Stratigraphy and Structure of a Georgia Barrier Island:
Hydrologic Impacts and Implications

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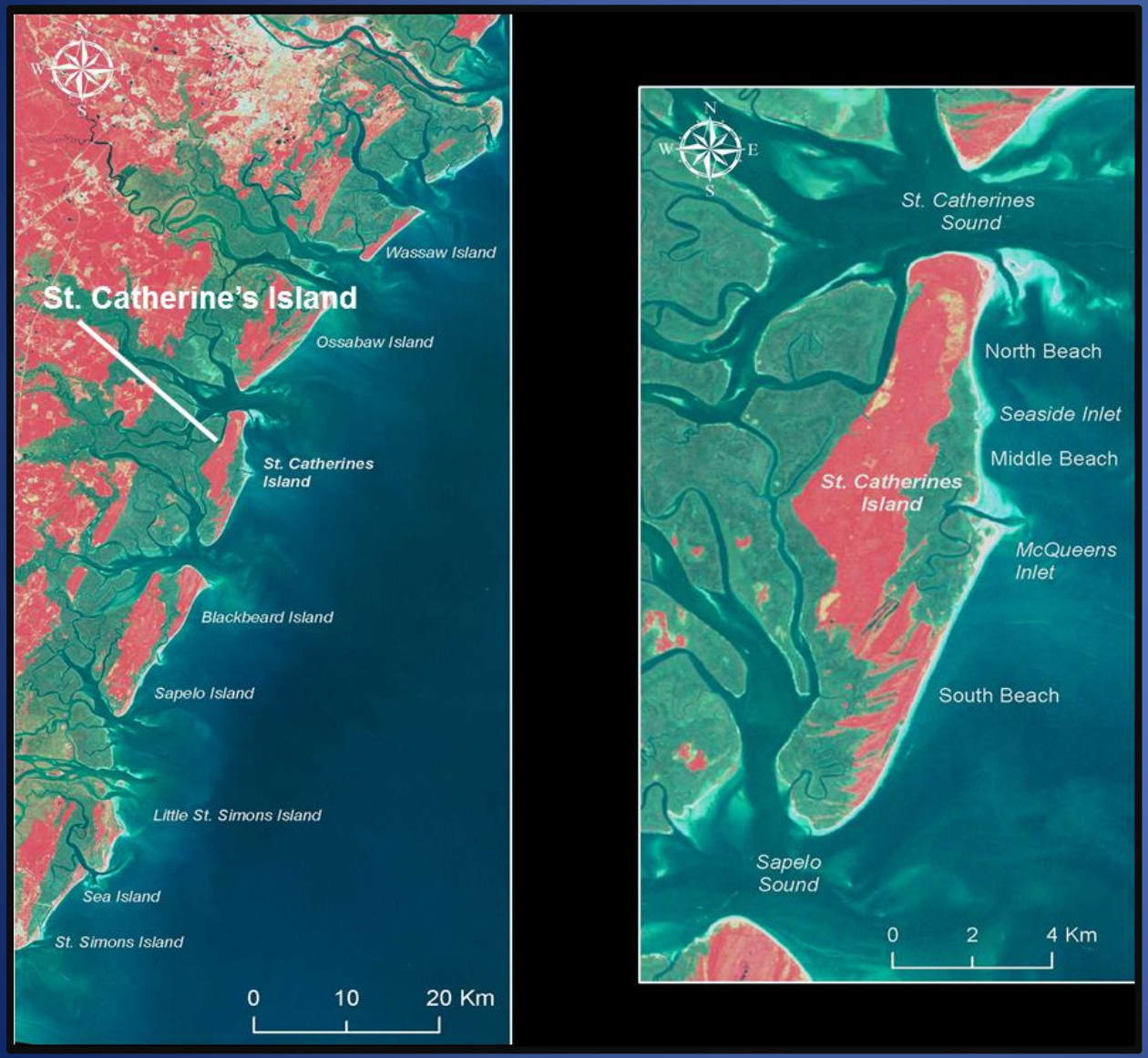
St. Catherines Island, Georgia



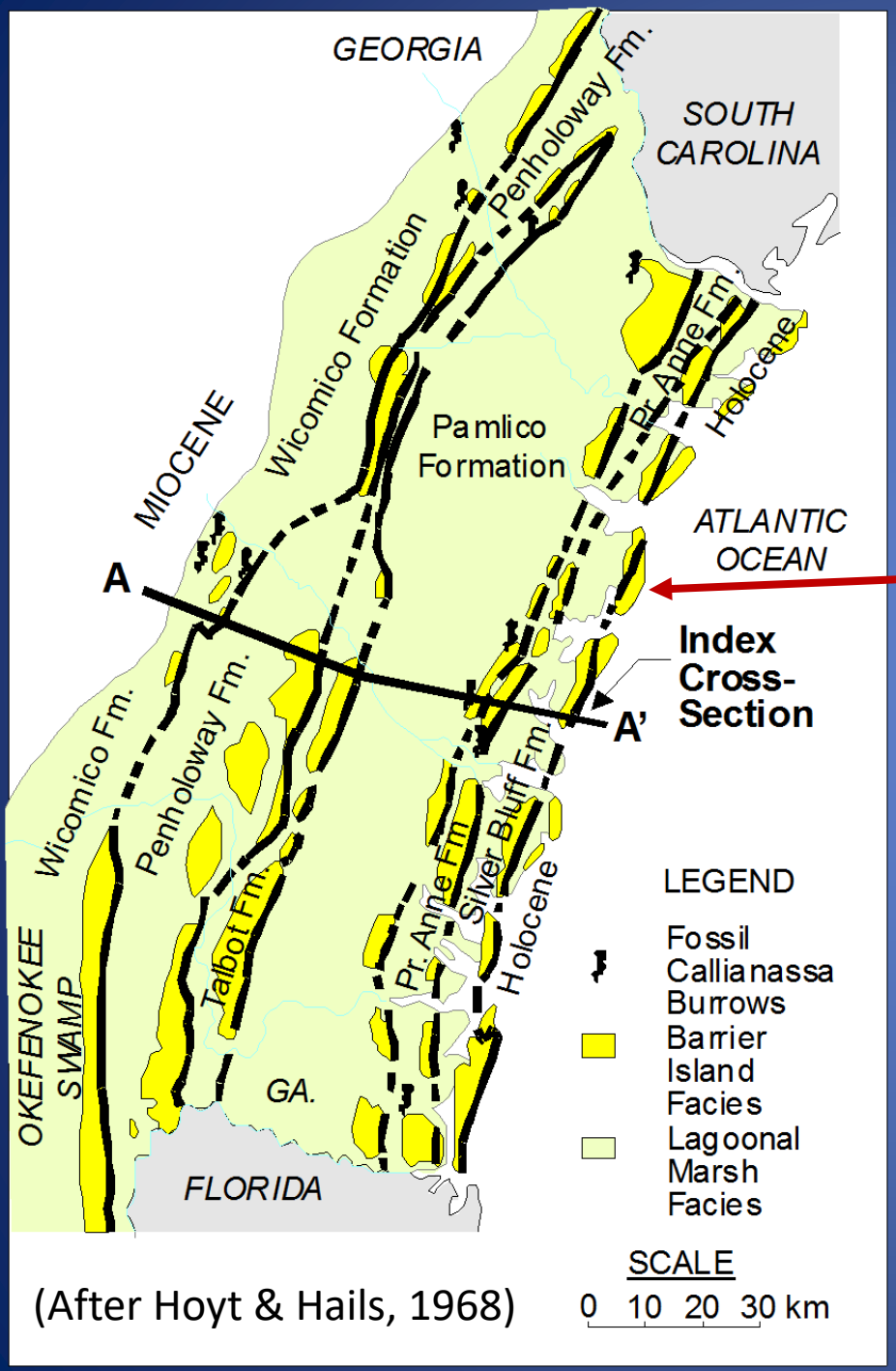
20 km long,
2 to 5 km wide

Pleistocene core with some Holocene cover and flanking Holocene ridge and swale terrain

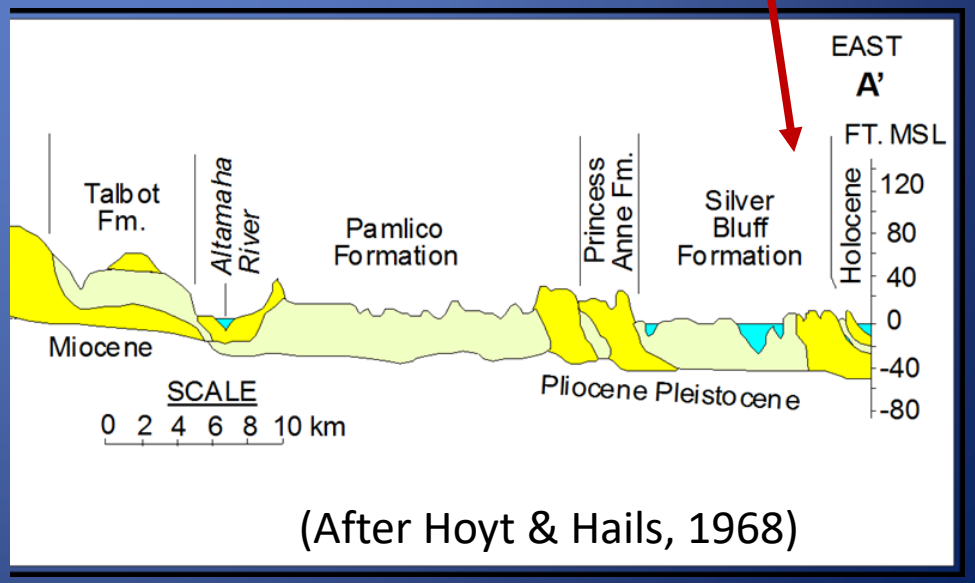
5,000 years of resource exploitation by humans !

