Determining the Effectiveness of Ferrate-Treated Slurry Precipitate as a Soil Conditioner

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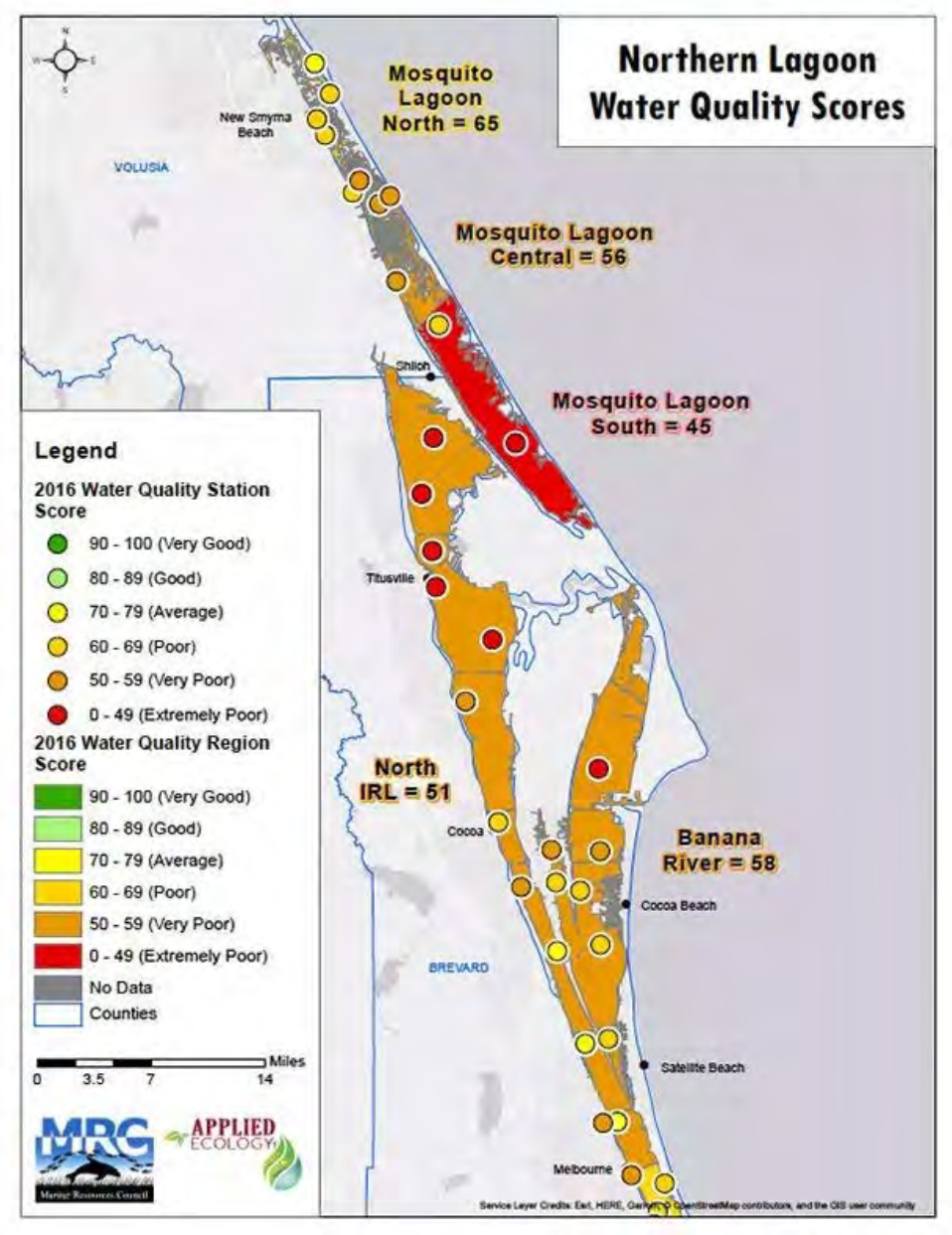
The Indian River Lagoon

- 156 mile long estuary spanning 7 counties
- Home to over 2000 species of both plants and animals
- Roughly $30 Million in annual revenue generated from fisheries (SJRWMD, 2018)
- Annual economic value of ~$7.6 Billion (SJRWMD, 2018)

(St. Johns River Water Management District , 2007)

A Mucked Up Situation



Miami Herald, 2016

- ~5 Million yd^3 of muck cover the Northern and Central parts of the IRL (Trefry, 2016)
- Muck is between 10-20% organic material and 60-80% clays, silts and fine sands when dry (Trefry, 2016)

