Resistivity and Shear Wave Velocity as a Predictive Tool of Sediment Type in Coastal Levee Foundation Soils

Association of Levee Boards of Louisiana
30th Annual Workshop

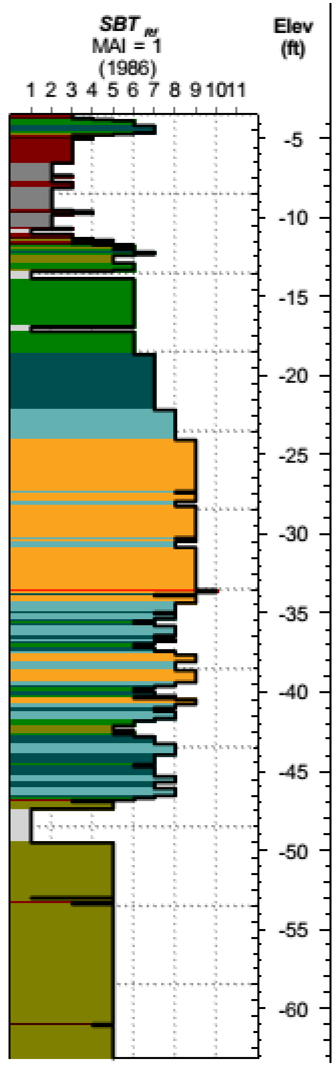
Derek Goff[1]
Juan Lorenzo[1]
Koichi Hayashi[2]

1: *Department of Geology & Geophysics, Louisiana State University, Baton Rouge, LA*
2: *Geometrics, San Jose, CA*

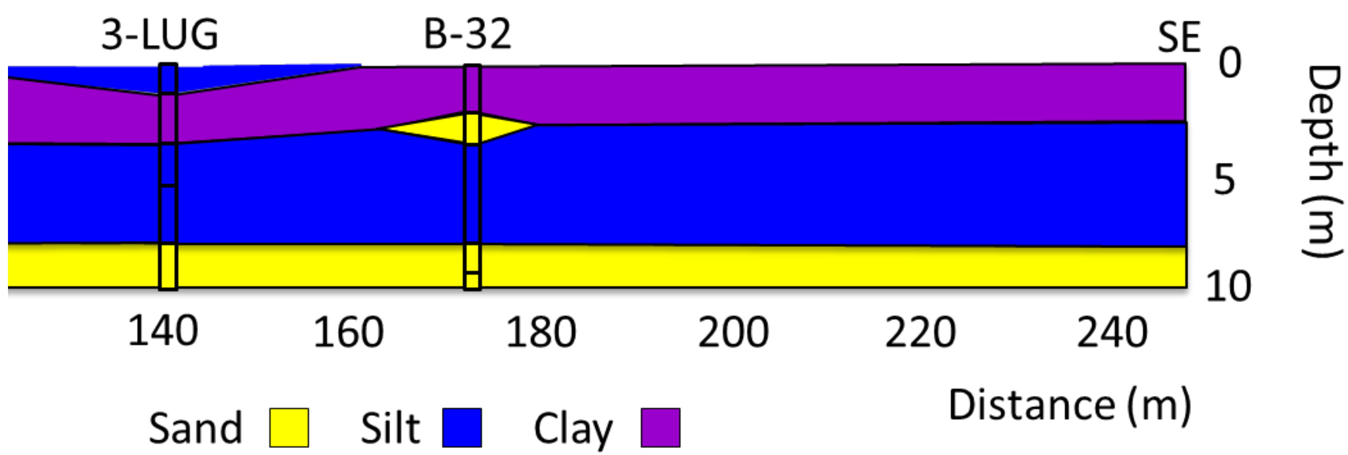
Outline

1. Geophysical Soil Analysis
2. Field Study – London Avenue Canal
3. Application and Methodology
4. Conclusions and Future Work

Geotechnical Analysis – CPT & Borings

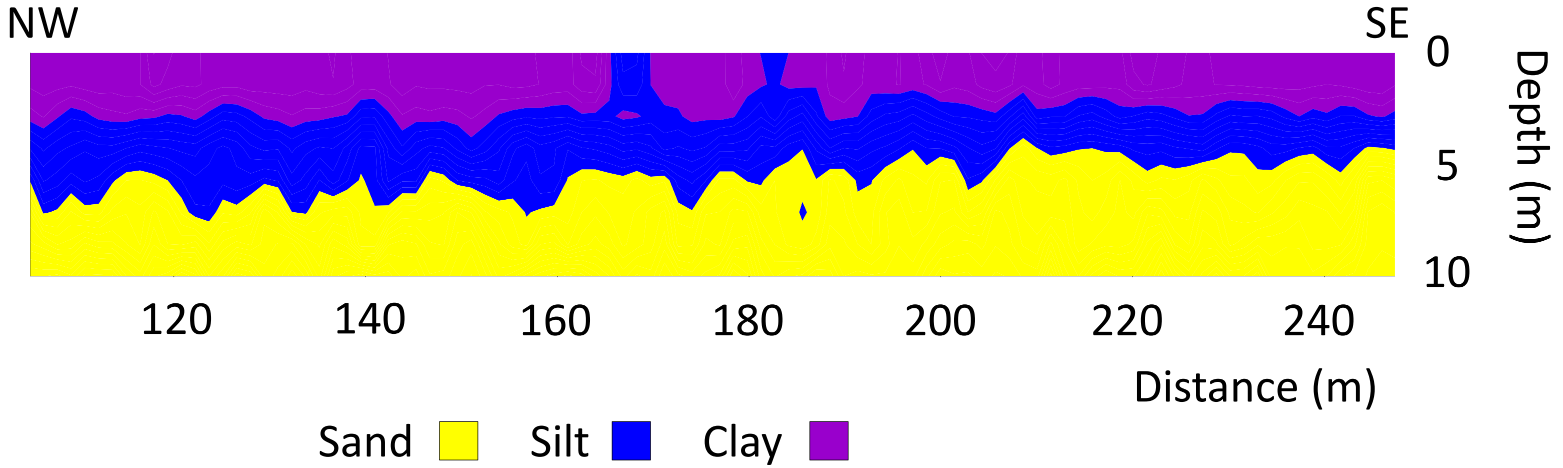


- Advantages
  - Highly detailed
  - Established empirical relationships
- Disadvantages
  - Lack of lateral control in heterogeneous environments



Geophysical Analysis

- Resistivity
  - Groundwater levels
  - Sensitive to saturation
- Shear Wave Velocity
  - Compaction differential
  - Shear modulus - Stiffness
- Soil Type Identification
  - Empirical model based on Japanese soil studies (Hayashi et al. 2013)



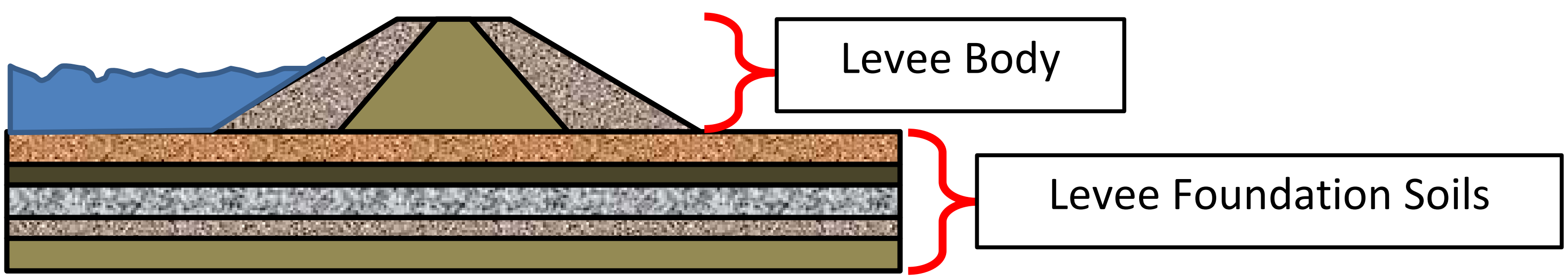
Geophysical Analysis

- Advantages
  - Fast data collection
    - Resistivity: ~10 km per day
    - Shear wave velocity: ~1 km per day
  - Near continuous measurements
    - Detect lateral heterogeneities in soils
  - Deployment in urban environments

Liberty and Gribler (2014)