Geological Setting

St. Catherines Island



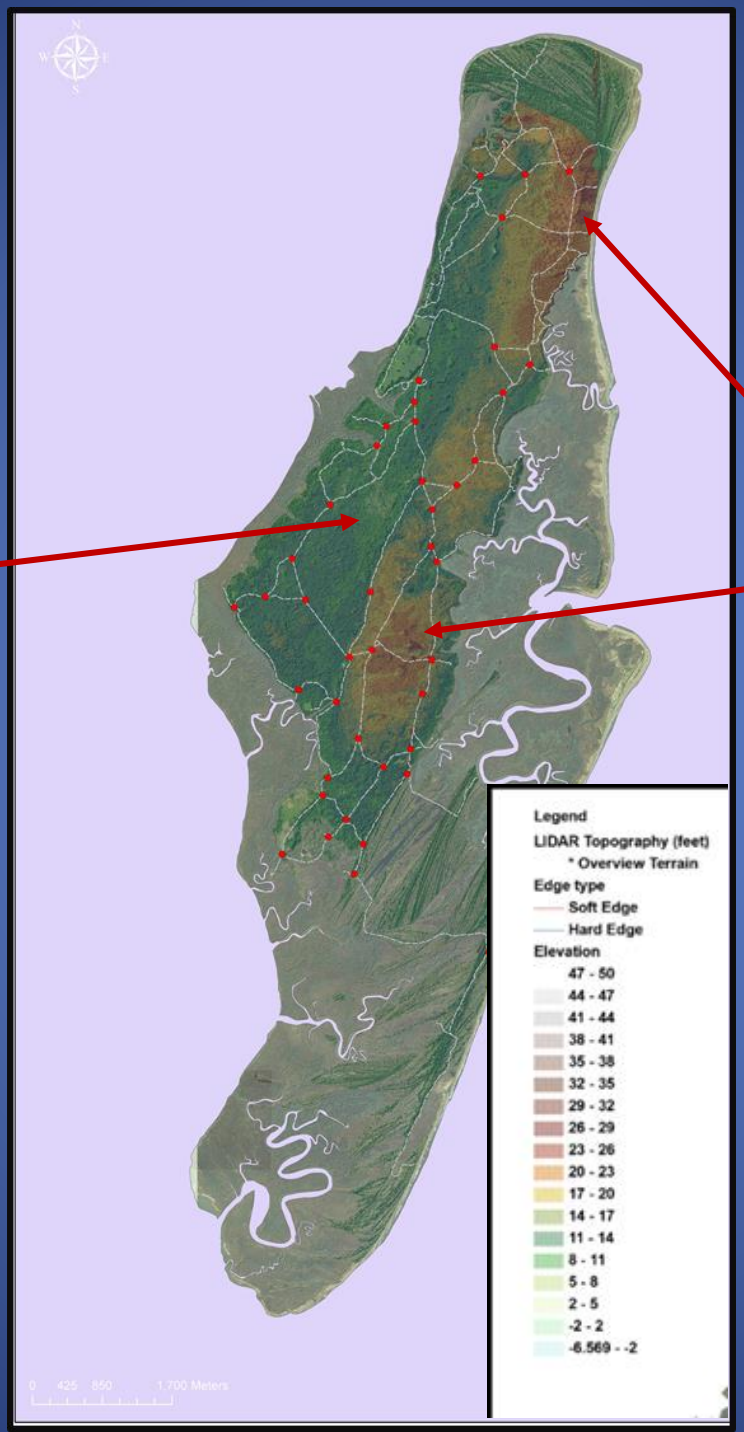
(After Hoyt & Hails, 1968)



(After Hoyt & Hails, 1968)