Scope of Work

Objective	Develop and test Ferrate- based coupled dredge- spoil residuals treatment system
Project Metrics	Can a dredge which effectively precludes coarse sediments larger than 0.2mm be developed
	Can ferrate treatment reduce phosphorous concentrations, as well as ammonia and suspended solids
	Can an efficient disposal method for solids be established

Funded By: State of Florida Department Environmental Protection, Natural Resources Management Department, Brevard County, FL

Approach: Dredge Head Design

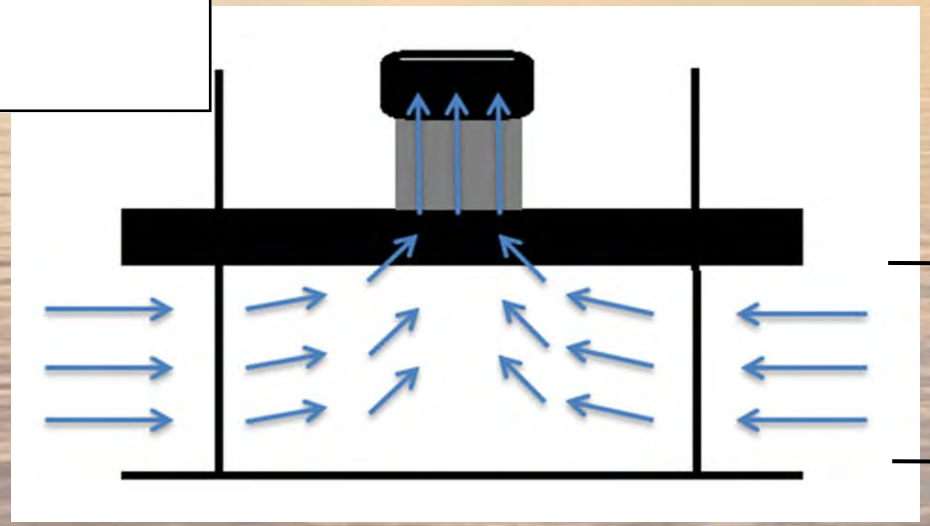
Underlying Principle:

$$Q=V_iA_i$$

Flow Rate
120 GPM

Intake Velocity

Intake Area
$A_i = 2\,\pi rh$



Setting Name	Opening Height (h)
Closed	5/8th in
Halfway	2 ½ in
Open	5 in

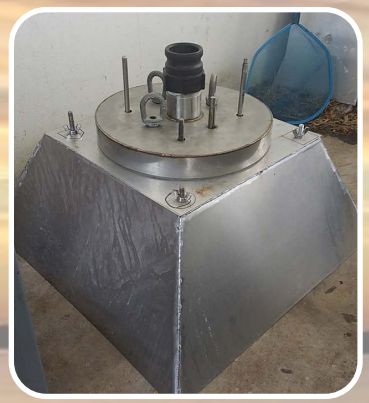
Control Test using 3 in Diameter Hose

Lab Testing Dredge Head

Weaver et al., 2018

No Shroud

Shroud



Passive Jets

Active Jets

Shroud Extension

Settlement Issues

Settled Slurry Sample

Poor water quality

Settled Material

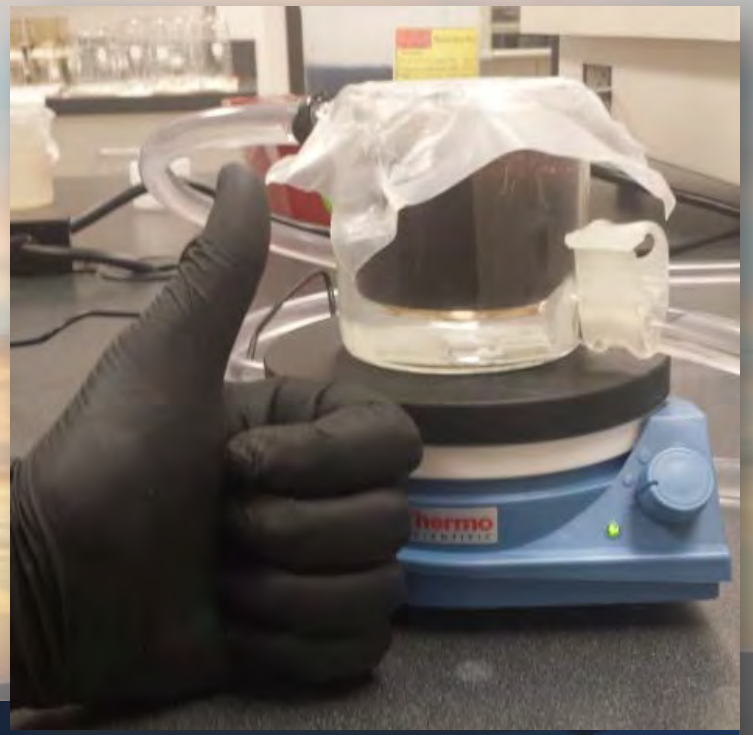
Time (min)	Level of suspended particles (mL)	Net settling (mL)
0	2020	0
16	1940	80
30	1900	40
45	1820	80
60	1700	120
75	1625	75
90	1590	35
105	1555	35
120	1530	25
135	1500	30
168	1460	40