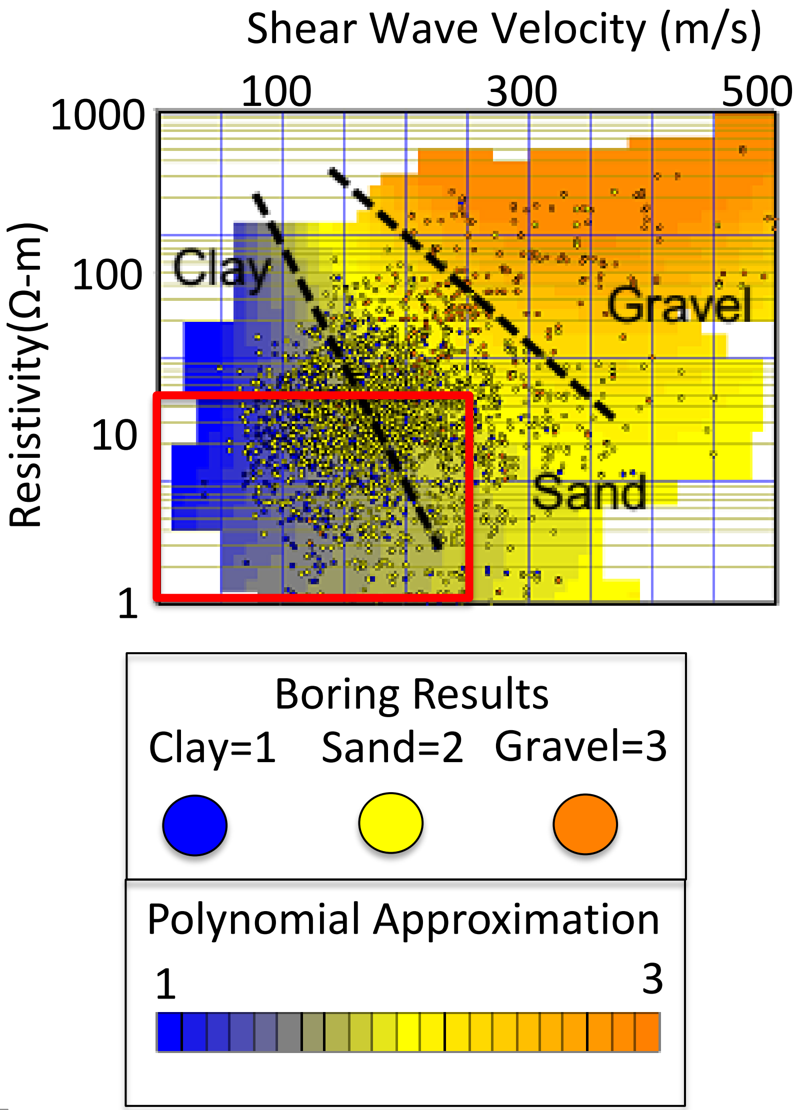
Foundation Soil Classification

- Soil Type Identification
  - Unified Soil Classification System (USCS)
    - Grain size
    - Plasticity distinguishes silts from clays
- Risk
  - Piping
    - Unconsolidated sands
  - Saturated soils
    - Dewatering & compaction



(Unified Soil Classification System, ASTM D2487)

Original Model

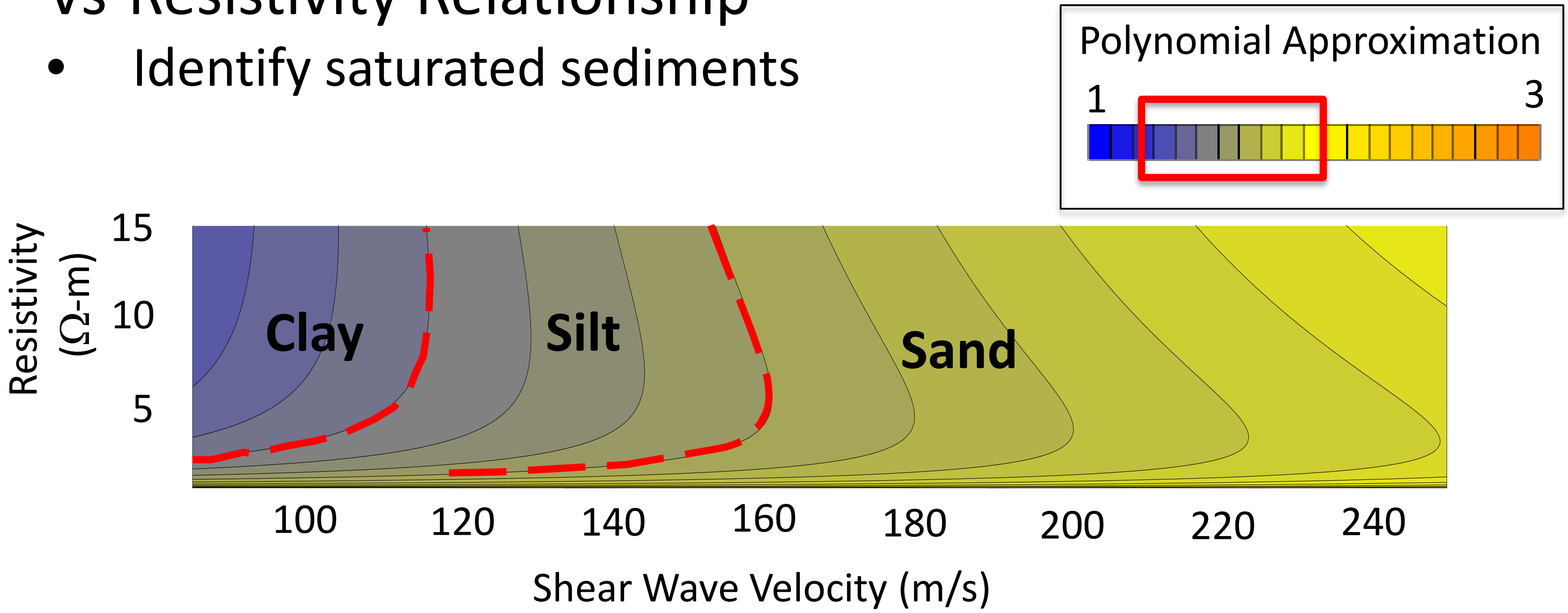


- Statistical Approach
  - Cross-plot of resistivity and V_s
  - Polynomial approximation
    - Predict soil type distribution
- Identifies 3 Soil Types
  - Clays, sand, gravel
  - Silt is not included
- Field Investigations
  - Japan
  - Washington state

(Hayashi et al., 2013)

Modified Estimation Model

- Identify Clay, Silt, and Sand
  - Plasticity difference between silt and clay
- Vs-Resistivity Relationship
  - Identify saturated sediments

