

BENTHIC ASSESSMENT OF KING'S BAY RESTORATION IN PHASES 2A and 2B

January 6, 2021

prepared for:

**Save Crystal River, Inc.
Post Office Box 2020
Crystal River, Florida 34423**



Prepared by:

JOHNSON
ENGINEERING

2122 Johnson Street

**Fort Myers, Florida 33901
(239) 334-0046**

www.johnsonengineering.com

SCOPE OF WORK:

This report includes the results of pre-restoration (baseline) and post-restoration benthic core sampling from ten locations in Phases 2A and 2B to document conditions before and after de-mucking and the planting of *Vallisneria americana*. The objectives were: 1) Document the efficiency of flocculent organic removal 2) Ascertain the suitability of post-restoration sediments for the growth and survival of *Vallisneria americana*. The methodology is described in the following section.

METHODS:

To determine that *Lyngbya (Microseira wollei)* and flocculent organic substrate has been sufficiently removed to sustain *Vallisneria americana* restoration, colonization, and survival; pre-restoration benthic core samples were collected August 5-6, 2019 and post-restoration samples on June 30 and July 1, 2020. Johnson Engineering Senior Aquatic Ecologist, assisted by Environmental Technicians, obtained benthic core samples in a stratified pattern from Phase 2A and 2B sample locations shown in Figure 1, with a total of ten (10) samples collected and analyzed from each phase. Samples were gathered using a customized vacuum core sampler developed by Florida Gulf Coast University for limnological studies and characterizing sediment types. The core sampler consists of a 3.8 cm diameter x 3.1 meter-long section of schedule 40 PVC, with a one-way ball valve, rubber coupler, and 7.6 cm diameter x 0.75 meter-long clear Plexiglas™ cylinder at the base for collecting and viewing samples (Figure 2). Upon collection cores were removed from the PVC extension and photographed against a white board with location and date for archival and later comparison with post-restoration sediment profiles. Flocculent (floc) unconsolidated organic materials were measured on the surface of sediments. Consolidated sediments were also measured in depth and characterized as either floc (including live and dead *Lyngbya*), mud, sand, sand/mud, sand/clay, shell/rock, and peat. The upper layer of flocculent material along with *Lyngbya* and unconsolidated organics, which is unsuitable habitat for the survival and growth of *Vallisneria americana*, is the focus of the present analysis. Core sample sites were GPS located during baseline sampling and we returned to the same locations post-restoration.



Figure 1. Core sampling locations for Phase 2A and Phase 2B



Figure 2. Custom core sampling device used to collect sediment samples for benthic assessment.

RESULTS:

The following are the results of the pre-restoration (baseline) core samples collected in August of 2019 and post-restoration samples in June and July of 2020. Phase 2A water depths ranged from 2.0 to 5.0 meters (average of 3.0 m) and 0.9 to 3.4 meters (average of 1.9 m) for baseline and post-restoration respectively (Table 1). The study area is tidally influenced; therefore, water depth fluctuates depending on tidal cycle. Most important are sediment core composition and depth of the flocculent organic layer. Phase 2A baseline floc layer depths ranged from 1.3 to 5.1 cm with an average of 3.0 cm (Table 1). Nearly all sample sites contained deep deposits of sand/mud, ranging from 10.2 to 22.9 cm (Table 1). Overall core depths ranged from 15.3 to 29.2 cm with an average of 22.7 cm (Table 1). 2A Post-restoration samples contained floc layer depths varying from 0.0-2.3 cm with an average of 1.0 cm, demonstrating a reduction in average floc by 66.7% (Table 1). Mud was not found in any post-restoration samples, however all cores contained sand/mud deposits, with overall core depth average increasing by 0.9 cm (Table 1). Figure 3 is a bar graph showing before and after restoration flocculent organic depths in cm.

| King's Bay Core Sample Locations | | | Pre-Restoration Sediment Profile (cm) | | | | | | | | | |
|----------------------------------|----------|-----------|--|------|------|------|----------|-----------|------------|------|--------------|--|
| Sample | Latitude | Longitude | Water Depth (m) | Floc | Mud | Sand | Sand/Mud | Sand/Clay | Shell/Rock | Peat | Overall (cm) | |
| 2A-1 | 28.88978 | -82.59511 | 5.0 | 3.8 | 10.2 | 0.0 | 15.2 | 0.0 | 0.0 | 0.0 | 29.2 | |
| 2A-2 | 28.88923 | -82.59538 | 3.0 | 2.5 | 10.2 | 0.0 | 12.7 | 0.0 | 0.0 | 0.0 | 25.4 | |
| 2A-3 | 28.88906 | -82.59487 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 16.5 | 0.0 | 0.0 | 19.0 | |
| 2A-4 | 28.88869 | -82.59416 | 3.0 | 1.3 | 0.0 | 0.0 | 19.1 | 0.0 | 0.0 | 0.0 | 20.0 | |
| 2A-5 | 28.88867 | -82.59365 | 3.0 | 3.8 | 7.6 | 0.0 | 15.2 | 0.0 | 0.0 | 0.0 | 26.6 | |
| 2A-6 | 28.88832 | -82.59317 | 3.0 | 1.3 | 0.0 | 0.0 | 22.9 | 0.0 | 0.0 | 0.0 | 24.2 | |
| 2A-7 | 28.88813 | -82.59257 | 3.0 | 3.8 | 10.2 | 0.0 | 12.7 | 0.0 | 0.0 | 0.0 | 26.7 | |
| 2A-8 | 28.88812 | -82.59190 | 2.8 | 4.5 | 7.0 | 0.0 | 10.2 | 0.0 | 0.0 | 0.0 | 21.7 | |
| 2A-9 | 28.88788 | -82.59161 | 2.5 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.0 | 19.1 | |
| 2A-10 | 28.88792 | -82.59135 | 2.0 | 1.3 | 0.0 | 0.0 | 14.0 | 0.0 | 0.0 | 0.0 | 15.3 | |
| Mean = | | | 3.0 | 3.0 | | | | | | | 22.7 | |
| | | | Post-Restoration Sediment Profile (cm) | | | | | | | | | |
| Sample | Latitude | Longitude | Water Depth (m) | Floc | Mud | Sand | Sand/Mud | Sand/Clay | Shell/Rock | Peat | Overall (cm) | |
| 2A-1 | 28.88978 | -82.59511 | 2.1 | 1.0 | 0.0 | 0.0 | 21.6 | 0.0 | 0.0 | 0.0 | 22.6 | |
| 2A-2 | 28.88923 | -82.59538 | 2.4 | 0.3 | 0.0 | 0.0 | 13.5 | 0.0 | 0.0 | 0.0 | 13.7 | |
| 2A-3 | 28.88906 | -82.59487 | 1.8 | 0.5 | 0.0 | 0.0 | 27.4 | 0.0 | 0.0 | 0.0 | 27.9 | |
| 2A-4 | 28.88869 | -82.59416 | 1.5 | 2.3 | 0.0 | 0.0 | 13.7 | 2.8 | 0.0 | 0.0 | 18.8 | |
| 2A-5 | 28.88867 | -82.59365 | 1.2 | 1.3 | 0.0 | 0.0 | 14.2 | 0.0 | 2.0 | 0.0 | 17.5 | |
| 2A-6 | 28.88832 | -82.59317 | 2.4 | 0.0 | 0.0 | 0.0 | 2.8 | 6.4 | 3.3 | 0.0 | 12.4 | |
| 2A-7 | 28.88813 | -82.59257 | 3.4 | 1.3 | 0.0 | 0.0 | 13.5 | 6.4 | 0.0 | 0.0 | 21.1 | |
| 2A-8 | 28.88812 | -82.59190 | 0.9 | 0.5 | 0.0 | 0.0 | 10.2 | 20.3 | 2.3 | 0.0 | 33.3 | |
| 2A-9 | 28.88788 | -82.59161 | 1.2 | 1.5 | 0.0 | 2.3 | 32.8 | 0.0 | 0.0 | 0.0 | 36.6 | |
| 2A-10 | 28.88792 | -82.59135 | 1.5 | 1.3 | 0.0 | 0.0 | 2.8 | 27.9 | 0.0 | 0.0 | 32.0 | |
| Mean = | | | 1.9 | 1.0 | | | | | | | 23.6 | |
| | | | Mean Removal Efficiency = 66.7% | | | | | | | | | |

