High Fines Content Beach Placement Project Case Studies Florida and Texas

Empirical Formula to Estimate Borrow Sediment Ultimate Capability

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US Army Corps Galveston
Branch Chief H&H
9 Feb 2018

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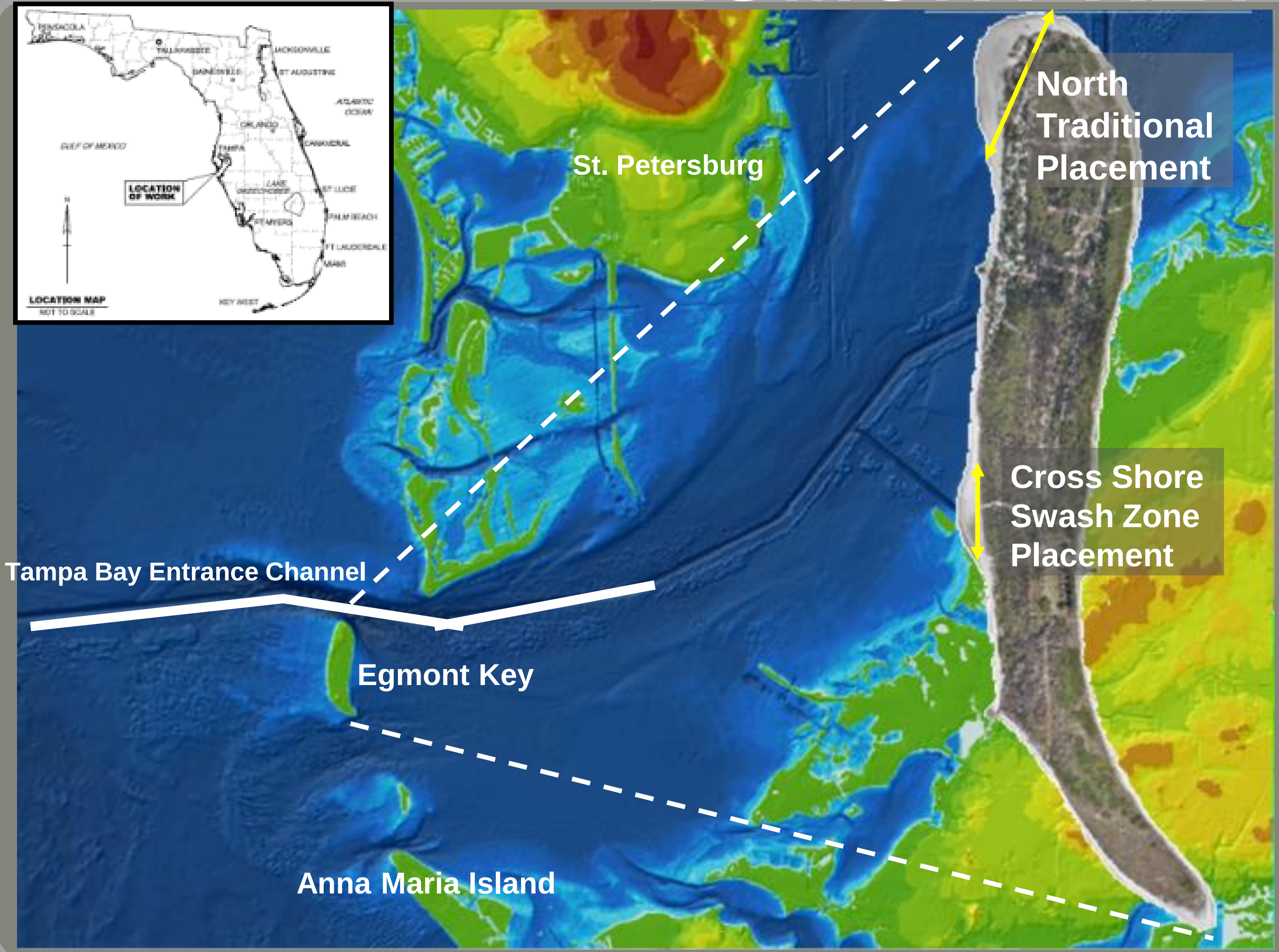
EGMONT KEY 2014/5



- Two placements
  - 320K CY placed
  - 107 CY placed
- +20% passing 230
- Sediment monitoring
  - Grain Size
  - Color
  - Compaction

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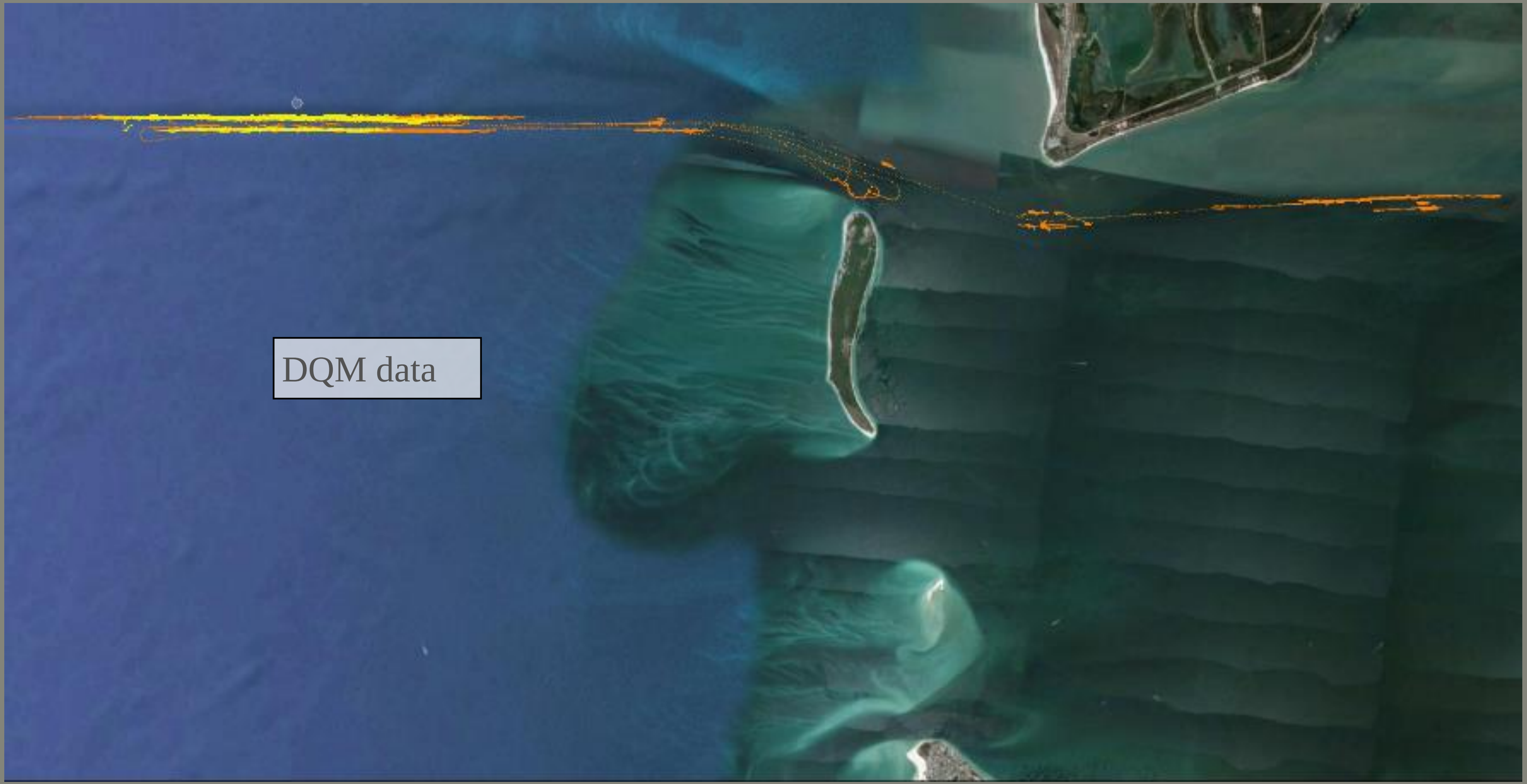
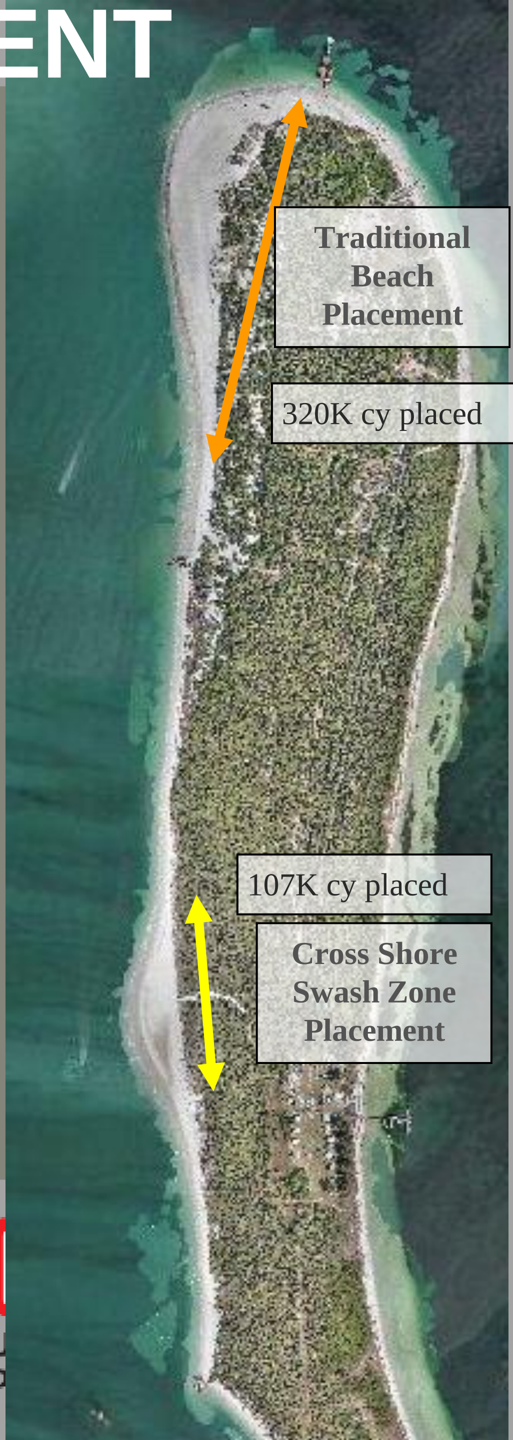
2014/5 DREDGING AND PLACEMENT