SCI Core Topography

Western core lowlands and axial depression elevation: 2.5 to 5 m



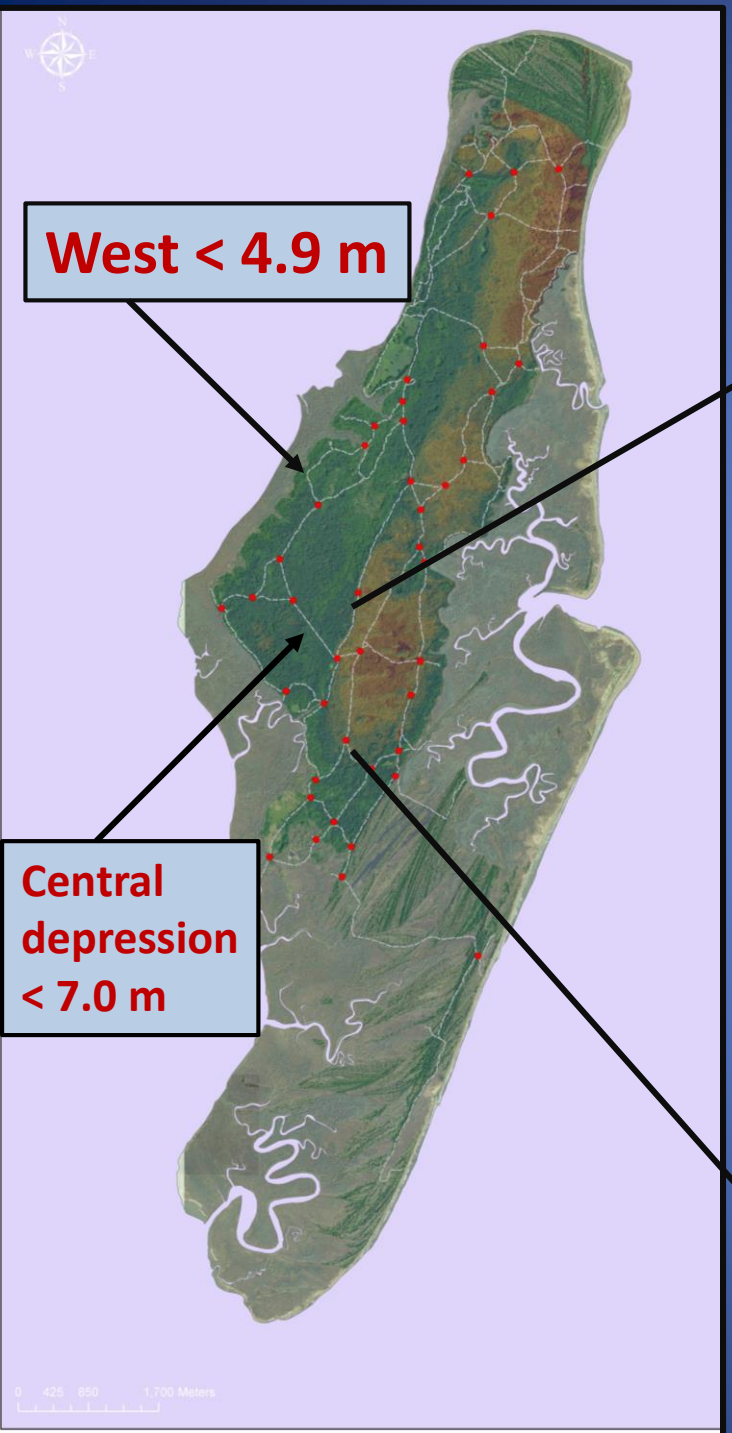
Eastern core elevation: 4.3 to 7.9 m

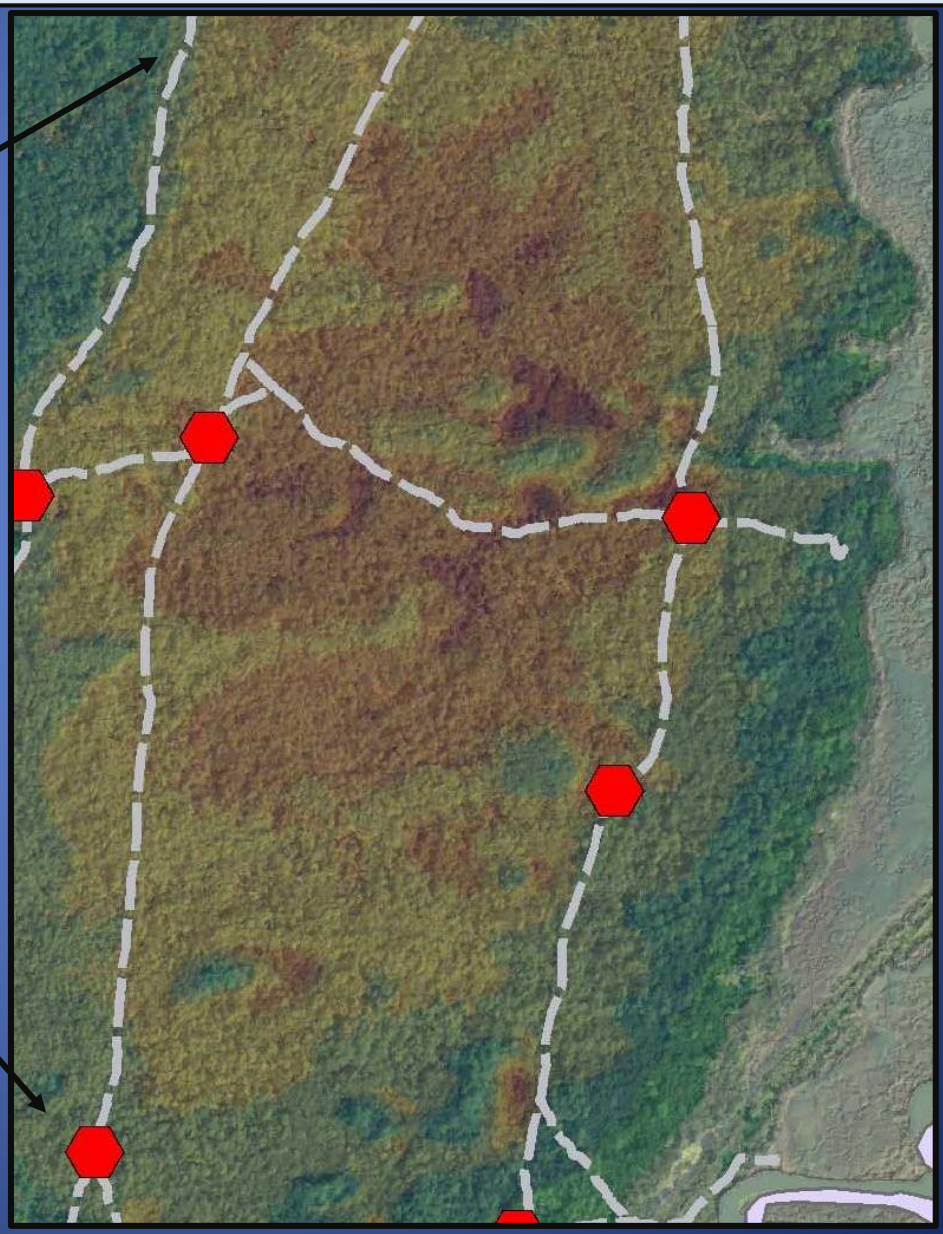
LiDAR images from Brian Meyer

Core data - surficial sand thickness: East > 10.7 m

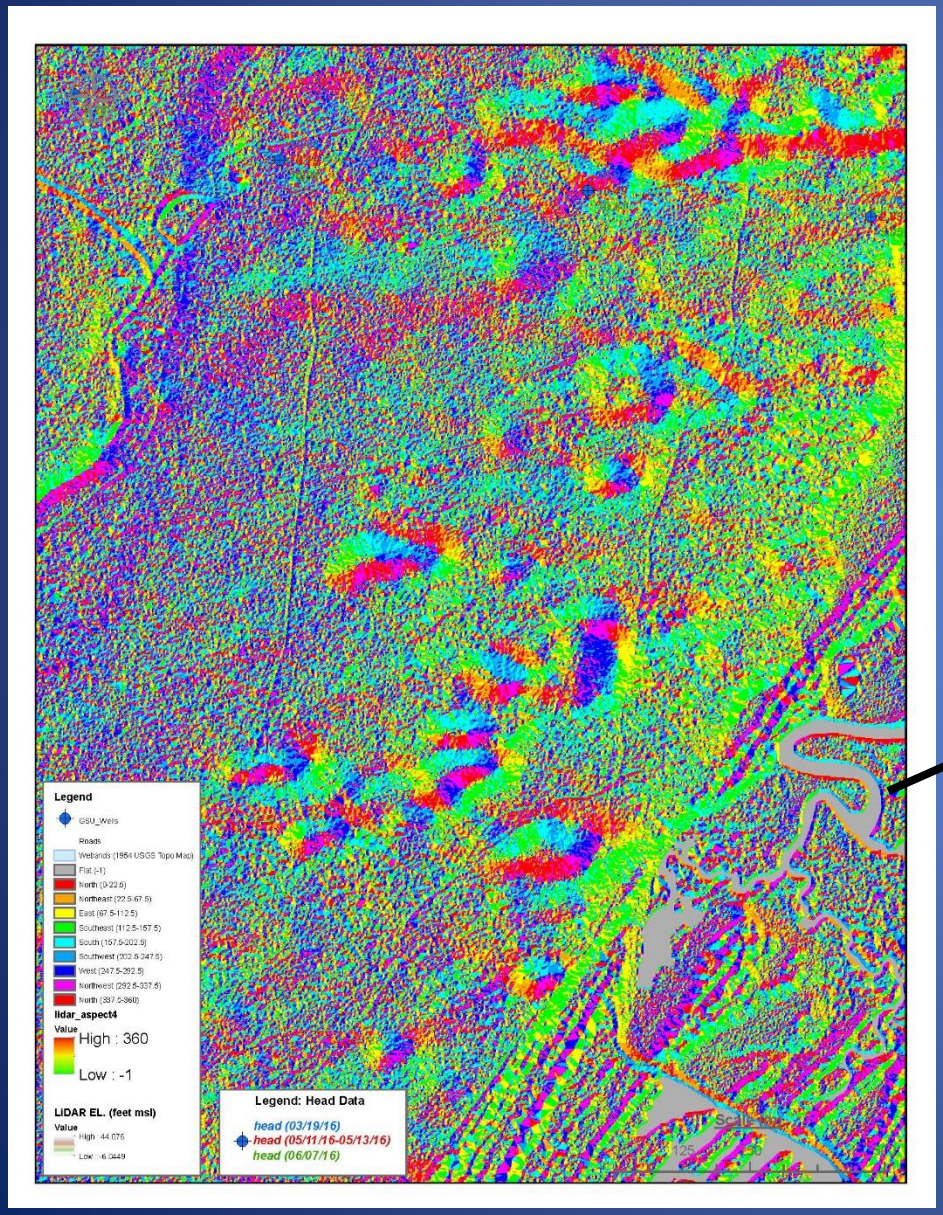
West < 4.9 m

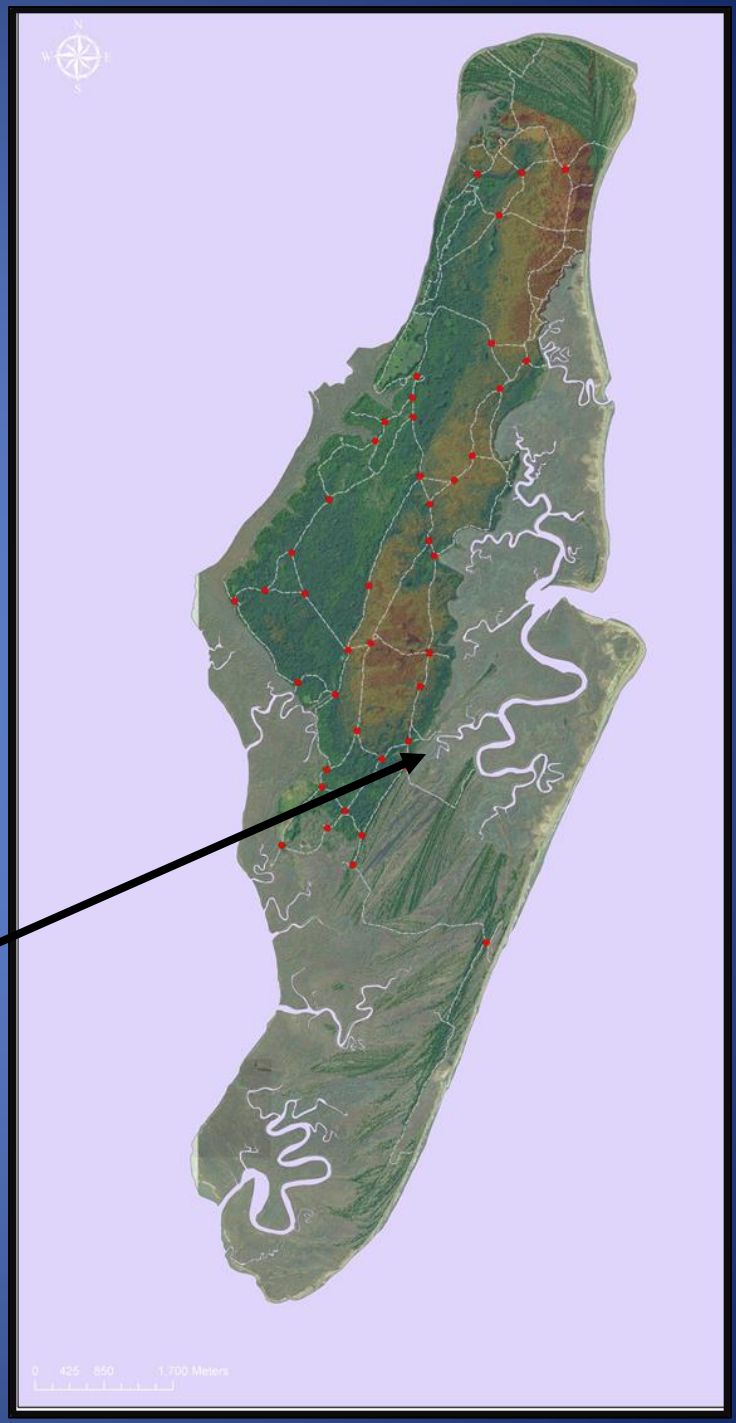
Central depression < 7.0 m