Ferrate Synthesis

$$2FeCl_3 + 3NaOCl + 10NaOH \rightarrow 2Na_2FeO_4 + 9NaCl + 5H_2O$$

$$2FeO_4^{2-} + 5H_2O \rightarrow 2Fe(OH)_3 + 1.5O_2 + 4OH^-$$

(Waite, 2012)



Ferrate is added to water sample and mixed

Acid is added to sample and mixed to neutralize pH

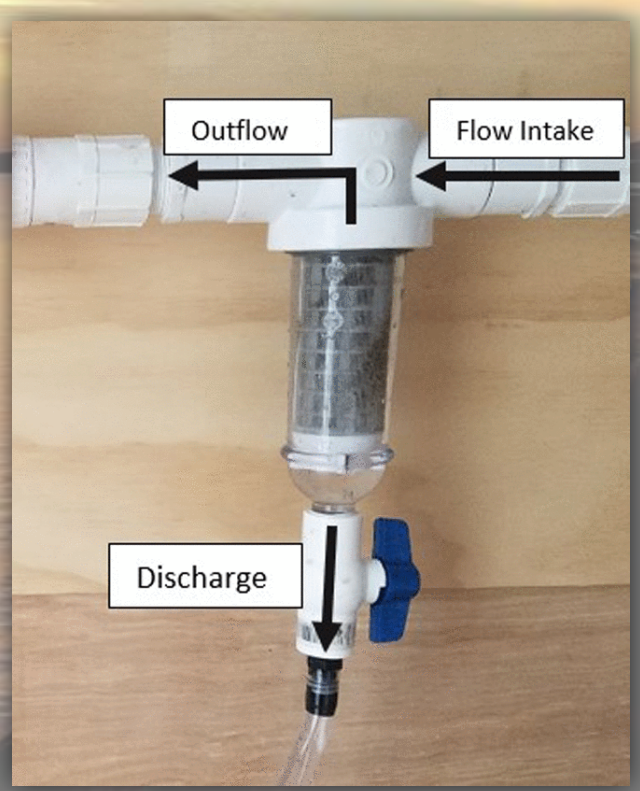
The sample is given time to settle (minutes rather than hours)

Coupled Slurry Treatment System

Treatment Trailer Phases:

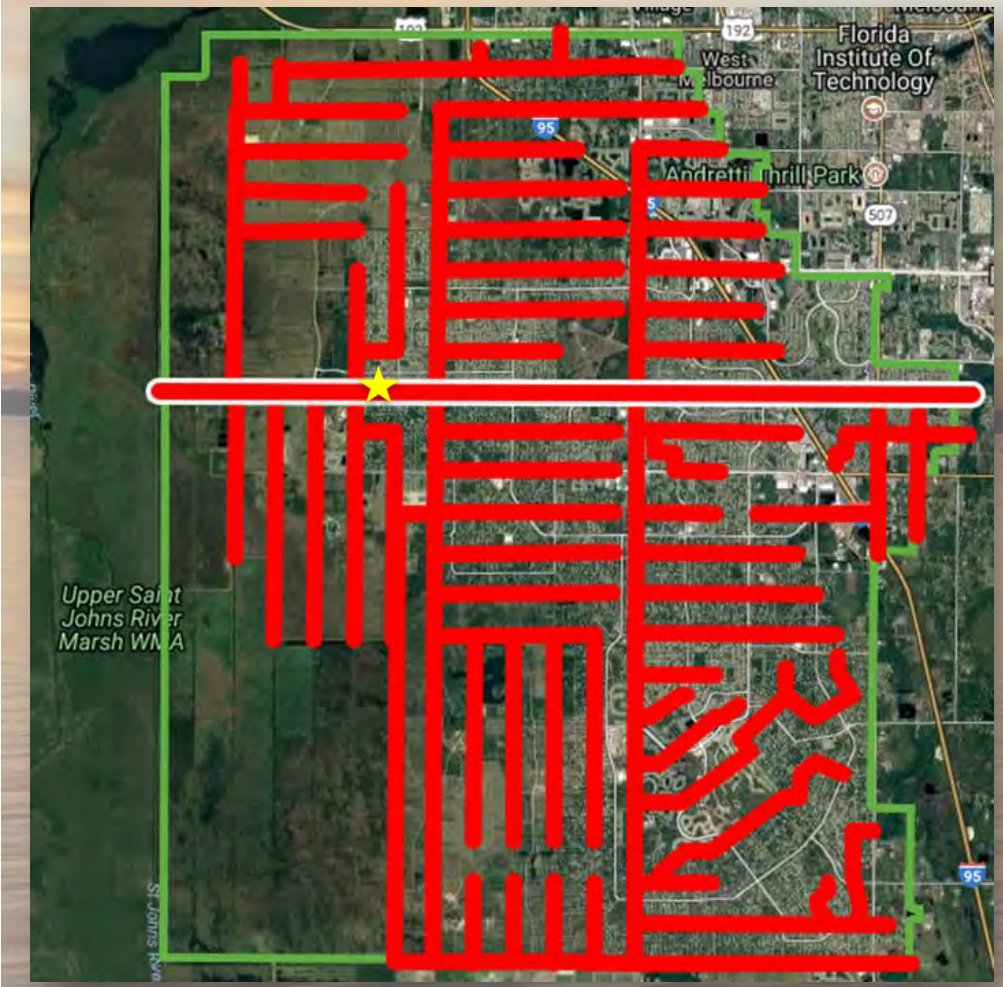
1. Dual Hydrocyclones (particle separation)
2. Ferrate Injection+mixing (Coagulating agent)
3. Acid Injection +mixing (pH Control)
4. Settling (fine particulate separation)