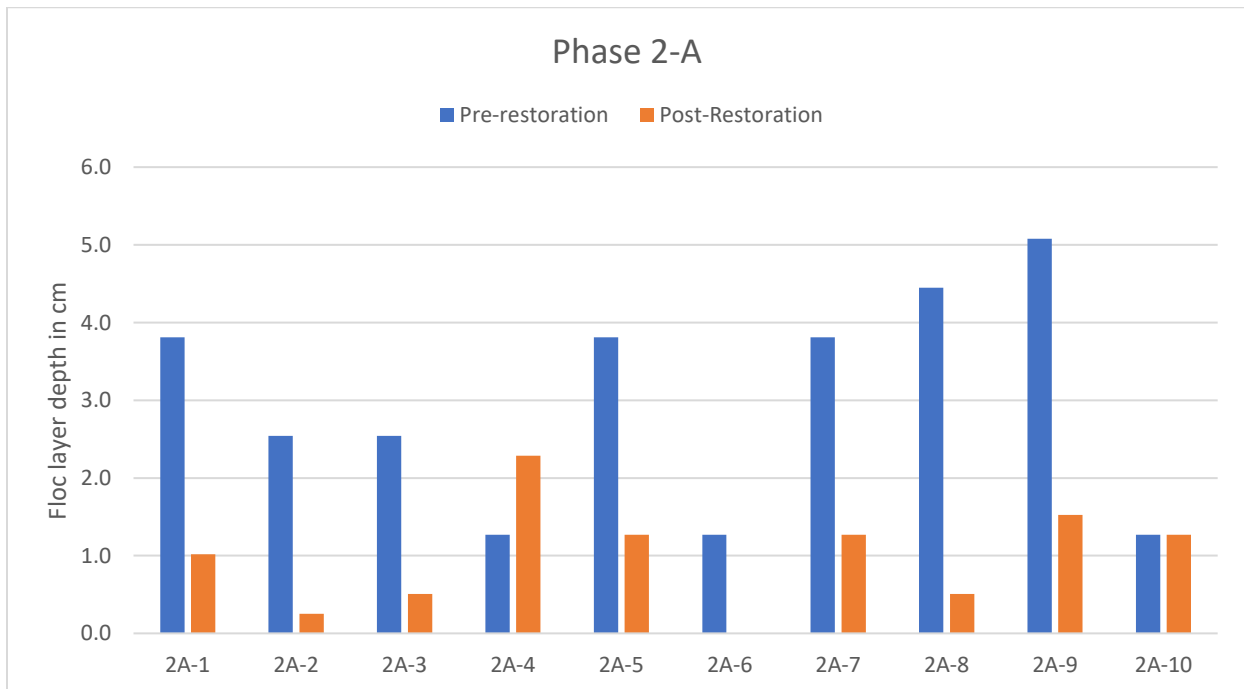


Figure 3. Phase 2A pre and post de-mucking flocculent organic depths as measured by core sampling with samples collected on August 6, 2019 and June 30-July 1, 2020.

| Table 2. Phase 2-B: Baseline results of Core Samples collected on August 6, 2019 and June 30 - July 1, 2020 | | | | | | | | | | | |
|---|----------|-----------|--|------|------|------|----------|-----------|------------|------|--------------|
| King's Bay Core Sample Locations | | | Pre-Restoration Sediment Profile (cm) | | | | | | | | |
| Site | Latitude | Longitude | Water Depth (m) | Floc | Mud | Sand | Sand/Mud | Sand/Clay | Shell | Peat | Overall (cm) |
| 2B-1a | 28.88972 | -82.59716 | 1.8 | 2.5 | 7.6 | 0.0 | 0.0 | 0.0 | 3.8 | 0.0 | 13.9 |
| 2B-1b | 29.88972 | -81.59716 | 1.8 | 5.1 | 11.4 | 0.0 | 21.6 | 0.0 | 0.0 | 0.0 | 38.1 |
| 2B-2 | 28.88989 | -82.59630 | 2.8 | 7.6 | 12.7 | 0.0 | 22.9 | 0.0 | 0.0 | 0.0 | 43.2 |
| 2B-3 | 28.89016 | -82.59601 | 2.5 | 6.4 | 12.7 | 0.0 | 25.4 | 0.0 | 0.0 | 0.0 | 44.5 |
| 2B-4 | 28.89023 | -82.59638 | 3.5 | 14.0 | 5.1 | 0.0 | 7.6 | 0.0 | 0.0 | 0.0 | 26.7 |
| 2B-5 | 28.88990 | -82.59695 | 2.0 | 6.4 | 7.6 | 0.0 | 0.0 | 11.4 | 0.0 | 0.0 | 25.4 |
| 2B-6 | 28.88887 | -82.59693 | 2.0 | 5.1 | 10.2 | 0.0 | 0.0 | 25.4 | 0.0 | 0.0 | 40.7 |
| 2B-7 | 28.88855 | -82.59693 | 2.5 | 1.3 | | 0.0 | 6.4 | 15.2 | 0.0 | 0.0 | 22.9 |
| 2B-8 | 28.88809 | -82.59599 | 2.5 | 7.6 | 11.4 | 0.0 | 0.0 | 19.1 | 0.0 | 0.0 | 38.1 |
| 2B-9 | 28.88831 | -82.59565 | 3.0 | 7.6 | 14.0 | 0.0 | 0.0 | 19.1 | 0.0 | 0.0 | 40.7 |
| 2B-10 | 28.88833 | -81.59610 | 3.0 | 5.1 | 8.9 | 0.0 | 0.0 | 21.6 | 0.0 | 0.0 | 35.6 |
| | | Mean = | 2.5 | 6.2 | | | | | | | 33.6 |
| | | | Post-Restoration Sediment Profile (cm) | | | | | | | | |
| Site | Latitude | Longitude | Water Depth (m) | Floc | Mud | Sand | Sand/Mud | Sand/Clay | Shell/Rock | Peat | Overall (cm) |
| 2B-1 | 28.88972 | -82.59716 | 2.4 | 9.9 | 0.0 | 0.0 | 22.9 | 0.0 | 0.0 | 0.0 | 32.8 |
| 2B-2 | 28.88989 | -82.59630 | 2.7 | 0.3 | 0.0 | 0.0 | 16.5 | 0.0 | 0.0 | 0.0 | 16.8 |
| 2B-3 | 28.89016 | -82.59601 | 3.4 | 4.3 | 12.2 | 0.0 | 22.9 | 0.0 | 0.0 | 0.0 | 39.4 |
| 2B-4 | 28.89023 | -82.59638 | 2.7 | 1.0 | 0.0 | 0.0 | 19.3 | 0.0 | 0.0 | 0.0 | 20.3 |
| 2B-5 | 28.88990 | -82.59695 | 1.2 | 2.3 | 0.0 | 0.0 | 14.0 | 0.0 | 0.0 | 0.0 | 16.3 |
| 2B-6 | 28.88887 | -82.59693 | 3.7 | 3.3 | 0.0 | 1.5 | 5.8 | 16.3 | 0.0 | 0.0 | 26.9 |
| 2B-7 | 28.88855 | -82.59693 | 1.5 | 1.8 | 0.0 | 2.3 | 8.9 | 24.4 | 0.0 | 0.0 | 37.3 |
| 2B-8 | 28.88809 | -82.59599 | 1.5 | 1.3 | 0.0 | 18.0 | 9.1 | 0.0 | 0.0 | 0.0 | 28.4 |
| 2B-9 | 28.88831 | -82.59565 | 2.4 | 2.8 | 0.0 | 2.8 | 3.3 | 28.4 | 0.0 | 0.0 | 37.3 |
| 2B-10 | 28.88833 | -81.59610 | 2.4 | 4.3 | 0.0 | 0.0 | 3.8 | 24.1 | 0.0 | 2.5 | 34.8 |
| | | Mean = | 2.4 | 3.1 | | | | | | | 29.0 |
| Mean Removal Efficiency = 50.0% | | | | | | | | | | | |