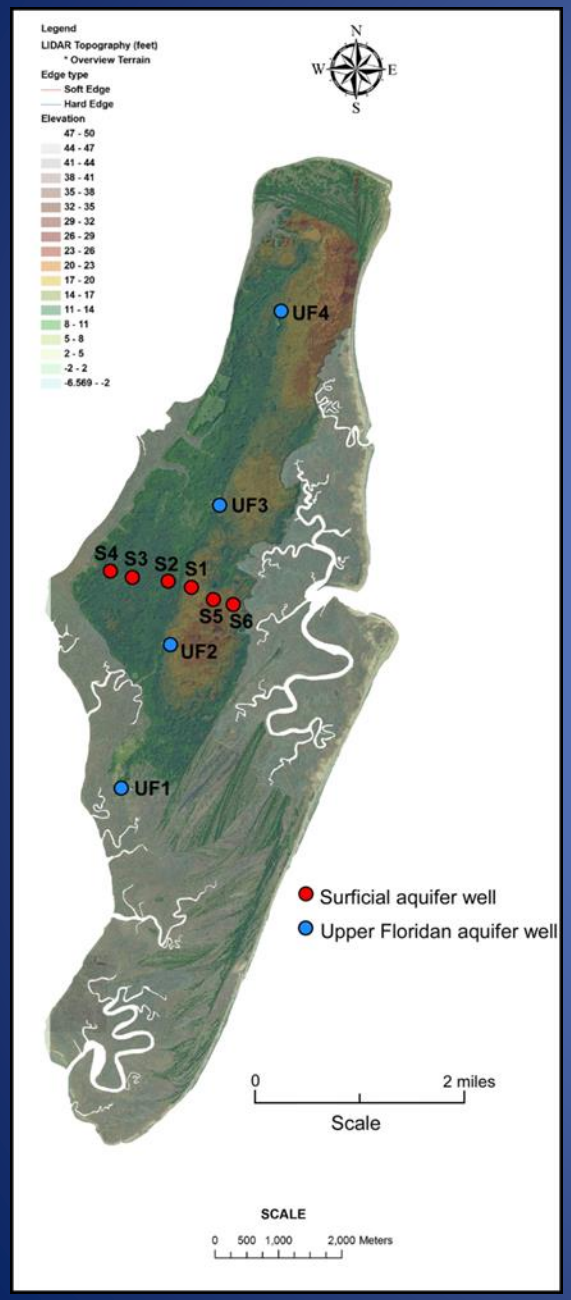


Eolian geomorphology on LiDAR–based aspect map



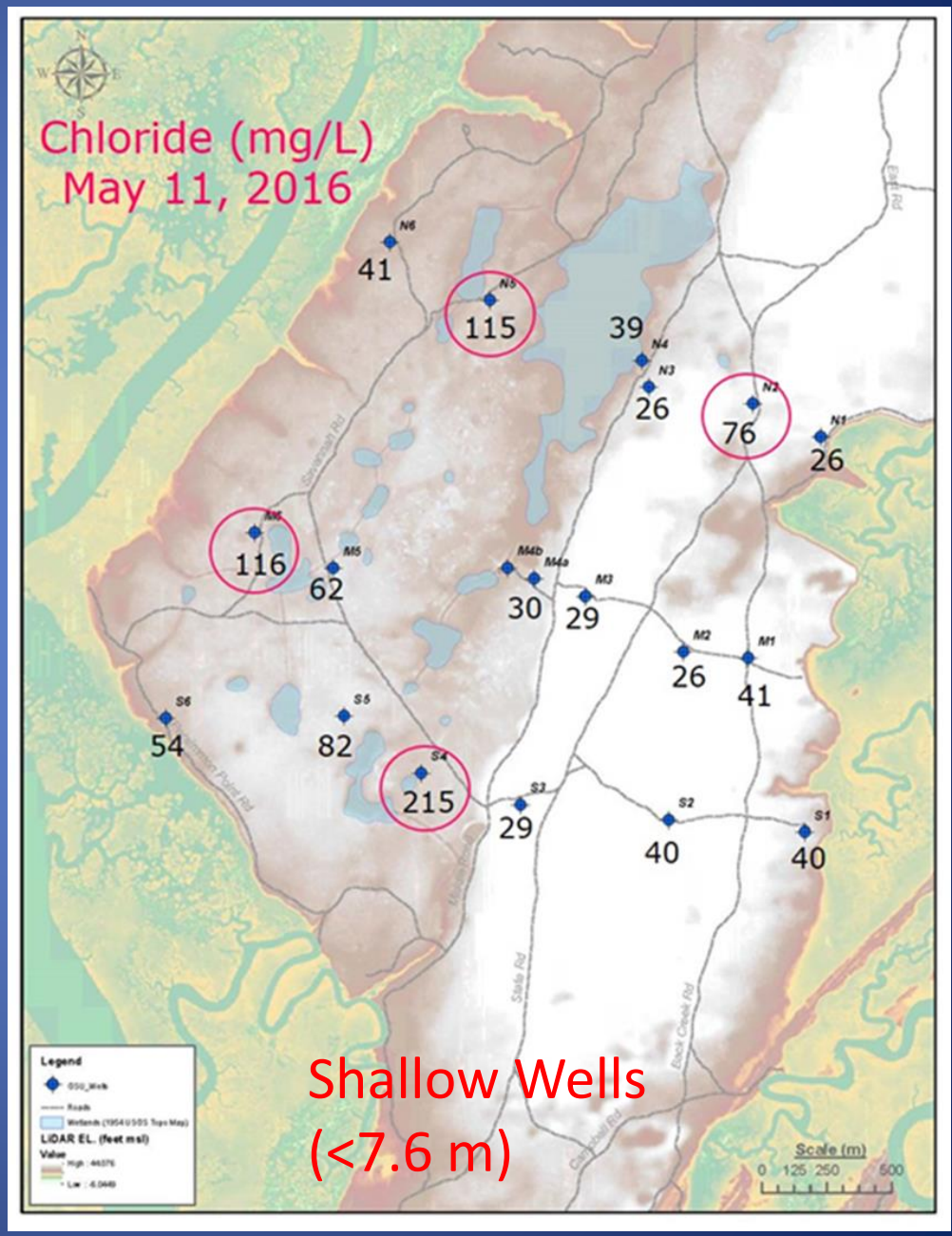


Hydrogeology Research Focus - Saltwater Intrusion

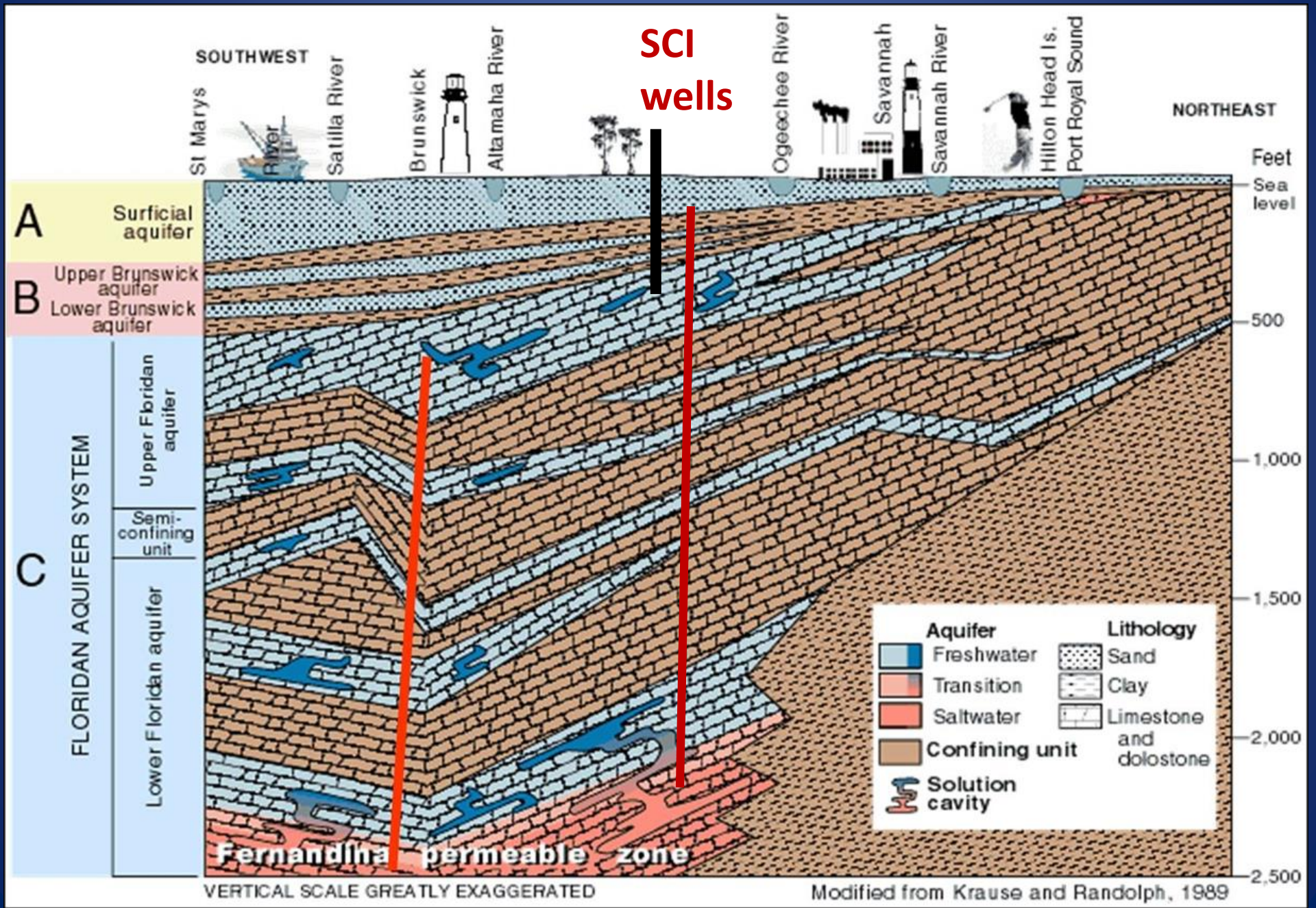


Saltwater Intrusion in Upper Floridan from brackish Lower Floridan.

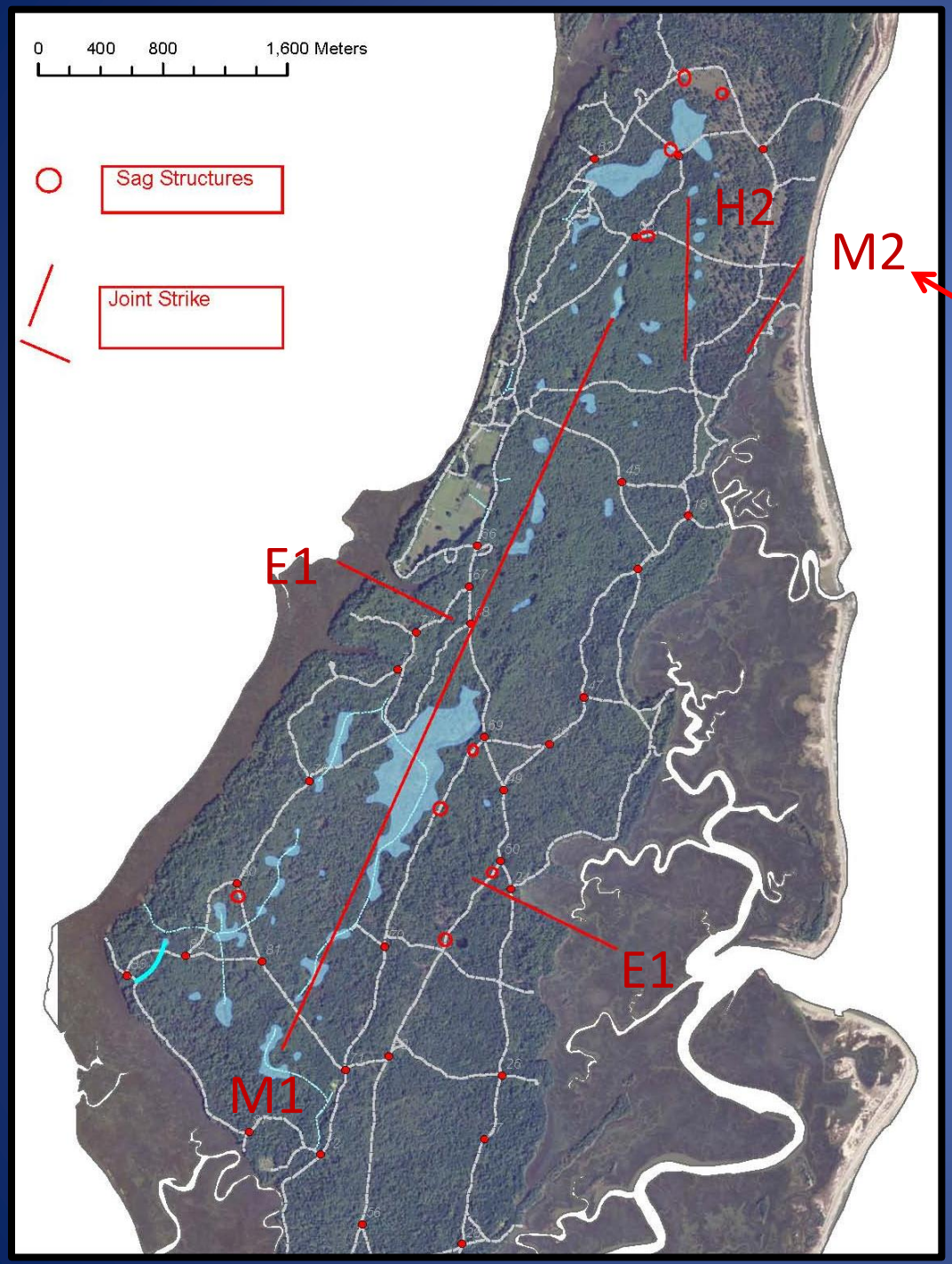
Saltwater intrusion in surficial aquifer from _?__.



