# *APPLICATION OF LABORATORY AND MODELING TOOLS TO DESIGN THIN LAYER PLACEMENT PROJECTS FOR MARSH NOURISHMENT*

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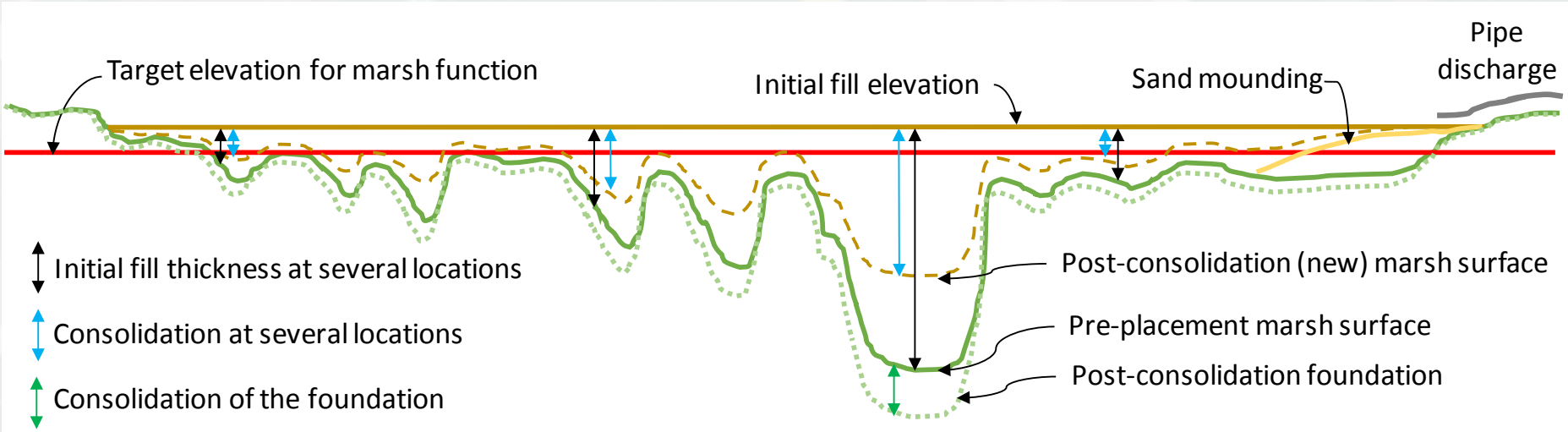
# Outline

- Thin Layer Placement Background
- Laboratory tests and numerical models
- Project and modeling specifics
- Analysis and Results
- Ongoing and future R&D

# Thin-Layer Placement

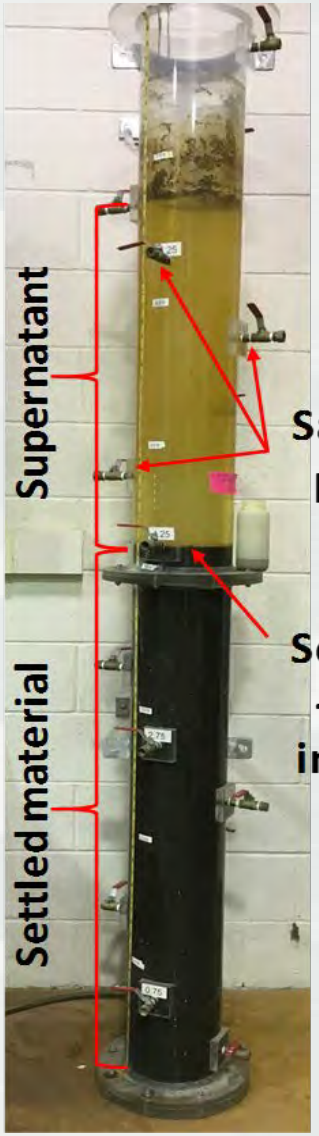
- Purposeful placement of thin layers of sediment (e.g., dredged material) in an environmentally acceptable manner to achieve a target elevation or thickness. Thin layer placement projects may include efforts to support infrastructure and/or create, maintain, enhance, or restore ecological function.
- Environmental enhancement objectives
  - Wetland (or marsh) nourishment
  - Counteract subsidence/sea level rise
  - Build “elevation capitol”
- Design of TLP operations
  - Need to know how much material to place in order to achieve target elevation
  - Understand dredged material behavior
    - Place as a slurry
    - Settling and Consolidation

# Conceptual Marsh Topography Changes as a Result of DM Placement and Consolidation




1. Existing (pre-placement) marsh surface (solid green line)
2. Place DM slurry to initial fill elevation (solid tan line)
3. Over time, the DM consolidates (dotted tan line)
4. Original marsh surface also consolidates (dotted green line) due to weight of placed DM

# Predicting Dredged Material Initial Behavior




## SETTLE

- Model originally designed for confined disposal facilities (CDFs).
- Models initial behavior during placement & dewatering
- Uses information from column settling test

# Predicting Dredged Material and Substrate Long Term Behavior

## PSDDF

**Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill**

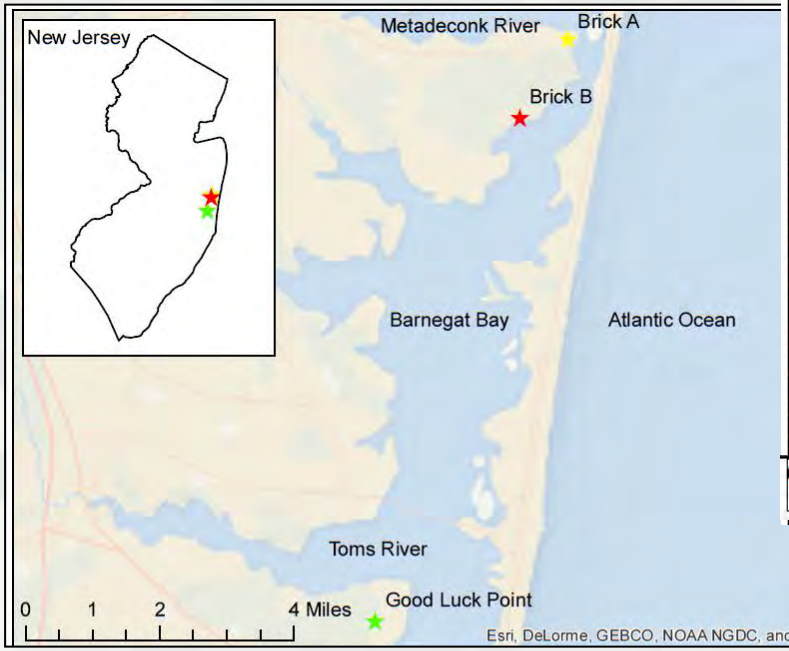
- Models longer term consolidation
- Uses data from laboratory consolidation tests
  - Self weight
  - Standard oedometer

- Models designed for CDFs.
- Currently evaluating model optimization to account for wetland processes.