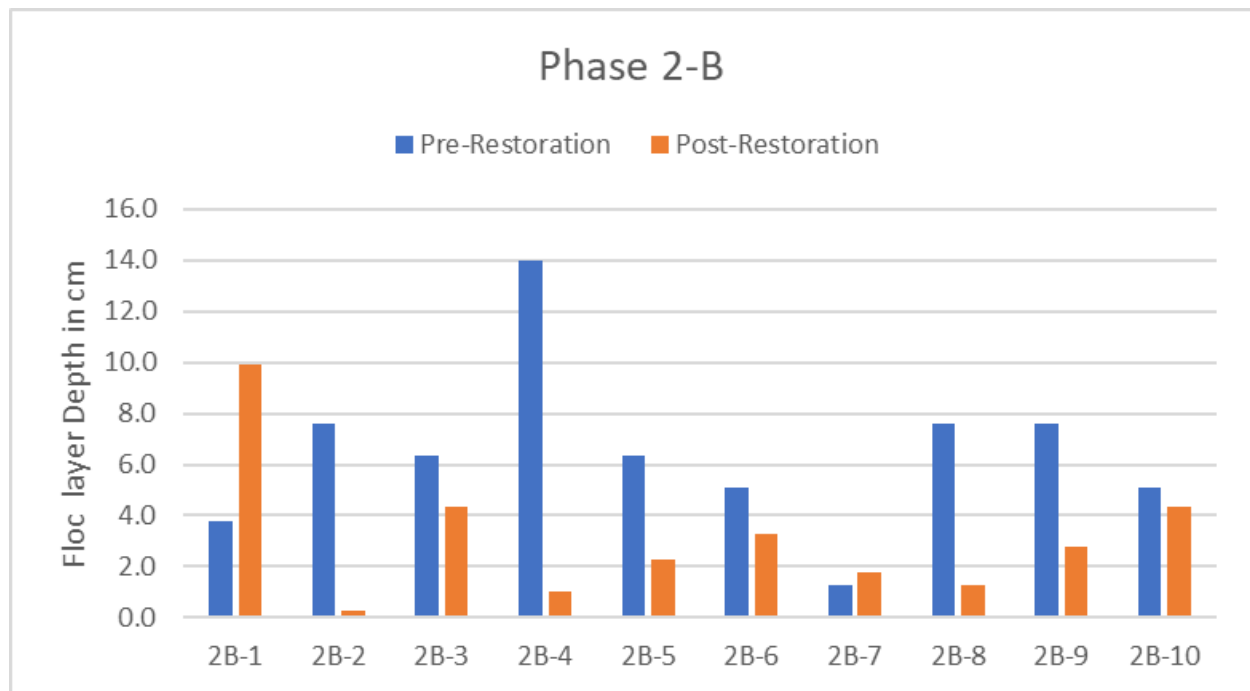


Figure 4. Phase 2B pre and post de-mucking flocculent organic depths as measured by core sampling with samples collected on August 6, 2019 and June 30-July 1, 2020.

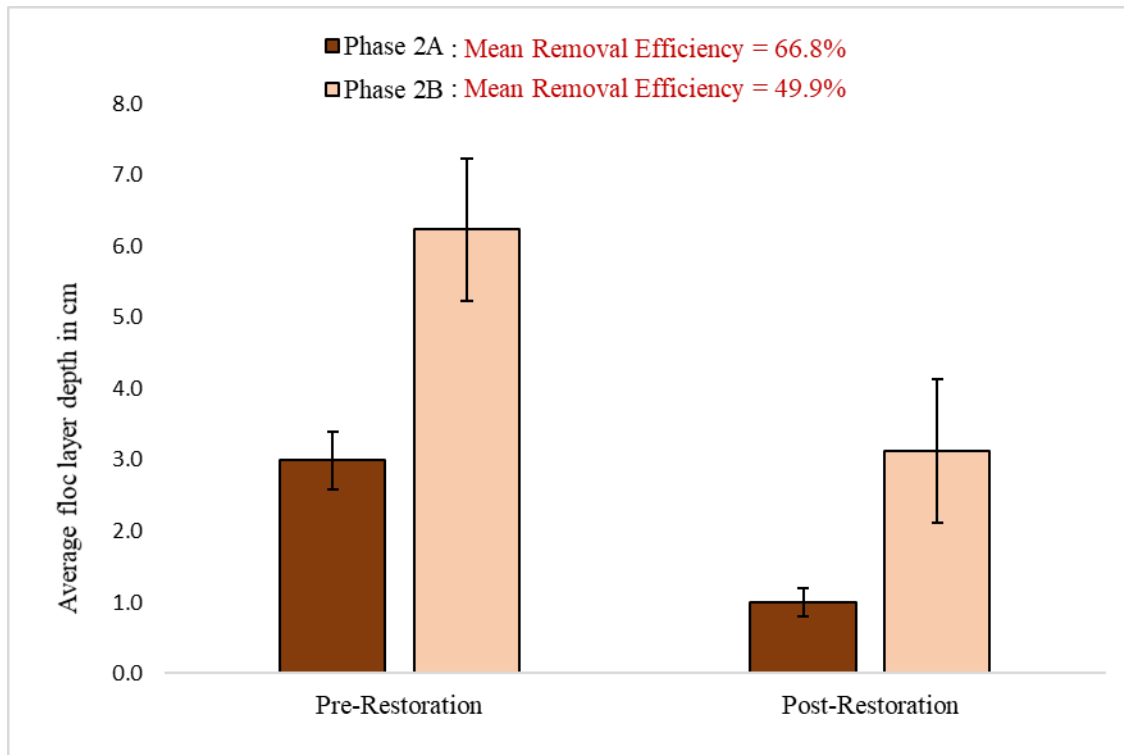


Figure 5. Average floc layer depth (cm) for Pre- and Post-Restoration core samples in both Phase 2-A and 2-B sample locations. Error bars represent standard error of the mean (SEM). ANOVA tests between Pre- and Post-restoration for each phase determined statistically significant difference between the means ($P < 0.05$).

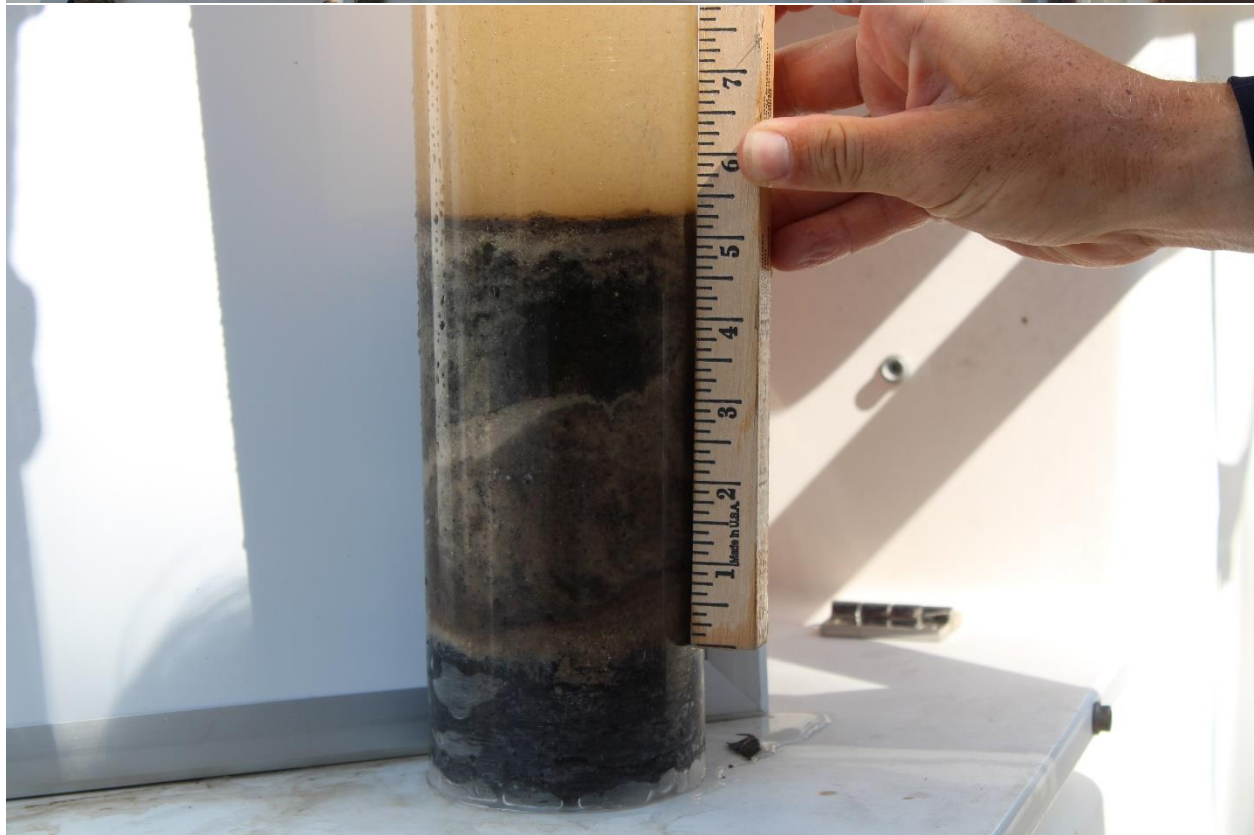
Figure 4 is a bar graph showing flocculent organic material depths in cm before and after restoration. Phase 2B water depths ranged from 1.8 to 3.5 meters (average of 2.5 m) for baseline and 1.2 to 3.7 meters (average of 2.4 m) for post-restoration (Table 2). Baseline flocculent organic layers varied substantially, ranging from 1.3 to 14 cm with an average of 6.2 cm (Table 2). Clusters of sites (2B-2 – 2B-5 and 2B-10 – 2B-8) in areas sheltered from the main waterway showed higher levels of floc than those directly exposed (Figure 1, Table 2). Due to shelter, water movement via wind, wave, and human activity (i.e., boating) is likely reduced, resulting in lower energy environments which promote deposition and accumulation of flocculants. All sample locations contained consolidated deposits of mud and/or sand/mud (Table 2). Overall core depth ranged from 44.5 to 13.9 cm with an average depth of 33.6 cm. 2B Post-restoration floc layers ranged from 0.3 to 9.9 cm with an average of 3.1 cm, representing an average floc removal efficiency of 50.0% (Table 1). Mud layers were reduced dramatically across Phase 2B, accompanied by an increase in sand and sand/mud deposits (Table 2). Overall core sample depth decreased by an average of 4.6 cm (Table 2).