Weaver et al., 2018

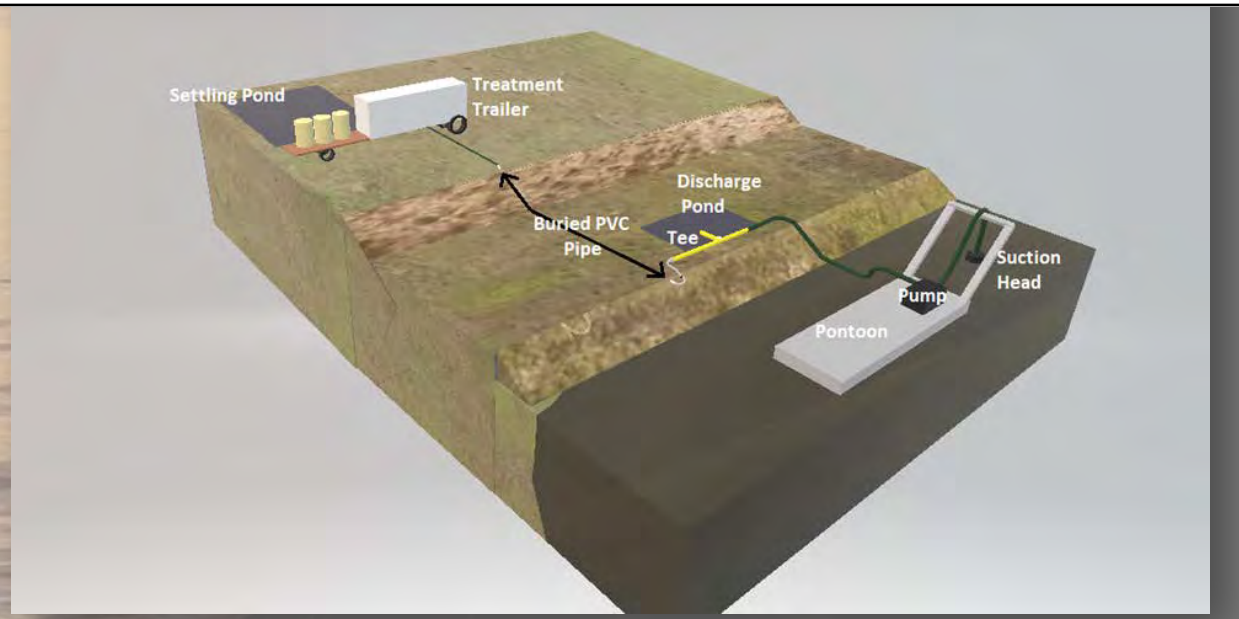


Provost et al., 2018

Field Testing Site



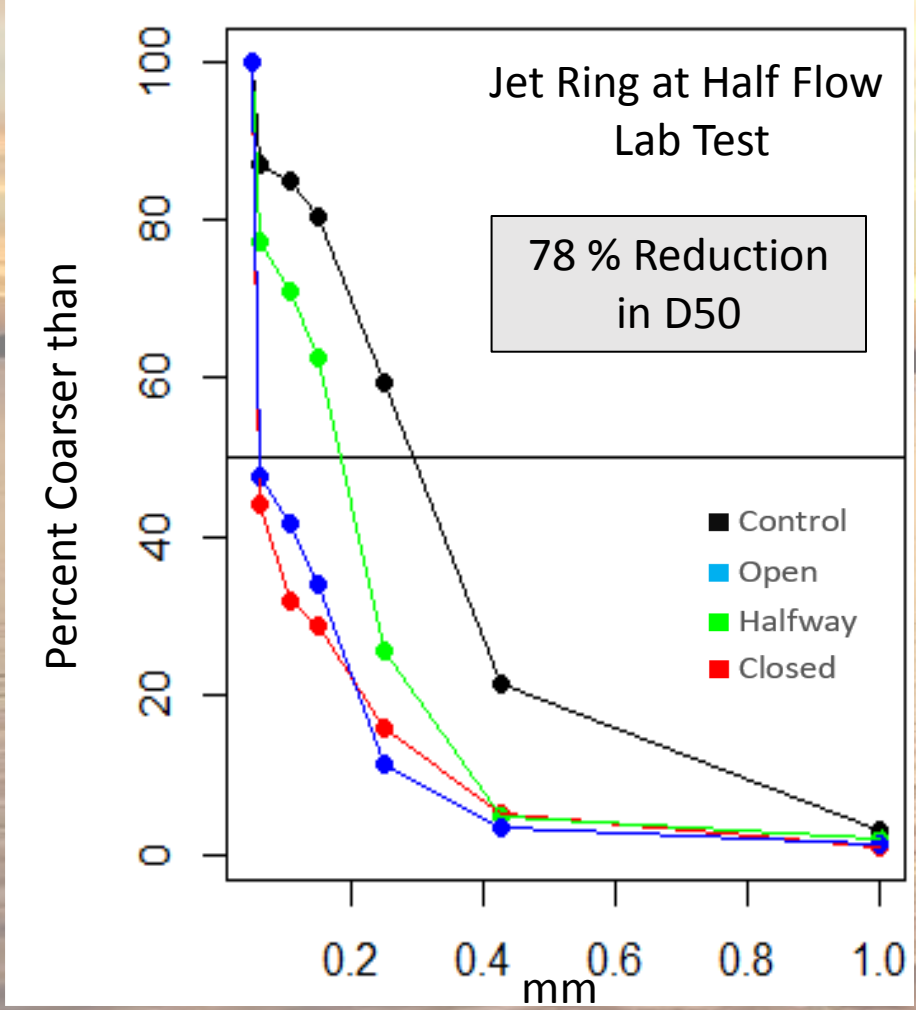
Melbourne-Tillman, 2018

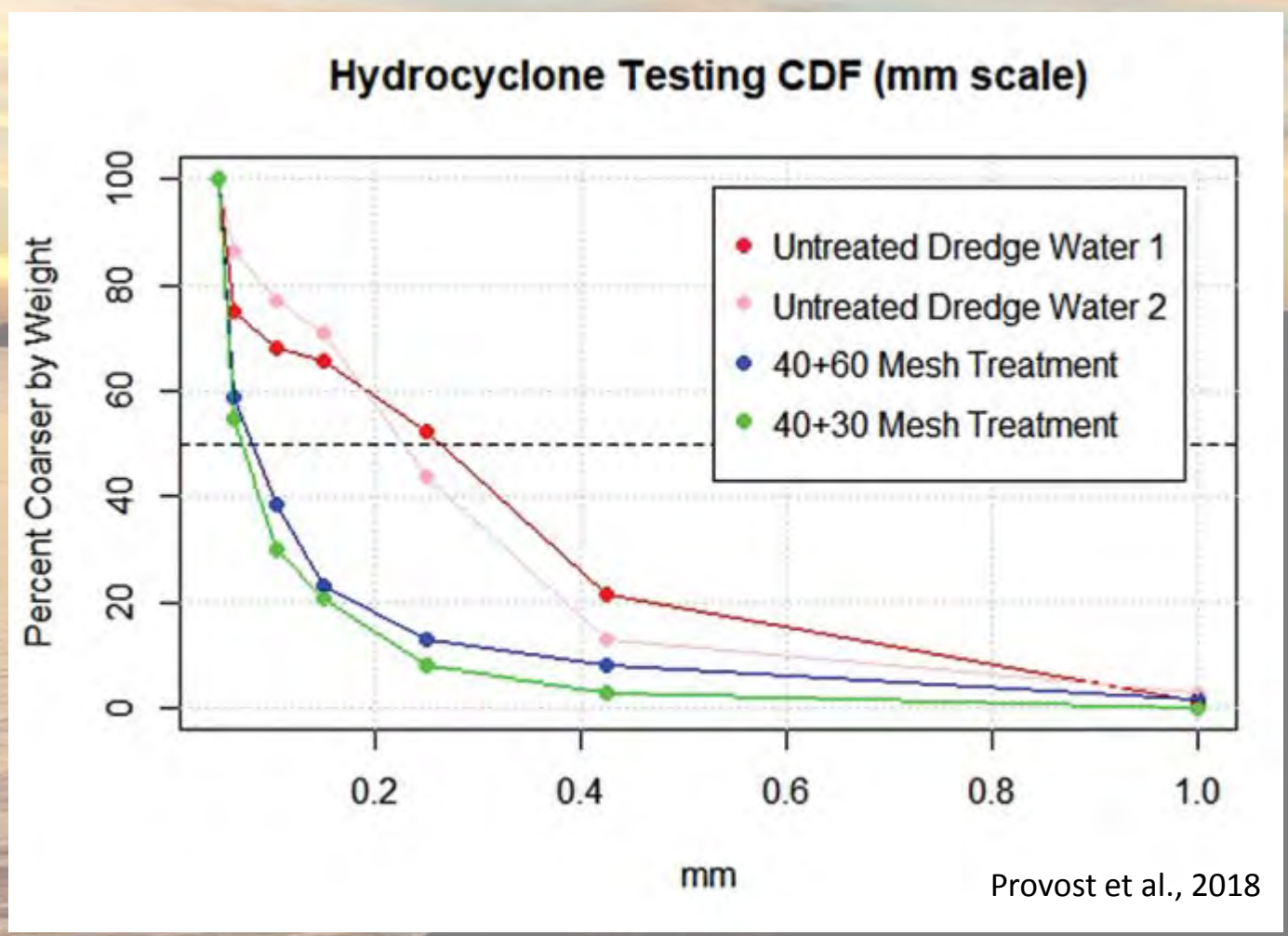