UAV flight aerial 16 March 2015



FINES CONTENT

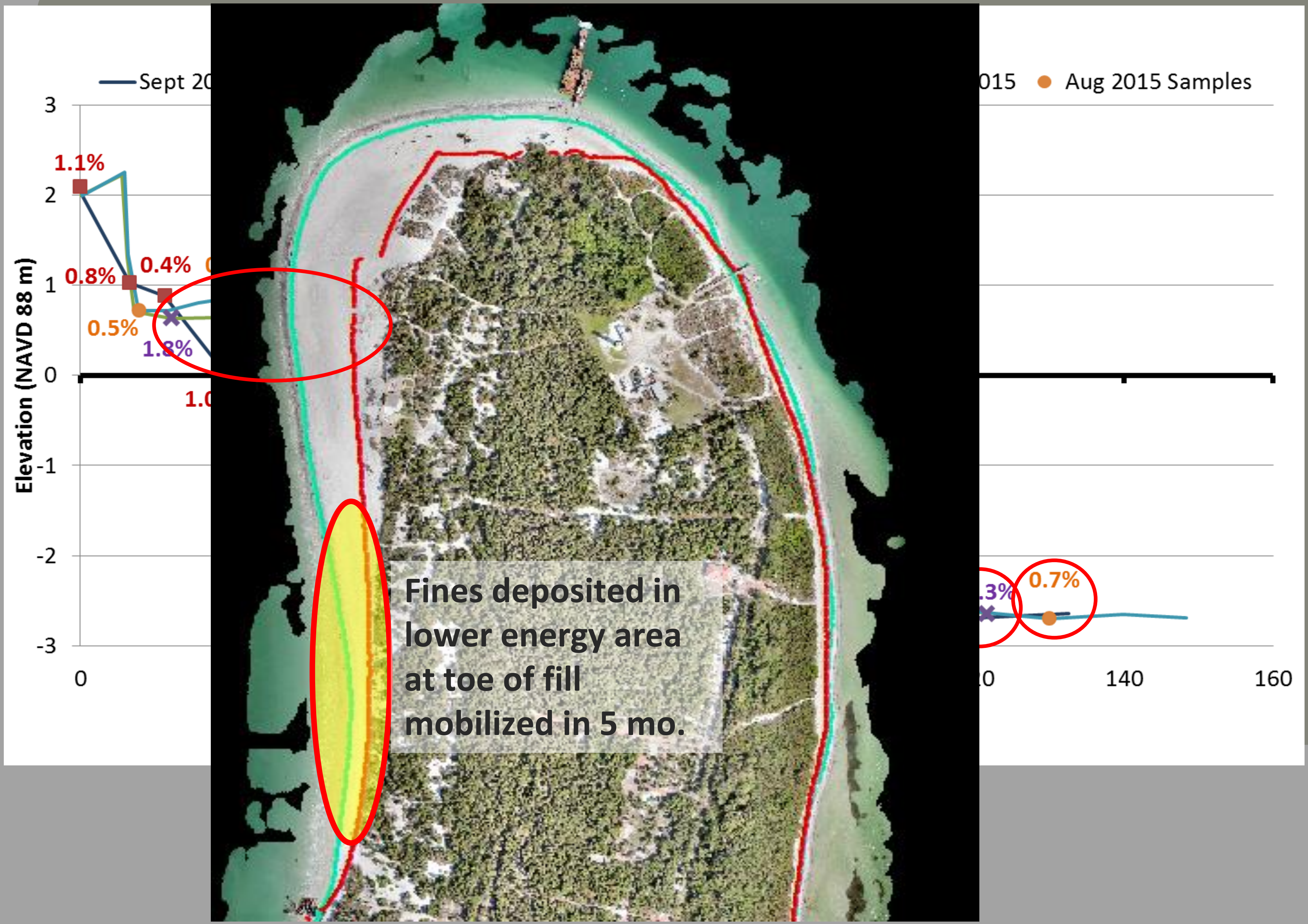
Tampa Harbor MD - Egmont Key 2014		
	# of Samples	Avg. % by wt. passing 230 sieve
In-situ avg.	80	20.7
In-situ Traditional	45	20*
In-situ CSSZ	35	24*
Pre-Beach	**6**	**0.03**
Post-Dredged avg.	21	0.51**
Post Traditional	14	0.52**
Post CSSZ	7	0.49**

Images Courtesy of GLDD

* Based on DQM and core boring data

**Sampling occurred within 72 hours of placement completion

WHERE DID THE FINES GO?



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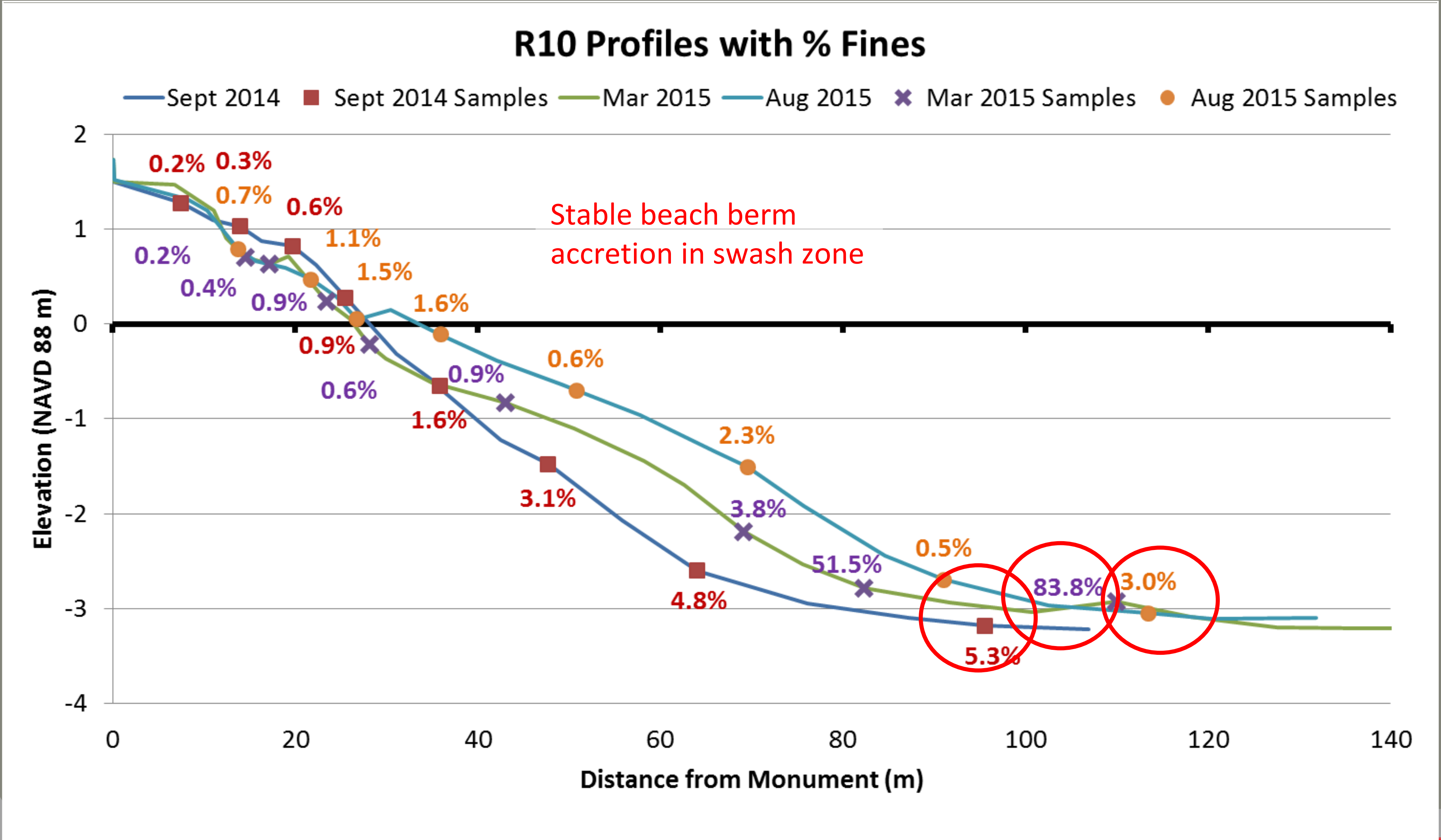
CCSZ PLACED FINES?



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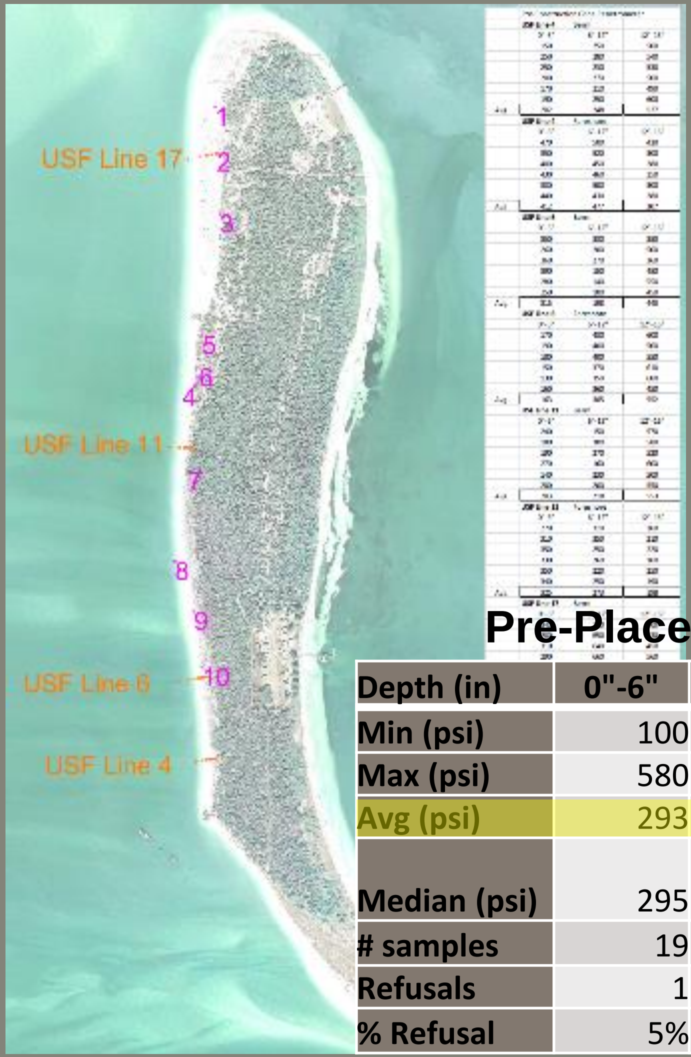
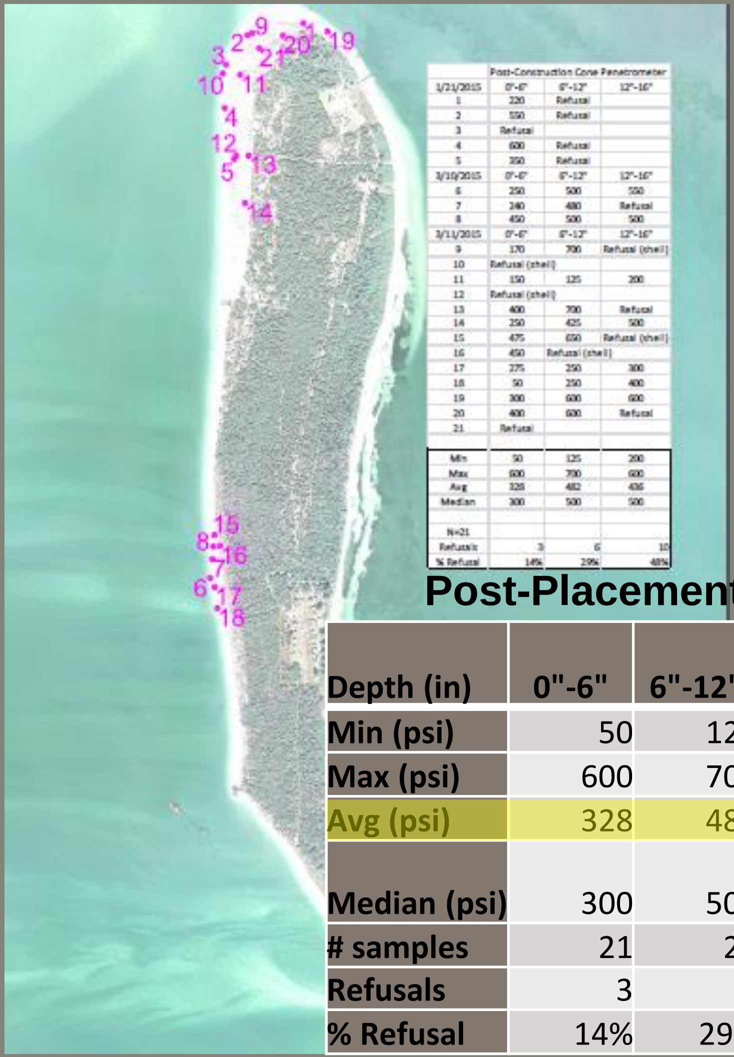
WHAT ABOUT COMPACTION?



Cone Penetrometer

Pre-Placement

Depth (in)	0"-6"	6"-12"	12"-18"
Min (psi)	100	100	198
Max (psi)	580	700	617
Avg (psi)	293	406	457
Median (psi)	295	431	515
# samples	19	19	19
Refusals	1	4	5
% Refusal	5%	21%	26%



Post-Placement

Depth (in)	0"-6"	6"-12"	12"-18"
Min (psi)	50	125	200
Max (psi)	600	700	600
Avg (psi)	328	482	436
Median (psi)	300	500	500
# samples	21	21	21
Refusals	3	6	10
% Refusal	14%	29%	48%

- Increase in refusals due to shell hash areas

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WHAT ABOUT COLOR?