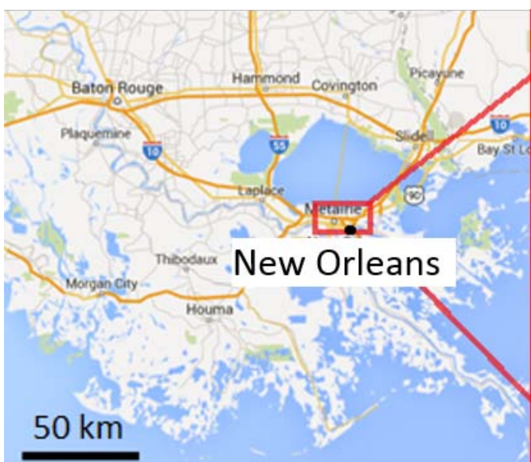


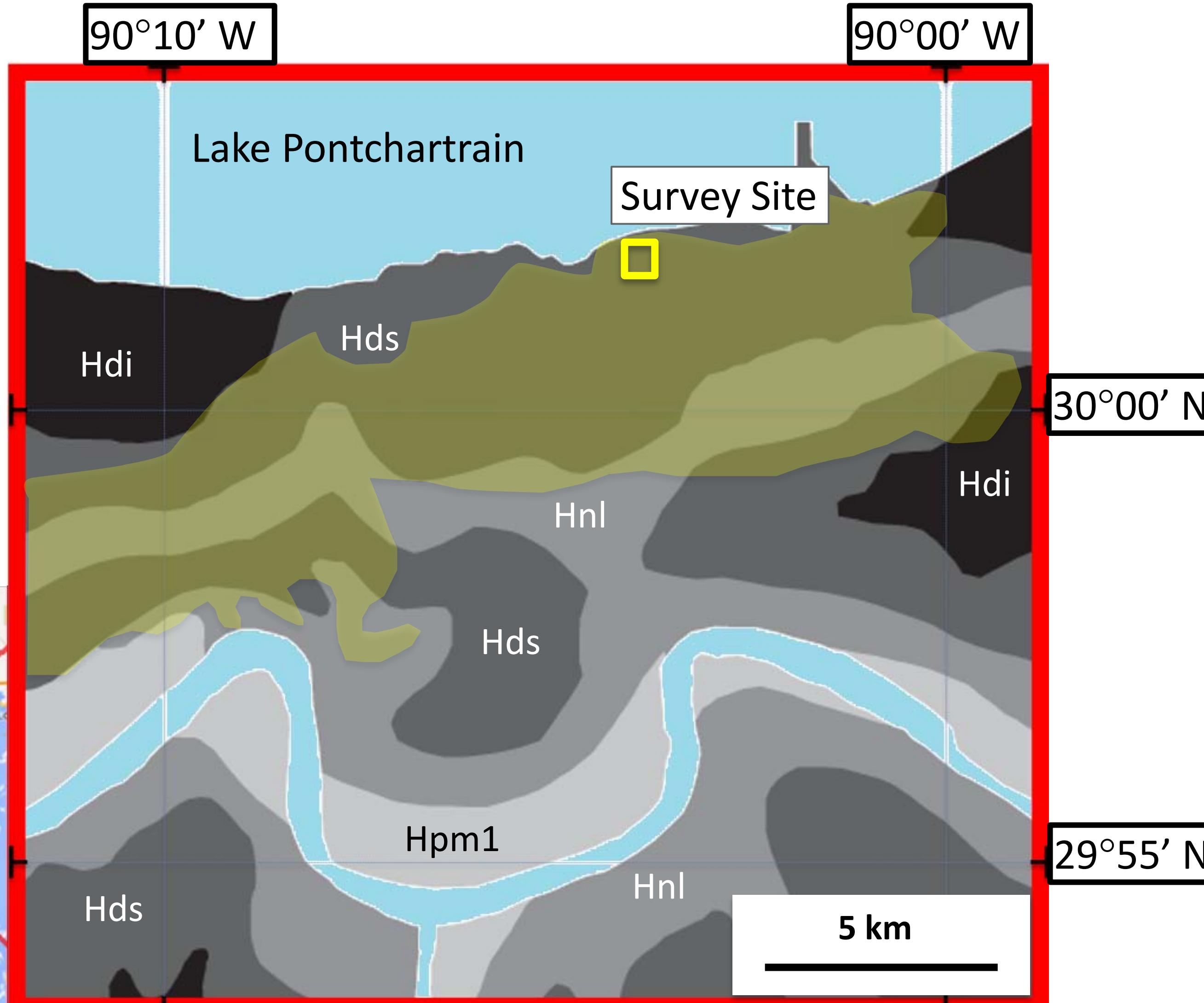
(Image Generated By Surfer)

London Park

Holocene Deltaic Sediments

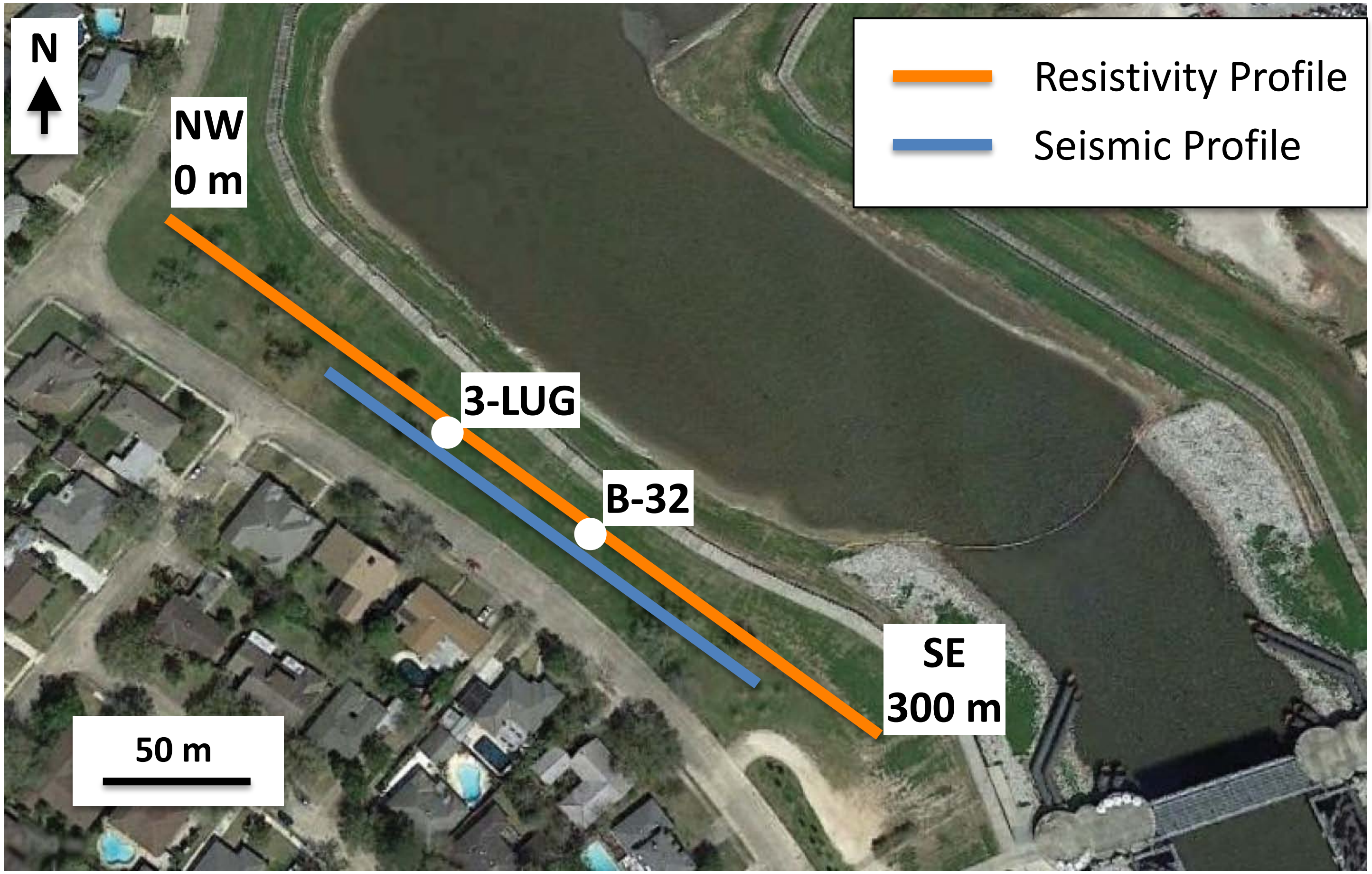
Hpm1	Point Bar
Hnl	Natural Levee
Hds	Swamp
Hdi	Brackish Marsh
	Pine Island Beach Sand





(Modified from Saucier, 1994)

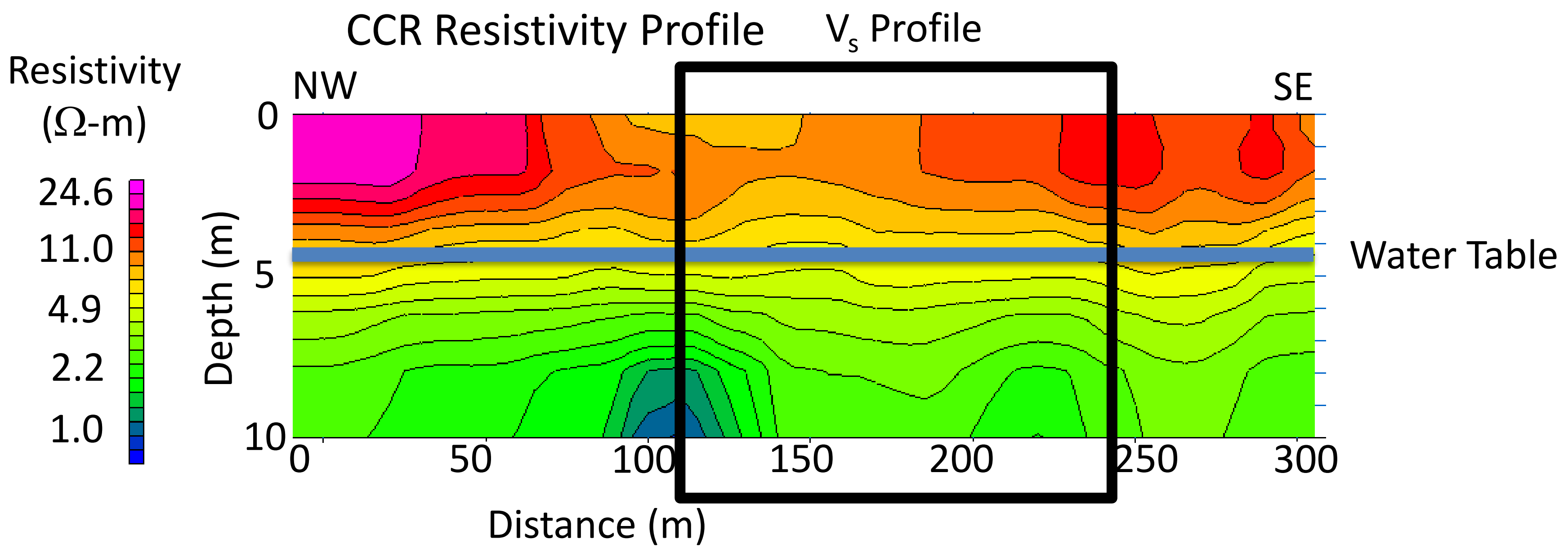
Seismic, Resistivity, and Boring Logs



(Google Earth, 2014)