Weaver et al., 2018

Results: Grain Size Reduction

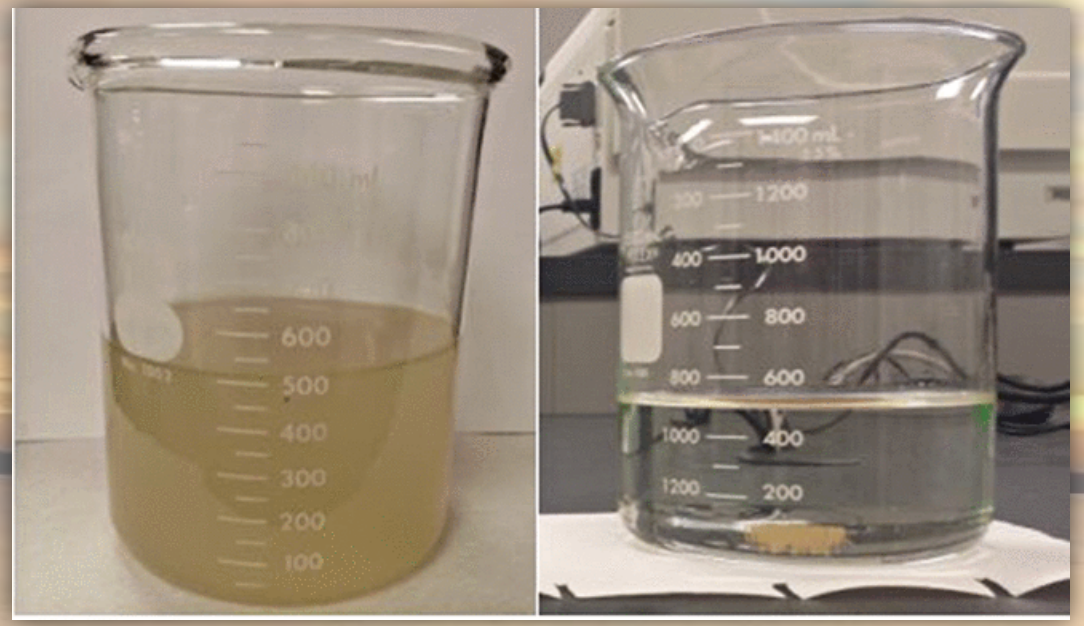
Sediment analysis performed used 7 different sieve sizes to generate CDF curves





