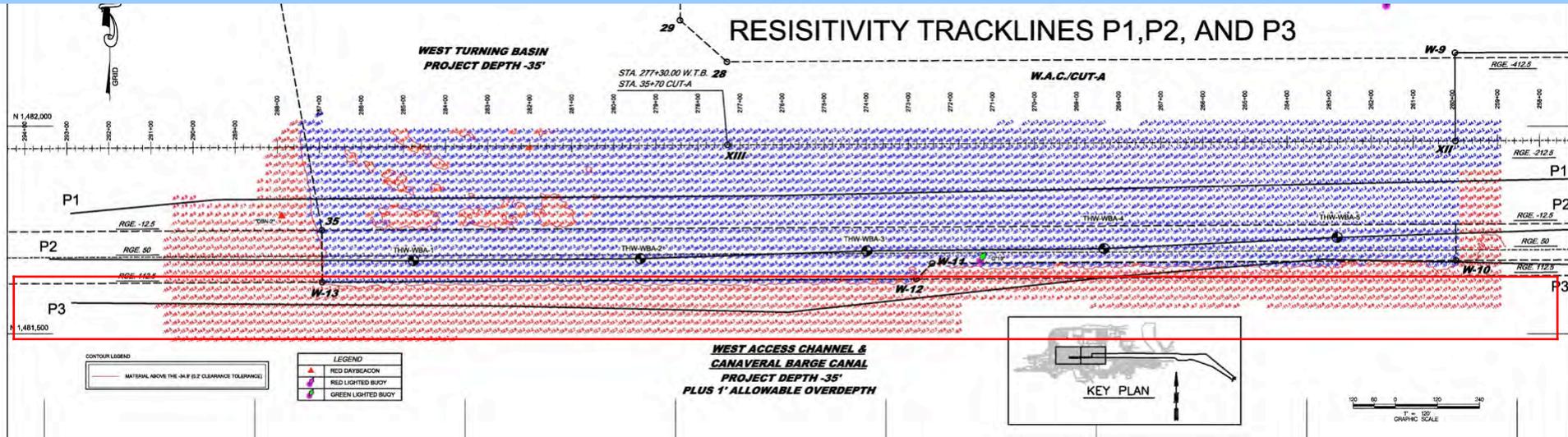
Resistivity Profile line 1.