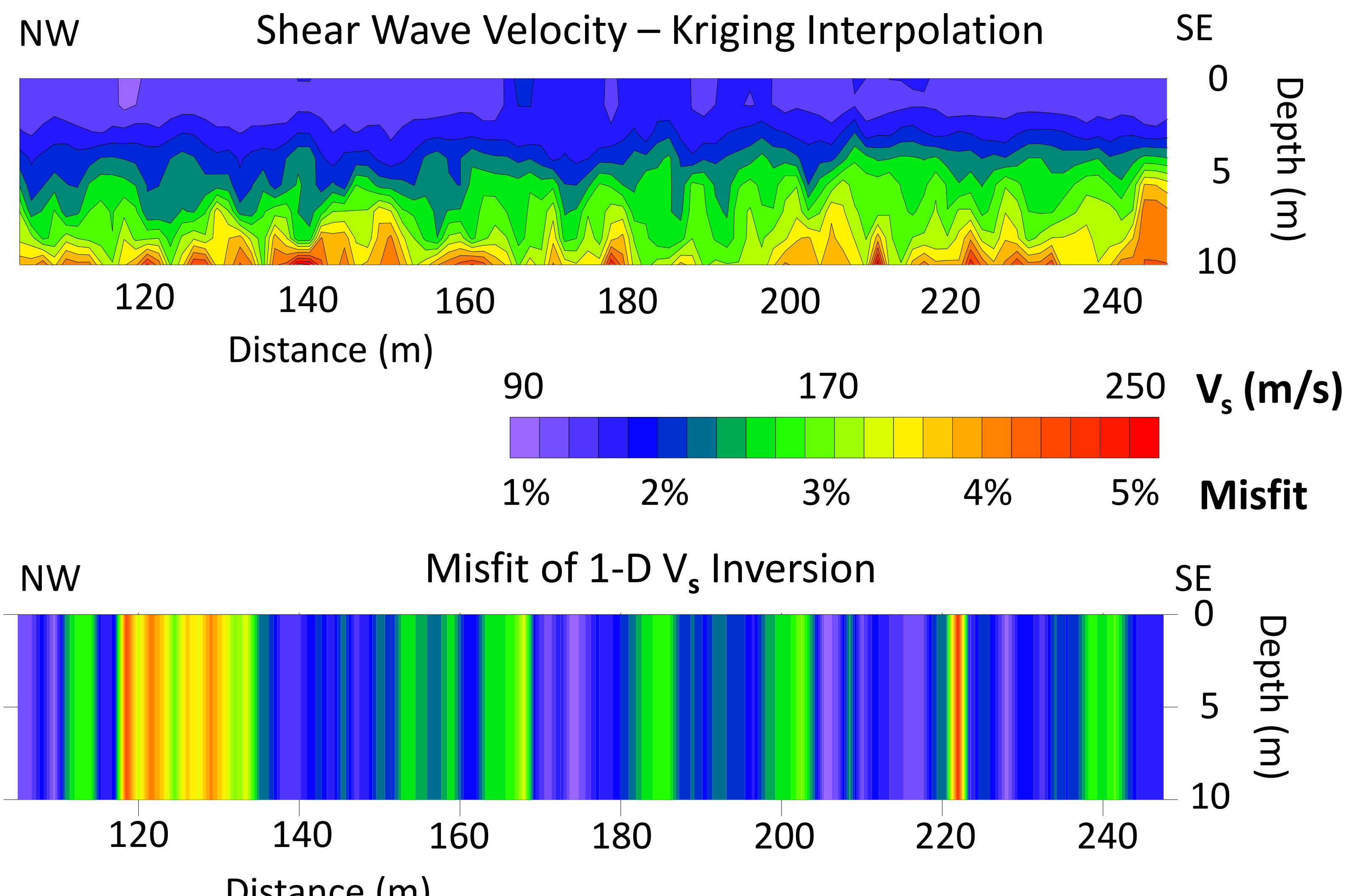
Resistivity Profile

- Capacitively Coupled Resistivity
- Decrease resistivity with depth
  - Increasing saturation
  - Soil type change
    - Increase grain size, increase connected pore space



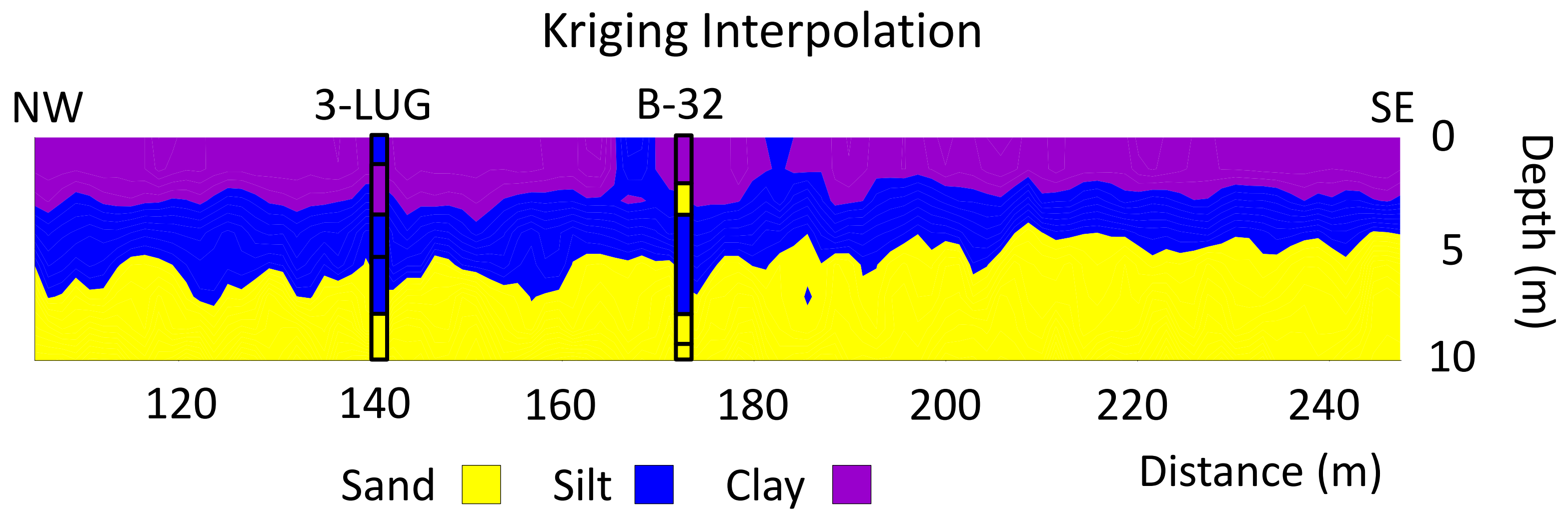
(Image from Geoplot)

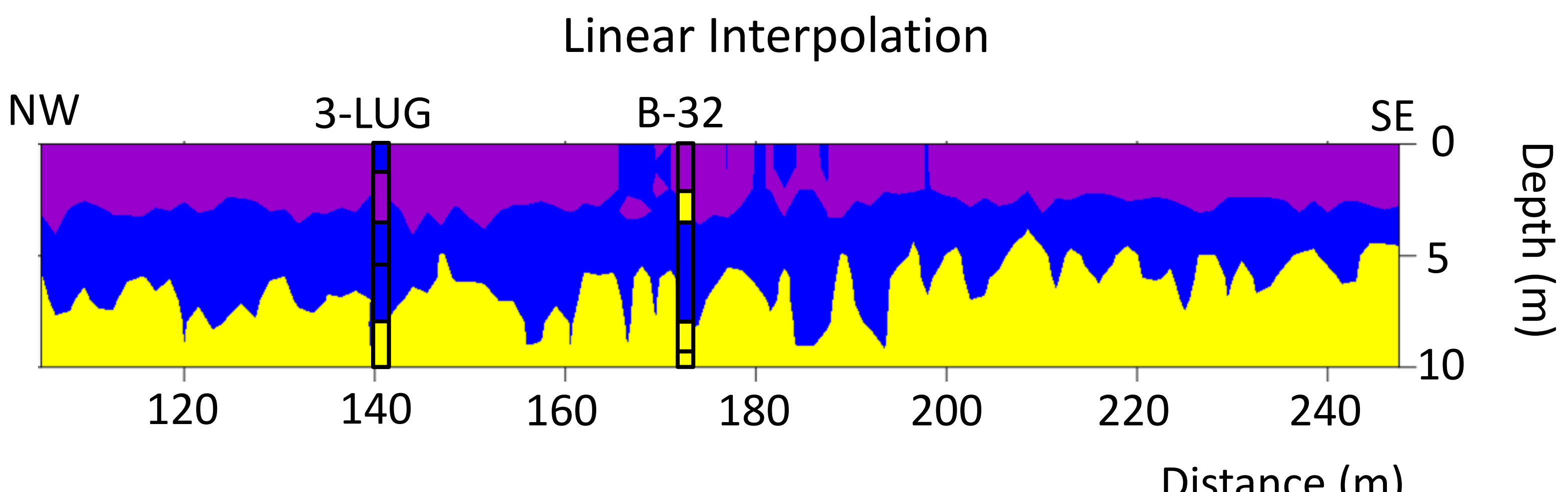
Seismic Velocity Models



(Images from Surfer)