Upper Floridan Salt water intrusion from below via fault system.



Joint trends, faults and sag structures.

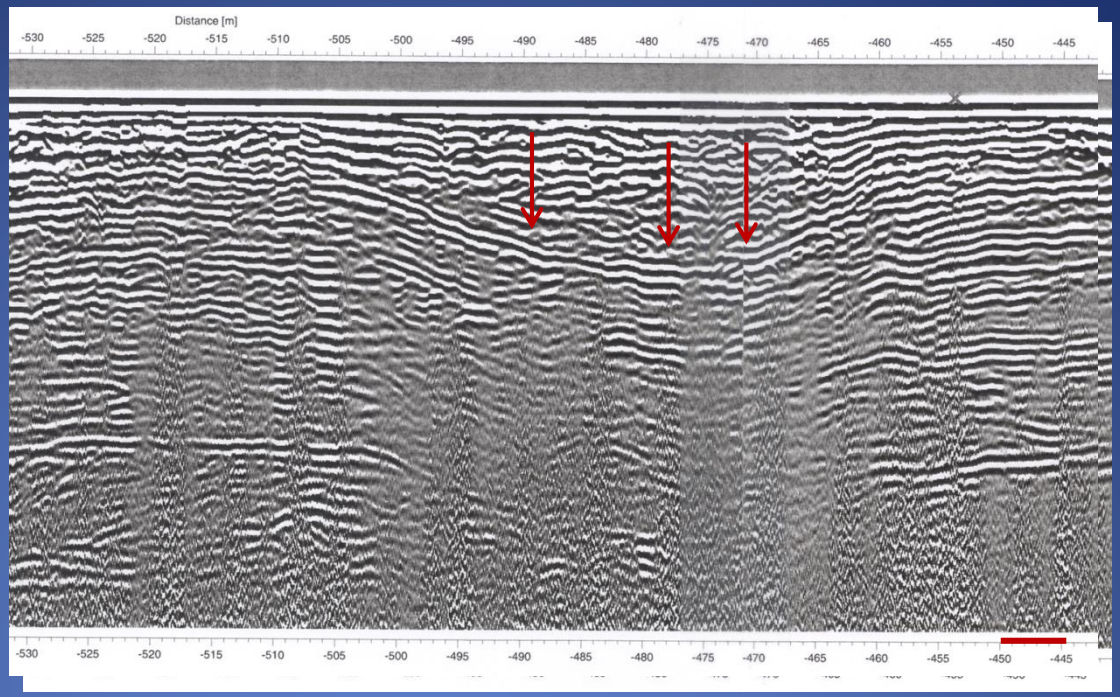


Yellow Banks Joint Trend

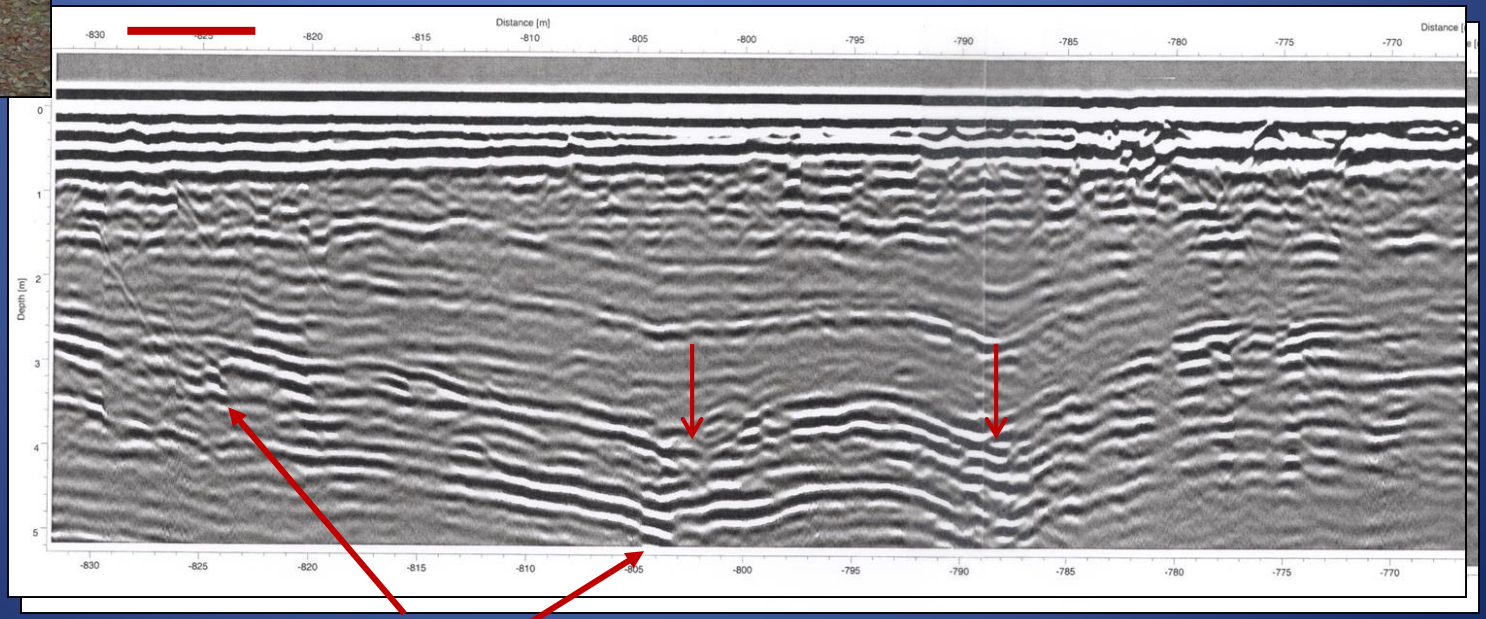
N24°E trend (M1) is same strike interpreted for Brunswick fault by Maslia and Prowell (1988)