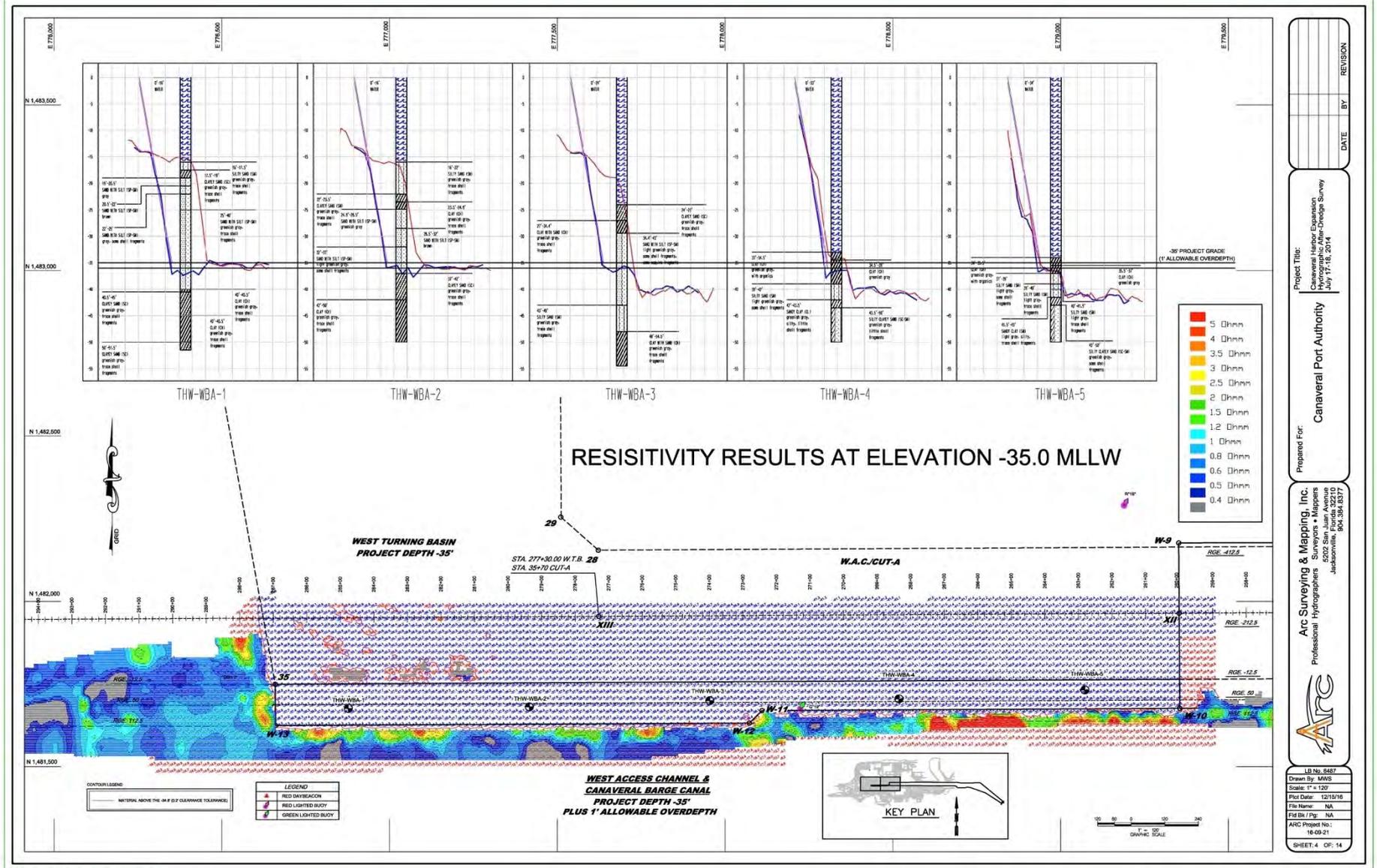


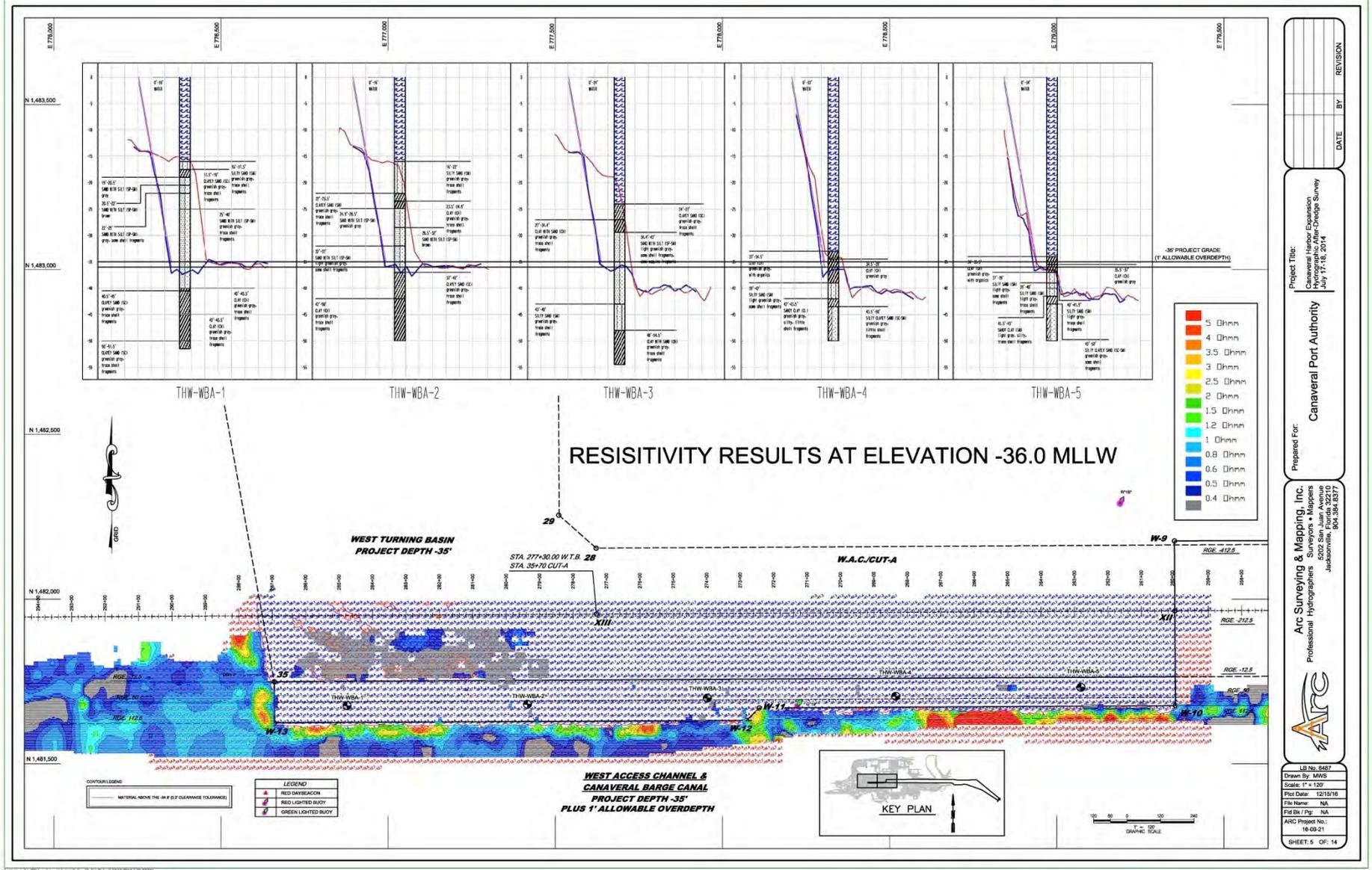
Resistivity Profile line 2.



Resistivity Profile line 3.







DATE	BY	REVISION

Project Title:
Canaveral Harbor Expansion
Hydrographic After-Change Survey
July 17/18, 2014

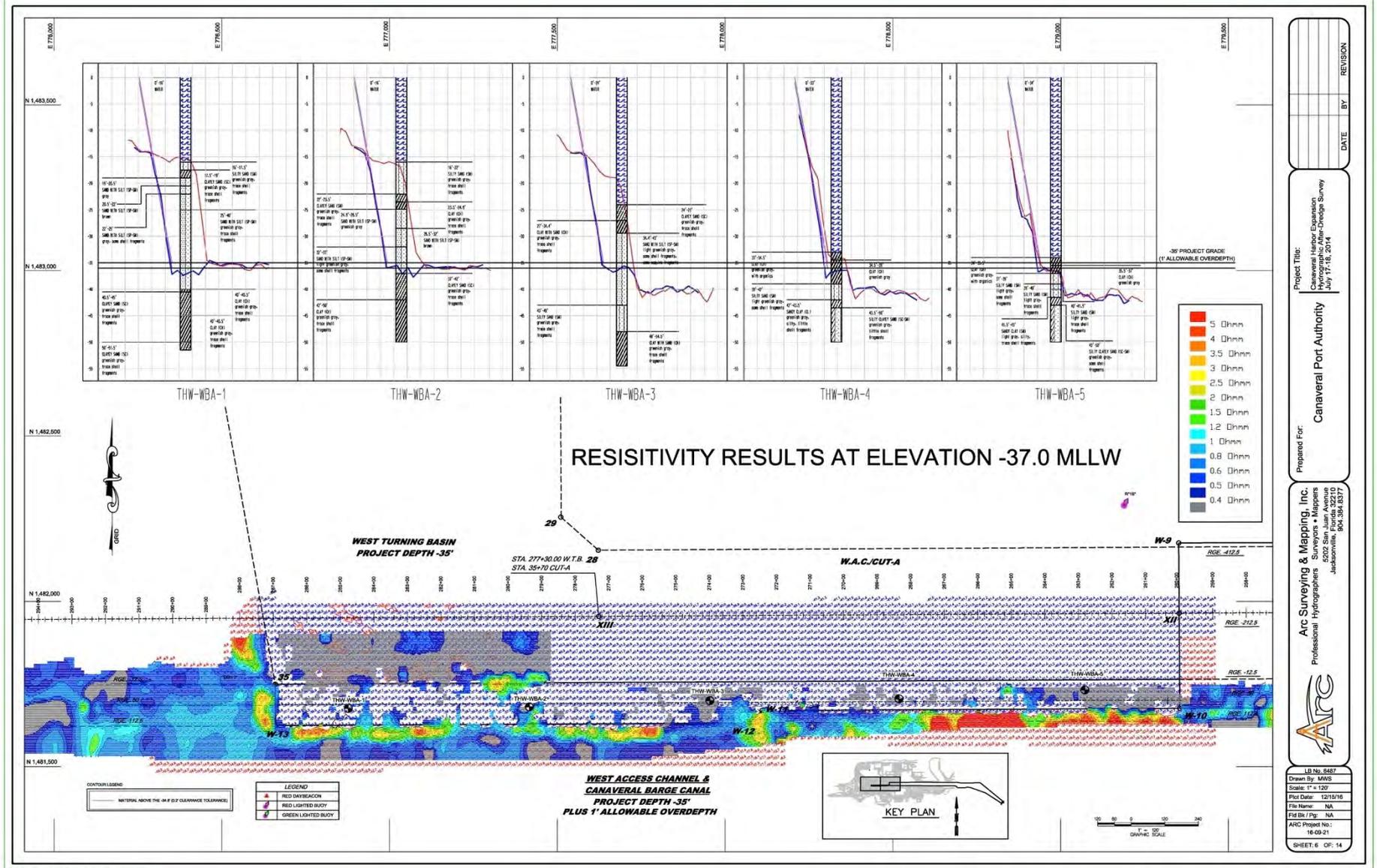
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Canaveral Port Authority