Provost et al., 2018

Results: Water Quality Improvement



Provost et al., 2018

Percent Reduction in Nutrients from untreated slurry to hydrocyclone treated (Provost et al., 2018)

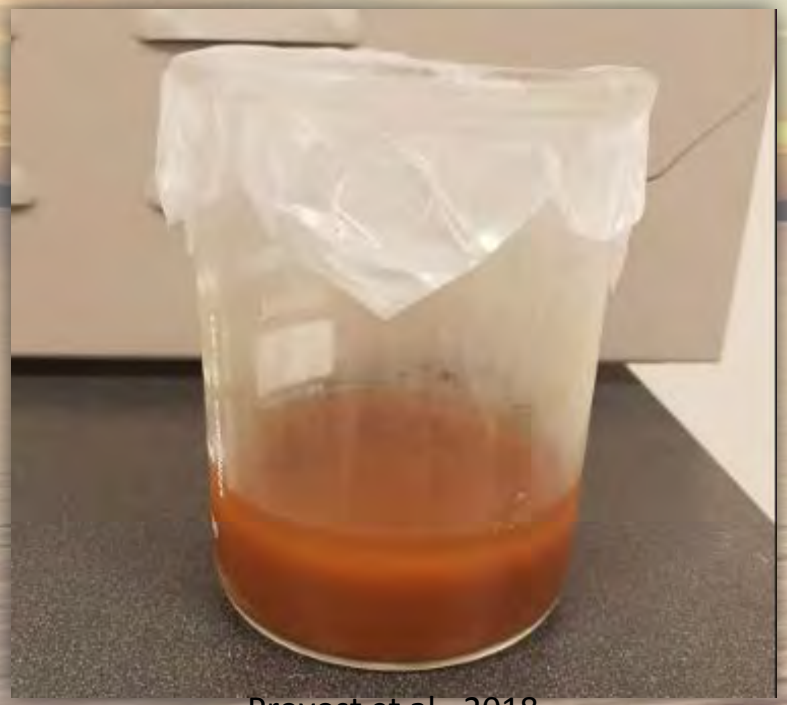
	Ammonium	Phosphate
40 + 30 Mesh Treatment	28.94%	37.19%
40 + 60 Mesh Treatment	21.82%	57.64%

Nutrient reduction of settled water using in-line ferrate treatment (Weaver et al., 2018)

	NH_4-N mg/L	NO_3-N mg/L	PO_4-P mg/L	$Fe_{(TOTAL)}$ mg/L	Turbidity NTU
Control	0.49	1.25	0.33	>3.0	245
Treated	<0.18 (BDL)	1.43	0.03	0.31	0.41
% Change	(-) >65	(+) 1	(-) 90	(-) >90	(-) 99.8

Soil Conditioning Capability

- Iron and nutrient content of precipitate allows for potential as a soil conditioner



Provost et al., 2018

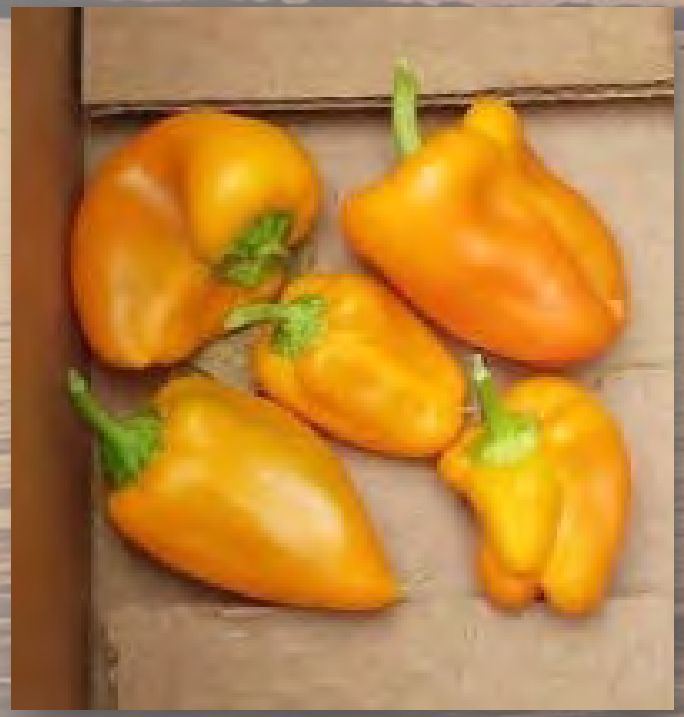
Planting and Treatment (Provost et al.,2018):