Certain sample sites in both Phase 2A and 2B showed increases in floc layer depth as well as sand/clay and sand/mud deposits (Table 1, Table 2). The displacement and subsequent re-distribution of flocculent organics and other sediments by ongoing de-mucking operations offers a plausible explanation for these observations. However, it was later learned that a sediment containment bag had ruptured and discharged dredge material back into the Phase 2B area adjacent to the spoil disposal area which necessitated the redeployment of vacuum dredging equipment that was ongoing during the core sampling on June 30 and July 1, 2020 (Carter Henne, personal communication). Reduction in floc and mud layers across both phases has produced sediment conditions that appear suitable for growth and spread of *Vallisneria* and other SAV species. Appendix A contains photographs of all post-restoration core samples from Phase 2A and Phase 2B. ANOVA tests identified an overall significant reduction in flocculent organic matter in both Phases 2A and 2B even with the rupture of containment bag at Phase 2B (Figure 5). Subsequent core sampling in this area is recommended to document the effectiveness of the second vacuum dredging.

APPENDIX A
Photographs of Core Samples



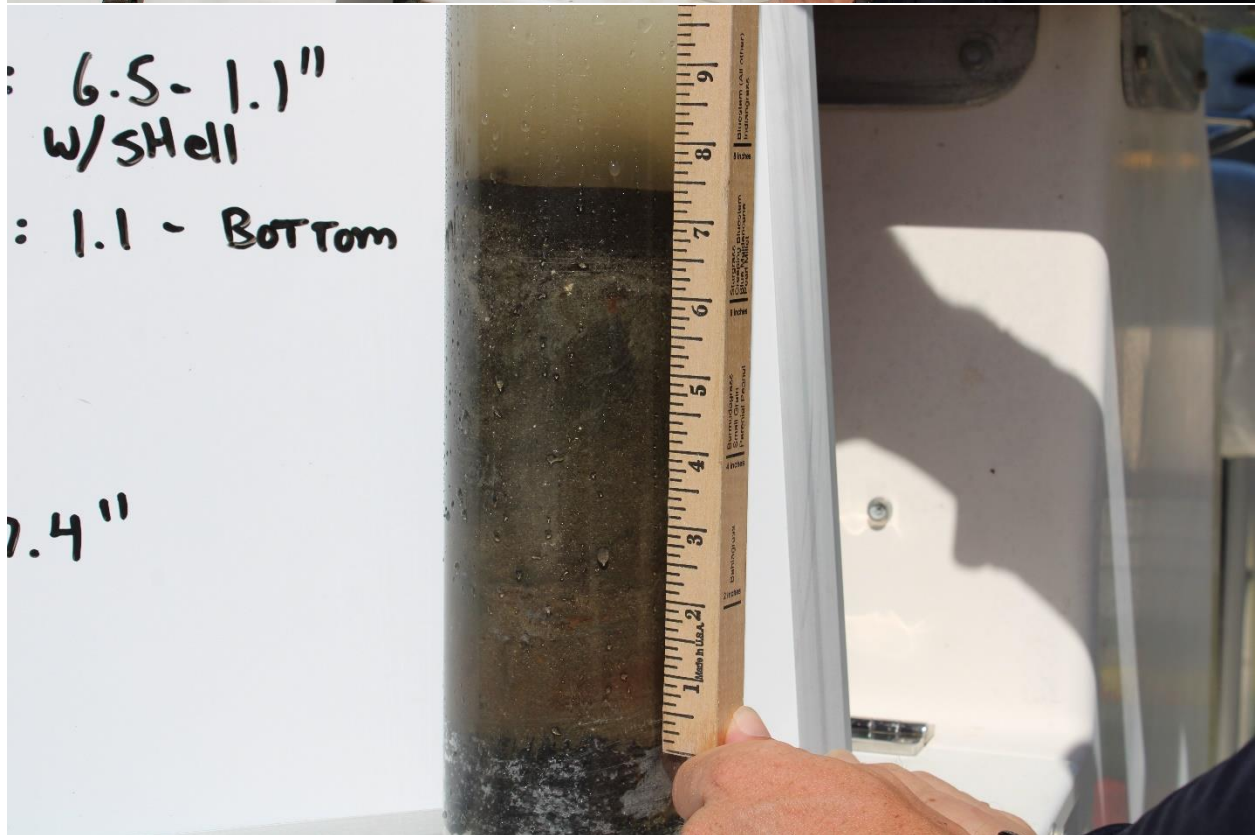
Phase 2-A: Core Sample 1 with 1.0 cm floc and 21.6 cm sand/mud.



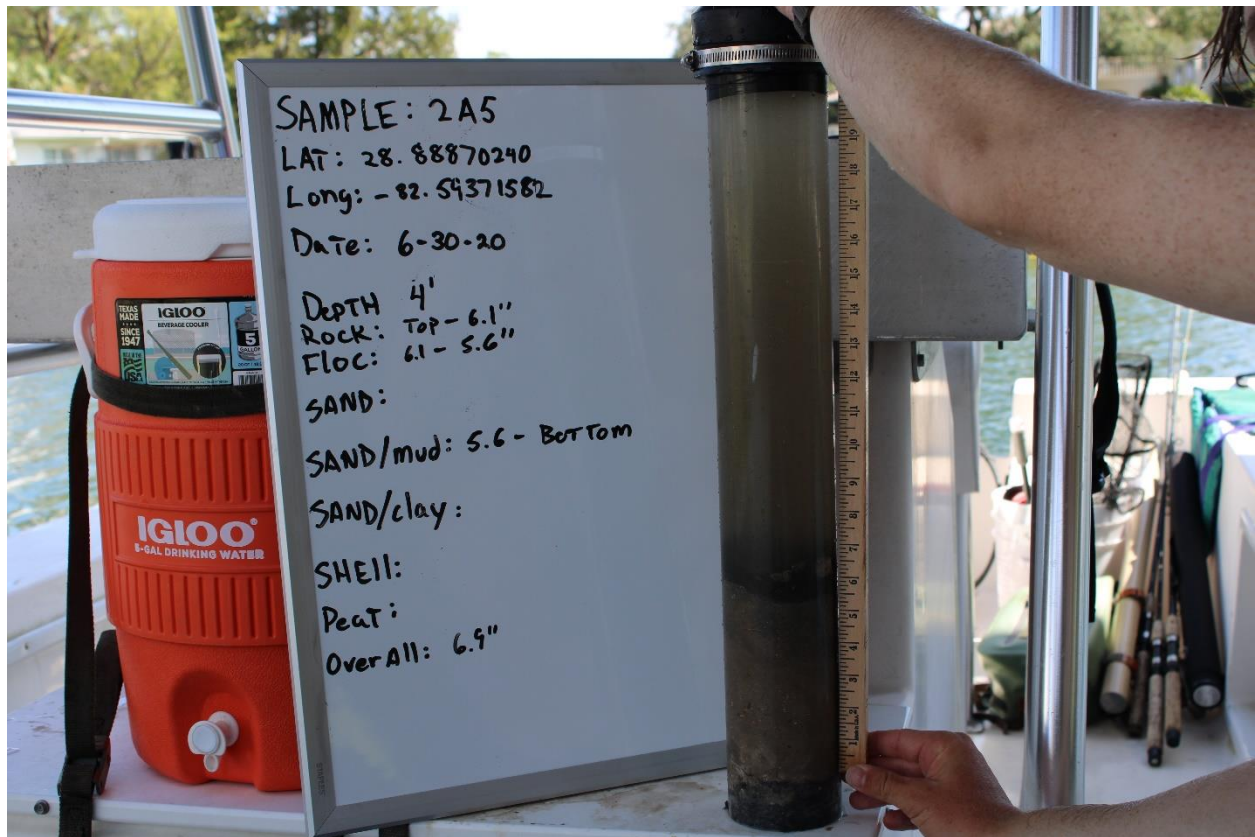
Phase 2-A: Core Sample 2 with 0.3 cm and 13.5 cm sand/mud layers.