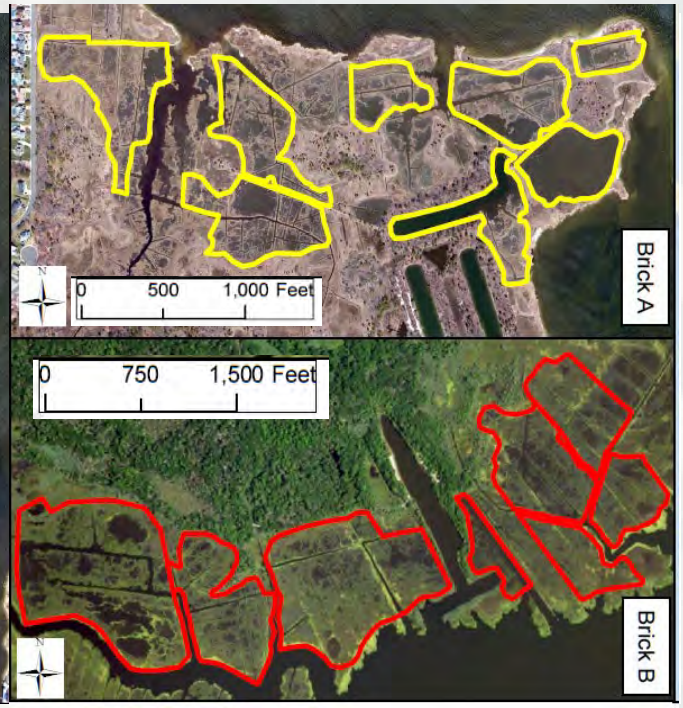
# Marsh Restoration Areas

Areas within Edwin B. Forsythe National Wildlife Refuge considered for marsh restoration via TLP:

- Good Luck Point
- Brick A
- Brick B








Multiple New Jersey Dept. of Transportation channels near each area to be dredged for marsh placement

# Dredged Material Evaluation

| | Good Luck Point | Kettle Creek (Brick B) | Beaver Dam Creek (Brick A) |
|---|---|---|---|
| Salinity, ppt | 21.05 | 20.24 | 22.42 |
| Total Solids, g/L | 615 | 393 | 432 |
| Water Content, % | 124 | 214 | 211 |
| Organic Matter, % | 5.4 | 13.4 | 24.0 |
| Estimated Sp. Gr. | 2.59 | 2.47 | 2.30 |
| **Grain size by volume** | | | |
| % Sand size | 54.4 | 26.1 | 19.2 |
| % Silt size | 36 | 55.1 | 65.8 |
| % Clay size | 9.6 | 18.8 | 15 |
| **Atterberg Limits** | | | |
| LL | | 127 | 264 |
| PL | | 52 | 128 |
| PI | | 75 | 136 |
| USCS Classification | SM | MH | OH |

*Believed to be organic, not sand*

# Column Settling Test

Kettle Creek and Good Luck Point – completed column settling tests

- 6 ft tall, 8-in diameter column
- Pour in DM slurry
- Record sediment-water interface over 15 days
- Sample supernatant for water quality data
- Use SETTLE model for data analysis

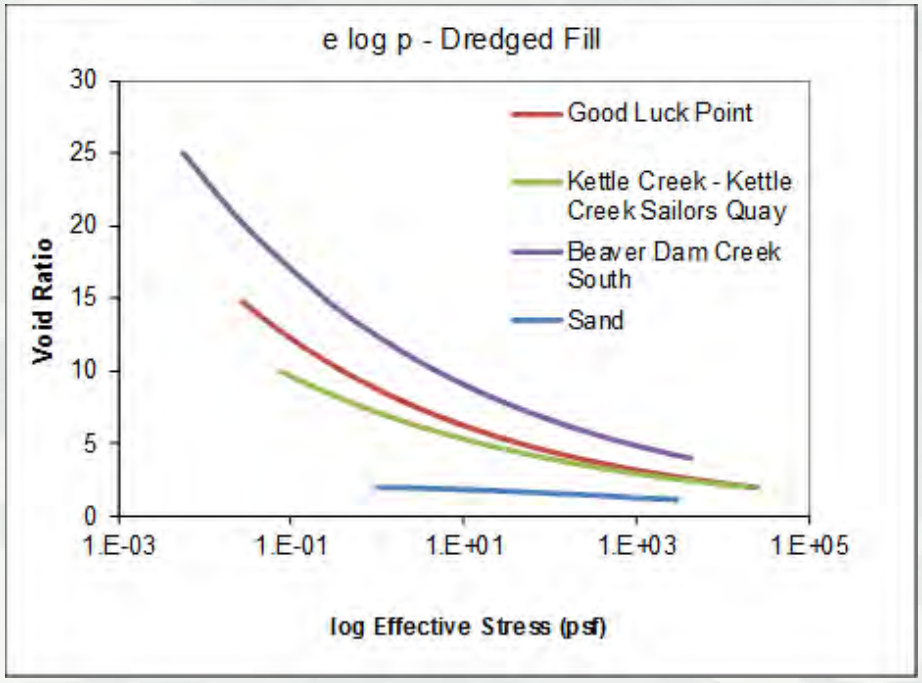
| | Good Luck Point | Kettle Creek | Beaver Dam Creek |
|---|---|---|---|
| Zone Settling Rate, cm/hr | 10.8 | 6.83 | 28.2 |
| Compression settling curve coefficients* $C = A\left(\frac{DTime}{2}\right)^{B}$ | A = 172.36<br>B = 0.1476 | A = 210.97<br>B = 0.0935 | A = 80.35<br>B = 0.1903 |