Tampa Harbor MD - Egmont Key 2014		
	# of Samples	Value avg.
In-situ	80	4.36*
pre-Beach	13	5.9
post-Dredged	24	5.3
Traditional	16	5.0
CSSZ	8	5.9

*Measurements made with chart. Munsell color value<5 unacceptable for beach placement in Florida

NOTES: Triplicate measurements of hue, value, and chroma were collected from three areas on each moist sand sample using a digital colorimeter (CR-400, Konica Minolta, Osaka, Japan).

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GALVESTON BENEFICIAL USE 2015/6

- Galveston Channel: 9.7%-99.5% fines
- Average: 38.1% fines
- Post-fill: 1.14% fines
- Minimal longitudinal dike used to capture placed materials basically CSSZ placement

Beach Pump out

Dredge Material entering the Hopper

94 samples collected on the dredge Terrapin Island – 2 loads

- 35 Inflow
- 59 overflow

330 samples collected at the beach over 3 months by GLDD

- Discharge slurry
- Carrier water
- Beach berm

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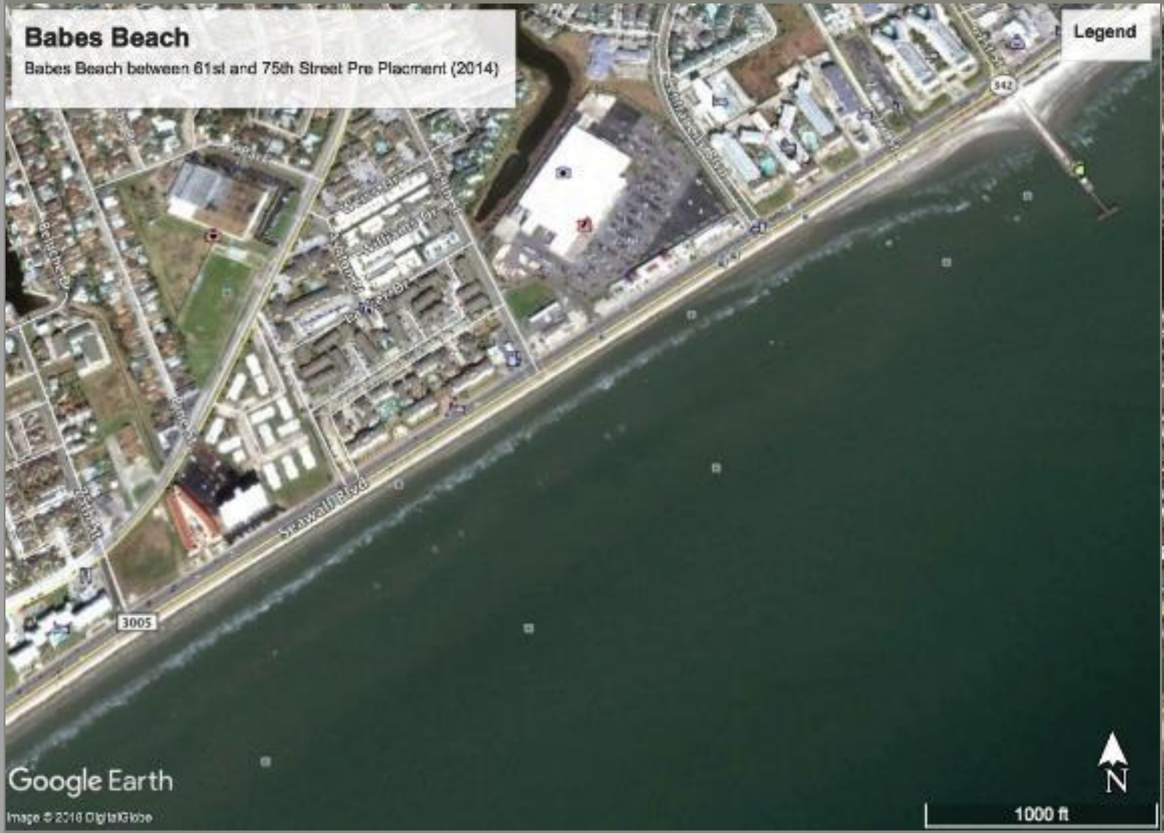
BABE’S BEACH 2015/6

January 2014



January 2017 ~ 1yr Post Placement

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BABE'S BEACH 2015/6

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GALVESTON BENEFICIAL USE 2015/6

Post Placement Survey showing Elevation change immediately following the conclusion of the project

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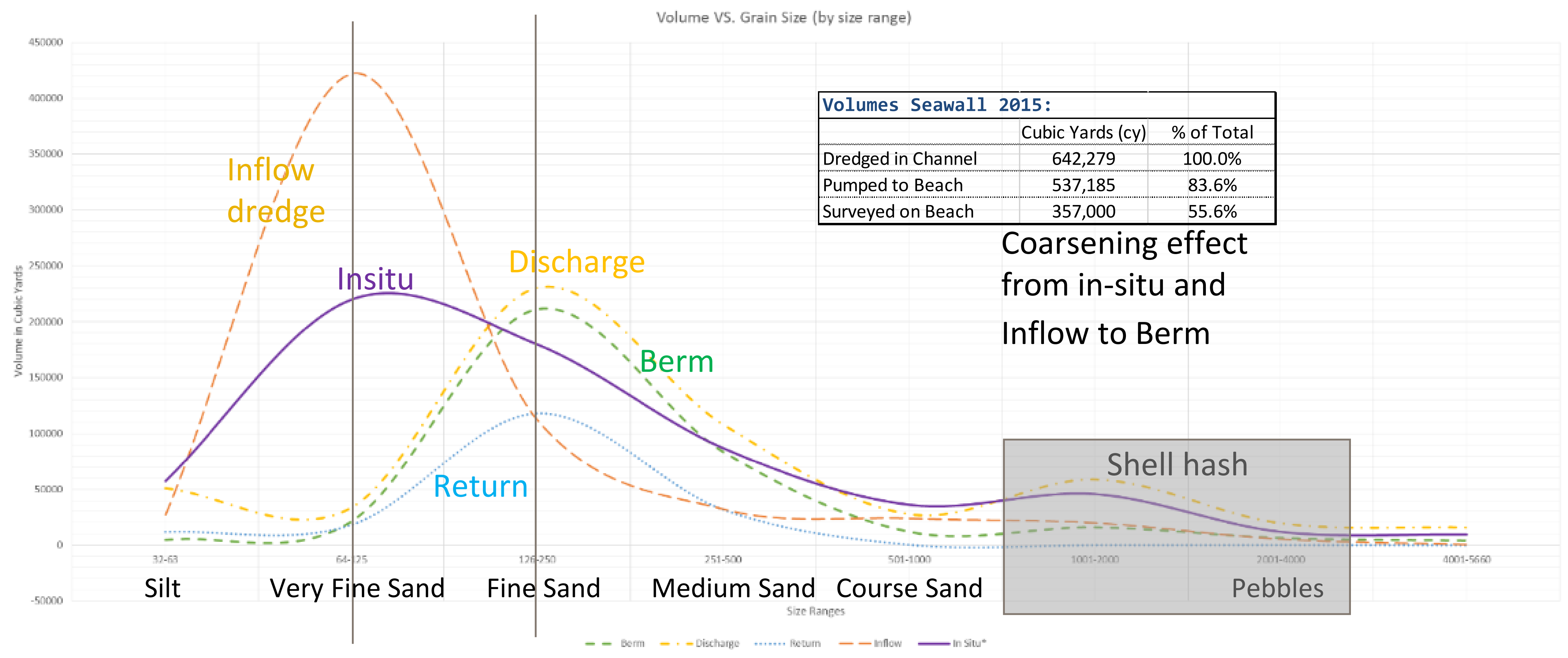
GALVESTON BENEFICIAL USE 2015/6



Volumes Seawall 2015:		
	Cubic Yards (cy)	% of Total
Dredged in Channel	642,279	100.0%
Pumped to Beach	537,185	83.6%
Surveyed on Beach	357,000	55.6%

Coarsening effect from in-situ and Inflow to Berm

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CONE PENETROMETER DATA

Pre-Fill

Depth in inches	0-6”	6-12”
Min (PSI)	350	400
Max (PSI)	600	650
Avg (PSI)	475	525
Median	475	525
# of Samples	6	6
Refusals	0	2
% Refusals	0%	33%

Post Fill

Depth in inches	0-6”	6-12”	12-18”
Min (PSI)	100	400	450
Max (PSI)	600	750	700
Avg (PSI)	386.11	538.46	590
Median	350	575	575
# of Samples	21	23	9
Refusals	3	5	4
% Refusals	14%	22%	44%

Post Fill that has been reworked in the swash

Depth in inches	0-6”	6-12”	12-18”
Min (PSI)	400	550	600
Max (PSI)	450	600	700
Avg (PSI)	425	575	650
Median	425	575	650
# of Samples	2	2	2
Refusals	0	0	0
% Refusals	0%	0%	0%

WHAT ABOUT THE COLOR?

	Hue	Value	Chroma
Inflow Grab Sample	2.25	3.28	1.52
Overflow Grab Sample	2.46	3.02	1.59
Pre-Fill Berm/Swash/Dune	17.61	3.96	1.63
Post Fill Berm/Swash/Dune	5.18	4.15	1.77
Total Change	2.93	0.87	0.25

- Because 71% of insitu sediment is quartz sand
- project experienced lightening effect and color change
- due to the loss of fines during the dredging and placement process.

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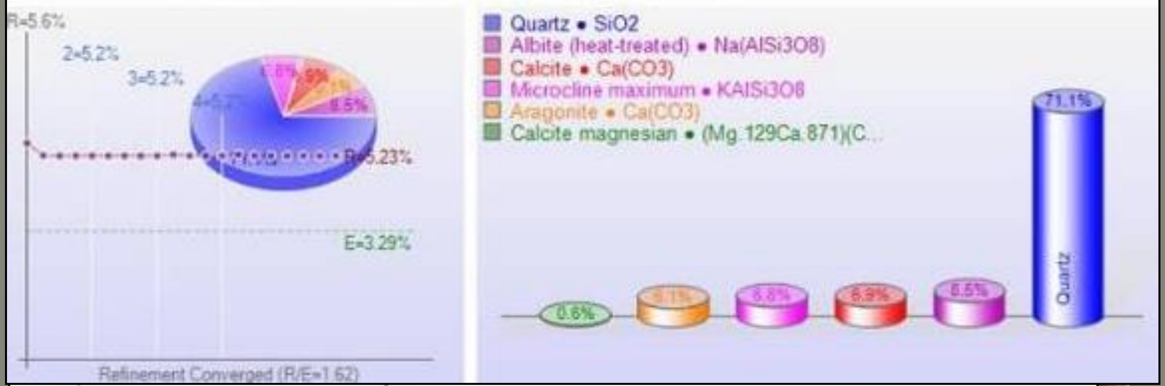
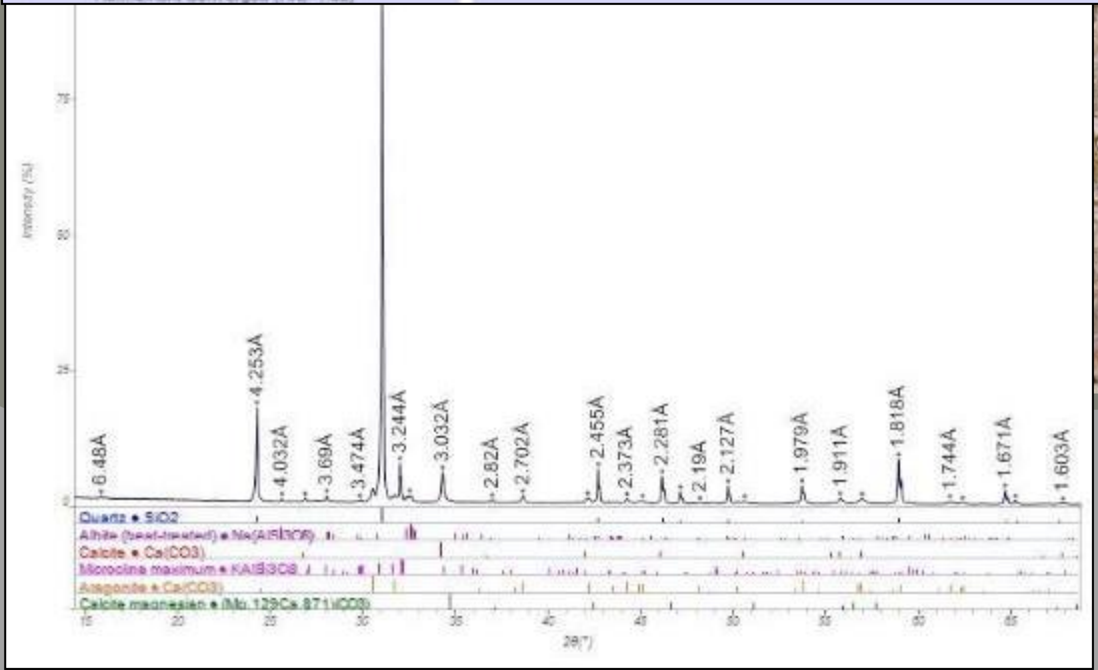
GALVESTON, TX 2016