Soil Type Predictions

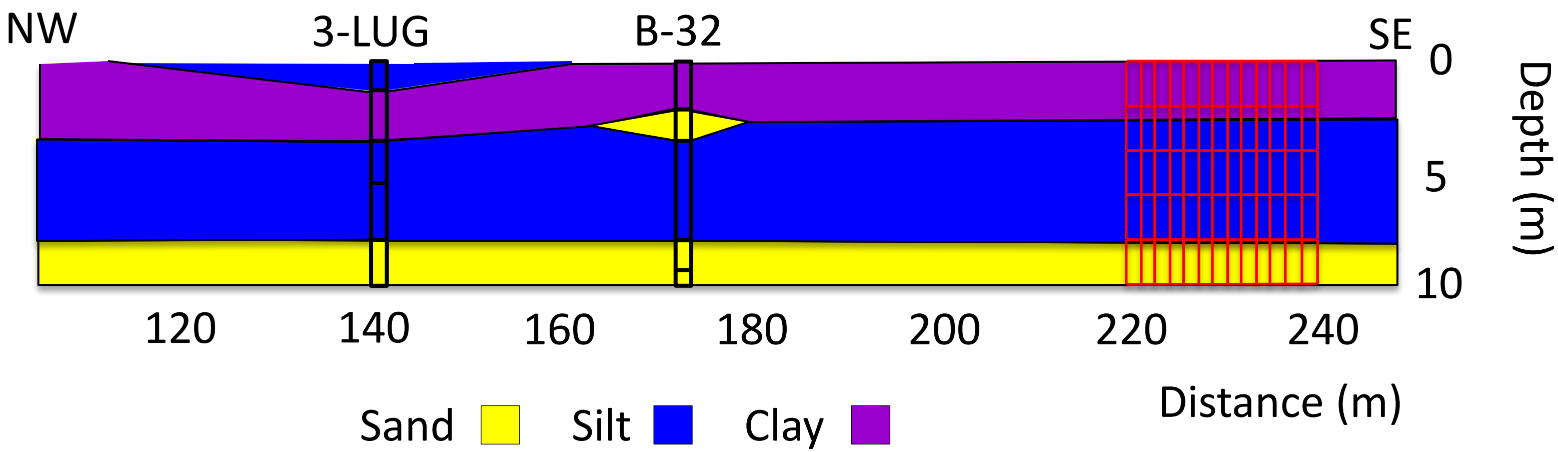




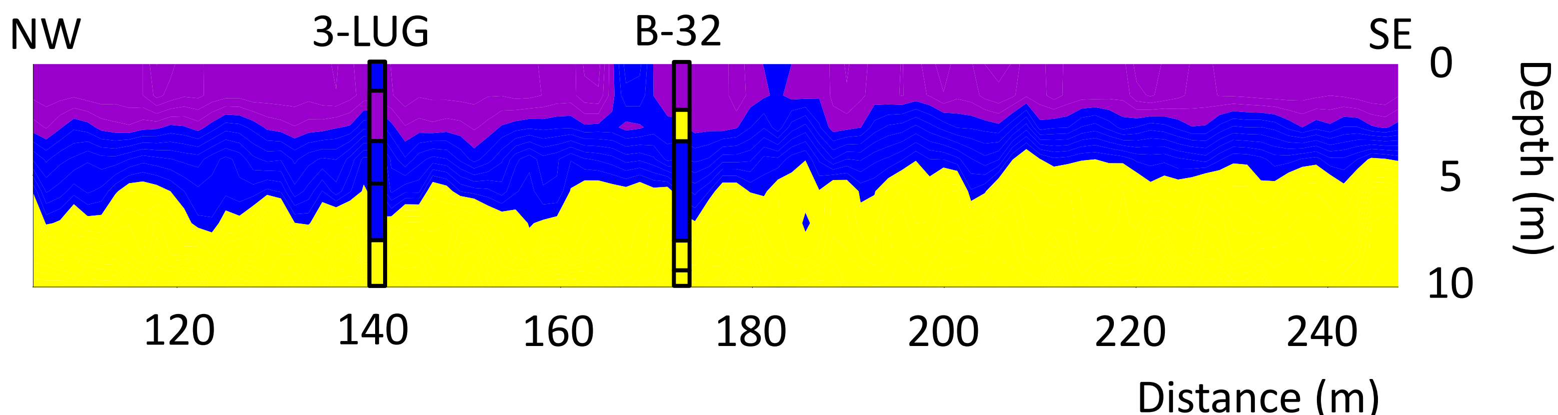
(Images from Surfer)

Geotechnical vs. Geophysical

Geotechnical Linear Interpolation

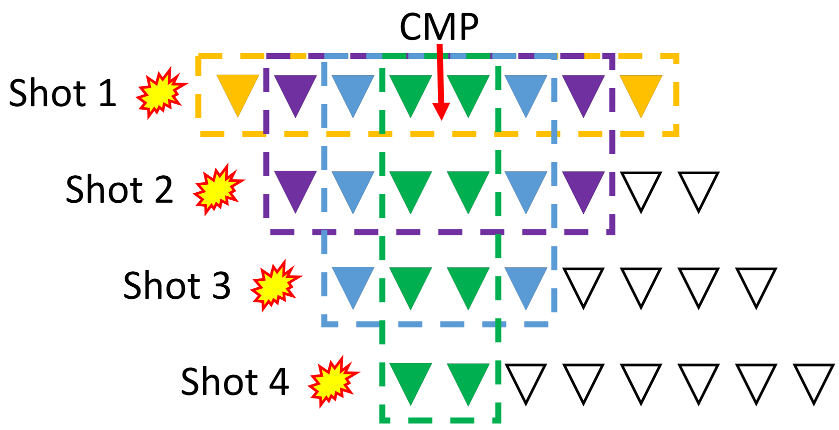


Kriging Interpolation

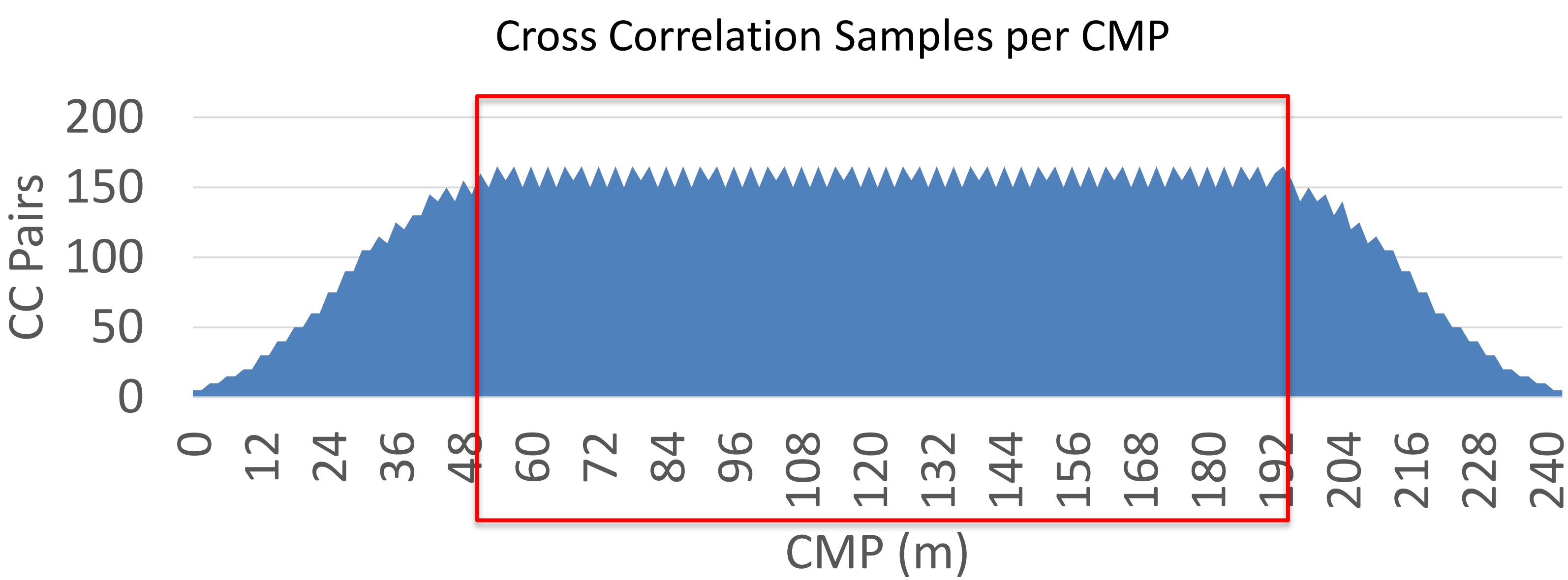


(Images from Surfer)