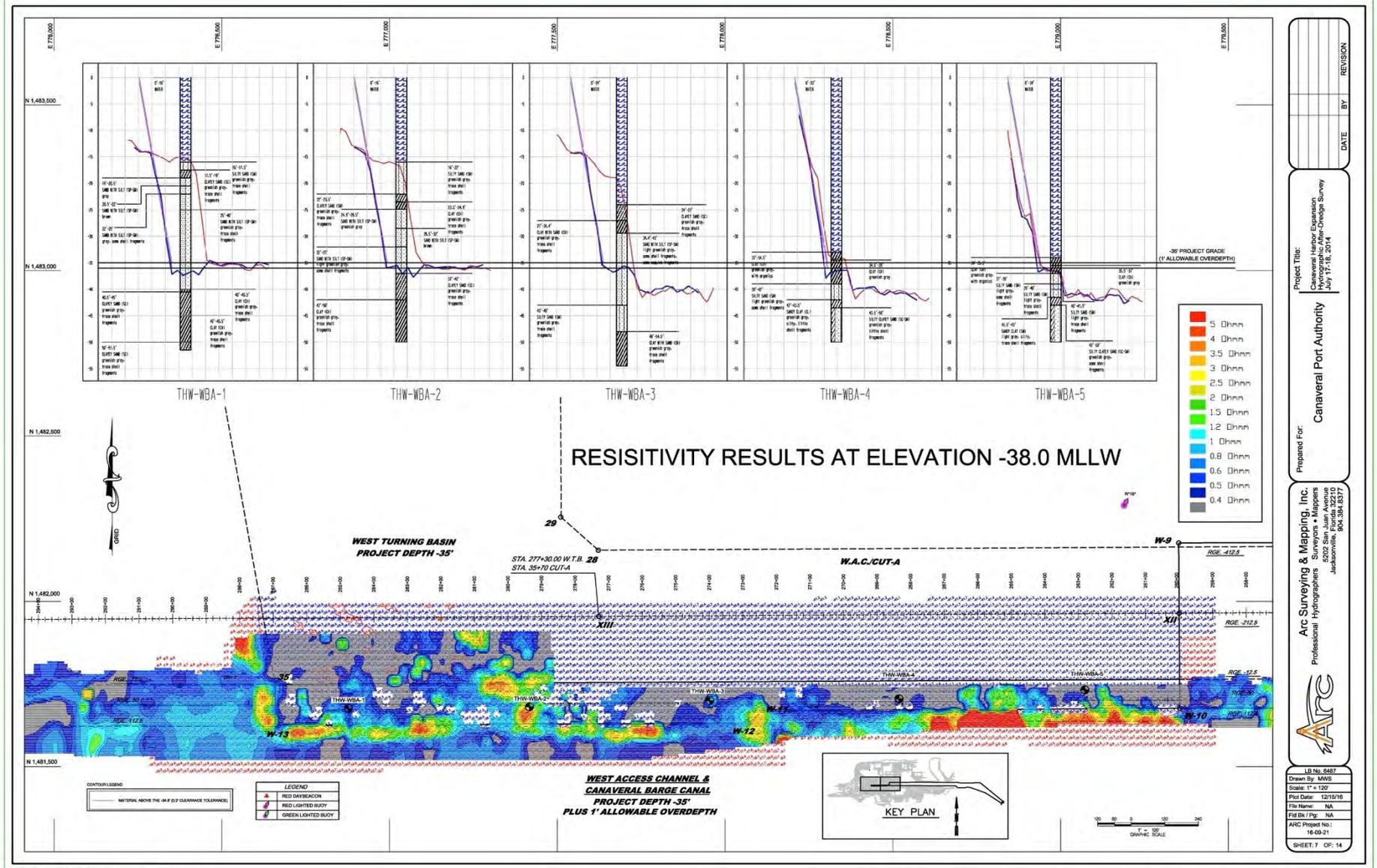
Prepared For:
Arc Surveying & Mapping, Inc.
Professional Hydrographers
Surveyors • Mapmakers
5202 San Juan Avenue
Florida 32910
888-354-8317
Jacksonville, FL

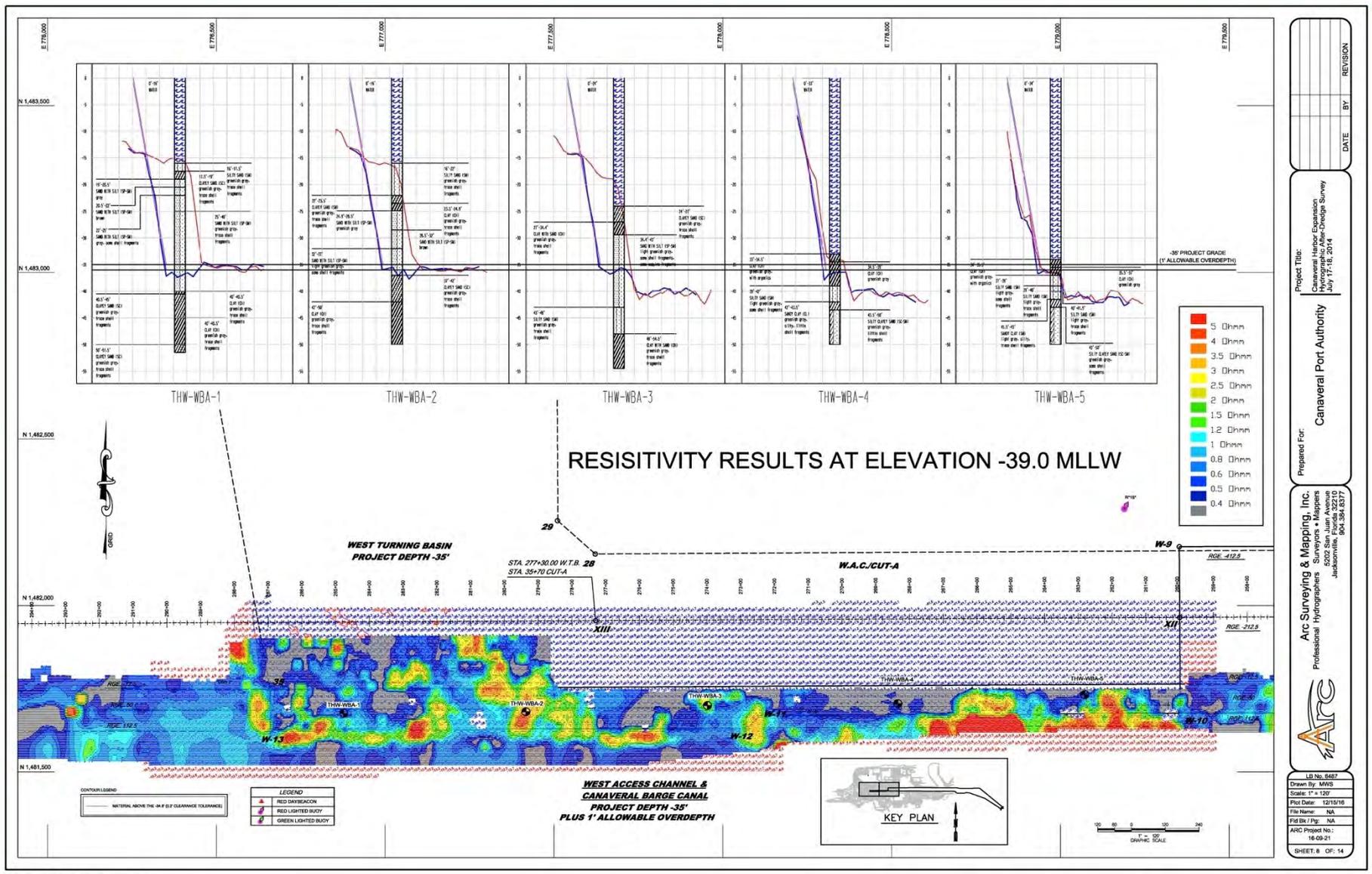
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Scale: 1" = 120'
Plot Date: 12/15/16
File Name: NA
Folio: 17g - NA
ARC Project No.: 18-09-21