Phase ID (6)	Chemical Formula	PDF-#	NA	NR	NP	Wt% (esd)	RIR
Albite (heat-treated)	Na(AlSi3O8)	01-089-6429	---	114	4	8.5 (0.2)	0.64
Aragonite	Ca(CO3)	01-075-2230	---	33	[illegible]	6.1 [illegible]	[illegible]
Calcite	Ca(CO3)	01-083-0577	---	12	8	[illegible]9 (0.1)	[illegible]
Calcite magnesian	(Mg.129Ca.871)(CO3)	01-086-2336	---	12	3	0.6 (0.1)	2.94
Microcline maximum	KAlSi3O8	01-076-0918	---	113	12	6.8 (0.1)	0.60
Quartz	SiO2	01-085-0794	---	12	11	71.1 (0.3)	3.11

XRF(Wt%): CaO=7.6%, K2O=1.1%, SiO2=81.3%, Al2O3=2.9%, MgO=0.0%, Na2O=1.0%, CO2=6.0%

Refinement Converged (R/E=1.62), ♣ Round=4, Iter=6, P=56, R=5.32% (E=3.29%, EPS=0.5)



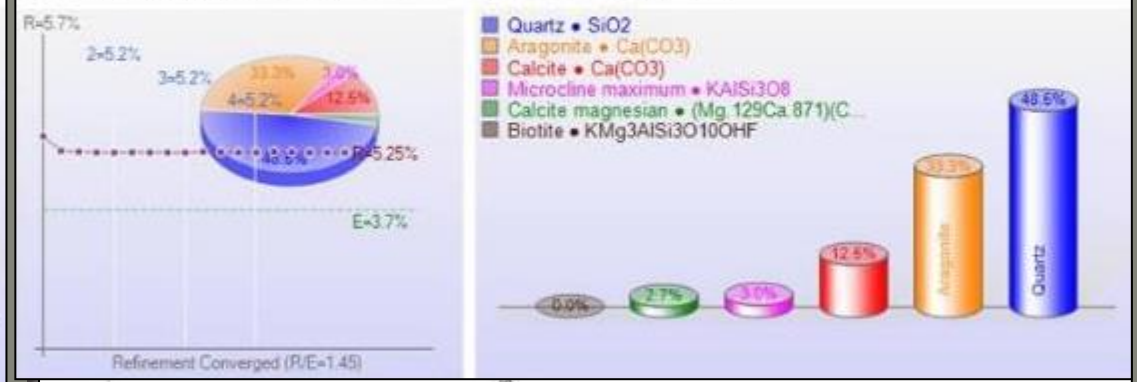


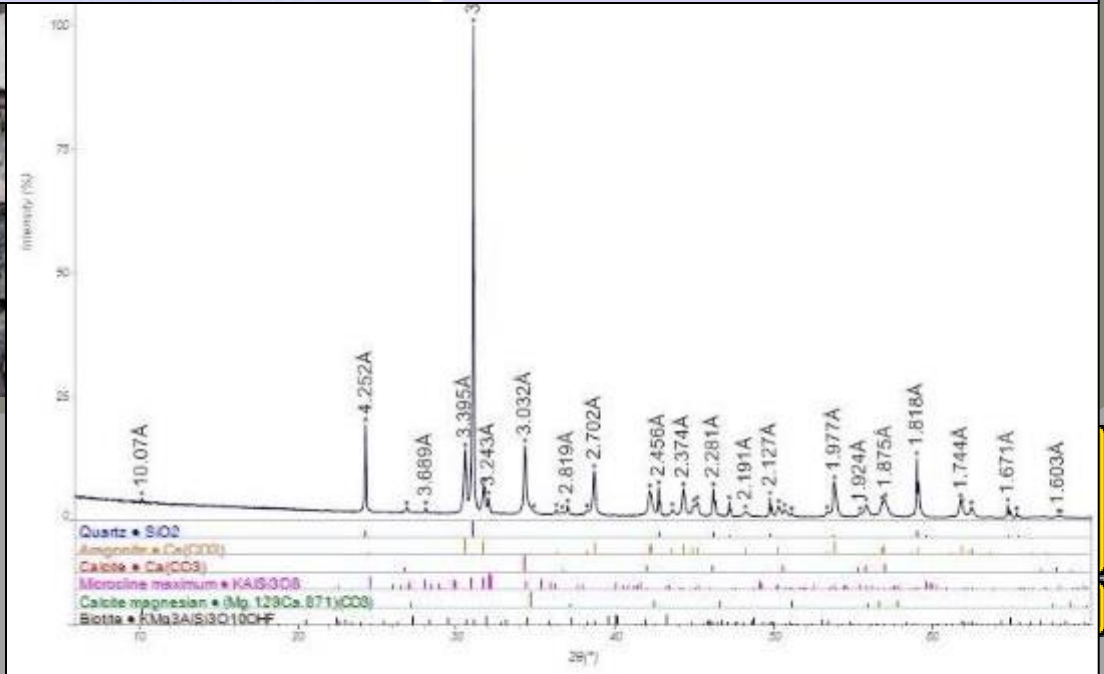
EGMONT KEY, FL 2015

Phase ID (6)	Chemical Formula	PDF-#	NA	NR	NP	Wt% (esd)	RIR
Calcite	Ca(CO3)	01-083-0577	---	12	11	12.5 (0.1)	3.21
Microcline maximum	KAlSi3O8	01-076-0918	---	113	10	3.0 (0.1)	0.60
[illegible]	KMg3AlSi3O10OHF	01-073-1661	---	107	3	0.0 (0.0)	1.04
Aragonite	Ca(CO3)	01-075-2230	---	33	12	33.3 (0.2)	1.14
Quartz	SiO2	01-085-0794	---	12	11	48.5 (0.3)	3.11
Calcite magnesian	(Mg.129Ca.871)(CO3)	01-086-2336	---	12	4	2.7 (0.2)	2.94

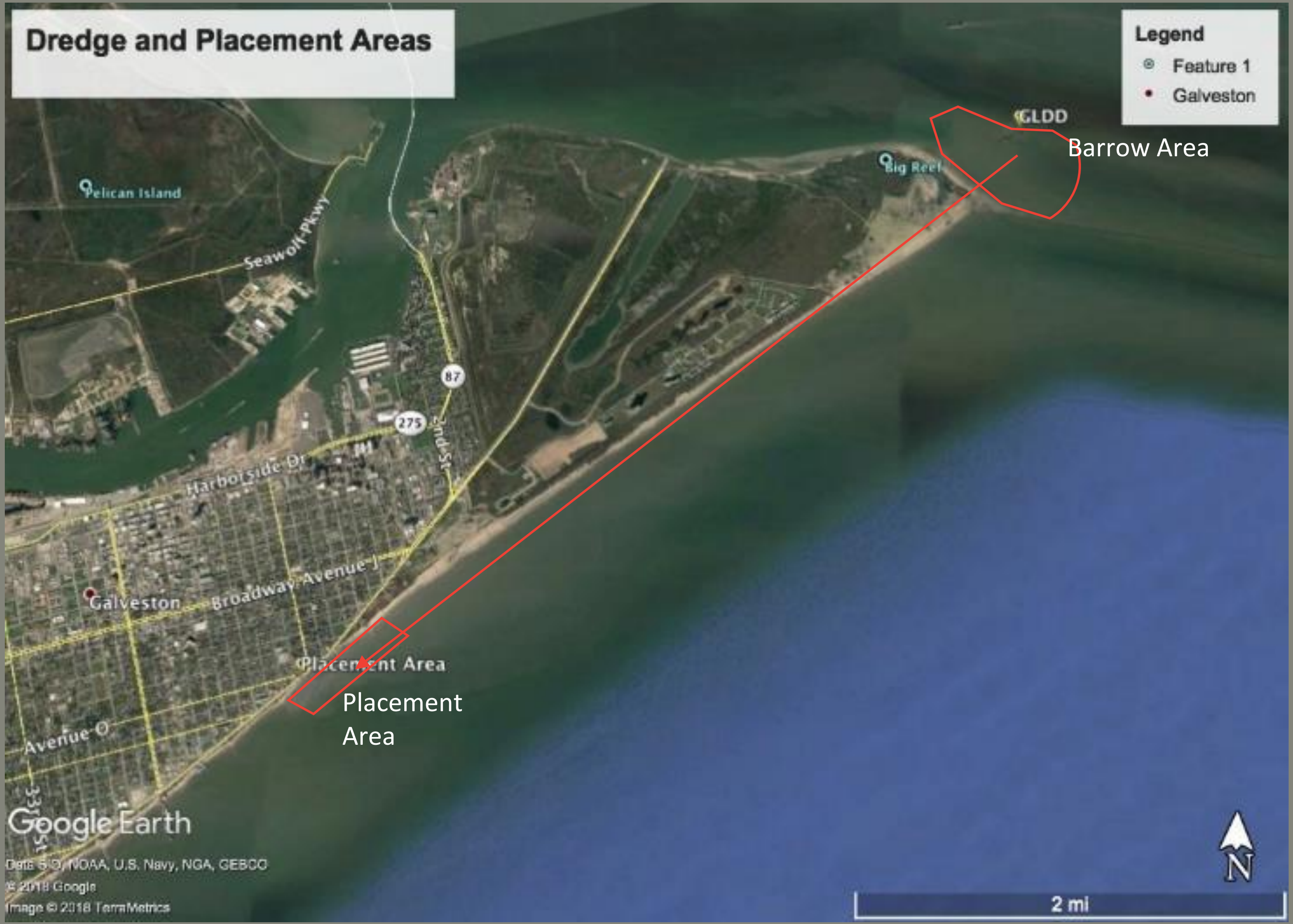
XRF(Wt%): CaO=27.0%, K2O=0.5%, SiO2=50.5%, Al2O3=0.6%, MgO=0.1%, CO2=21.3%

Refinement Converged (R/E=1.45), ♣ Round=4, Iter=4, P=62, R=5.35% (E=3.70%, EPS=0.5)





GALVESTON 2017 NOURISHMENT



RS Weeks 30" Cutter Suction Dredge

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GALVESTON NOURISHMENT 2017 – AERIAL

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GALVESTON NOURISHMENT 2017 - OPERATIONS