Shear Wave Velocity Processing



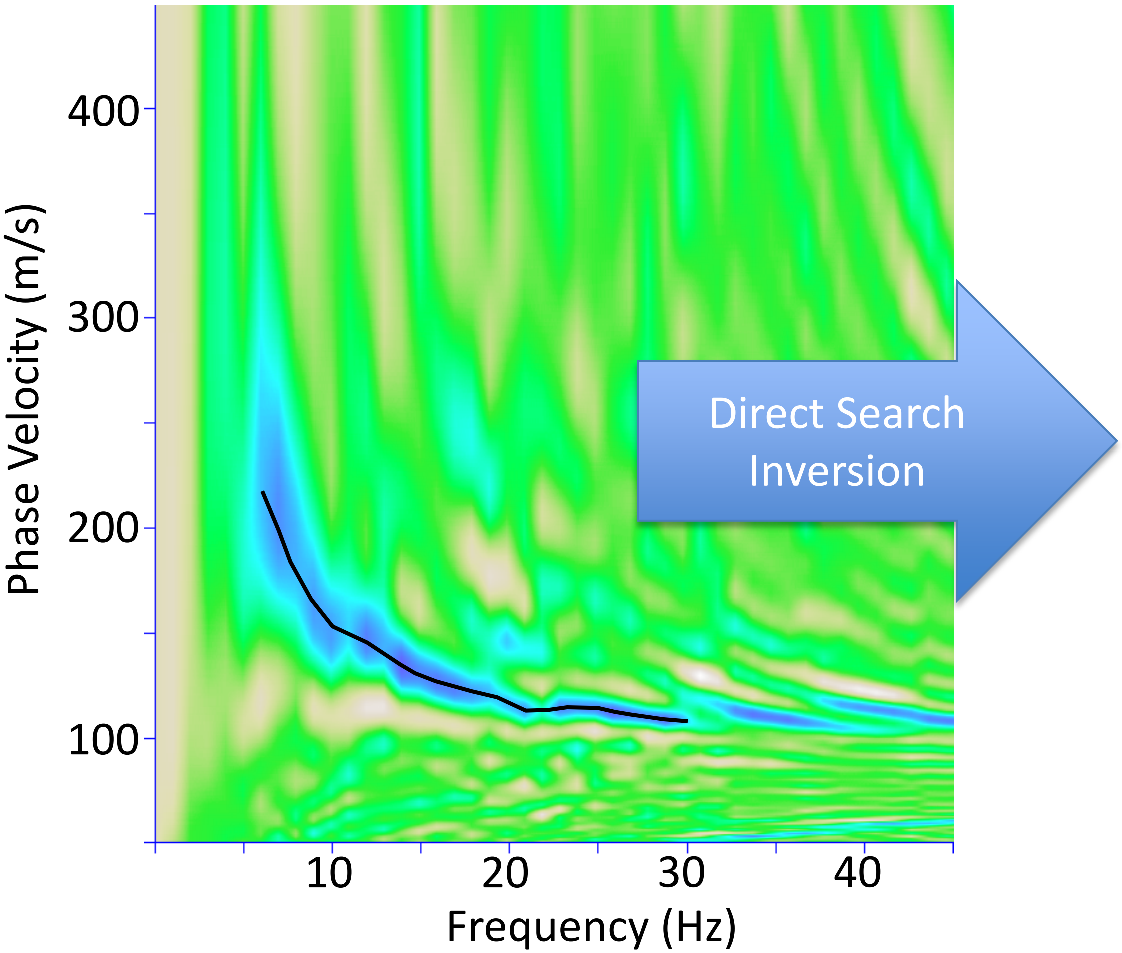
- Common Midpoint Cross Correlation
  - CMP located between receiver pairs
  - Improves lateral resolution



(Hayashi and Suzuki, 2004)

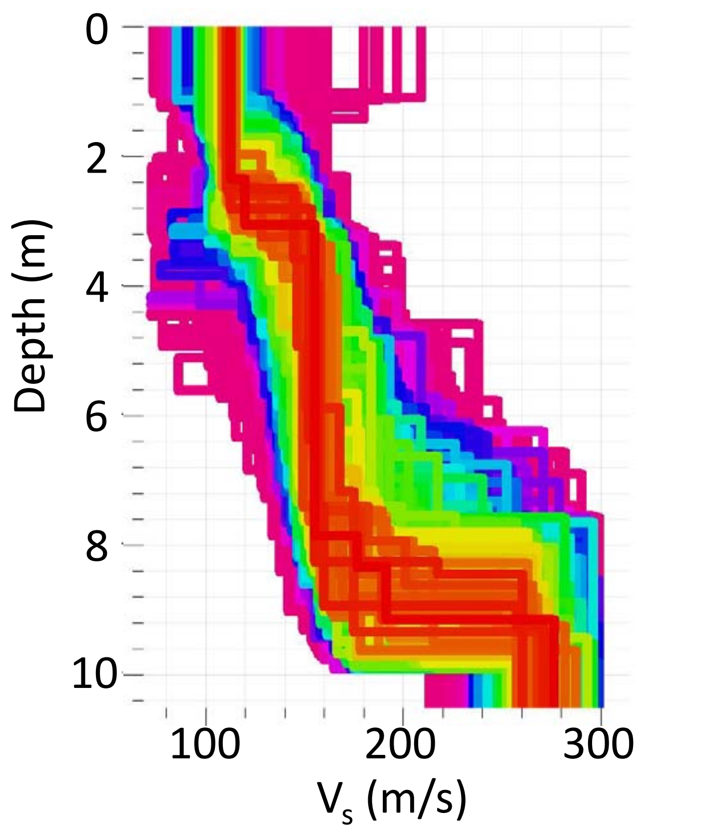
Shear Wave Velocity Processing

Dispersion Image: CMP= 171



(SeismicUnix using Park et al. 1999)

1-D V_s Profile



(Geopsy using Wathelet, 2004)

Conclusions

- Geophysical investigation can save time and cost by identifying low and high risk areas of a foundation study
- Soil type estimation picks up large geologic trends, such as the dipping Pine Island Beach Sand
- New model for Mississippi Delta distinguishes silt from clay and sand

Future Work & Recommendations

- Gather more geophysical data over existing geotechnical sites
  - Create best fit model from a coastal zone dataset
- Identify organic soils
- Compensate for changes in overburden pressure with depth

Acknowledgements

Coastal Protection and Restoration Authority
CPRA

Sea Grant
LOUISIANA

GEOMETRICS
Innovation • Experience • Results

LSU | College of Science
Department of Geology & Geophysics

Thank You

Physical Properties

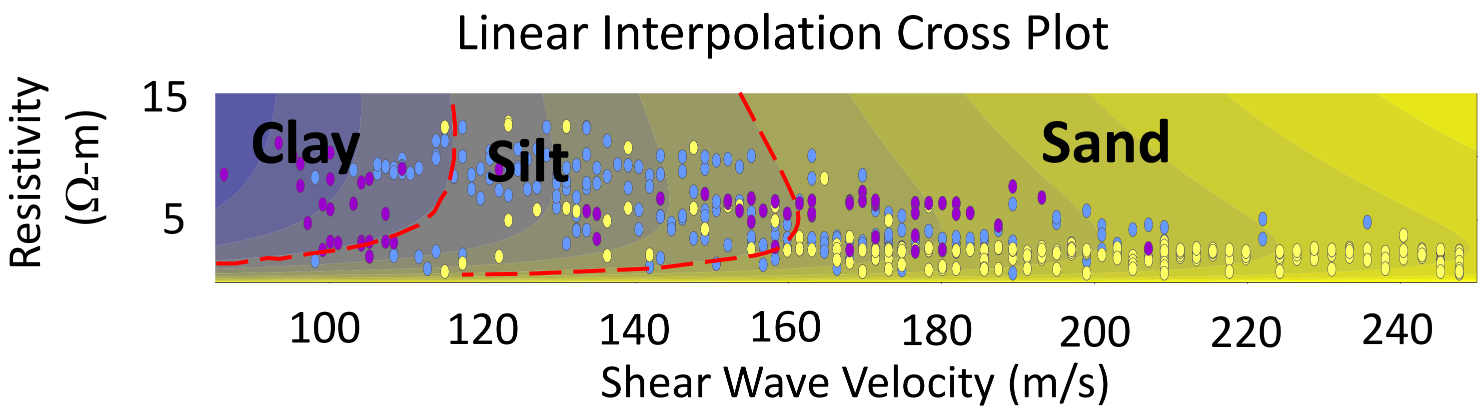
- Resistivity (Porosity, Fluid Saturation)