Coastal Plain joint trends after Bartholomew et al., 2007

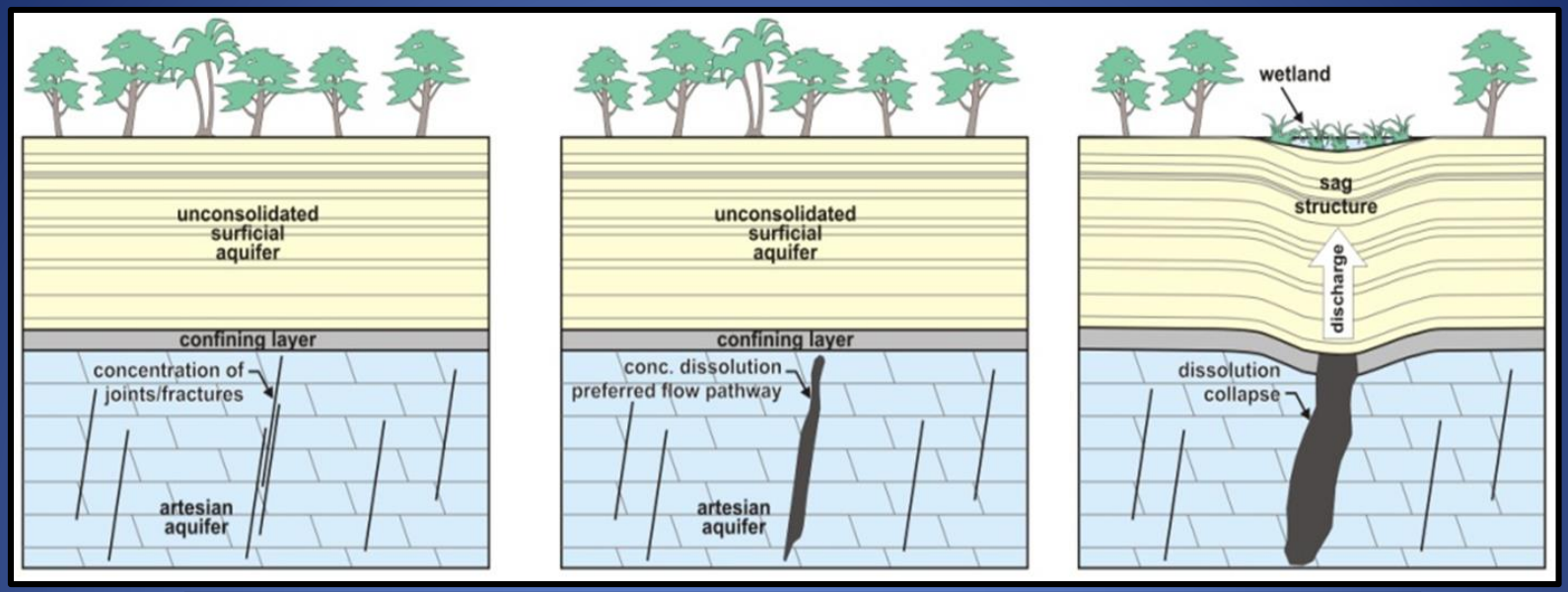
Sag Structures on 100 MHz GPR Profiles

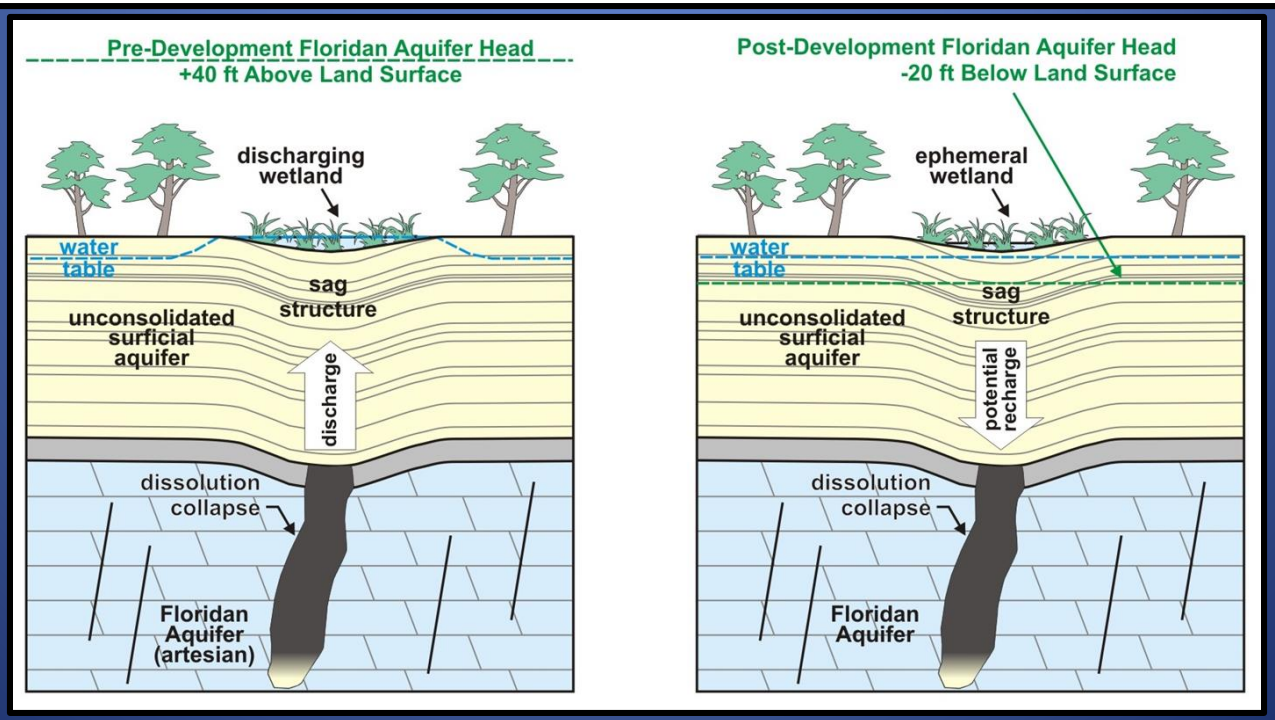


5 m



Sag structure development and hydrogeology





From: Brian Meyer

Central Depression vibracores

Organic sediment with fresh water palynoflora

Ghost shrimp burrows

Sinkhole near Middleground Community, Bulloch County, GA

Diameter ~ 26 meters, Depth to Upper Floridan carbonates > 300 ft

Initial Sinkhole Development – Bulloch County, GA Feb. 2019

origin by cavern collapse in Upper Floridan carbonates (> 300 ft)

Groundwater Monitoring

- Upper Floridan aquifer – 4 wells
- Surficial unconfined (WT) aquifer - 18 wells < 8 m deep
- Surficial semi-confined aquifer – 6 wells 12-15 m deep
- Head and specific conductivity loggers
- Quarterly water sampling and analyses

Additional Data Sources:

Core samples & logs

GPR profiles

Resistivity profiles

Palynology

Radiocarbon dating – Beta Analytic


Coring

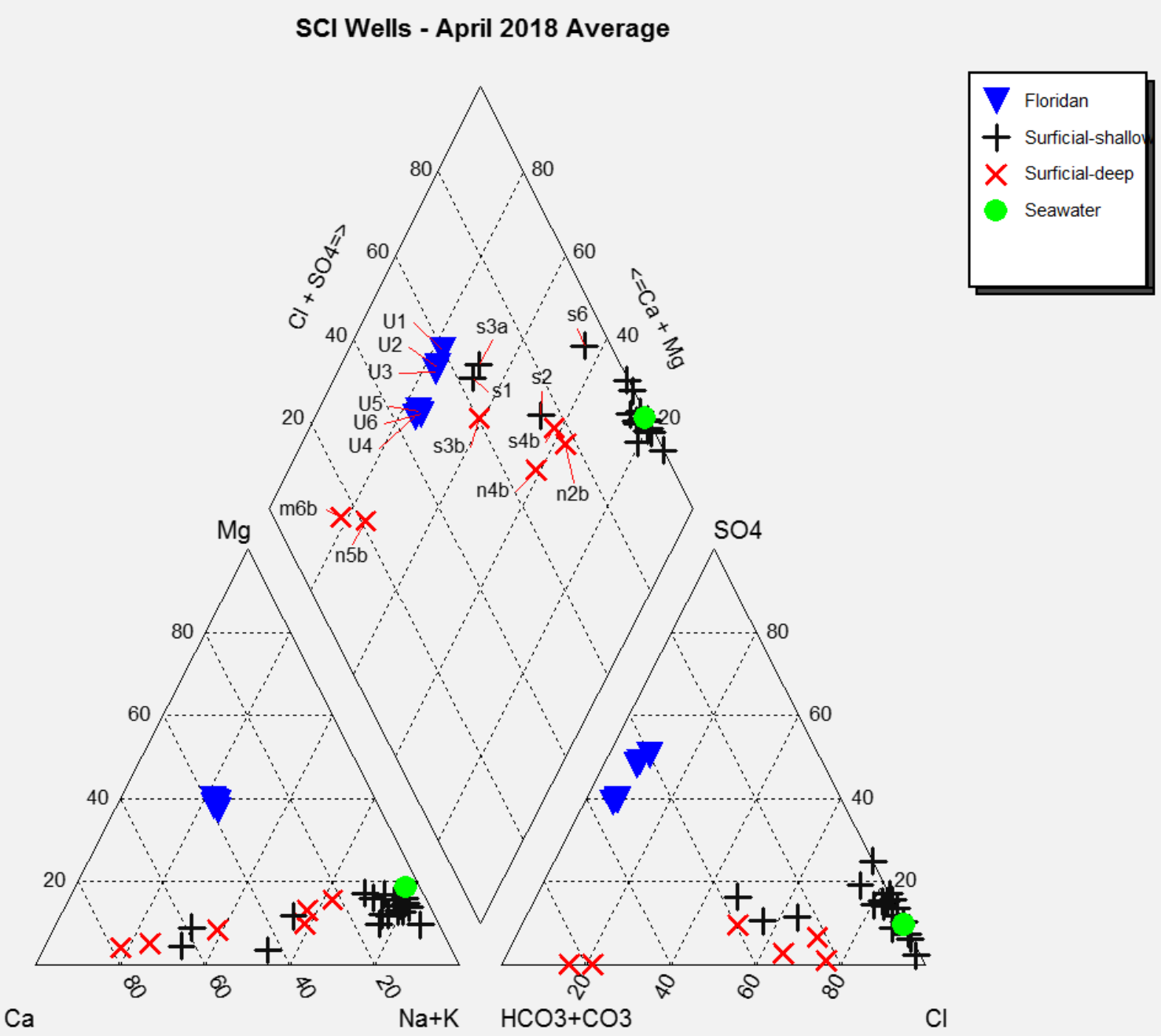

ER Survey


Water sampling
08/04/2016

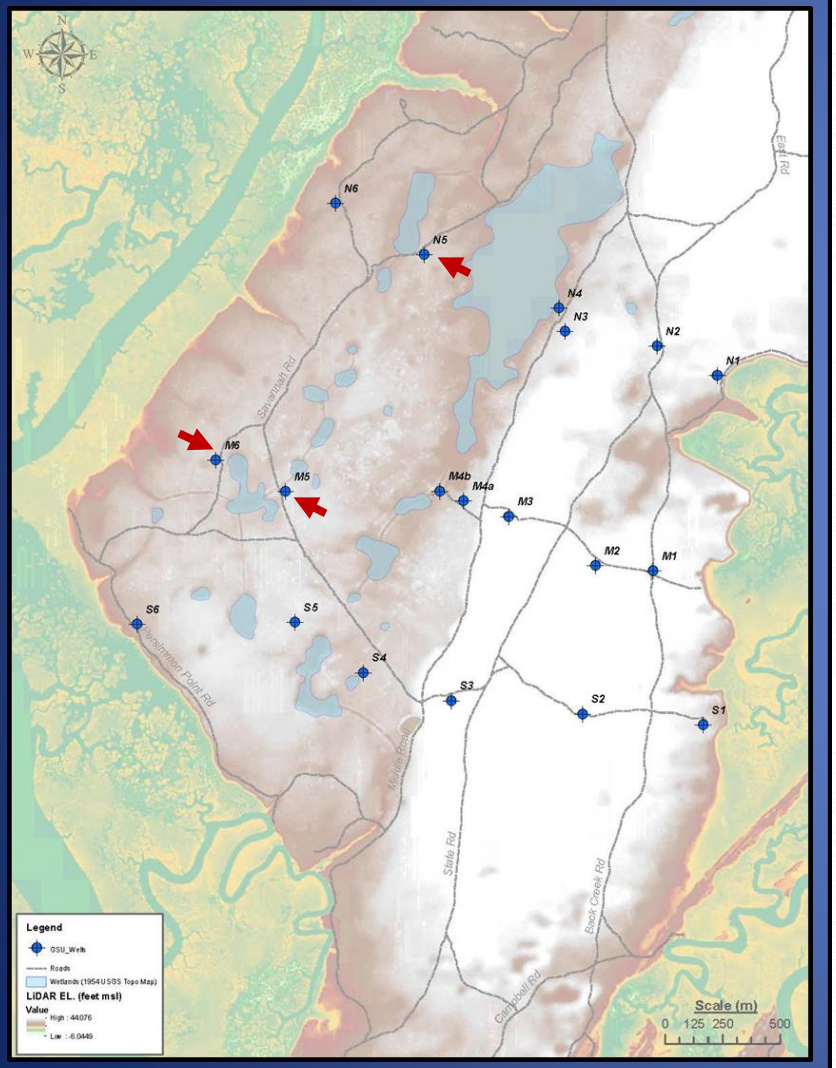

GPR rig

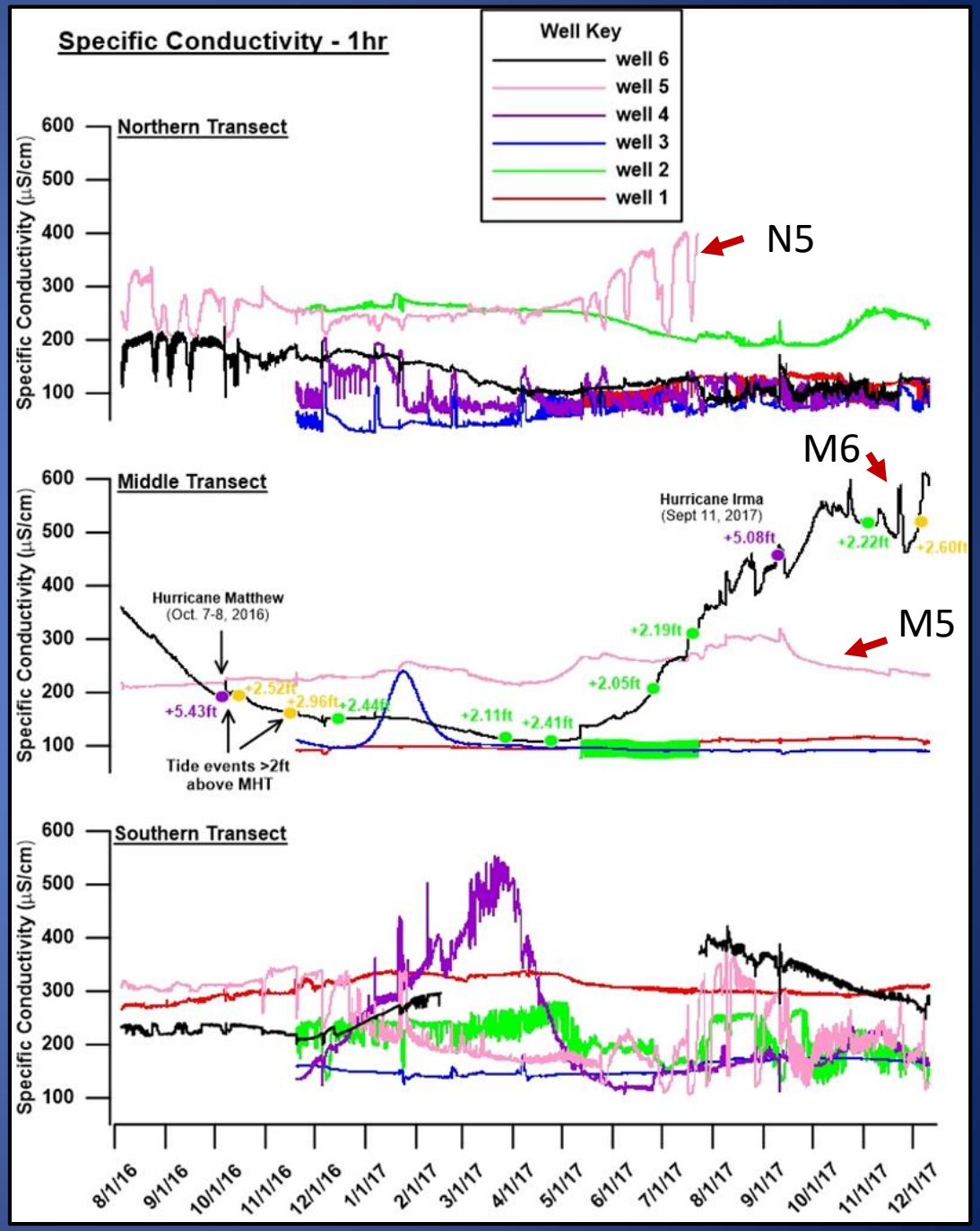
Surficial Aquifer System Findings

- Shallow WT aquifer – sand host
- Shallow aquitard – dense muddy sand & clay
- Shallow semi-confined aquifer – (1) sand host and (2) muddy shell-rich sand host
- Lateral strata variation
- Aquitard elevation variation
- Salinity variation among wells
- Variation in vertical communication
- Variation in tidal response among wells

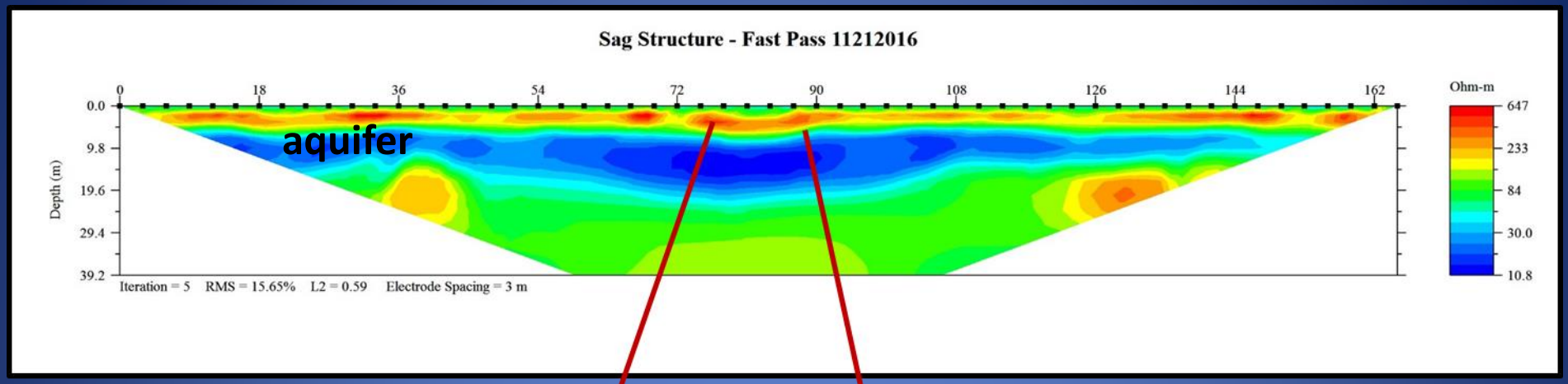

SCI Wells - April 2018 Average
Floridan
Surficial-shallow
Surficial-deep
Seawater
Cl + SO4=>
=<Ca + Mg
Mg
SO4
Ca
Na+K
HCO3+CO3
Cl
U1
U2
U3
U5
U6
U4
s3a
s1
s3b
s6
s2
s4b
n4b
n2b
m6b
n5b
80
60
40
20

Well N 5, M5, M6 lie along same lineament



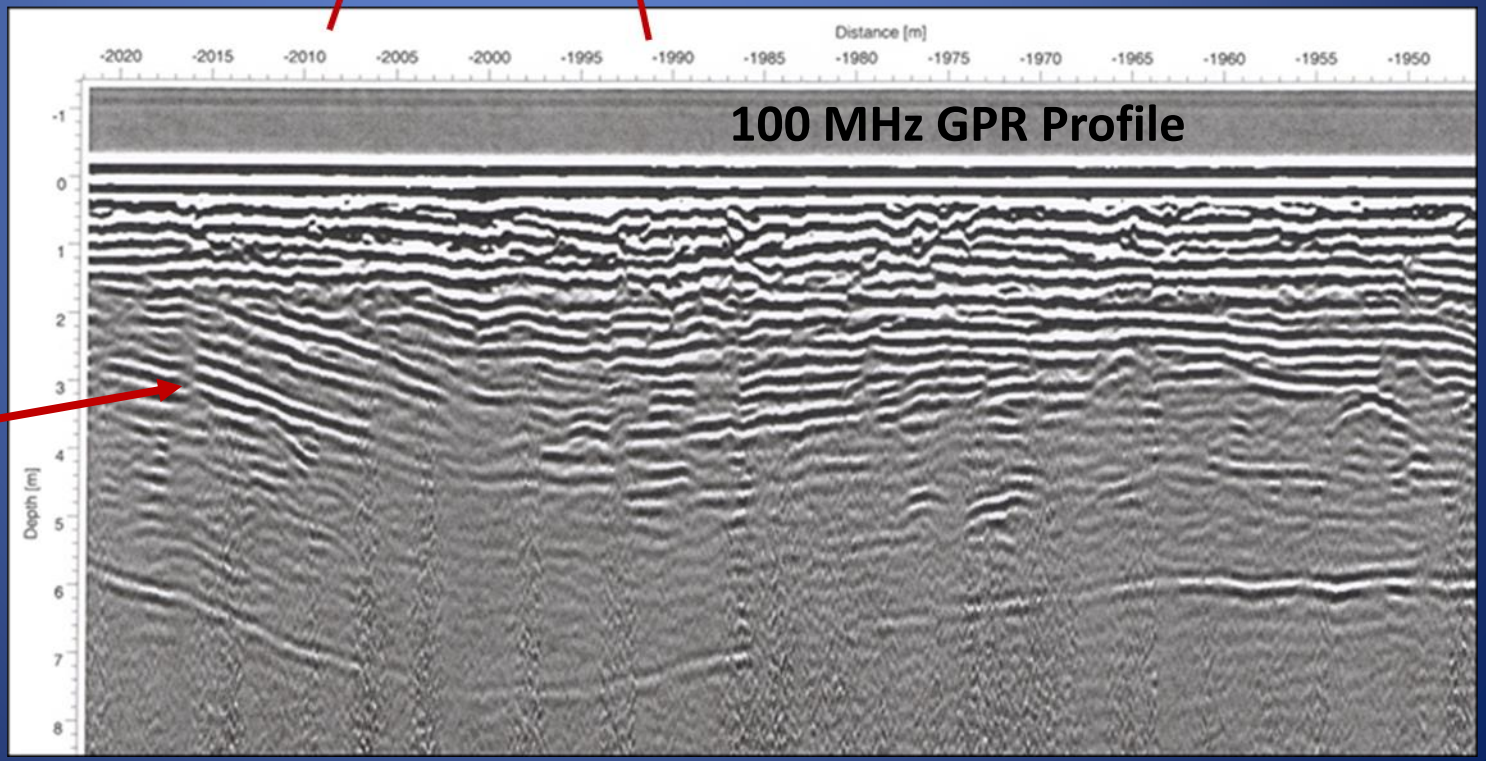


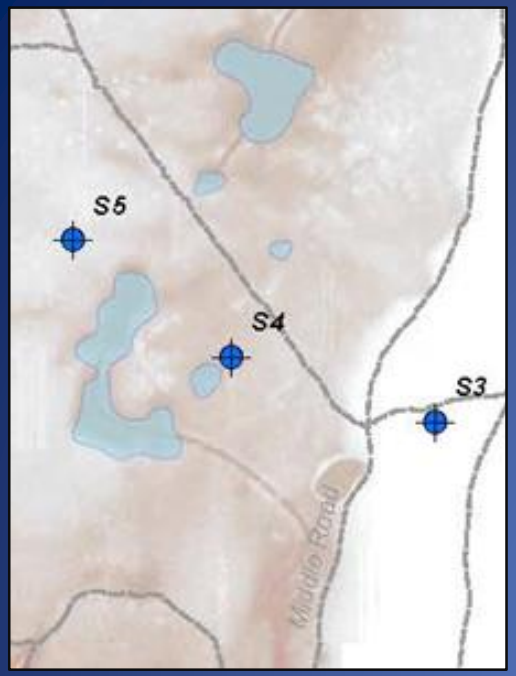
Exploring Links Between Structure and Hydrology



Profile between M5 & M6 well sites

Off-sets in radar elements – faults ?