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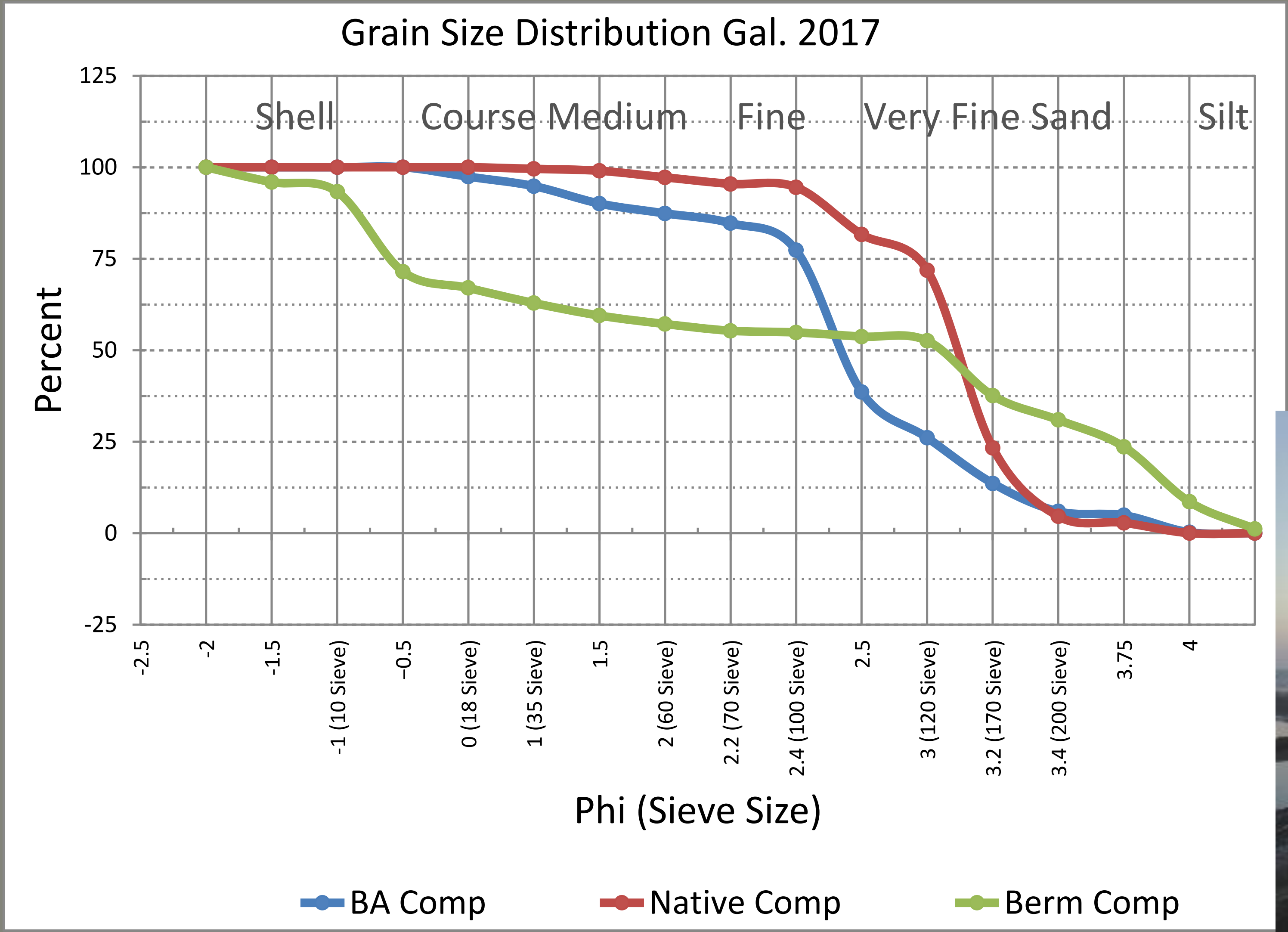
GALVESTON 2017 – GRAIN SIZE



Galveston Seawall Beach Nourishment 2017		
Material Source	D50 (mm)	% Fines (200 Sieve)
Native Beach Sand	0.14*	2.9*
South Jetty Borrow Area	0.16*	9.2*
Post-Fill Samples	0.15	8.6

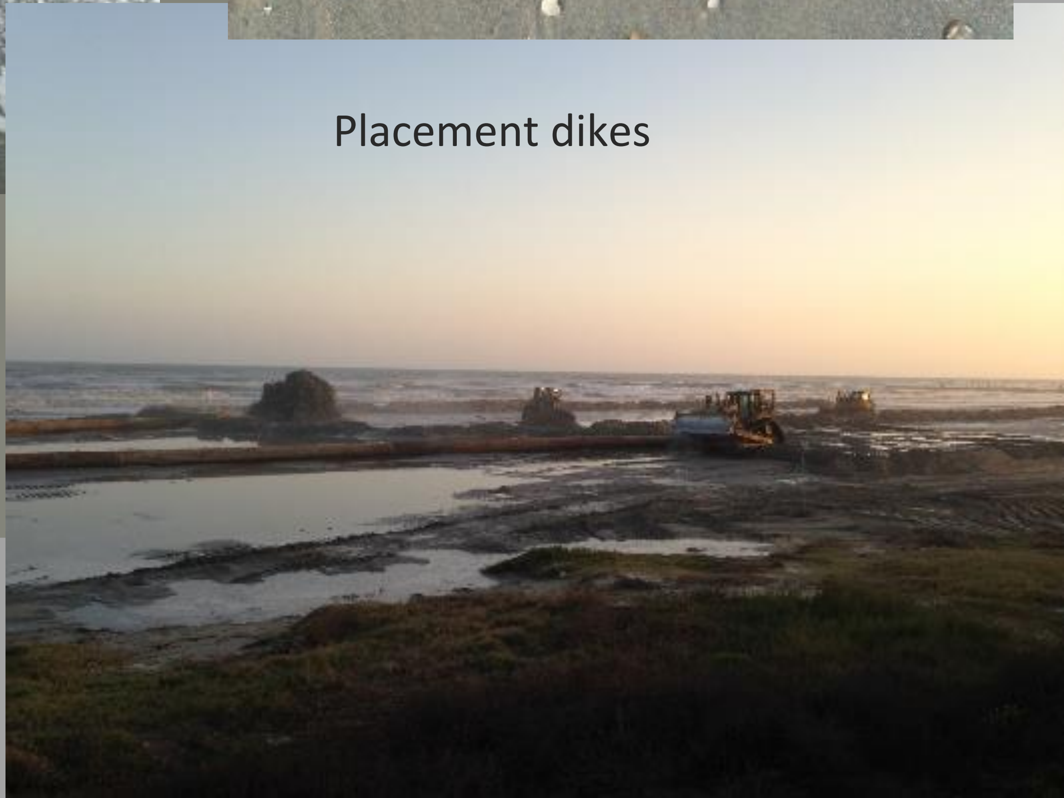
* data from HDR Design Memo dated 30 Nov 2015

Finer sediment was trapped in the fill during the placement event primarily due to methodology

GALVESTON 2017 - PICTURES

- Fi

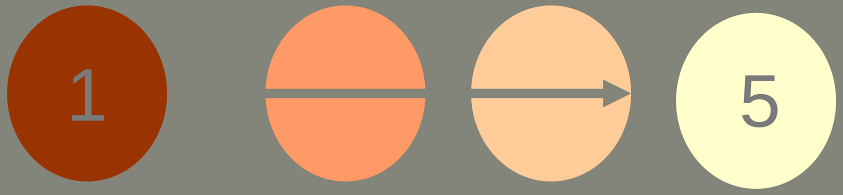
nd should not be
designated by other



APPLIED R&D – MUNSELL COLOR COLOR CHANGE PROPENSITY

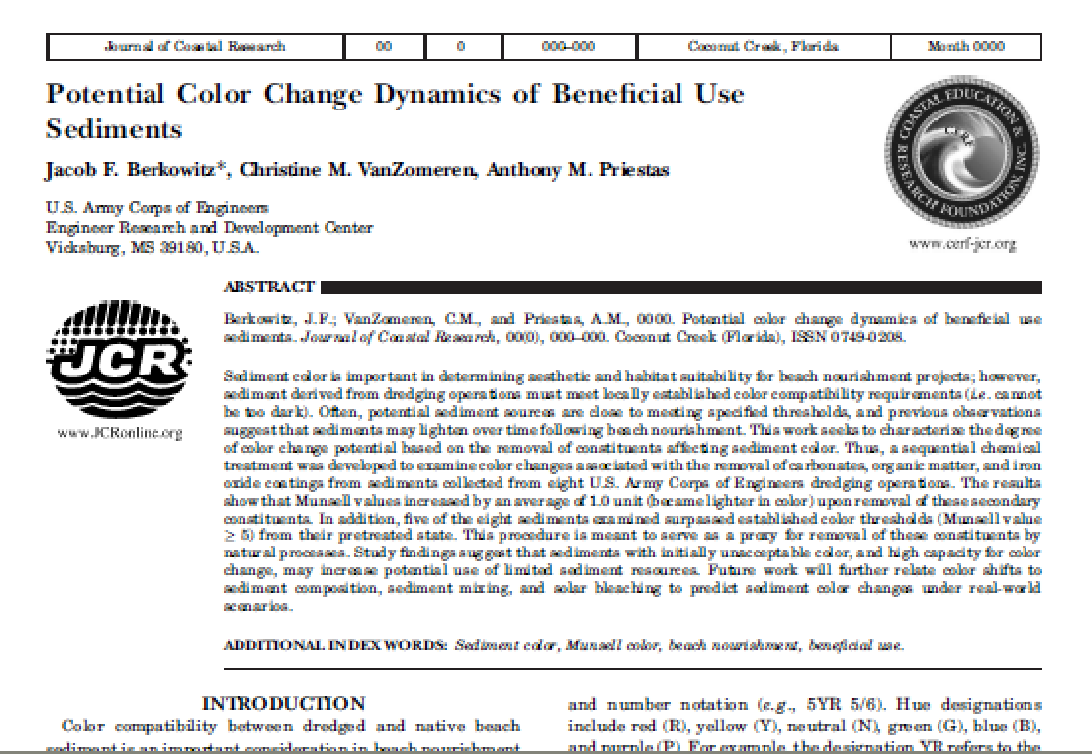
Problem? Dark materials not allowed

Only Light materials applied to beach



R&D by:
J. Berkowitz, A. Priestas, C. VanZomeren, Jodi Smith

- Bulk color is due to:
  - % Dark minerals
  - Staining
  - % Dark Organics
- Sediment Color Change is due to:
  - Bleaching
  - Mixing (Losses)
  - Abrasion



Journal of Coastal Research	00	0	000–000	Coconut Creek, Florida	Month 0000

Potential Color Change Dynamics of Beneficial Use Sediments

Jacob F. Berkowitz*, Christine M. VanZomeren, Anthony M. Priestas

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Engineer Research and Development Center
Vicksburg, MS 39180, U.S.A.

www.cerf-jcr.org

www.JCRonline.org

ABSTRACT

Berkowitz, J.F.; VanZomeren, C.M., and Priestas, A.M., 0000. Potential color change dynamics of beneficial use sediments. *Journal of Coastal Research*, 00(0), 000–000. Coconut Creek (Florida), ISSN 0749-0208.

Sediment color is important in determining aesthetic and habitat suitability for beach nourishment projects; however, sediment derived from dredging operations must meet locally established color compatibility requirements (*i.e.* cannot be too dark). Often, potential sediment sources are close to meeting specified thresholds, and previous observations suggest that sediments may lighten over time following beach nourishment. This work seeks to characterize the degree of color change potential based on the removal of constituents affecting sediment color. Thus, a sequential chemical treatment was developed to examine color changes associated with the removal of carbonates, organic matter, and iron oxide coatings from sediments collected from eight U.S. Army Corps of Engineers dredging operations. The results show that Munsell values increased by an average of 1.0 unit (became lighter in color) upon removal of these secondary constituents. In addition, five of the eight sediments examined surpassed established color thresholds (Munsell value ≥ 5) from their pretreated state. This procedure is meant to serve as a proxy for removal of these constituents by natural processes. Study findings suggest that sediments with initially unacceptable color, and high capacity for color change, may increase potential use of limited sediment resources. Future work will further relate color shifts to sediment composition, sediment mixing, and solar bleaching to predict sediment color changes under real-world scenarios.

ADDITIONAL INDEX WORDS: *Sediment color, Munsell color, beach nourishment, beneficial use.*

INTRODUCTION

Color compatibility between dredged and native beach

and number notation (*e.g.*, 5YR 5/6). Hue designations include red (R), yellow (Y), neutral (N), green (G), blue (B),

APPLIED R&D COLOR CHANGE PROPENSITY

Problem - Dredged material color limits BU due to agency regarding turtle nesting and habitat concerns, etc.