SHEET: 5 OF: 14







DATE	BY	REVISION

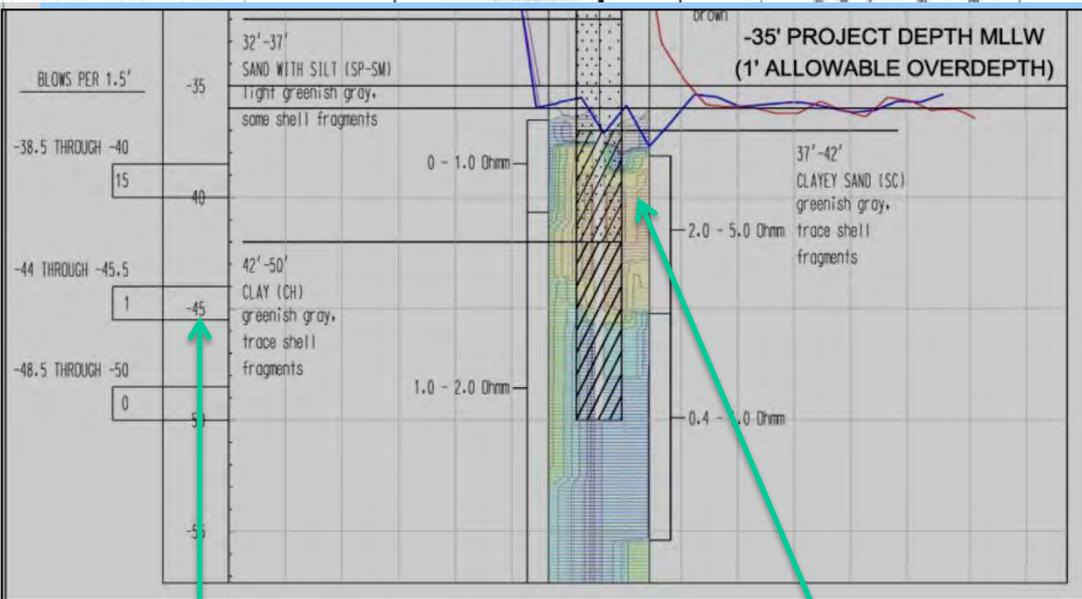
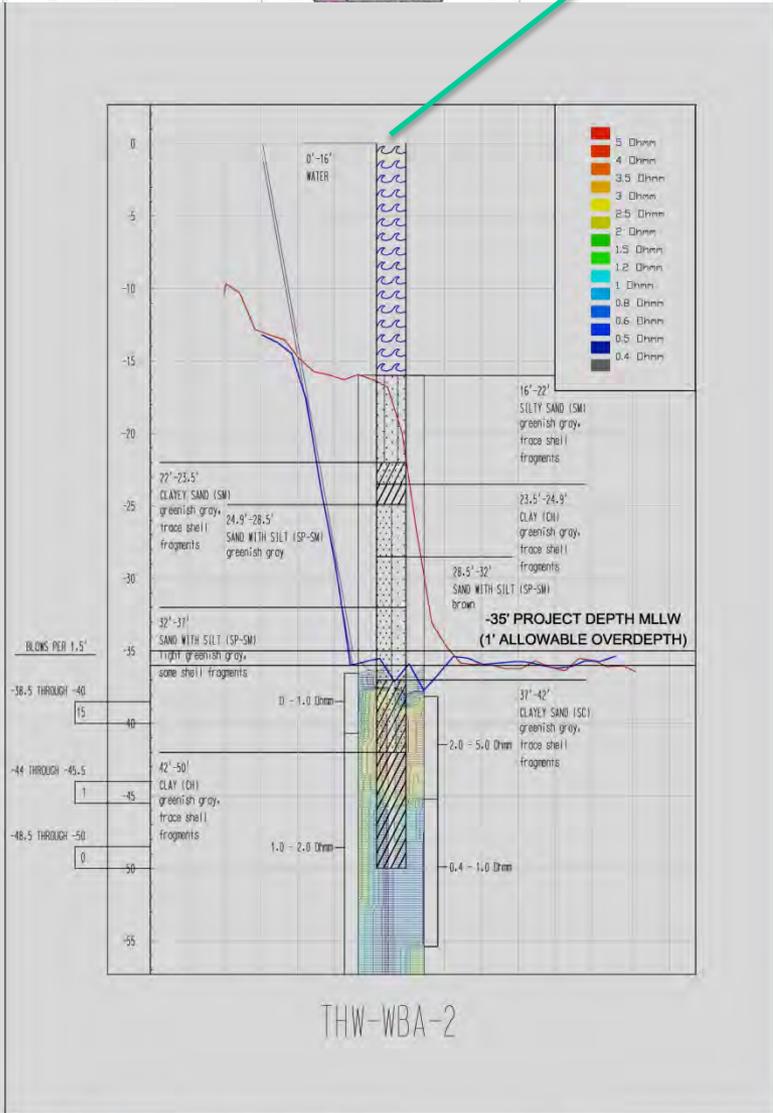
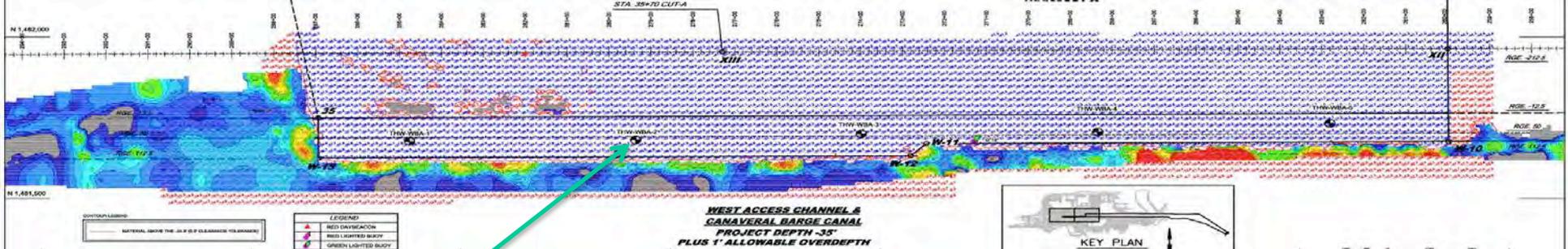
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Prepared For:
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Prepared For:
 Arc Surveying & Mapping, Inc.
 Professional Hydrographers, Surveyors & Mappers
 Florida 32210
 Jacksonville, FL 32204 (904) 254-5317



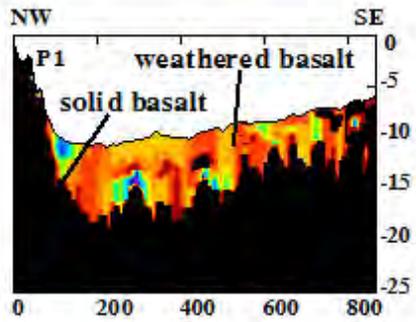
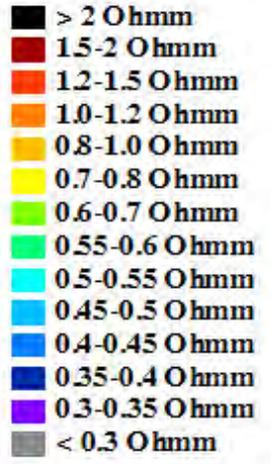
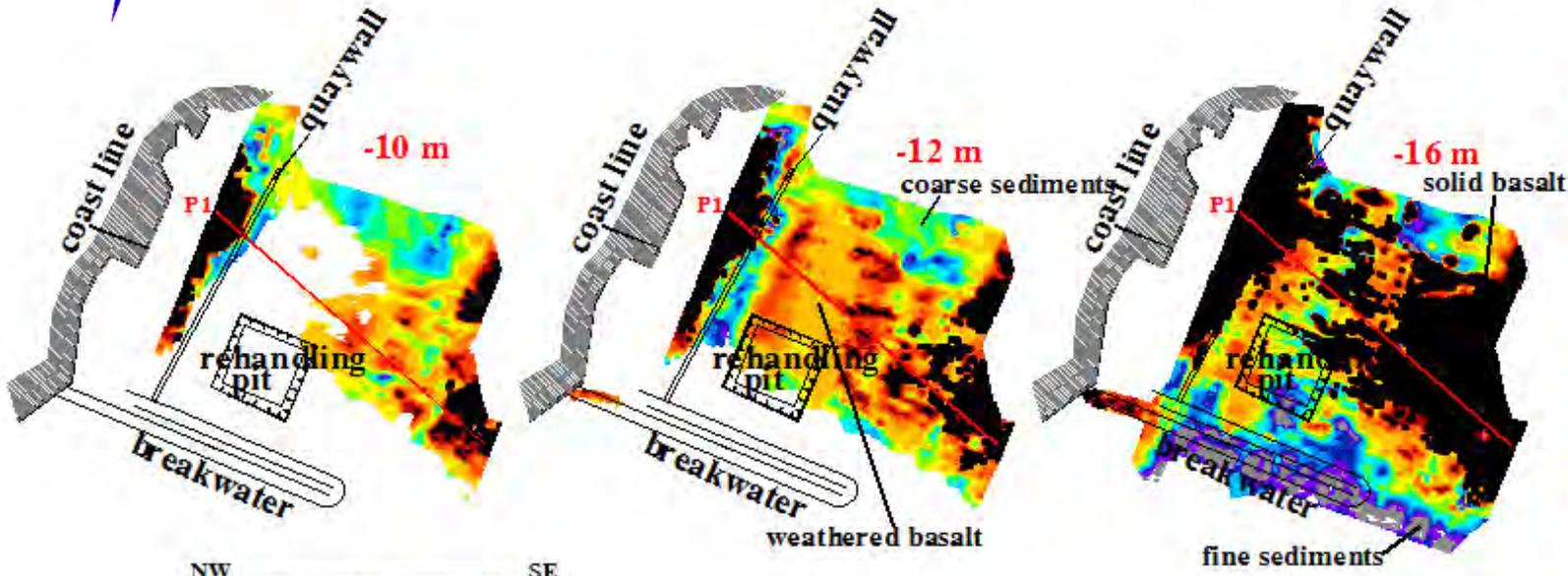
Job No. 8487
 Drawn By: MMS
 Scale: 1" = 120'
 Plot Date: 12/15/16
 File Name: NA
 Project: NA
 ARC Project No.: 16-09-21
 SHEET: 8 OF 14