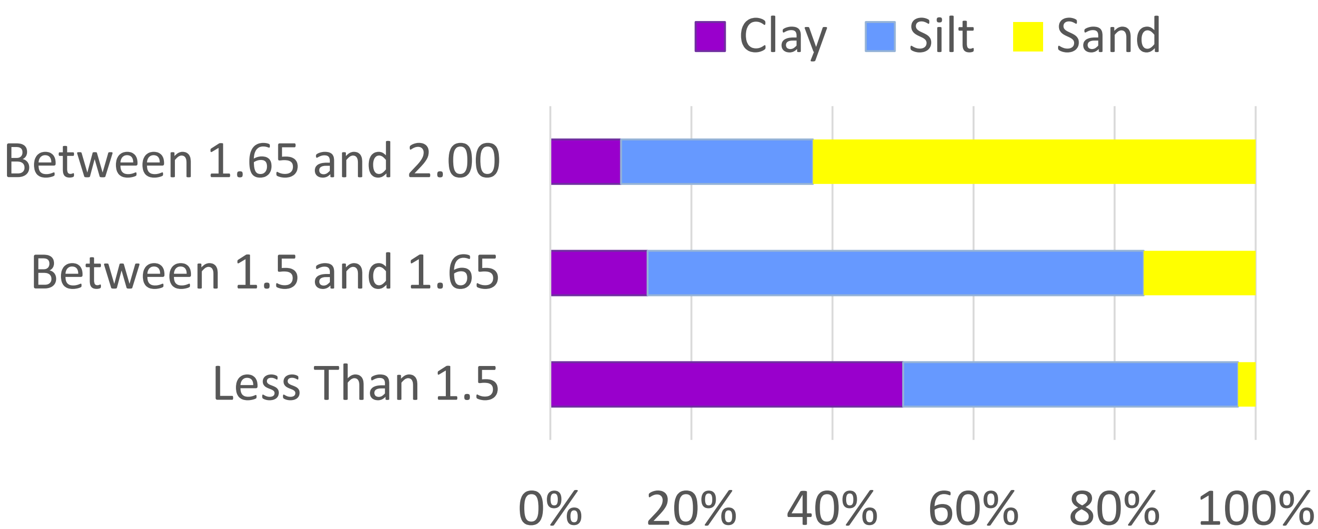
Resistive Soils	Conductive Soils
Silts	Clays
Unsaturated Sand	Saturated Sands

- Shear Wave Velocity (Stiffness, Density)

High Vs (>120 m/s)	Low Vs
Silts	Clays
Consolidated Sand	Unconsolidated Soils

Soil Type Distribution – Modified Model

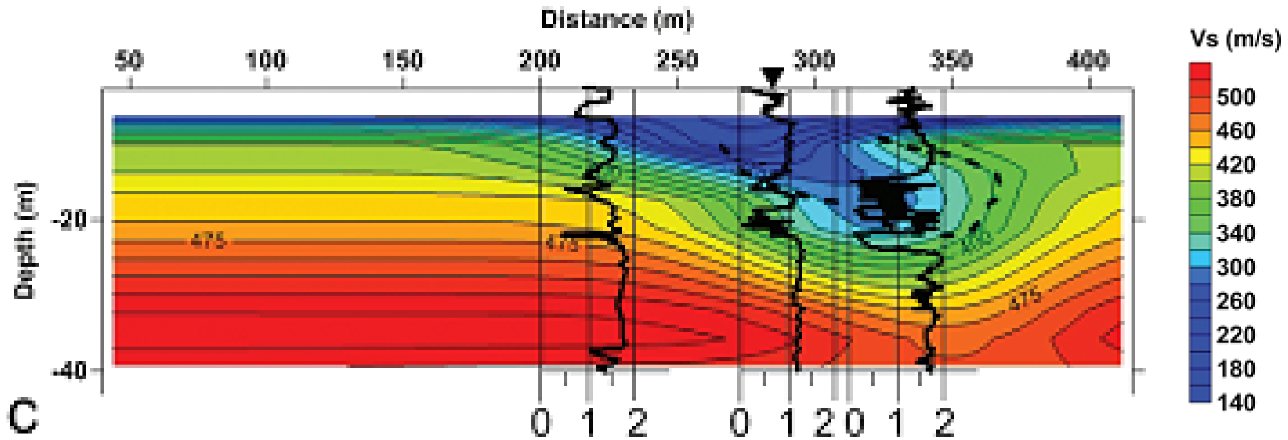




Expected Soil Type:
Sand
Silt
Clay

Applications of Geophysical Tests

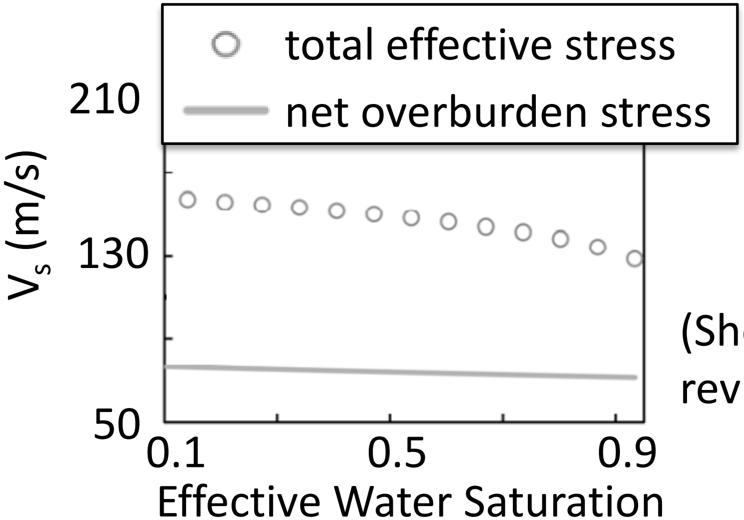
- Reconnaissance
  - Identify High Risk Areas
    - Lateral heterogeneity
    - Low Vs
- Calibrate
  - Existing geology



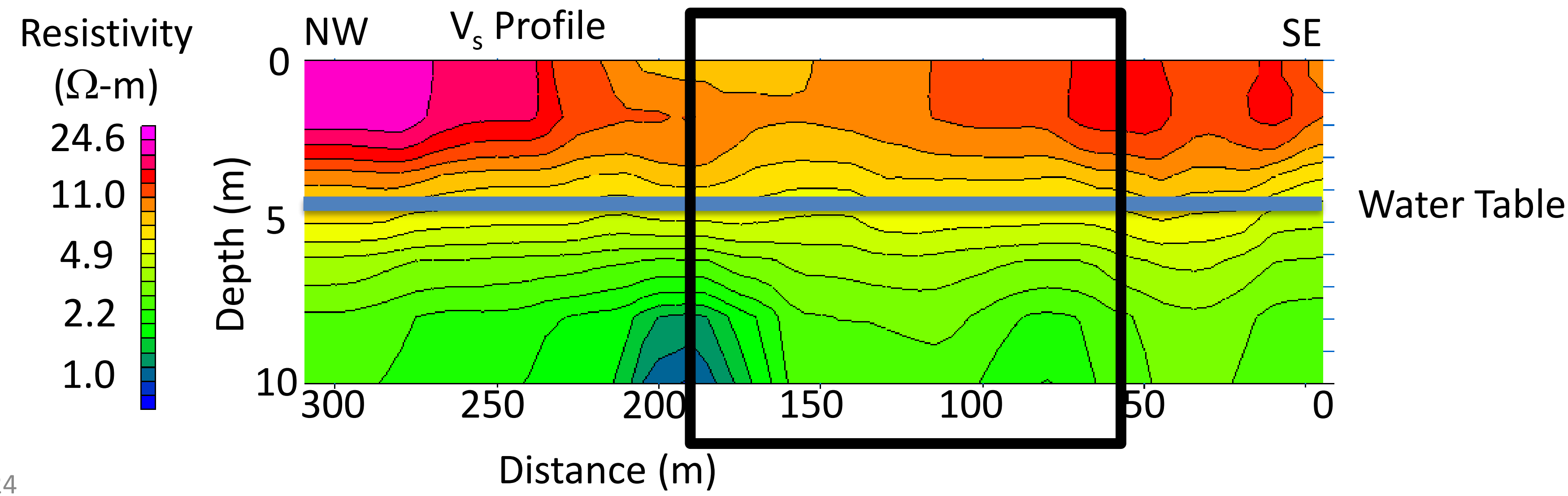
Samyn et al. (2013)