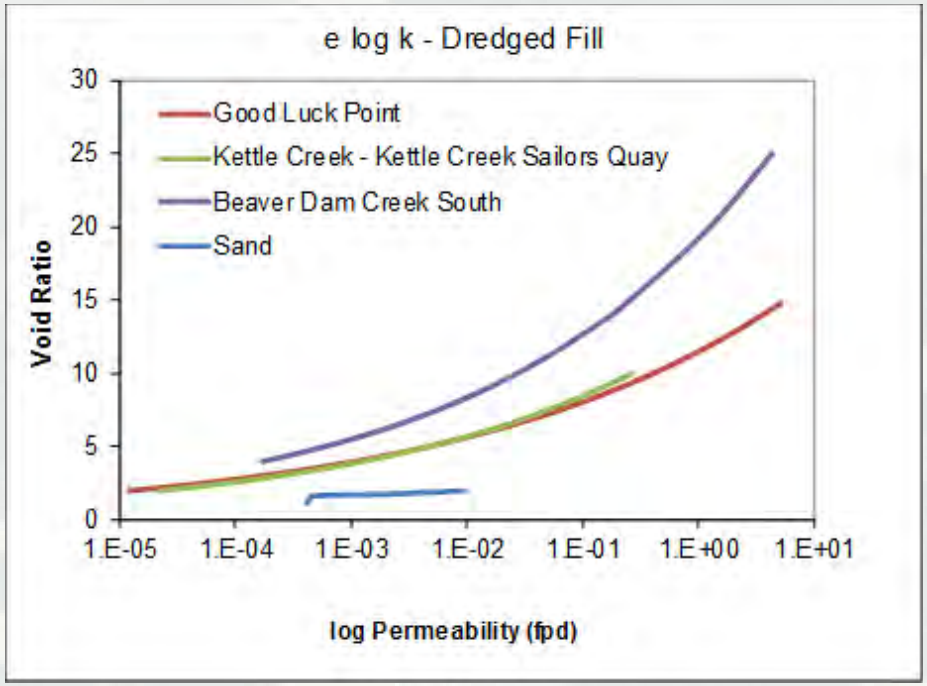
** C = concentration of fines at the end of placement (g/L), and DTIME = placement period (days)*

Information can be used to predict "bulking" ($V_{final}$ / $V_{in\ situ}$)

# Laboratory Consolidation Tests

- Generated from self-weight and standard oedometer consolidation tests



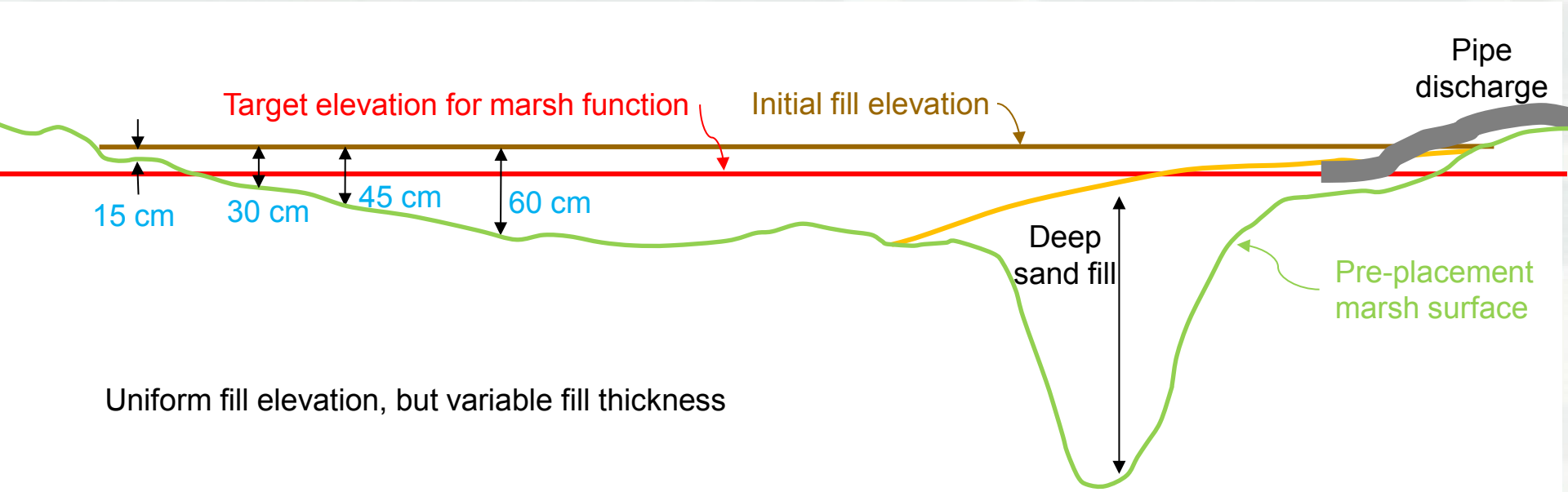



# Site Conditions and Target Elevations

| | Existing Elevation, ft | | Target Low Marsh Elevation, ft | Target High Marsh Elevation, ft |
|---|---|---|---|---|
| | Average | Lowest | | |
| Good Luck Point | 0.21 | -0.7 | 0.62 | |
| Brick A<br>- w/o ponds | -2.5<br>0.11 | -14.3<br>-0.4 | 0.44 | 0.77 |
| Brick B | 0.26 | -0.9 | 0.33 | 0.66 |