Boring # 2

**Note: Blow Counts = 15 Blows Per Ft.
Resistivity Measures 4.0 to 5.0 Ohmm
Both indicating the presence of firm materials**

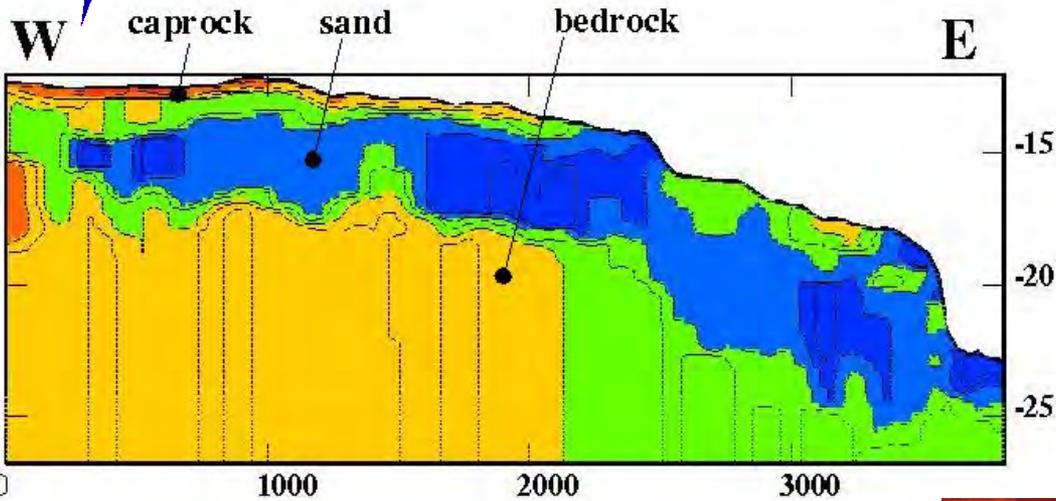
Port of Limbe, Cameroon





Sand exploration in the Persian Gulf

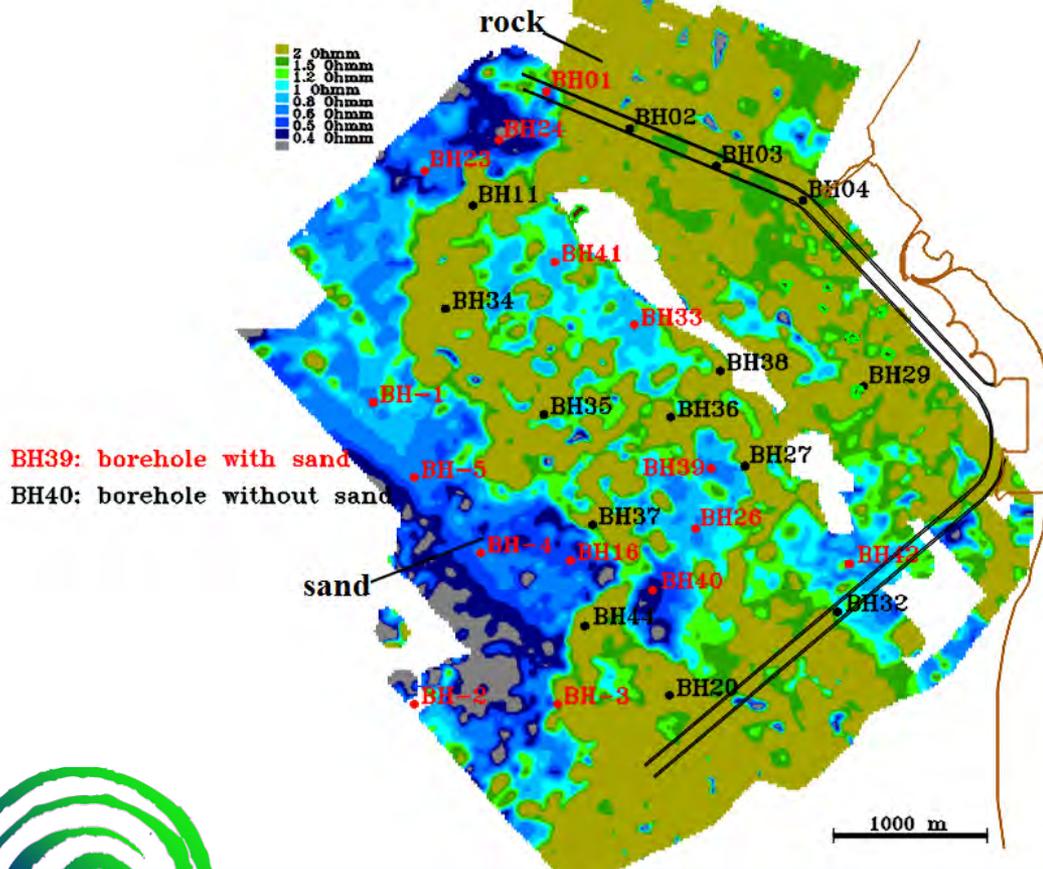
Caprock



Hawar Sand search