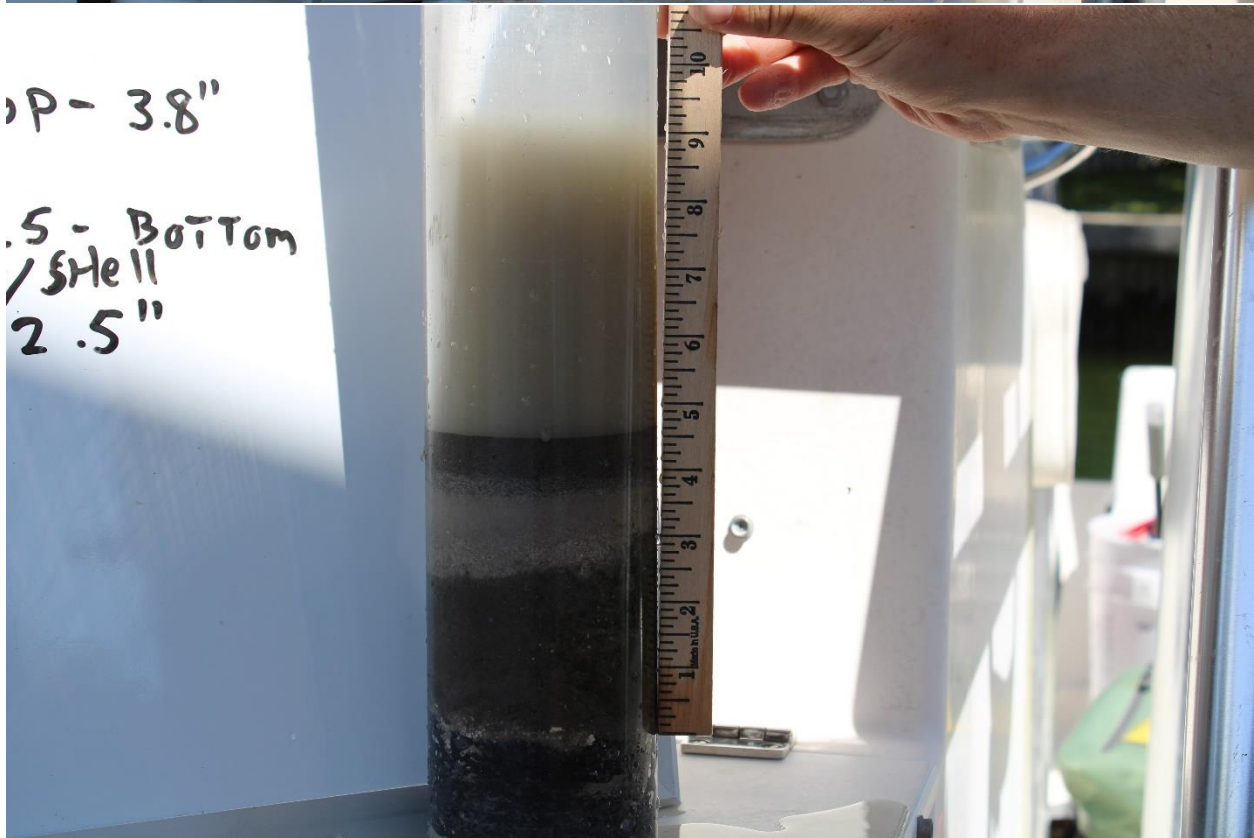
Phase 2-A: Core Sample 3 with 0.5 cm floc and 27.4 cm sand/mud.



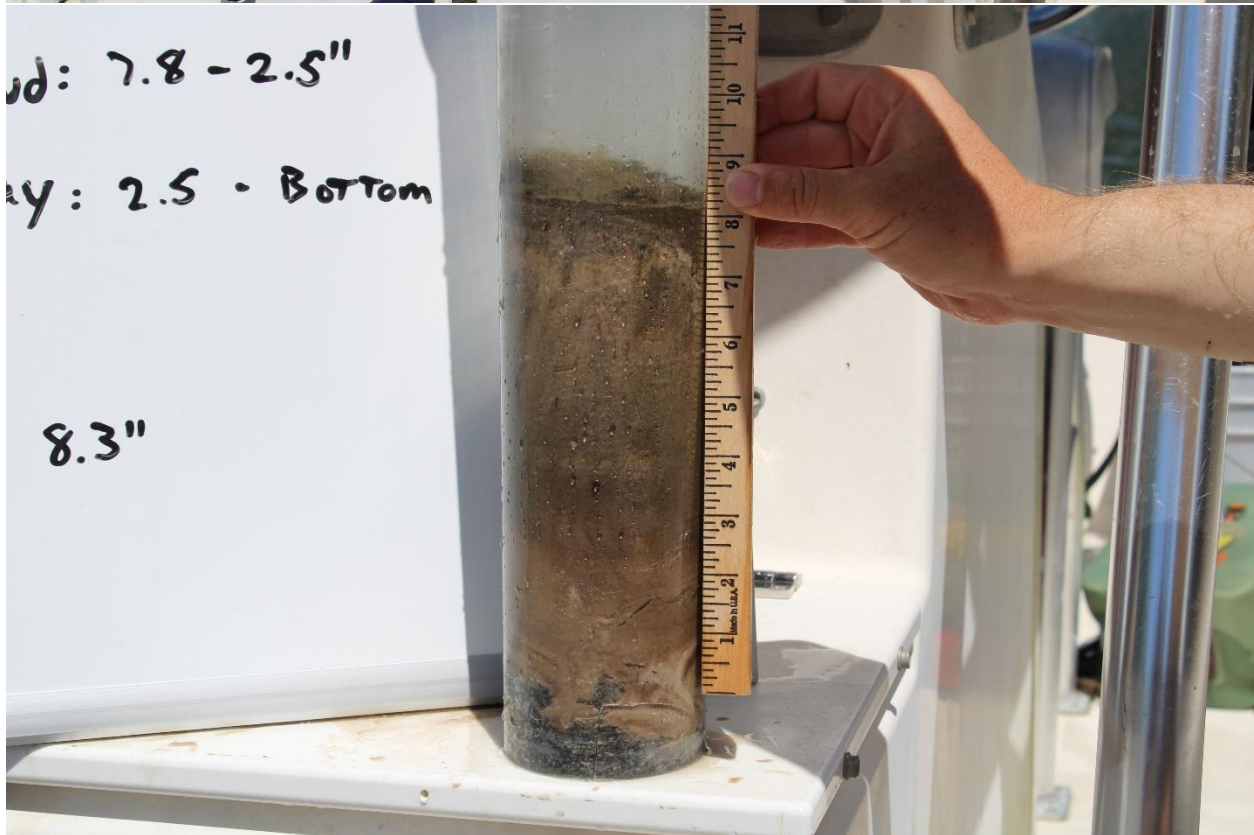
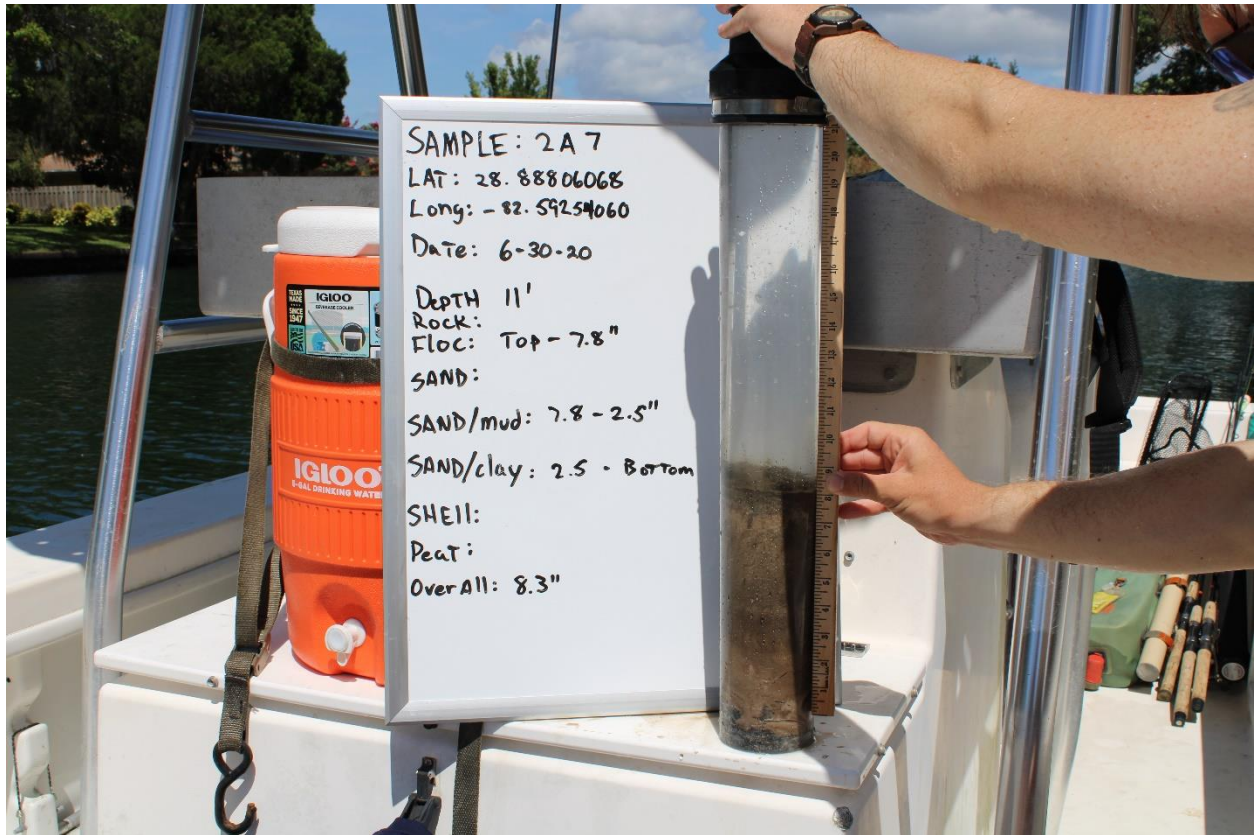
Phase 2-A: Core Sample 4 with 2.3 cm flock and 16.5 cm sand/mud/clay layers with shell.