# Modeling Scenarios

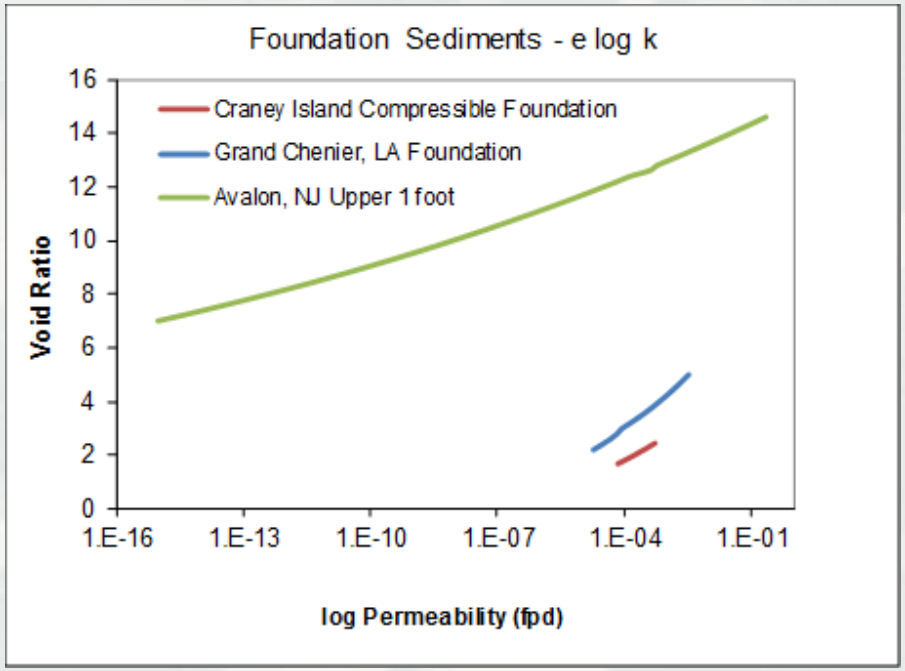
- Fines
  - One fill elevation, but four fill thicknesses 15 cm – 60 cm (0.5 ft – 2 ft)
- Sand
  - 1.5 m and 4.2 m (5 ft and 14 ft) fill thicknesses (deep ponds in Brick A)

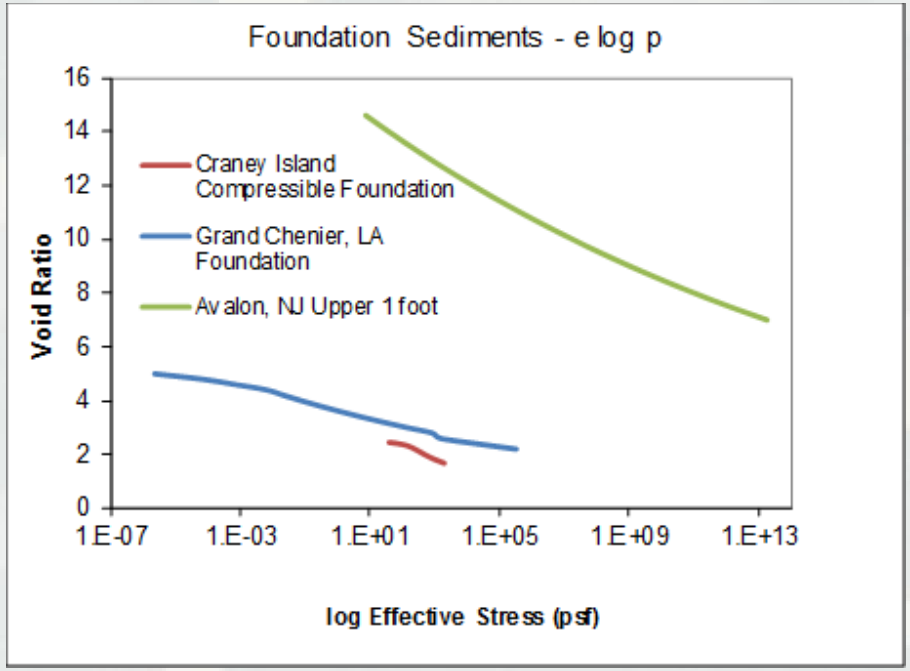


# Modeling – Output from SETTLE

| | Units | Good Luck Point | Brick B | Brick A |
|---|---|---|---|---|
| Estimated volume to fill to 30 cm elevation | $m^3$ | 14,783 | 64,496 | 104,362 |
| In situ dredging volume required | $m^3$ | 4,893 | 30,582 | 36,469 |
| Void ratio of fines at end of placement | v/v | 11.964 | 8.064 | 16.868 |
| Percent of volume occupied by sand | % | 14.9 | 6.6 | 0.5 |