horizontal resistivity section
1 m below seabed level





Panama Canal Resistivity Survey

Vertical and horizontal resistivity sections

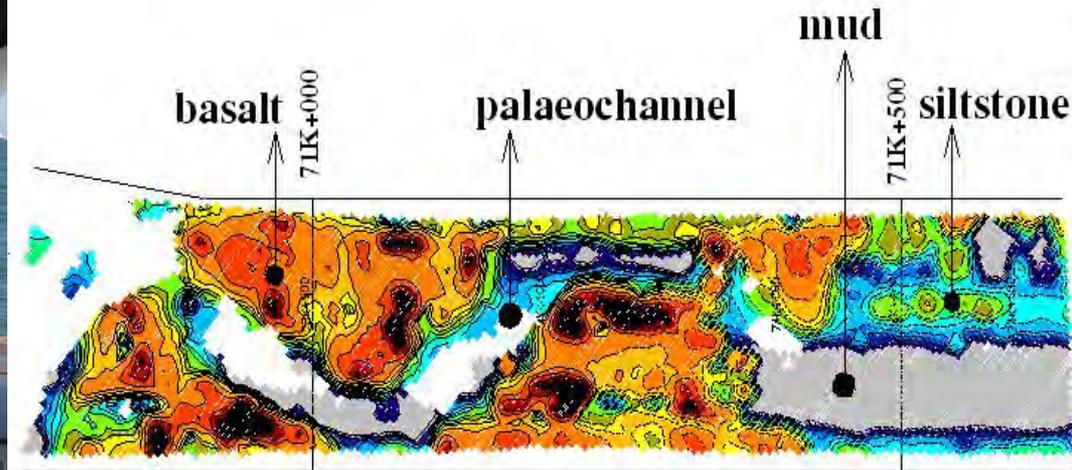
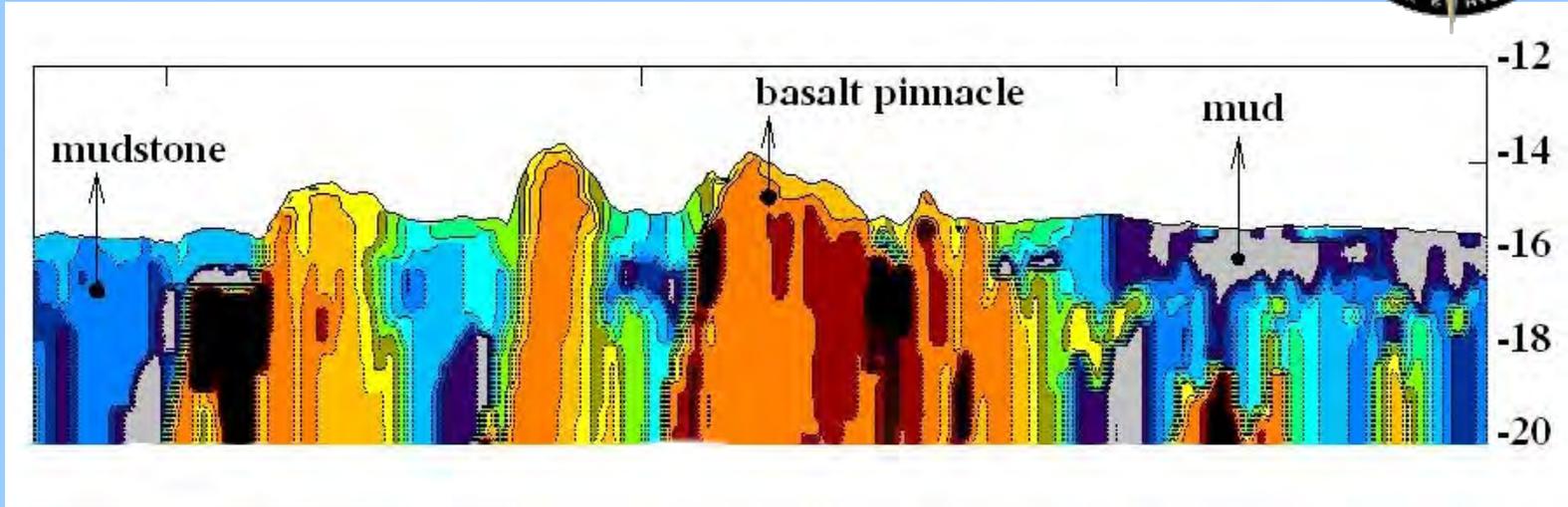
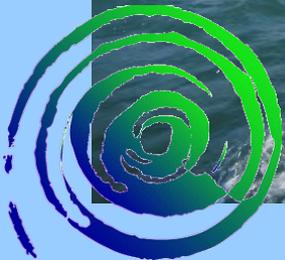
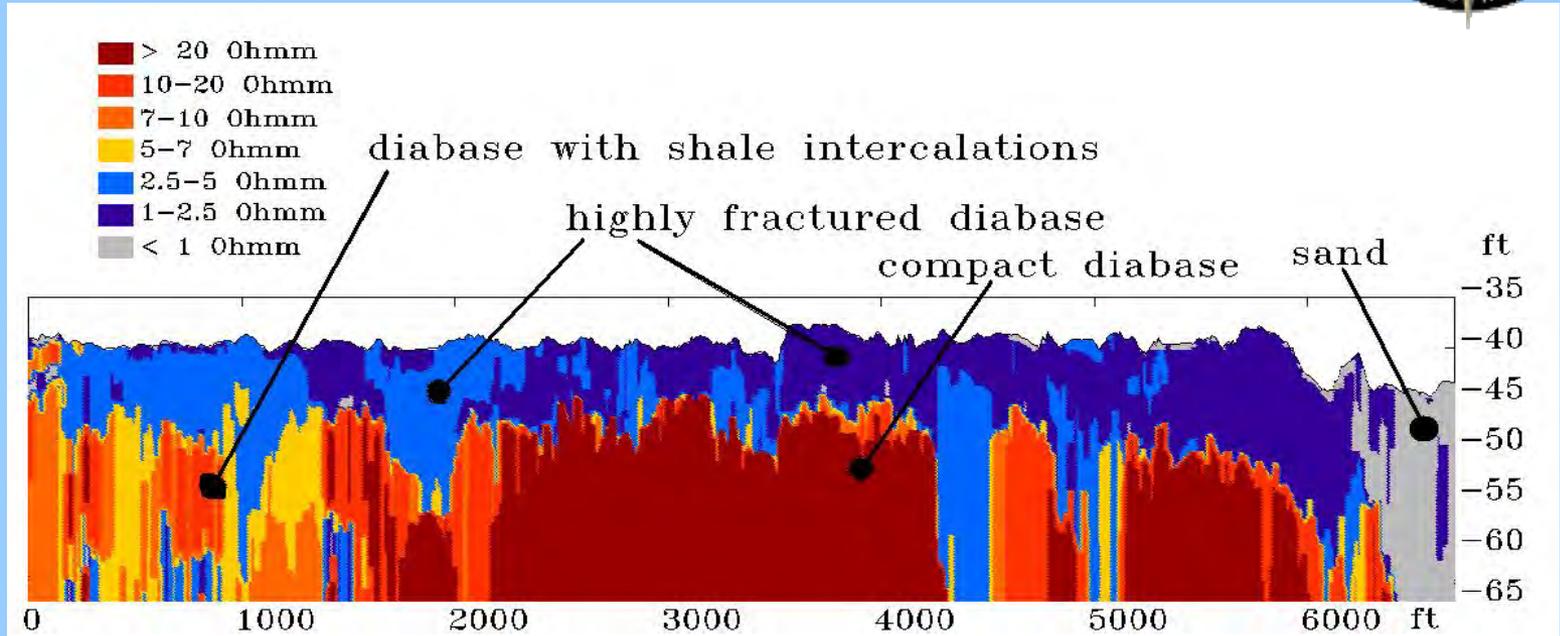