Objectives - Understand sediment color change capacity
- Develop predictive capability for color change to promote BU

Category A - meets criteria in un-treated condition

Category B1 - potential for rapid color change

Category B2 - potential for color change over time

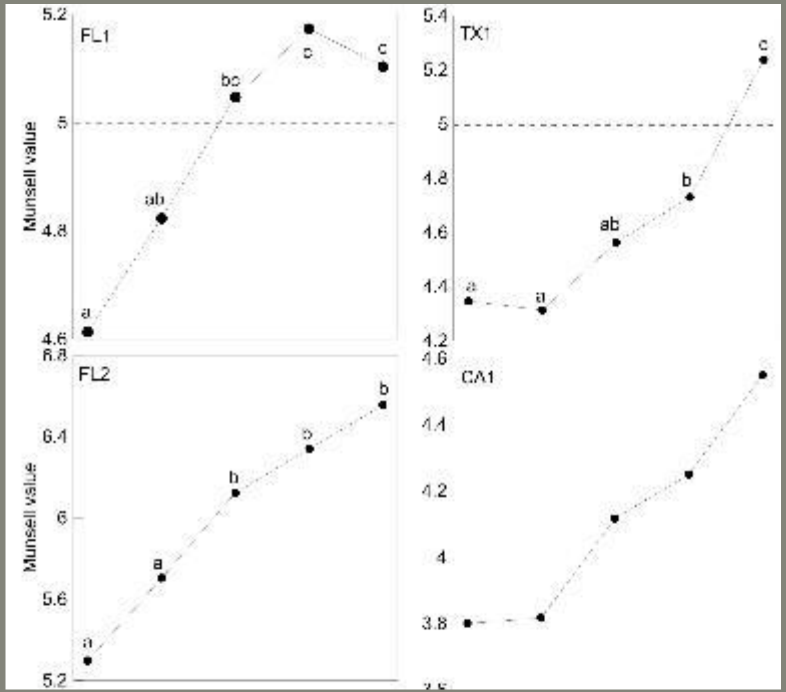
Category C - low potential for color change

Recalcitrance to color change

	MD1 Category A		FL1 Category B1		AL1 Category B2		CA1 Category C	
Treatment	Value	Chroma	Value	Chroma	Value	Chroma	Value	Chroma
Untreated			X		X	X	X	
Carbonates			X		X	X	X	
Organic matter					X	X	X	
Amorphous Fe							X	
Crystalline Fe							X	

Beneficial use potential

Category B1 Category B2



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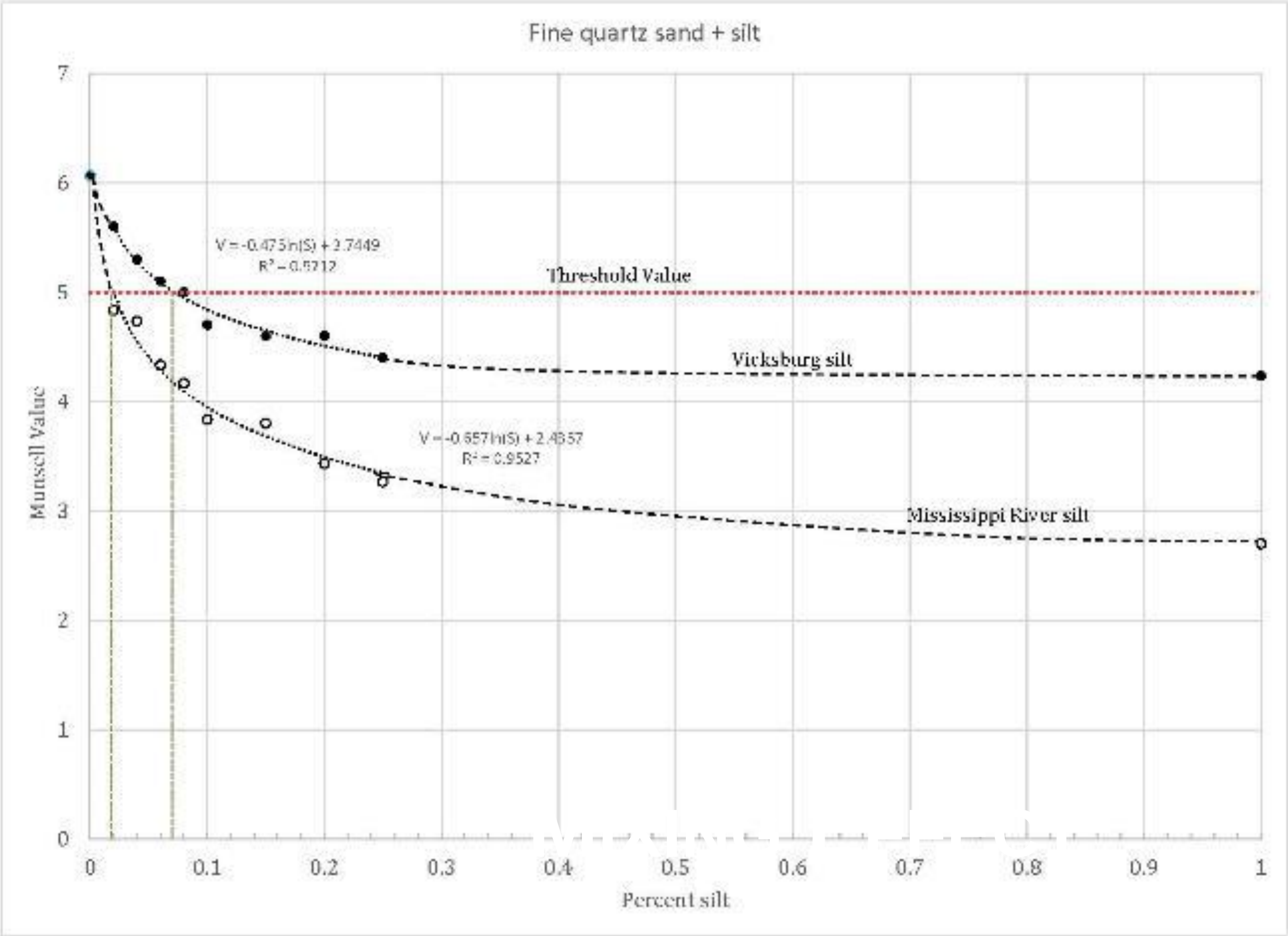
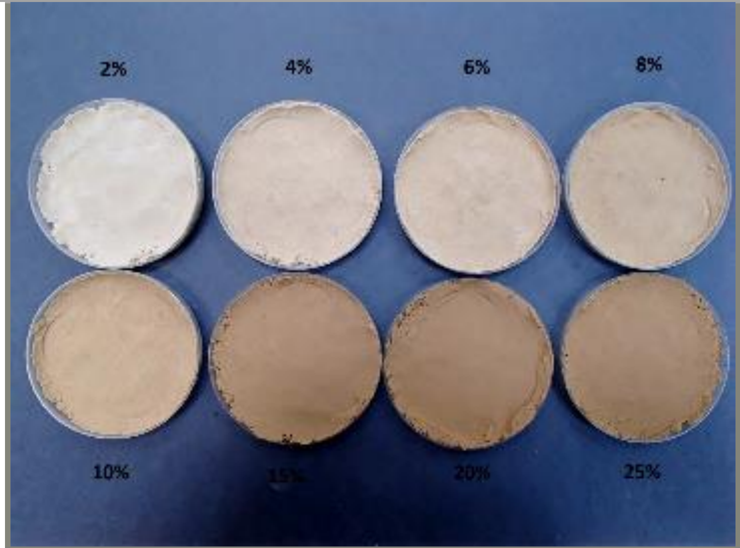
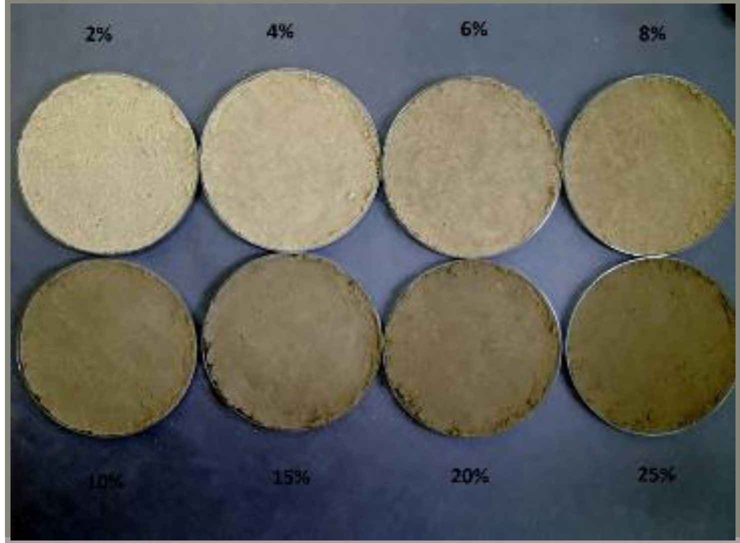
DOES SILT DECREASE MUNSELL COLOR VALUE?

Addition of 2-5% fines resulted in darkening beyond established color thresholds







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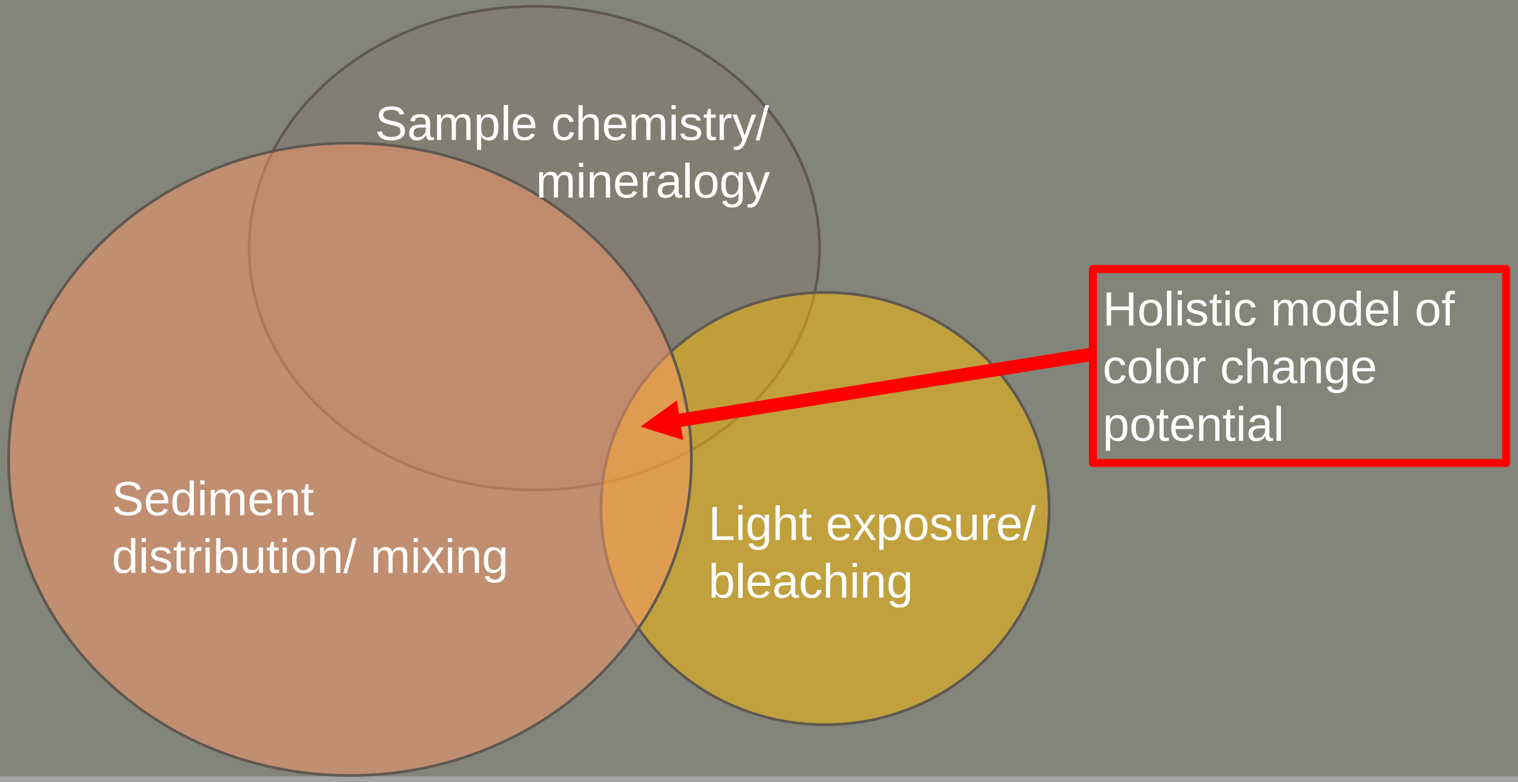
UV LIGHT INDUCED COLOR CHANGE