# Foundation Consolidation

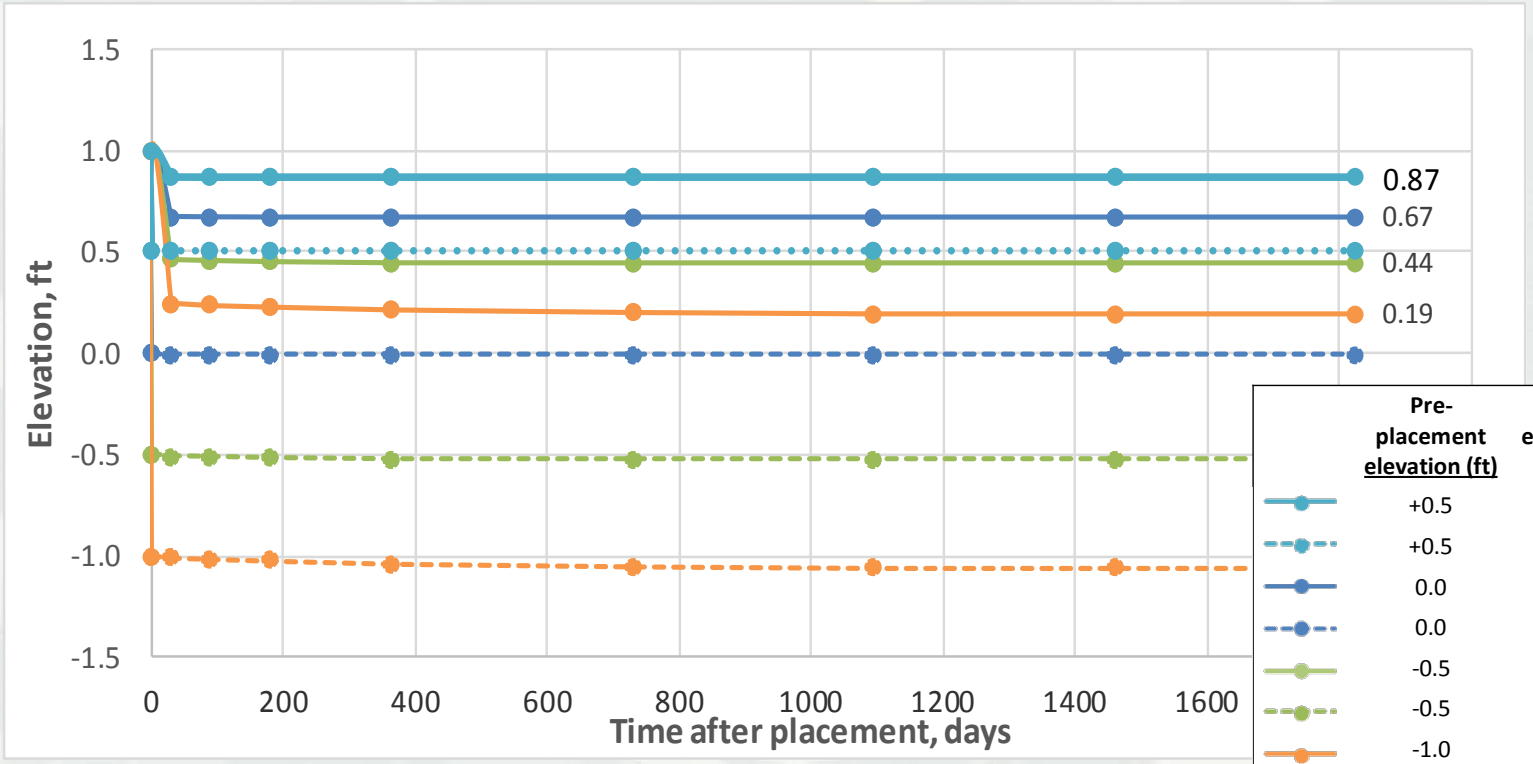



Foundation sediment was not sampled. Used several surrogate consolidation curves to evaluate potential compression of the foundation material.

# Results – Fines Consolidation

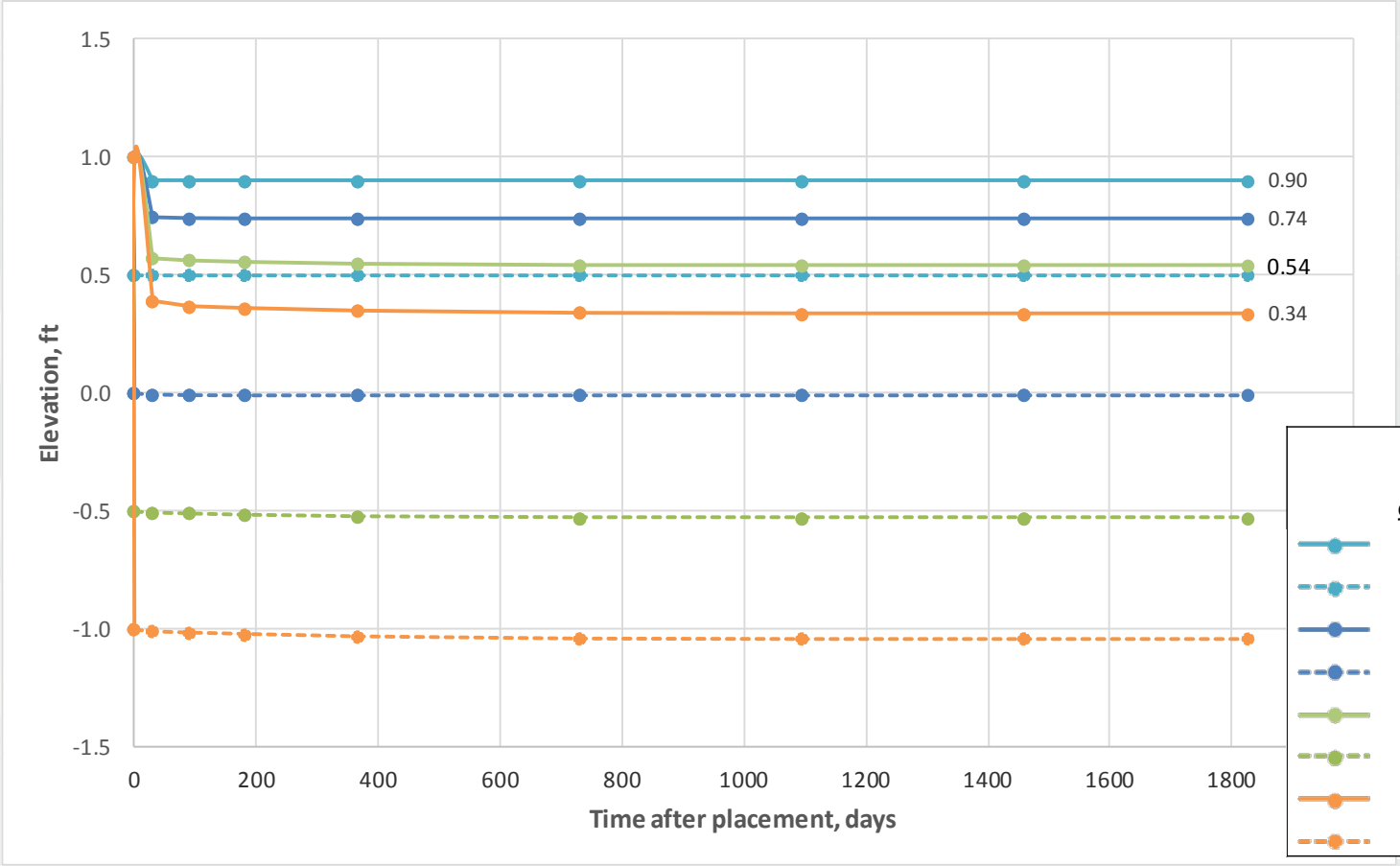
- Good Luck Point - material placed to +30 cm elevation (dotted lines = compressible foundation)




| | Pre-placement elevation (ft) | Fill elevation (ft) | Modeled surface |
|---|---|---|---|
| | +0.5 | 1.0 | Fill |
| | +0.5 | 1.0 | Foundation |
| | 0.0 | 1.0 | Fill |
| | 0.0 | 1.0 | Foundation |
| | -0.5 | 1.0 | Fill |
| | -0.5 | 1.0 | Foundation |
| | -1.0 | 1.0 | Fill |
| | -1.0 | 1.0 | Foundation |