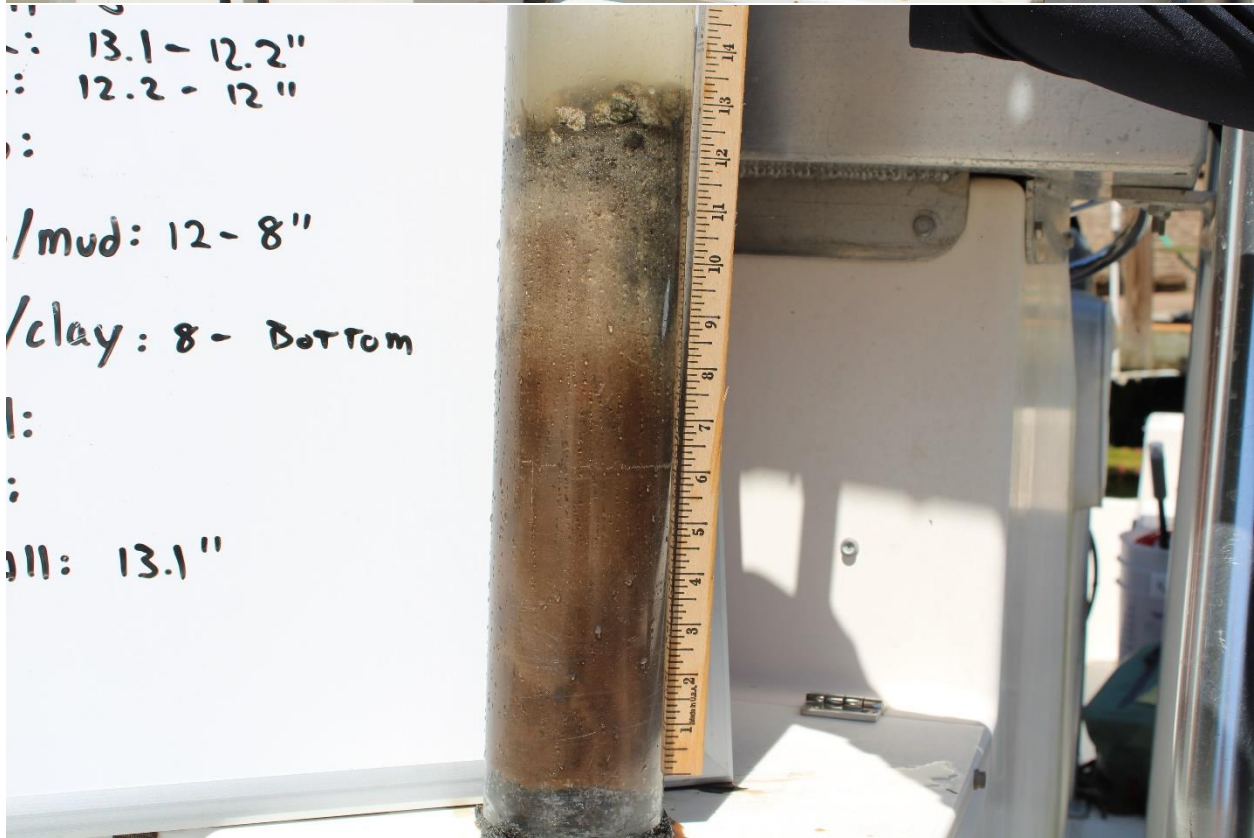
Phase 2-A: Core Sample 5 with 1.3 cm floc and 16.2 cm sand/mud and rock/shell layers.



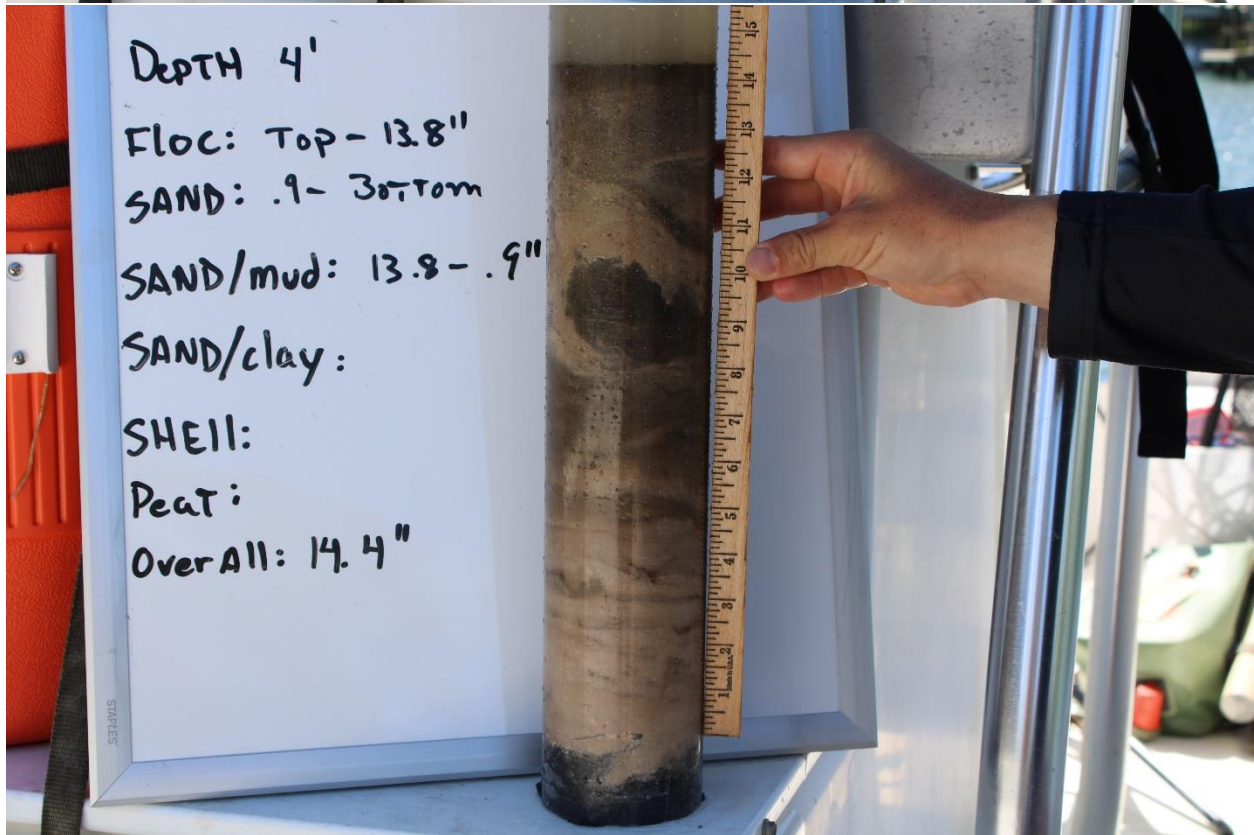
Phase 2-A: Core Sample 6 with 0.0 cm floc and 12.4 cm sand/mud/clay with shell layers.