Resistivity Profiles, Core & well data (site S4):

0 – 1.5 m: hydric black sandy top soil

1.5 m - 7.3 m: sand

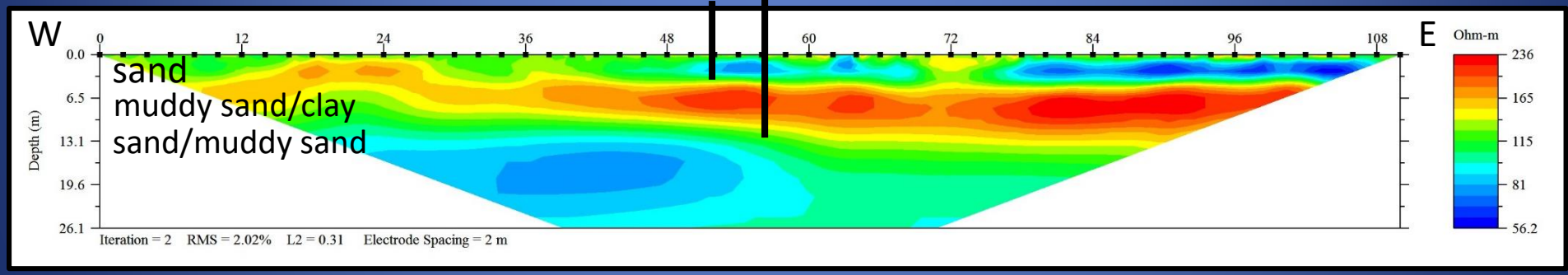
(3.0 m - plant clast 9516-9401 cal BP)

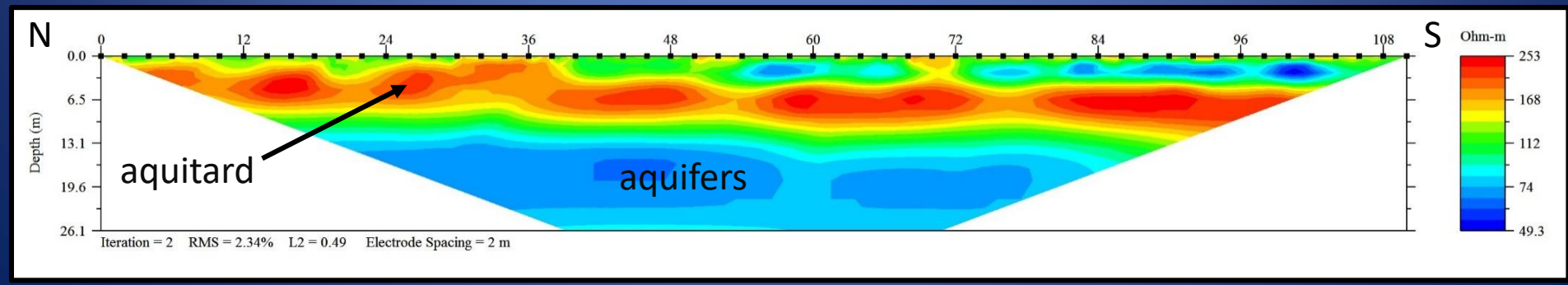
7.3 m – 12.2 m: dense muddy sand & clay

(7.6 m – plant clast >43,500 BP)

12.2 – 13.4 m: sand & muddy sand

Wells: shallow - Cl 39.28
deep - Cl 26.96

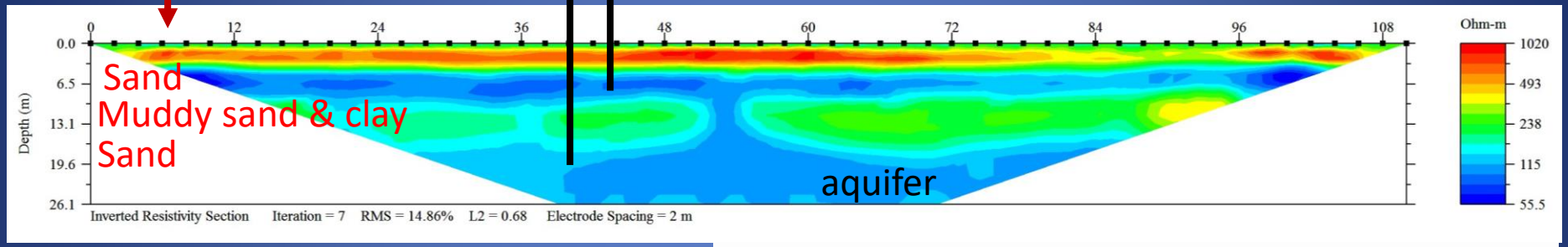




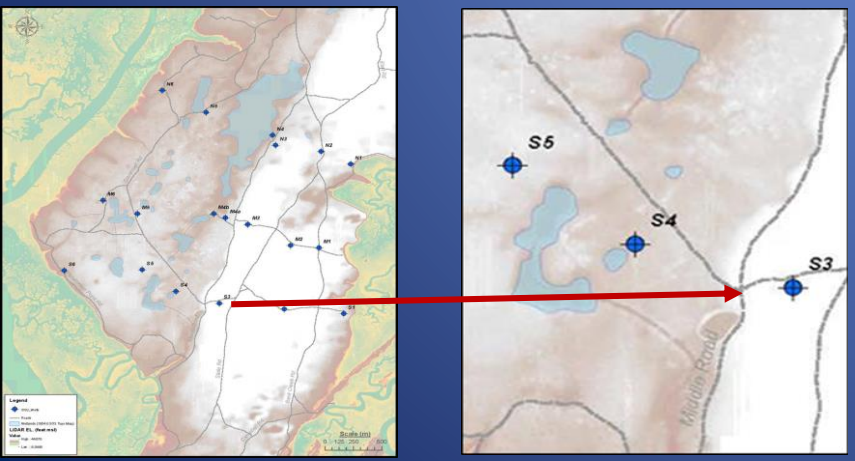
Resistivity Profile across S3 Well Site

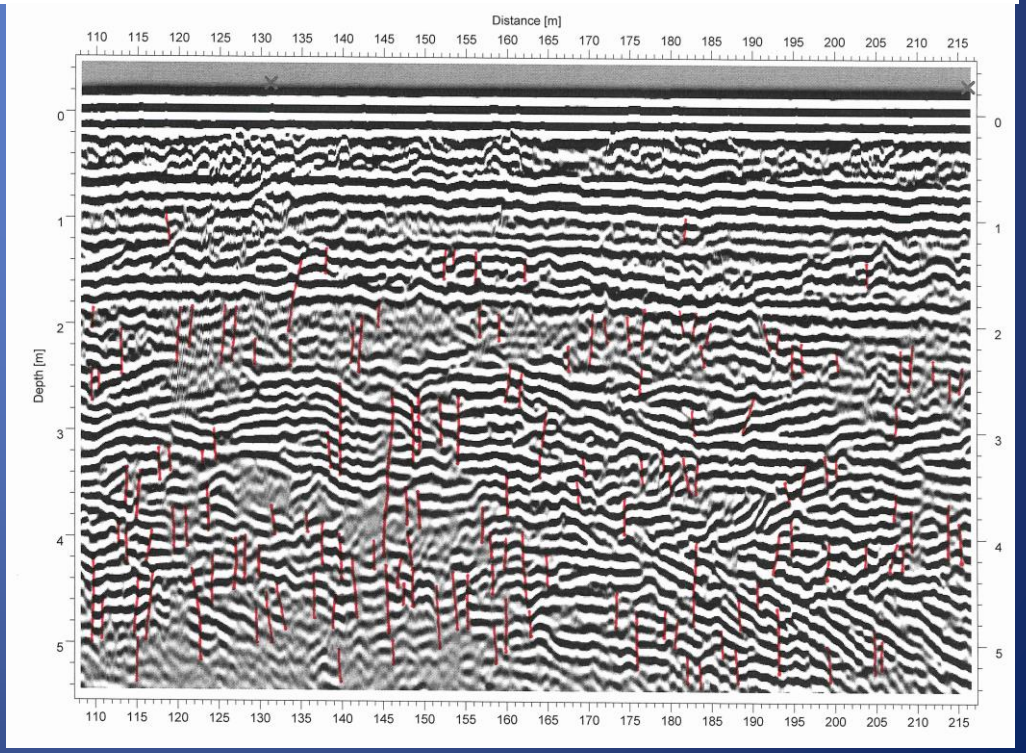
Wells: shallow Cl 28.5
deep Cl 28.1

Core Data



250 MHz GPR profile →





Notes on faulting in soft sediments:

Combined seismic and GPR surveys in the Dead Sea Rift reveal a transition from a single fault at depth to fault splays at ~ 35 to 20 m depth (Basson et al., 2002)

Hamilton, NZ: *Waikato Times*, L. Wilson, 2017

Summary

- The surficial aquifer system is complex!
- Most unconfined surficial wells are more saline than semi-confined wells.
- Vertical communication between unconfined and semi-confined surficial wells is in part fault dependent.
- The unconfined and semi-confined wells vary greatly in response to spring tides, king tides and storm surges.
- Salt water intrusion in the surficial aquifer system appears to be determined by the presence of high permeability pathways associated with faults and perhaps locally by paleo-tidal channels.
- Deep faults are required for former artesian springs and current Floridan upconing. Sag structures formed by deep cavern collapse localized along faults.

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