# Results – Fines Consolidation

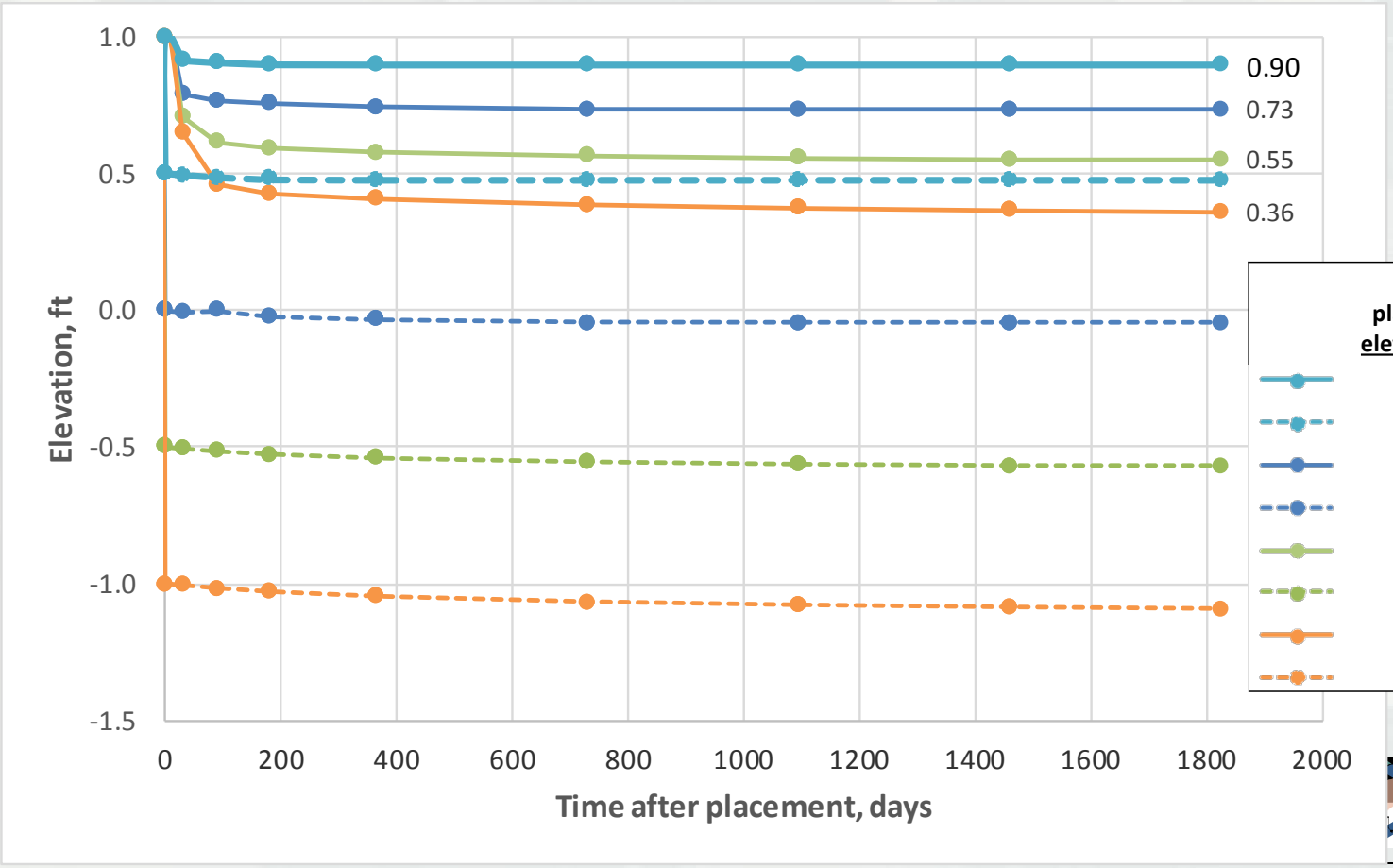
- Brick A – Beaver Dam Creek material placed to +30 cm elevation (dotted lines = compressible foundation)




| | Pre-placement elevation (ft) | Fill elevation (ft) | Modeled surface |
|---|---|---|---|
| | +0.5 | 1.0 | Fill |
| | +0.5 | 1.0 | Foundation |
| | 0.0 | 1.0 | Fill |
| | 0.0 | 1.0 | Foundation |
| | -0.5 | 1.0 | Fill |
| | -0.5 | 1.0 | Foundation |
| | -1.0 | 1.0 | Fill |
| | -1.0 | 1.0 | Foundation |

# Results – Fines Consolidation

- Brick B –Kettle Creek material placed to +30 cm elevation (dotted lines = compressible foundation)



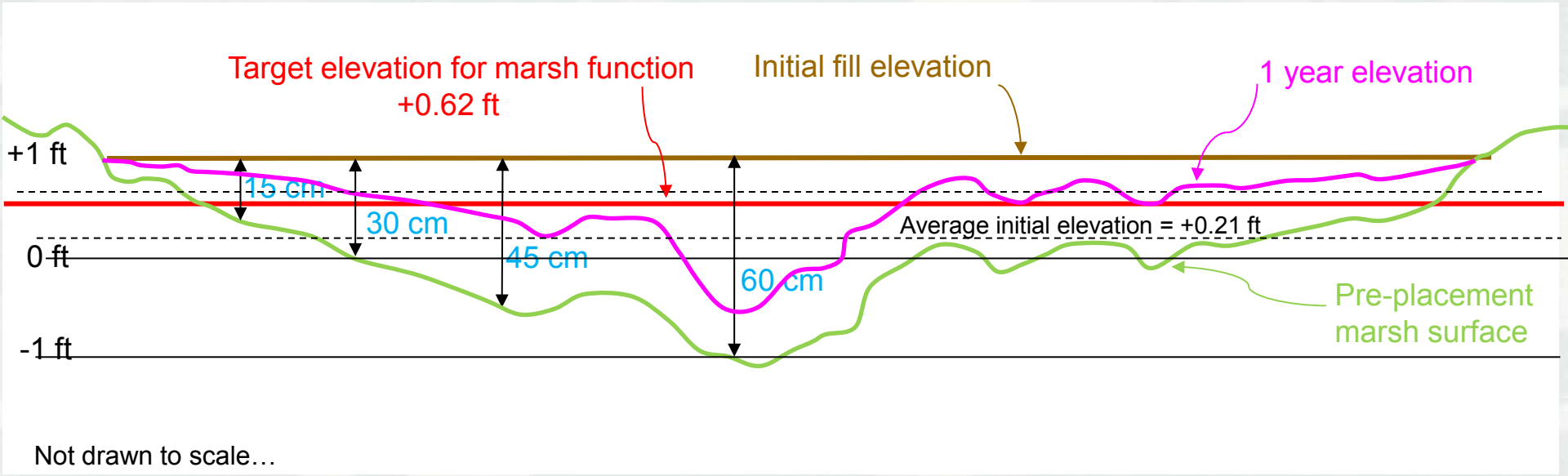

| | Pre-placement elevation (ft) | Fill elevation (ft) | Modeled surface |
|---|---|---|---|
| | +0.5 | 1.0 | Fill |
| | +0.5 | 1.0 | Foundation |
| | 0.0 | 1.0 | Fill |
| | 0.0 | 1.0 | Foundation |
| | -0.5 | 1.0 | Fill |
| | -0.5 | 1.0 | Foundation |
| | -1.0 | 1.0 | Fill |
| | -1.0 | 1.0 | Foundation |