Resistivity Profile

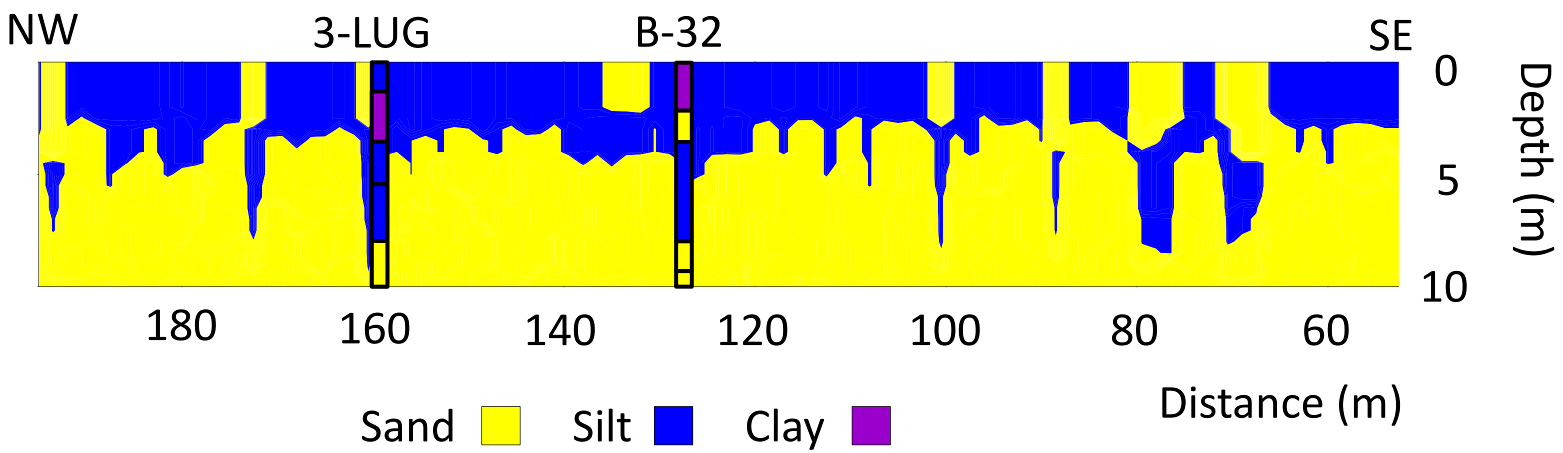
- Capacitively Coupled Resistivity
- Decrease resistivity with depth
    - Increasing saturation

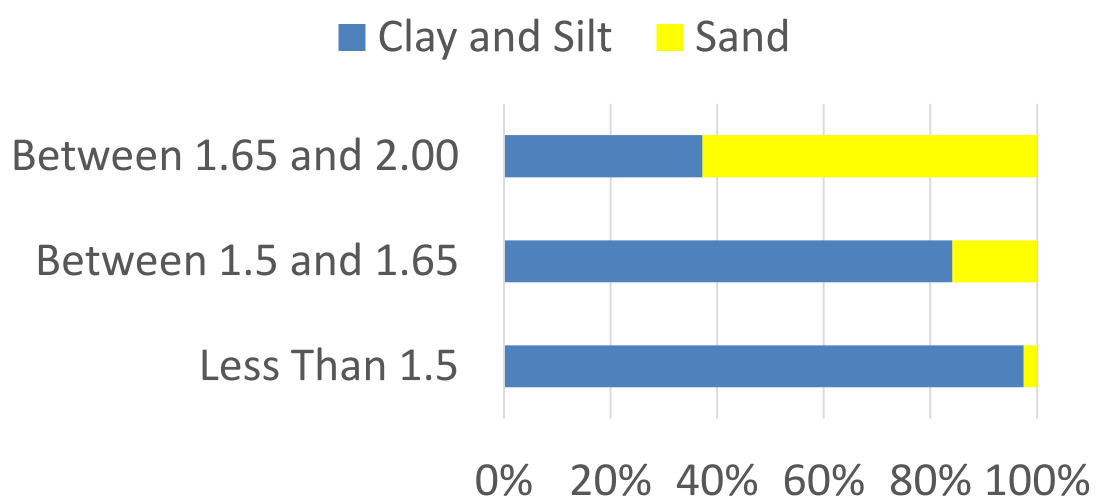


(Shen et al., in review)

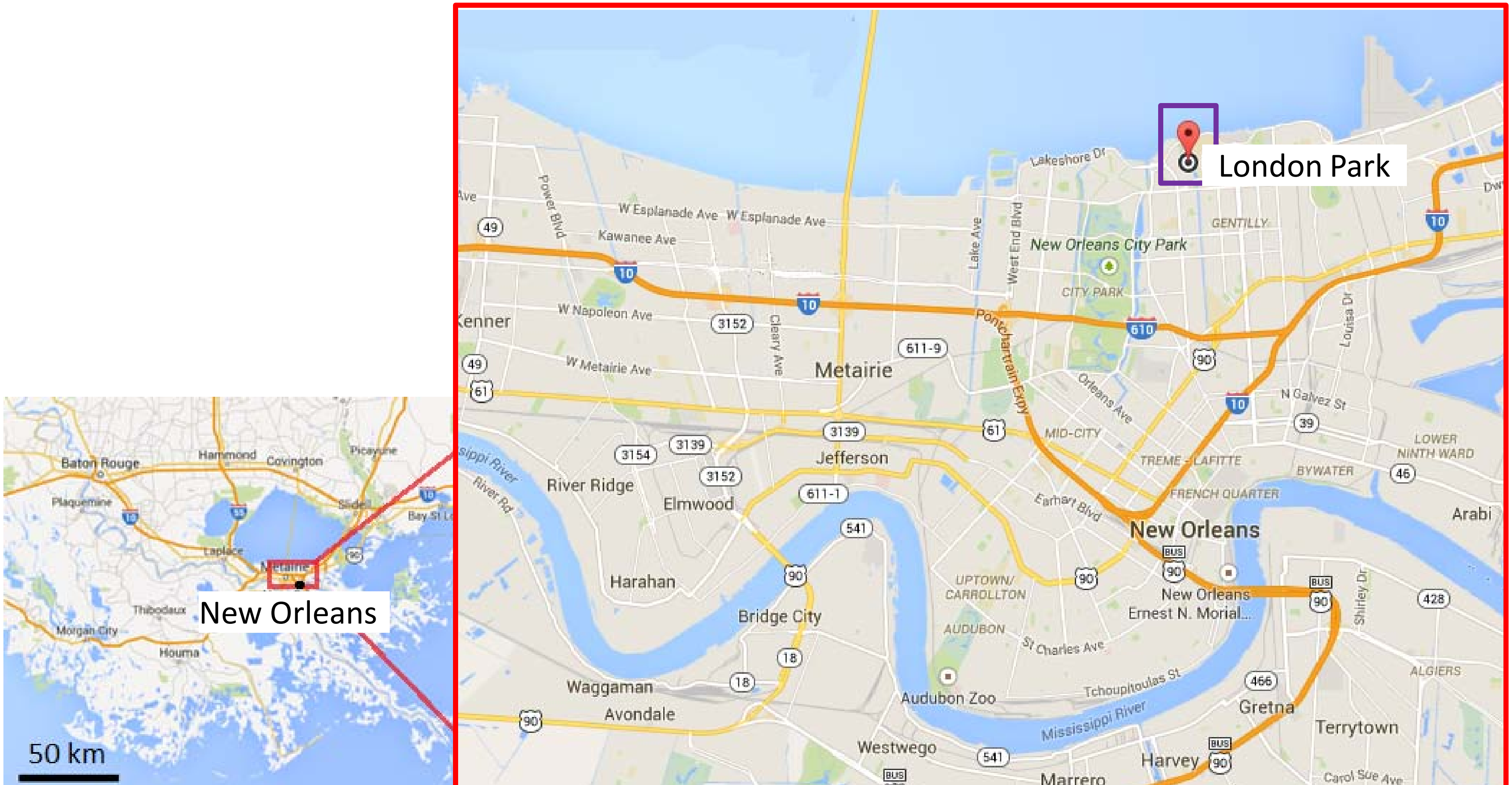


Original Model Statistics





London Park



London Park
New Orleans
50 km
Baton Rouge
Hammond
Covington
Metairie
Kenner
Jefferson
River Ridge
Elmwood
Harahan
Bridge City
Waggaman
Avondale
Westwego
Marrero
Harvey
Gretna
Terrytown
Arabi
New Orleans City Park
Audubon Zoo
Mississippi River