Exposure to high intensity light resulted in color change within 4 weeks of exposure

APPLIED R&D COLOR CHANGE PROPENSITY

1. Synthesize bleaching, mixing, and chemistry effects into holistic model
2. Develop predictive guidance → color change propensity



EMPIRICAL FORMULA TO ESTIMATE BORROW SEDIMENT ULTIMATE CAPABILITY

MAGLIO AND DAS FORMULA

- Given
  - Dredged sediment dramatically changes during the dredging and placement process
  - Every dredge project is highly variable: in terms of its operations
  - Formula non-dimensional
- Based on previous work and field observations
  - A few key parameters appear to control sediment changes
  - Number of times material was slurried (washed)
  - Slope of the discharged return water channel on the beach (velocity)
  - Sediment fall velocity (sedimentation)
    - Specific gravity
    - Size of particle
    - Shape factor
    - Salinity
    - Temperature

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MAGLIO AND DAS FORMULA FOR EMPIRICAL DREDGED SEDIMENT CHANGE

$$\% \text{ Loss} = \sqrt{X} e^{(-10(2\sigma-1)\sqrt{RS})}$$

X = No. of times sediment slurried
S = Berm Slope
R = Shape Factor adj. Particle Reynolds No.
= Rep * Z , for sphere, Z = 1

$$R_{ep} = (1 + 0.222 \frac{(S-1)gd^3}{16\upsilon^2})^{0.5}-1$$

S = Specific Gravity of sediment
υ = Kinematic viscosity of water (m^2/s)
d = Nominal diameter (m)
g = acceleration of gravity = 9.81 m/s^2
Z = Shape Factor Adjustment (Fitted)
= [0.16 ln(d) +1.7] * SF
SF = Shape factor (0.3 to 1.0)

σ = sediment sorting parameter

$$\sigma = \frac{\phi_{84}-\varphi_{16}}{4} + \frac{\phi_{95}-\varphi_5}{6.6}$$

$$\sigma < 0.5\ (Well\ sorted);$$
$$\sigma = 0.5 - 1.0\ (Moderately\ sorted);$$
$$\sigma = 1 - 2\ (Poorly\ sorted);$$

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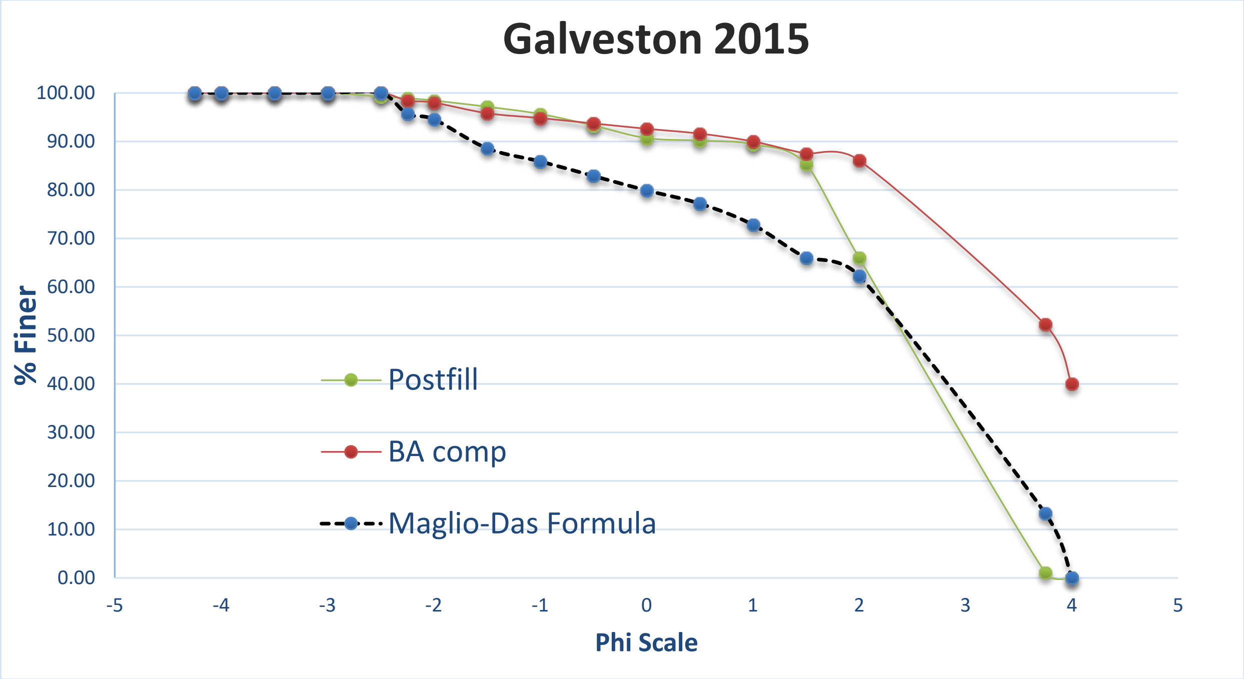
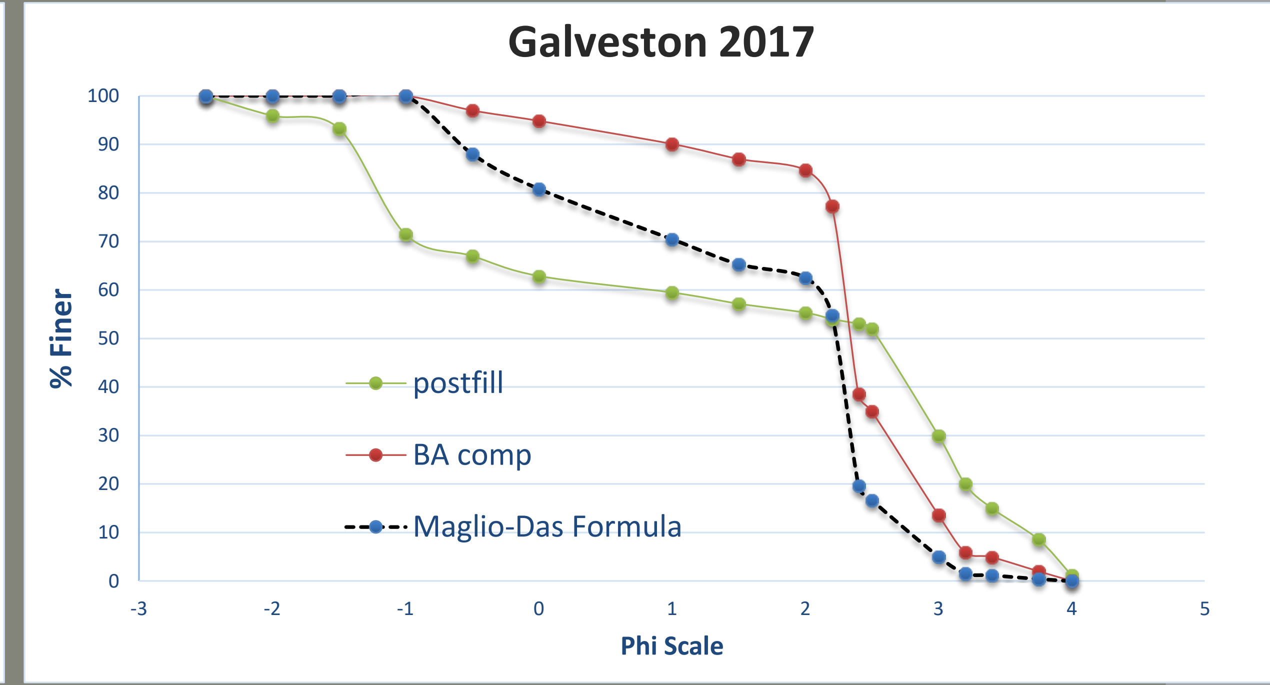
MAGLIO AND DAS FORMULA FOR EMPIRICAL DREDGED SEDIMENT CHANGE

$$\% \text{ Loss} = \sqrt{X}e^{(10(1-2\sigma)\sqrt{RS})}$$





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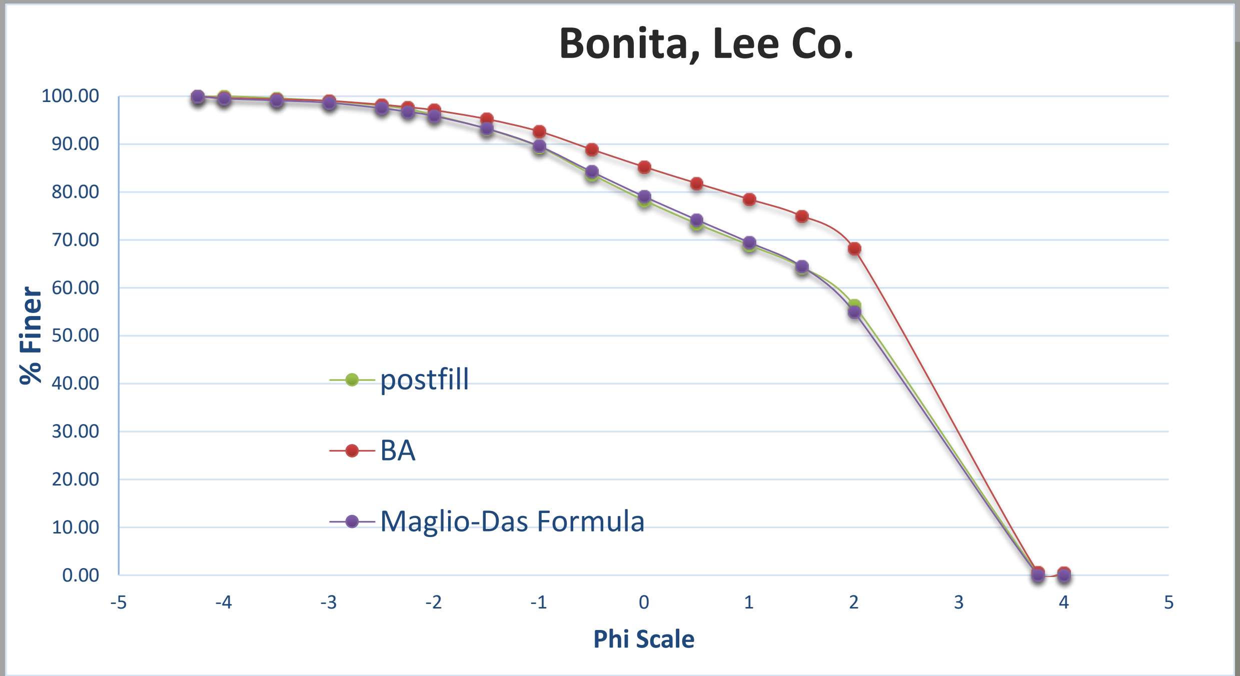
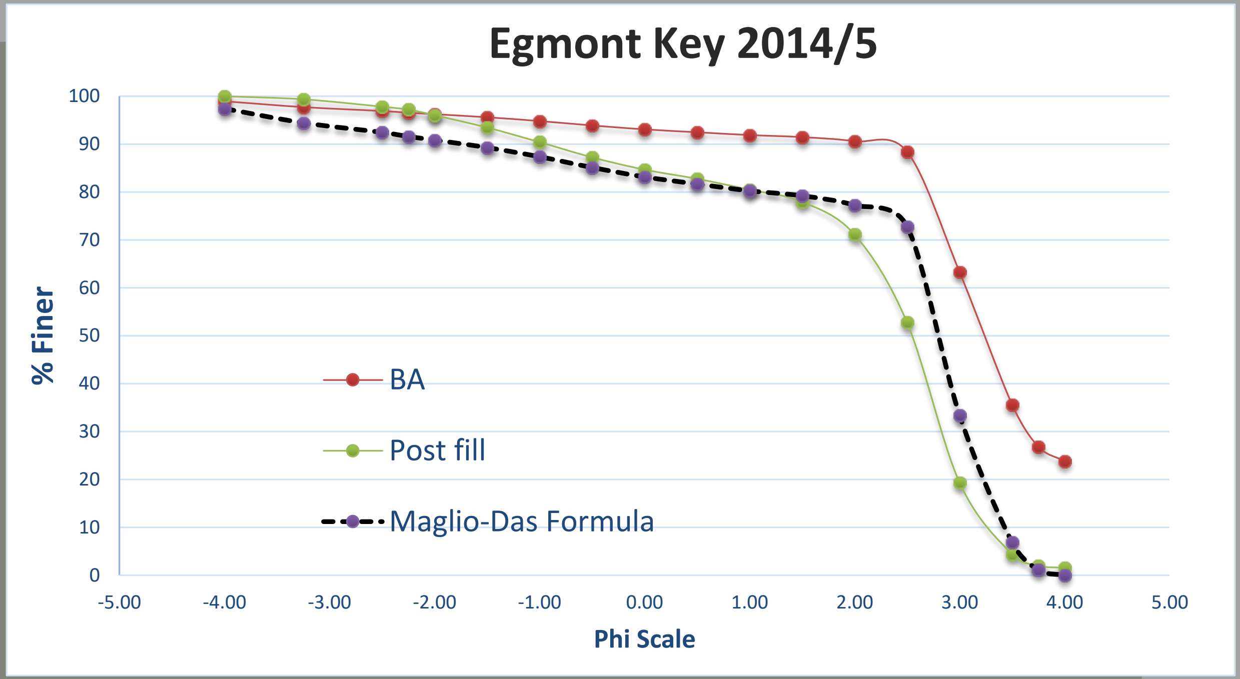