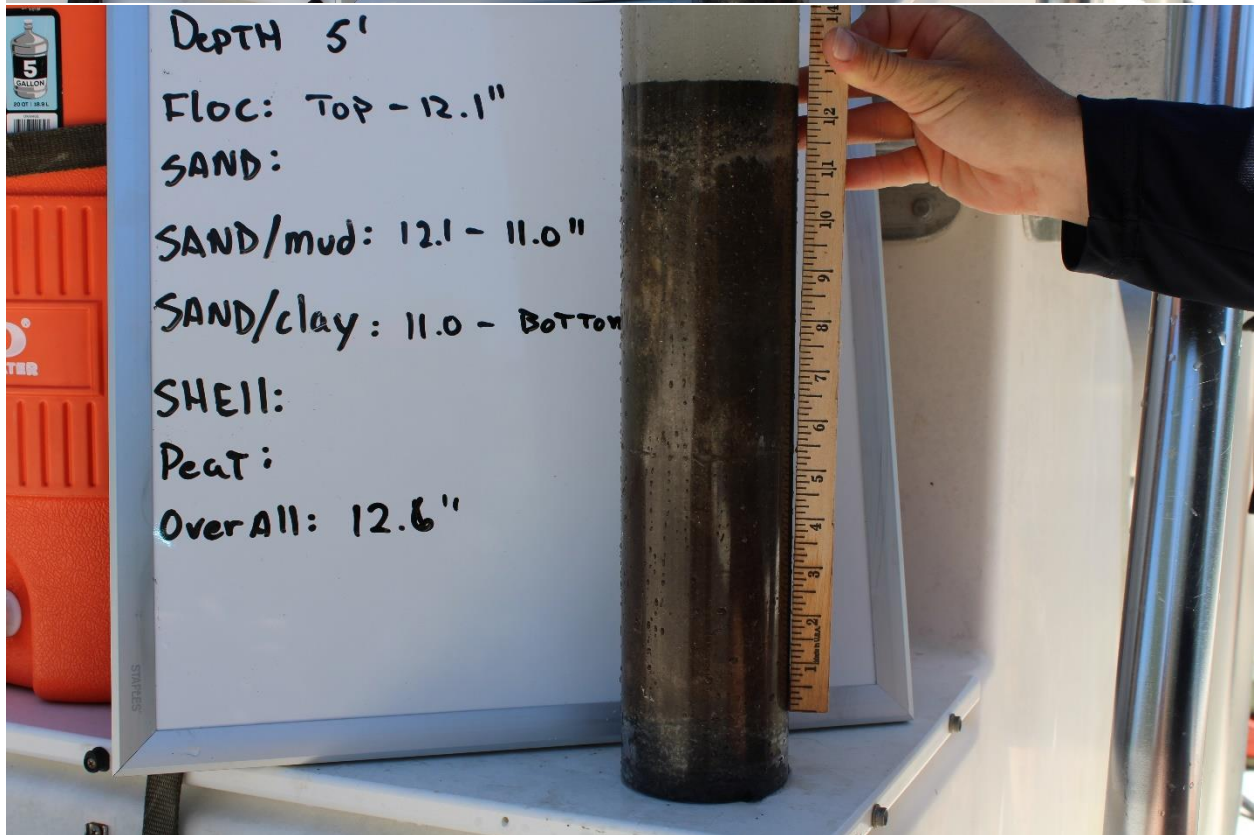
Phase 2-A: Core Sample 7 with 1.3 cm floc and 19.9 cm sand/mud/clay layers.



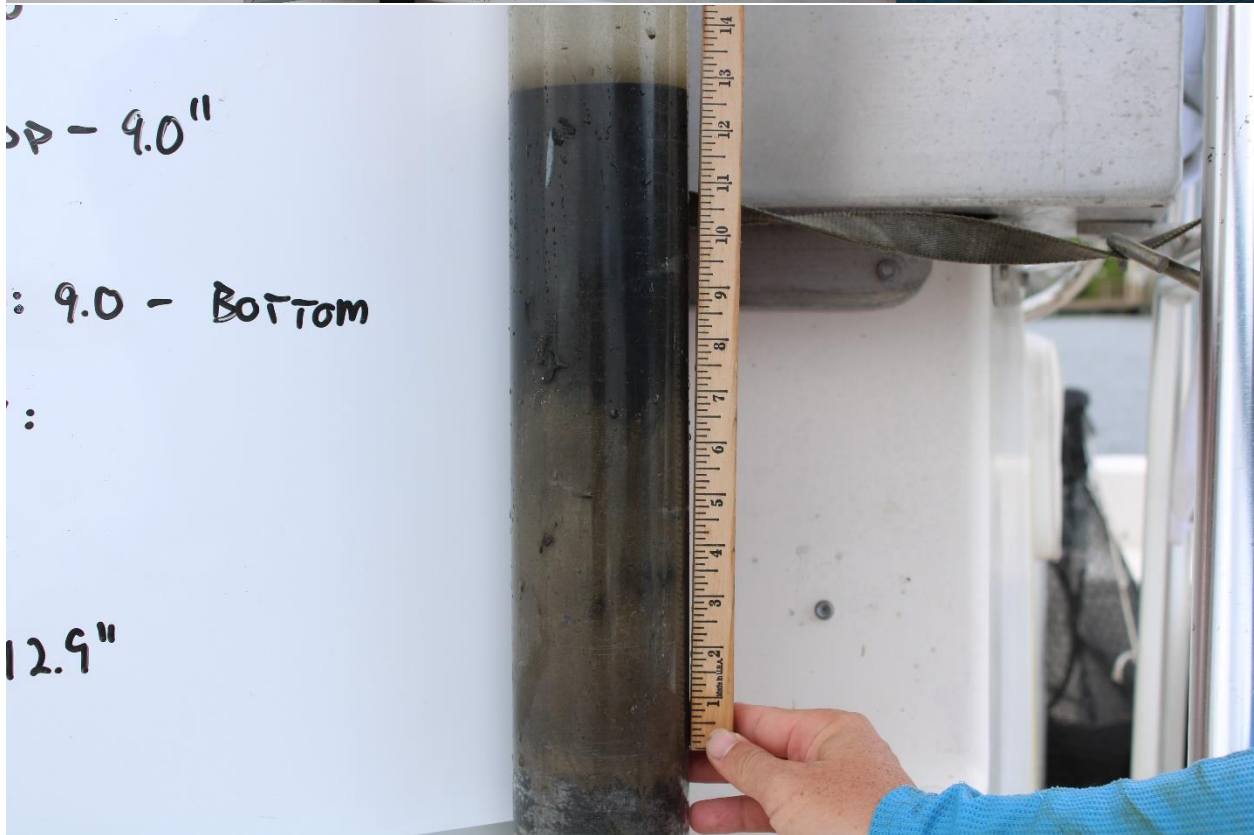
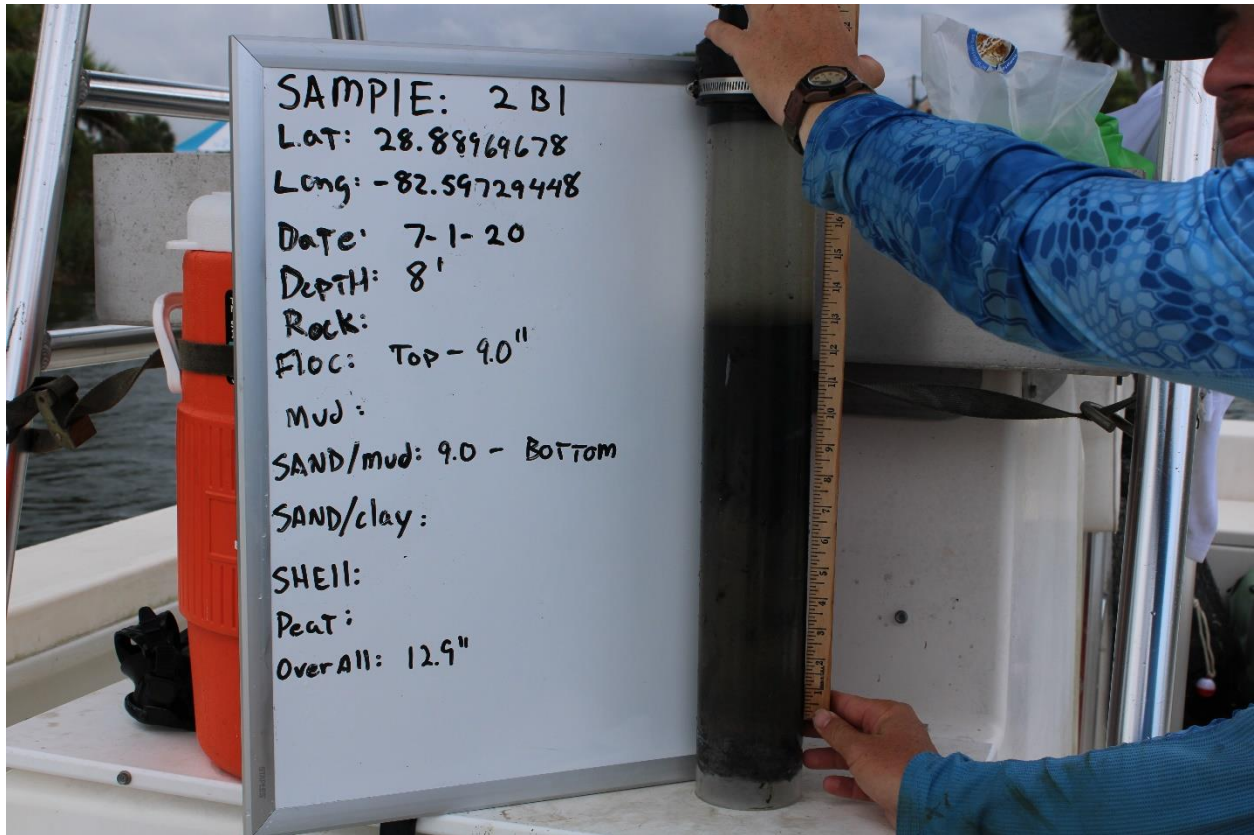
Phase 2-A: Core Sample 8 with 0.5 cm floc and 32.8 cm sand/mud/clay and shell/rock layers