Chart Datum -14.8 m

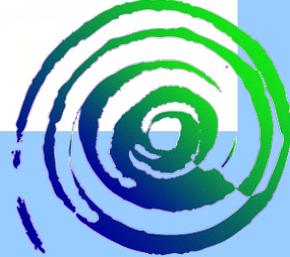
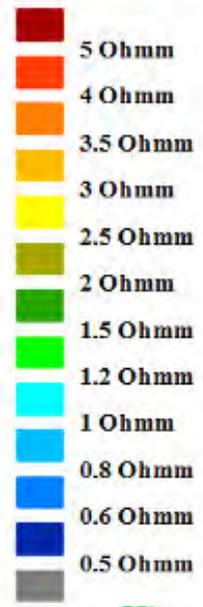
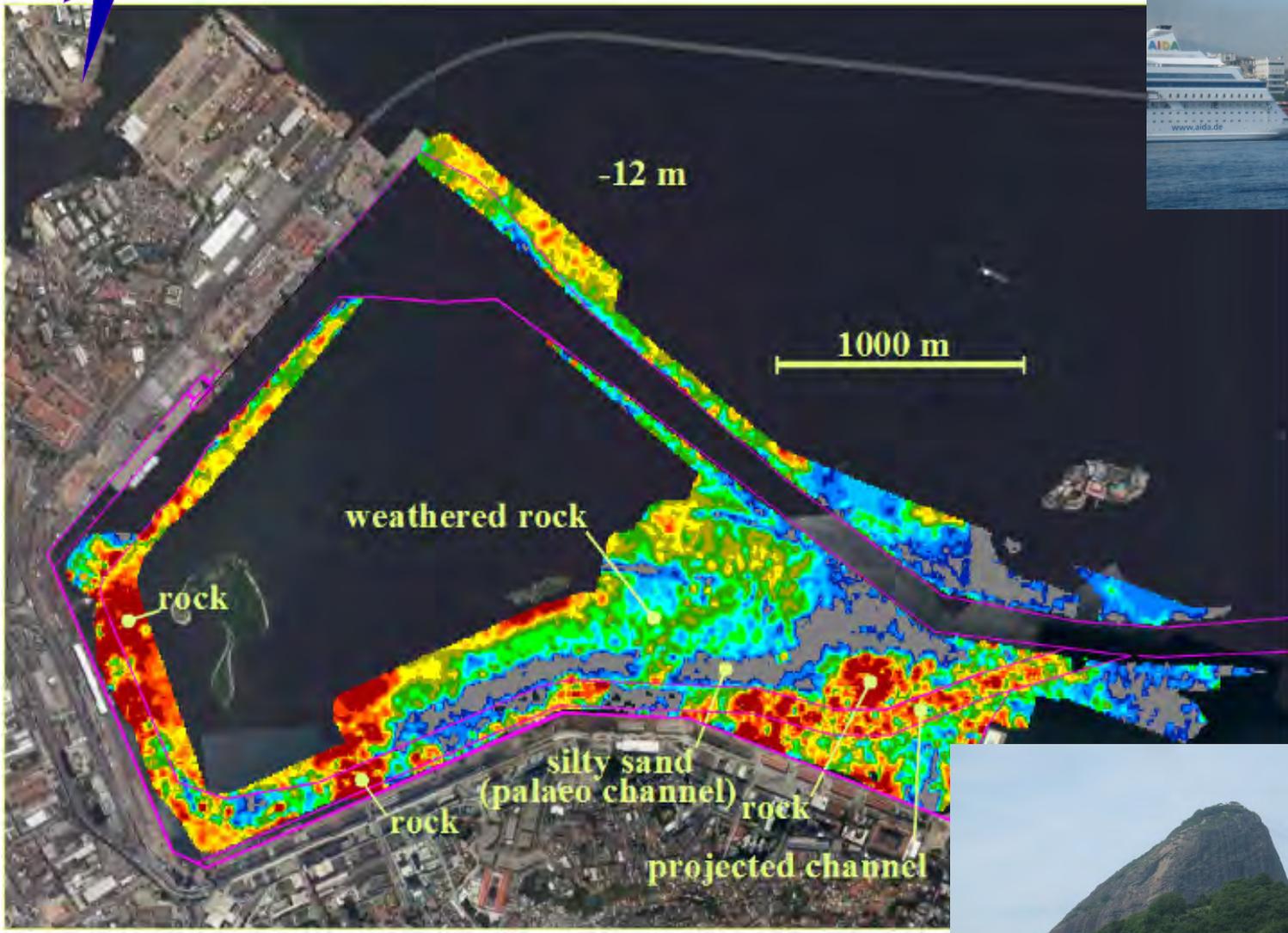




Rock dredging – Kill van Kull, New York



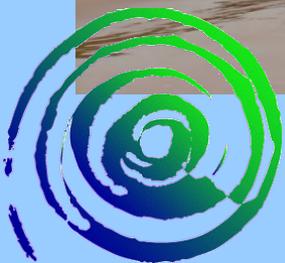
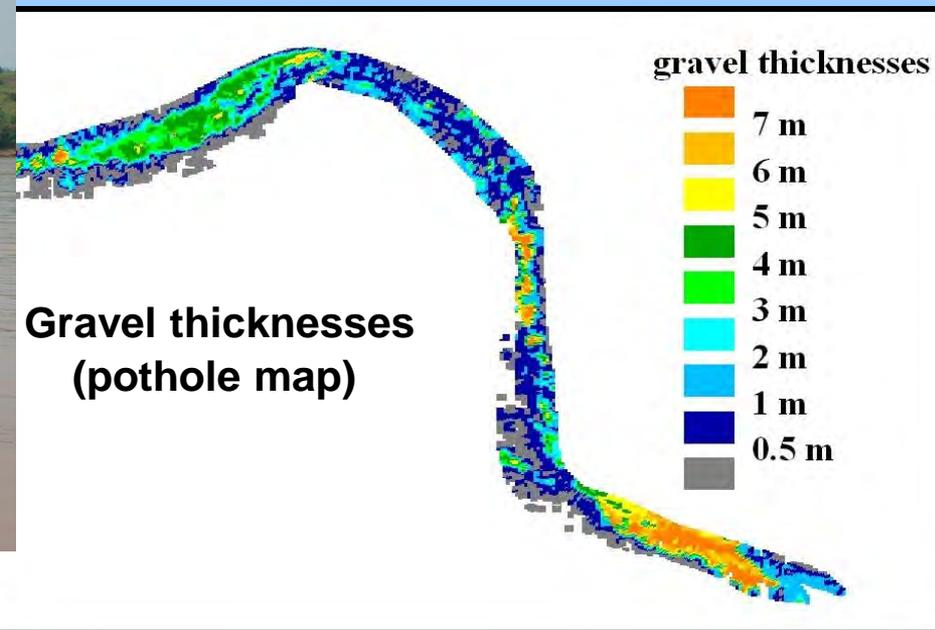
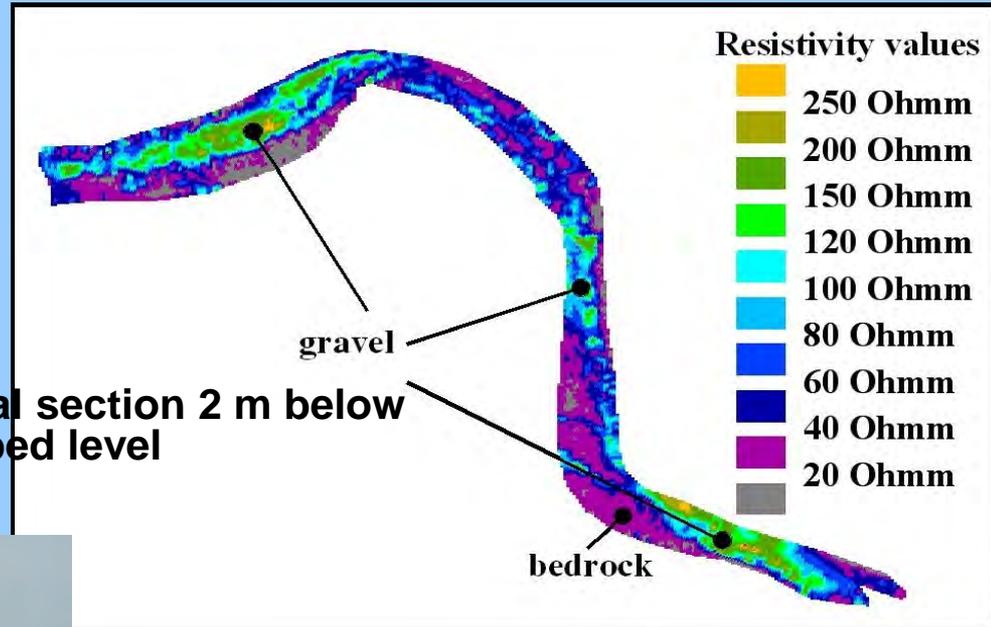
Rio de Janeiro Terminal de Pasajeros