Bonita, Lee Co.
% Finer
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-5
-4
-3
-2
-1
0
1
2
3
4
5
Phi Scale
postfill
BA
Maglio-Das Formula


Egmont Key 2014/5
% Finer
100
90
80
70
60
50
40
30
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-5.00
-4.00
-3.00
-2.00
-1.00
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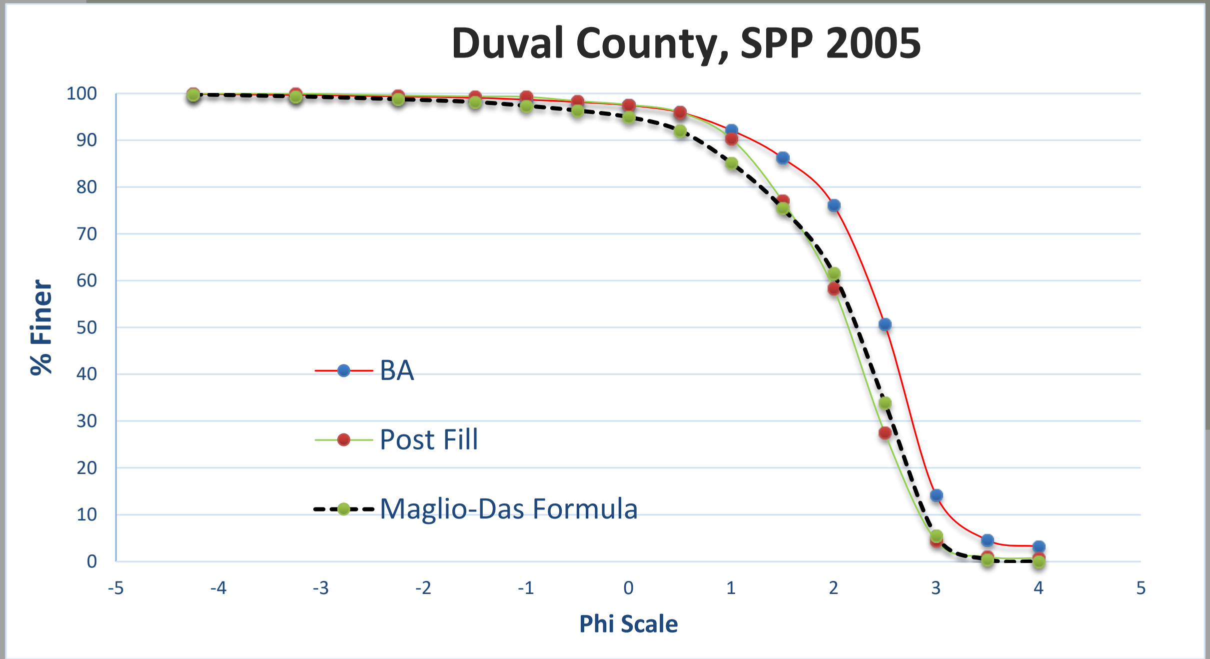
Phi Scale
BA
Post fill
Maglio-Das Formula


Duval County, SPP 2005
% Finer
100
90
80
70
60
50
40
30
20
10
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-4
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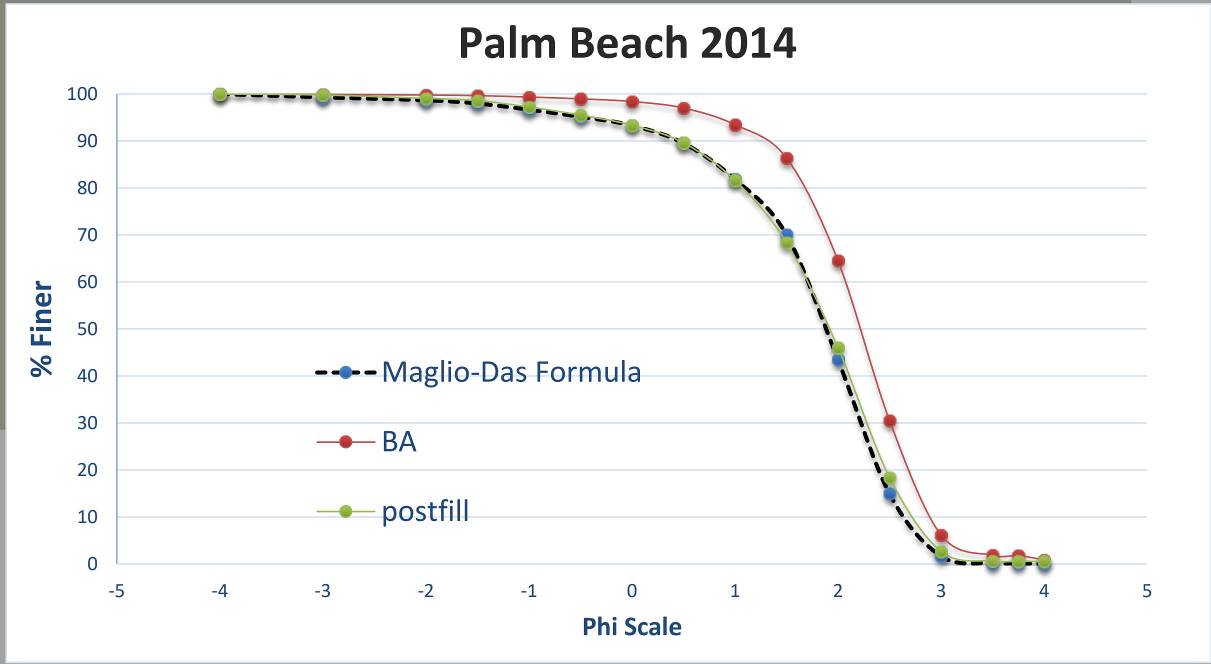
-2
-1
0
1
2
3
4
5
Phi Scale
BA
Post Fill
Maglio-Das Formula


Palm Beach 2014
% Finer
100
90
80
70
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50
40
30
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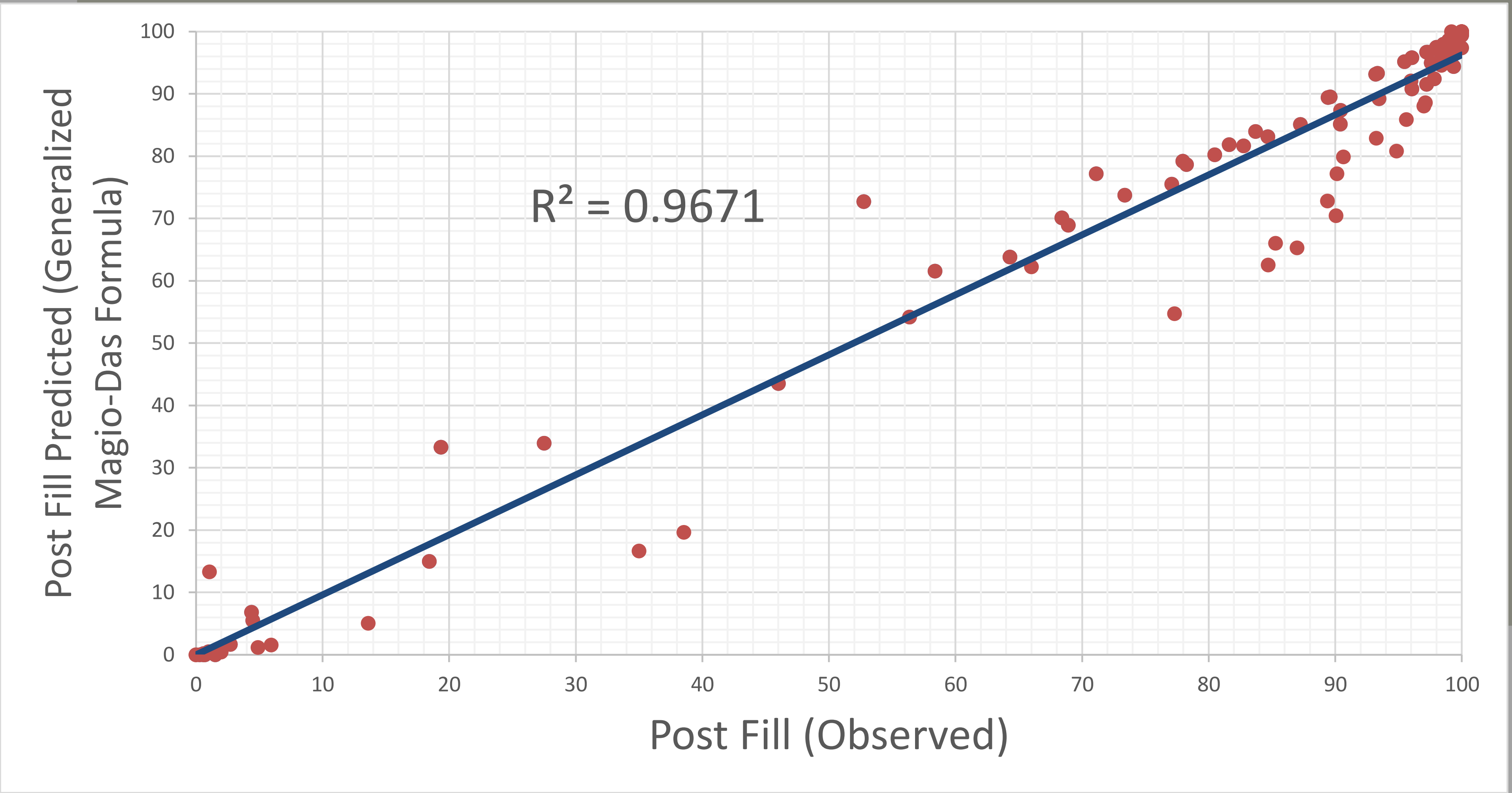
10
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
Phi Scale
Maglio-Das Formula
BA
postfill

EMPIRICAL FORMULA TO ESTIMATE SEDIMENT CAPABILITY

MAGLIO AND DAS FORMULA

$$\% \text{ Loss} = \sqrt{X} e^{\left(-10(2\sigma - 1)\sqrt{RS}\right)}$$



- Next step Beaches and Shores Article
- Conduct sensitivity analysis of factors
- Provide data to peers for validation
- Journal publication

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SUMMARY AND CONCLUSIONS

Sediment Sampling

- Grain Size indicates significant “fines” losses during dredging process
  - If allowed for in operations
- Fine material post-placement located at the toe of the fill
  - Mobilized during high energy events
- Munsell Color similar to pre-conditions
- Compaction similar to pre-conditions

Predictive Capabilities

- ERDC working on sediment color change potential, 3rd year, to assist BU acceptance
- Maglio-Das empirical formula appears to have significant promise

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QUESTIONS?

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