# Results - Fines

| | Existing Elevation, ft | | Target Low Marsh Elevation, ft | Target High Marsh Elevation, ft | Elevation 1 year post-placement (ft) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average | Lowest | | | Average pre-placement elevation | -1.0 ft pre- | -0.5 ft pre- | 0.0 ft pre- | +0.5 ft pre- |
| Good Luck Point | 0.21 | -0.7 | 0.62 | | 0.75 | 0.21 | 0.45 | 0.67 | 0.87 |
| Brick A (BDC) - w/o ponds | -2.5<br>0.11 | -14.3<br>-0.4 | 0.44 | 0.77 | 0.78 | 0.35 | 0.55 | 0.74 | 0.90 |
| Brick B | 0.26 | -0.9 | 0.33 | 0.66 | 0.80 | 0.41 | 0.58 | 0.74 | 0.90 |

- Areas at the average elevation (at all 3 sites) will be above the target elevation if DM is placed to +1.0 ft. Thus, most of the site will be too high.
- It is not possible to achieve the target elevation across the entire site due to the variable topography.
- If the goal is to achieve the target elevation for the average site condition, then a lower fill elevation is needed.
- Additional modeling should be performed.

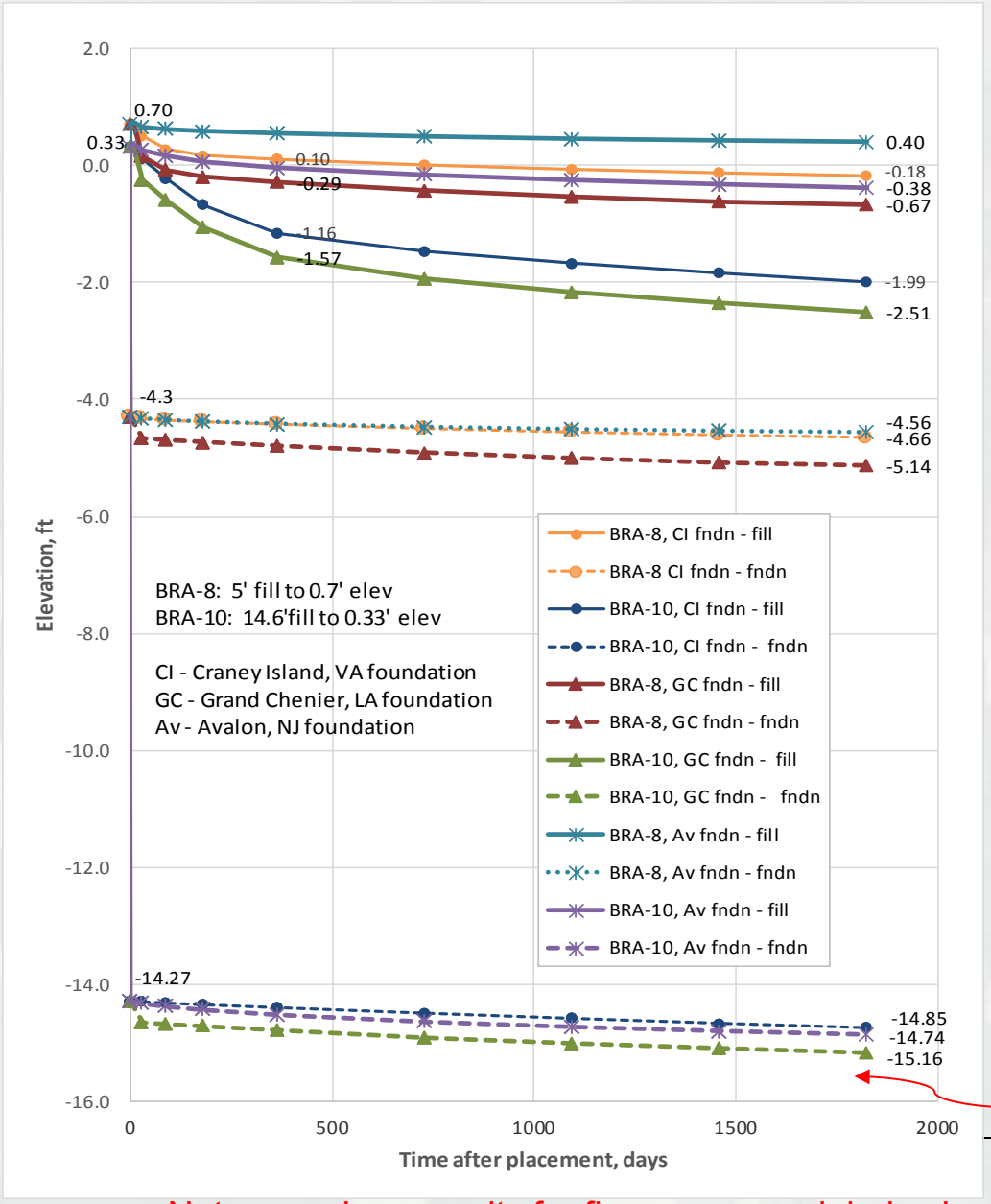
# Illustration of Results – Good Luck Point




Not drawn to scale…

| Pre-placement elevation | Average (+0.21 ft) | -1.0 ft | -0.5 ft | 0.0 ft | +0.5 ft |
|---|---|---|---|---|---|
| 1 year elevation | 0.75 | 0.21 | 0.45 | 0.67 | 0.87 |

# Results – Sand Consolidation




3 Compressible foundation materials modeled for each pond:

- Craney Island, VA (CI)
- Grand Chenier, LA (GC)
- Avalon, NJ (Av)

Pond in BRA-8

- Initial elevation -4.3 ft
- Fill to target elevation +0.7
- Foundation consolidated 0.26 – 0.84 ft (after 5 years)