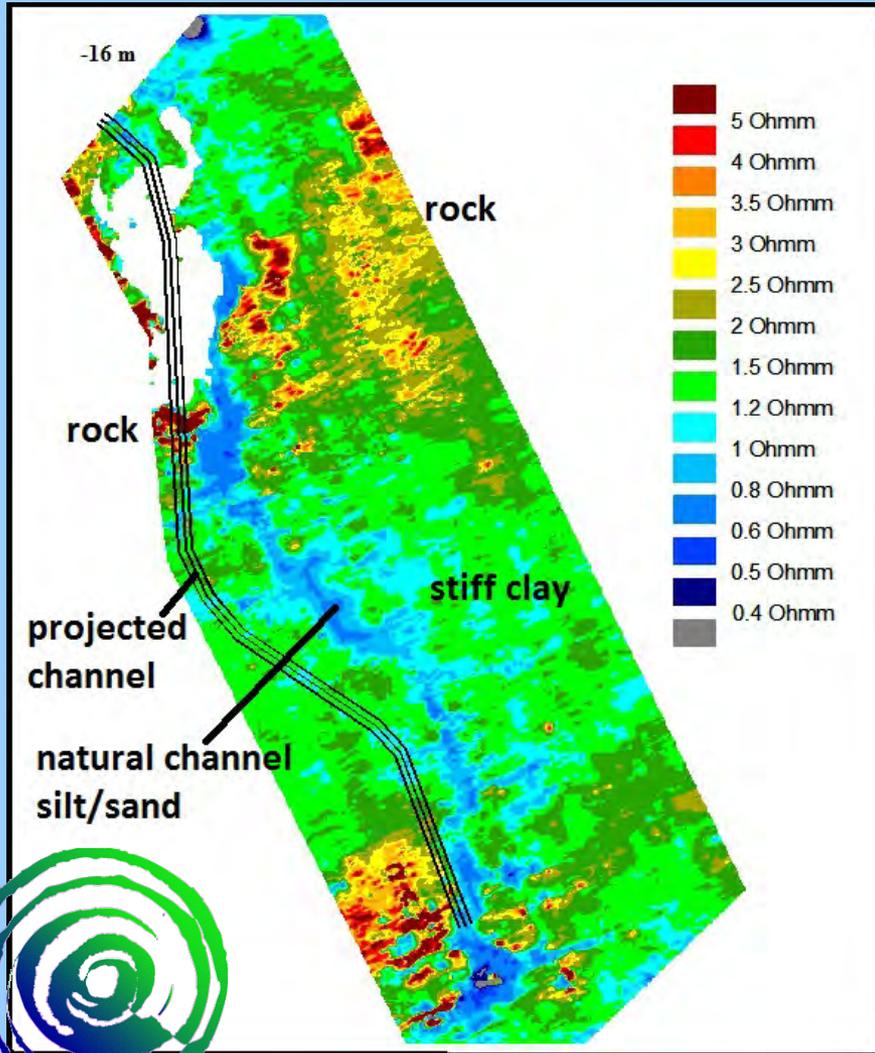
Diamond exploration on the Sankuru river

Horizontal section 2 m below river bed level





Papua New Guinea Port Darú



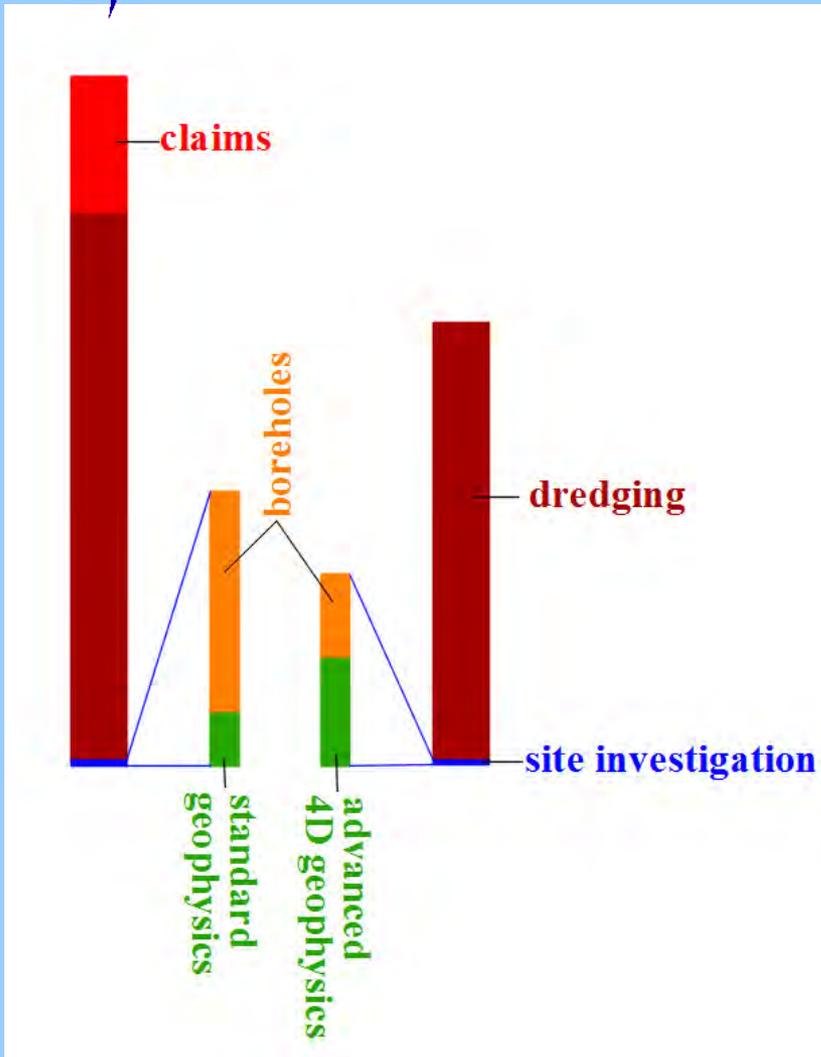
Previous investigations:

- seismic reflection
- 77 vibrocores and 116 random boreholes
- 12 milliones de dollar exploration costs
- no sand
- undefined dredging risks
- uncertainty regarding project viability





Economics of enhanced geophysics on dredging contracts



Higher geophysical costs

Lower drilling costs

- significant reduction of boreholes
- boreholes only for sampling known geophysical structures
- no requirement for boreholes to locate geological structures

Lower dredging costs

- more economical design
- lower geological risks

Avoiding claims

- linked to geological uncertainties





Why is enhanced geophysics not systematically being used everywhere?



Economical interests >< high quality geophysics

- Diminished income from lucrative claims linked to poor geological information
- Diminished income from lucrative geotechnical / drilling contract

Client should control the site investigation!

Poorly defined tender specifications

- Imposing irrelevant geophysical methods instead of specifying desired results
- Price motivation rather than quality motivation

Specify aims rather than methods!

Selection criteria based on price rather than technical aspects

- The cheapest is not the best: ref. Lake Gatun case
- Survey cost included in consultancy fee -> Price motivated selection

Selection based on technical criteria!

Separate geophysical budget from consultancy budget and from geotechnical (drilling) budget!



Questions?

Arc Surveyors & Mapping – booth 37