- 80 pepper seeds planted total (40 control, 40 treated)
- 4mL of ferric-phosphate treatment bi-weekly
  - 0.22 mg of iron and 0.05 mg of OP

Soil Conditioning Capability

	Control Group	Test Group
Germination	80%	85%
Production	5 Peppers	9 Peppers

Provost et al., 2018



Provost et al., 2018

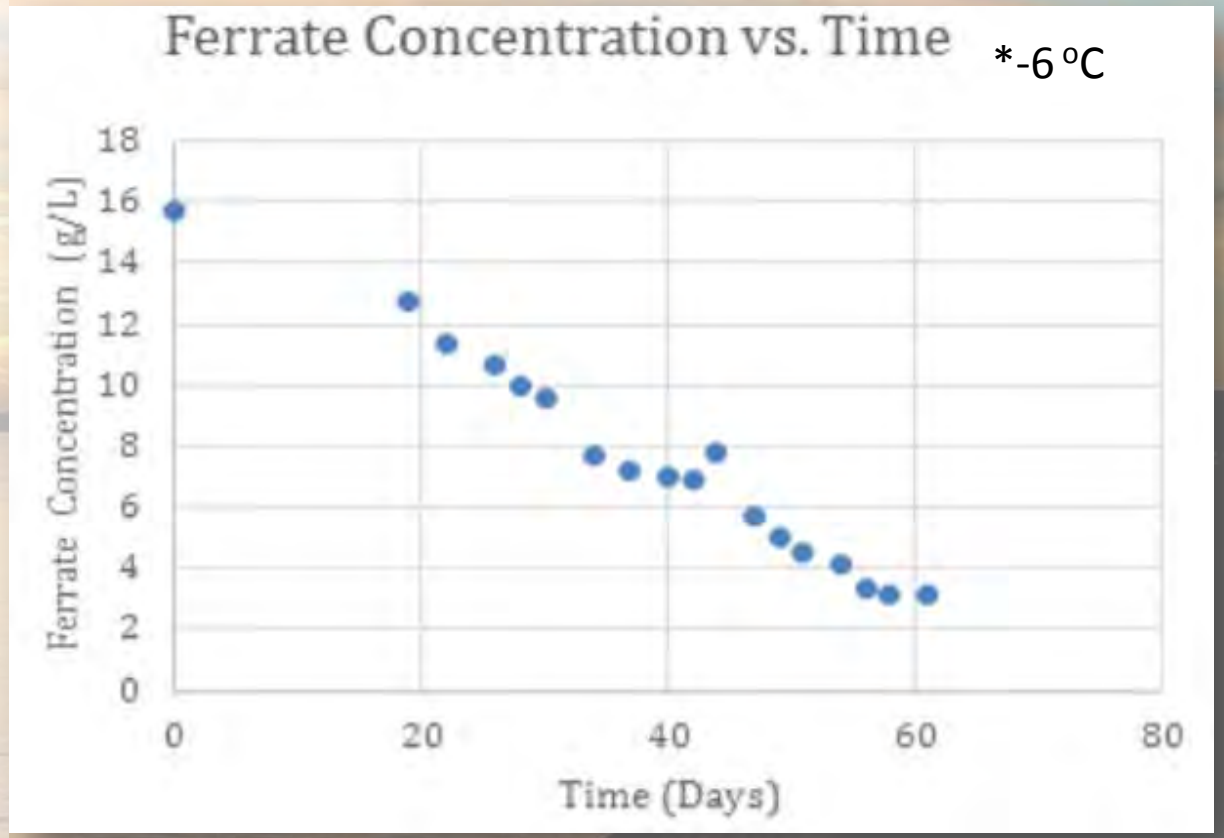
Soil Conditioning Feasibility

Pros

- Ferrate cost can be reduced from $60/lb to $5/lb when produced on site (Waite, 2012)
- ~$0.3/lb to remove N+P+TSS (Waite, 2012)
- Coupled system lessens slurry disposal volumes

Cons

- Stability
- Storage
- Potential environmental risks?



Weaver et al., 2018

Thank you!

Florida Legislature

Brevard County Natural Resources Management Department

Brevard County, FL

Melbourne-Tillman Water Control District

Indian River Lagoon Research Institute

Florida Institute of Technology

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