Pond in BRA-10

- Initial elevation -14.27 ft
- Fill to target elevation +0.33
- Foundation consolidated 0.58 – 0.89 ft (after 5 years)

Note these curves have not flattened out, thus additional consolidation is expected to occur beyond 5 years



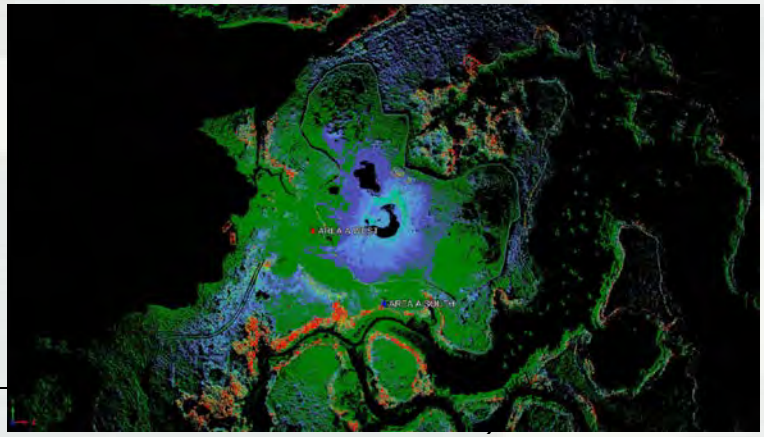
Note: previous results for fines were modeled using Craney Island foundation

# Analysis Conclusions

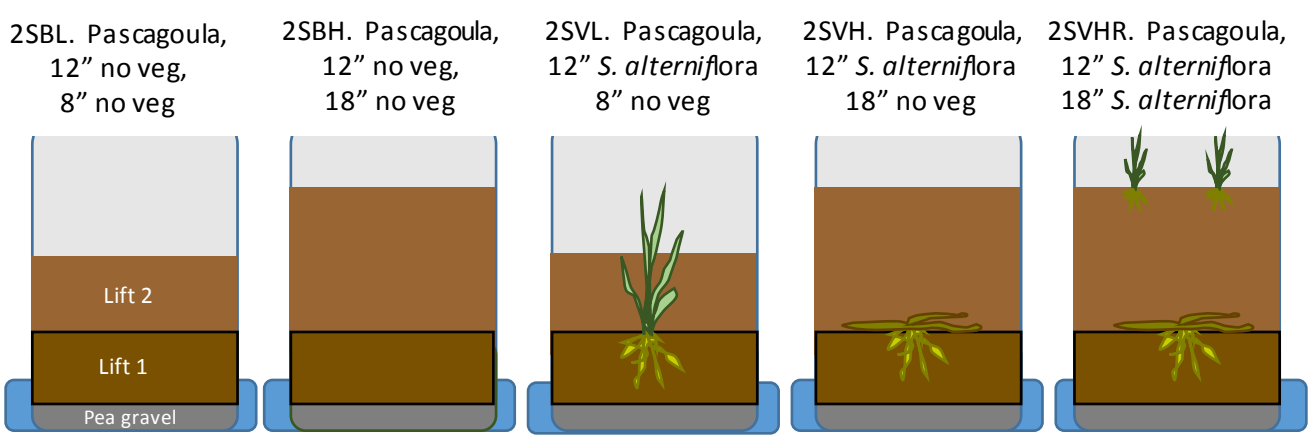
- Fill to +30 cm was too high to achieve target elevations (for both high and low marsh target elevations)
  - Need to avoid high elevations that allow invasives (*Phragmites australis*) to establish
  - Additional modeling could be done to optimize the fill elevations to reach target elevation across majority of the site.
- Consolidation behavior variable between the different materials
- Use of surrogate consolidation curves for foundation provided a range of possible compression of the existing marsh foundation
- Longer term modeling could be done to determine the extent of consolidation beyond 5 years.
- Application of the model to design for thin layer placement was demonstrated. However, research is being conducted to optimize use of the models for wetland processes.

# R&D Aspects

# Ongoing R&D

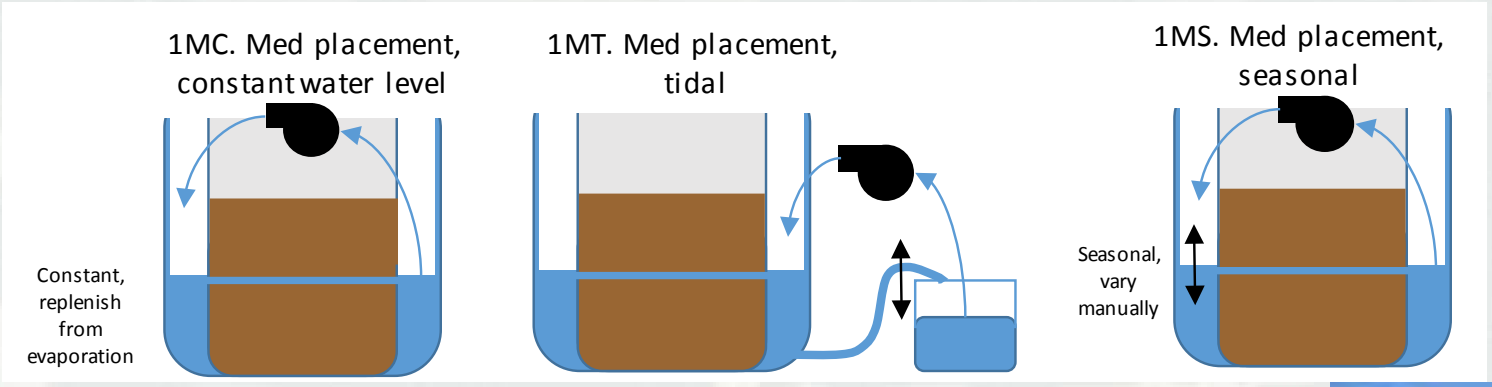


# Lab study setup




**Impacts of vegetation:**

- Place lift of DM.
- Plant 3 of the containers.
- Measure consolidation over time.
- After plants mature, add another lift
- At two lift thicknesses. Replant one.
- Continue to measure consolidation.




**Impacts of variable water table:**

- Place lift of DM.
- Subject to 3 water table conditions:
  - Constant
  - Tidally varying
  - Seasonally varying
- Use 3 separate DM thicknesses, two reps of each.

# QUESTIONS?