Phase 2-A: Core Sample 9 with 1.5 cm floc and 35.1 cm sand and sand/mud layers.



Phase 2-A: Core Sample 10 with 1.3 cm floc and 30.7 cm sand/mud/clay layers.



Phase 2-B: Core Sample 1 with 9.9 cm floc and 22.9 cm sand/mud layers.



Phase 2-B: Core Sample 2 with 0.3 cm floc and 16.5 cm mud/sand layers.



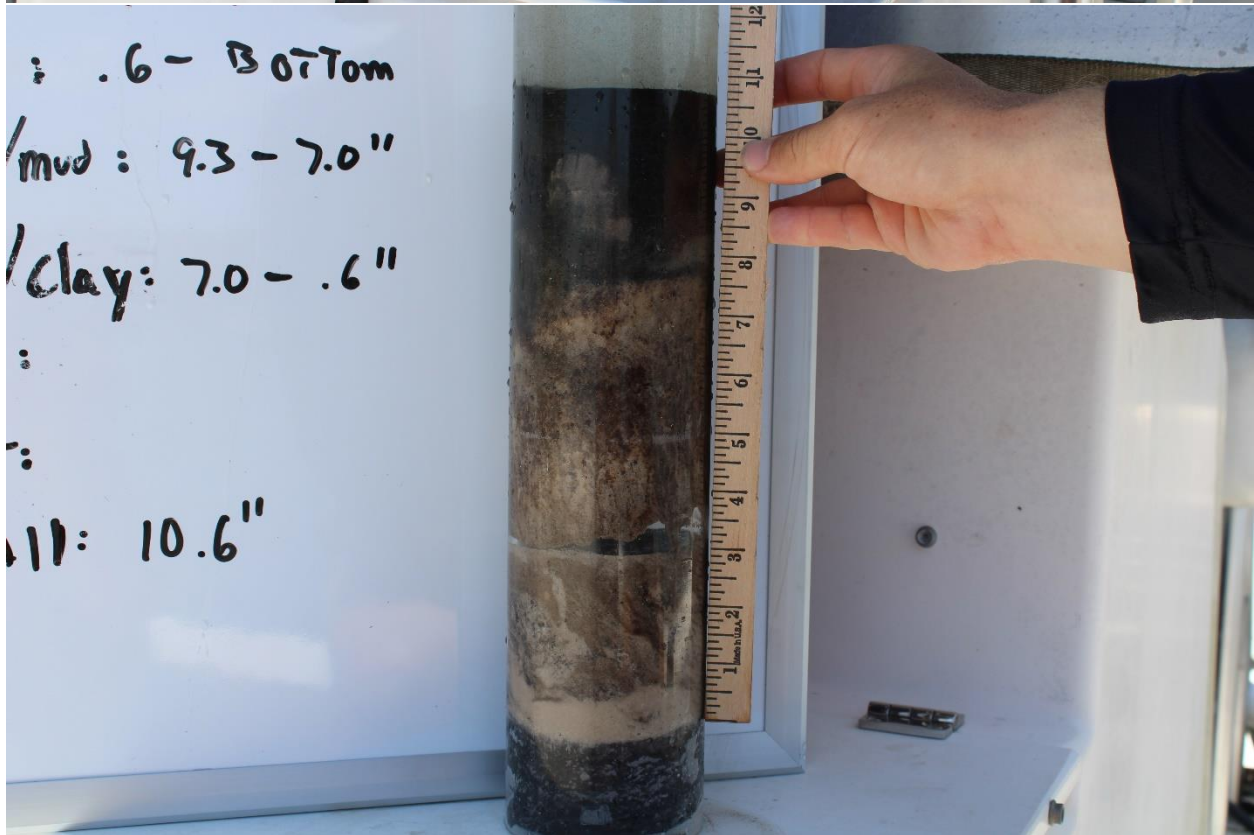
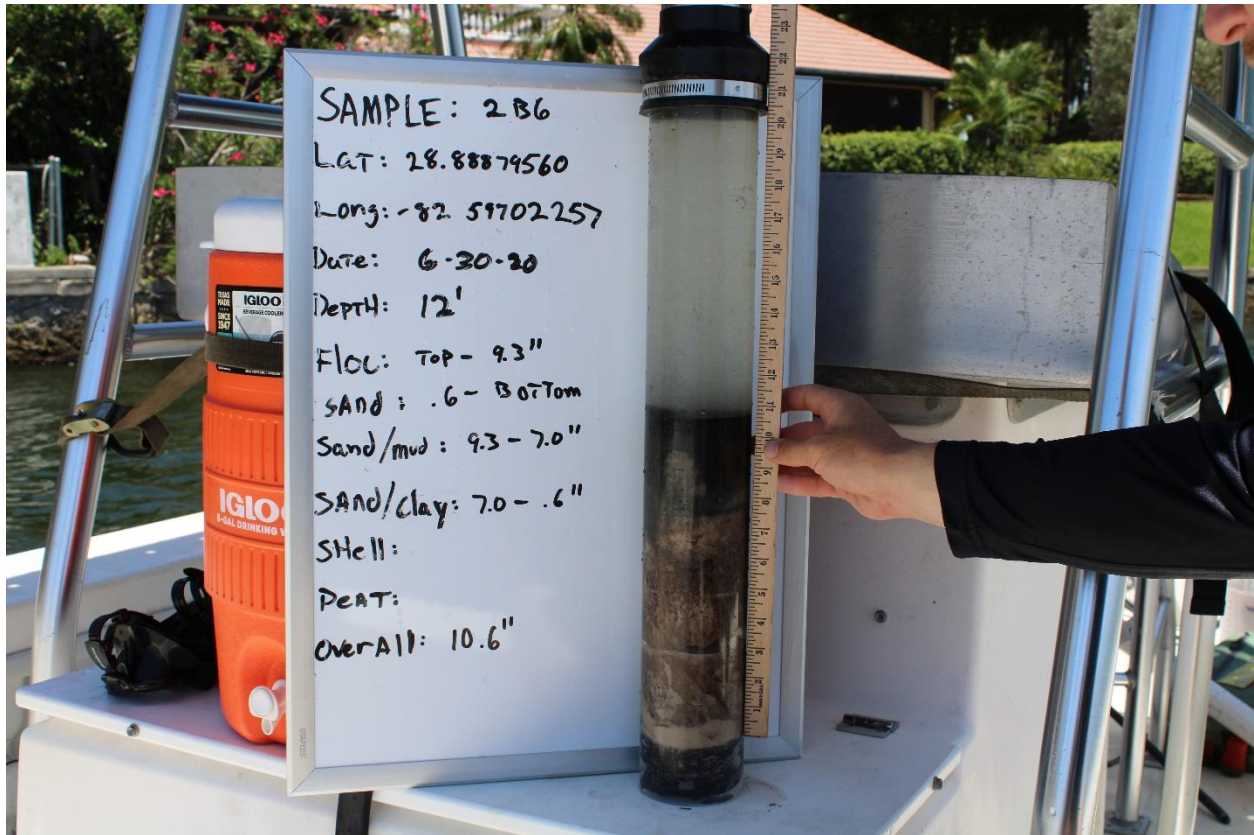
Phase 2-B: Core Sample 3 with 4.3 cm floc and 35.1 cm mud and sand/mud layers.



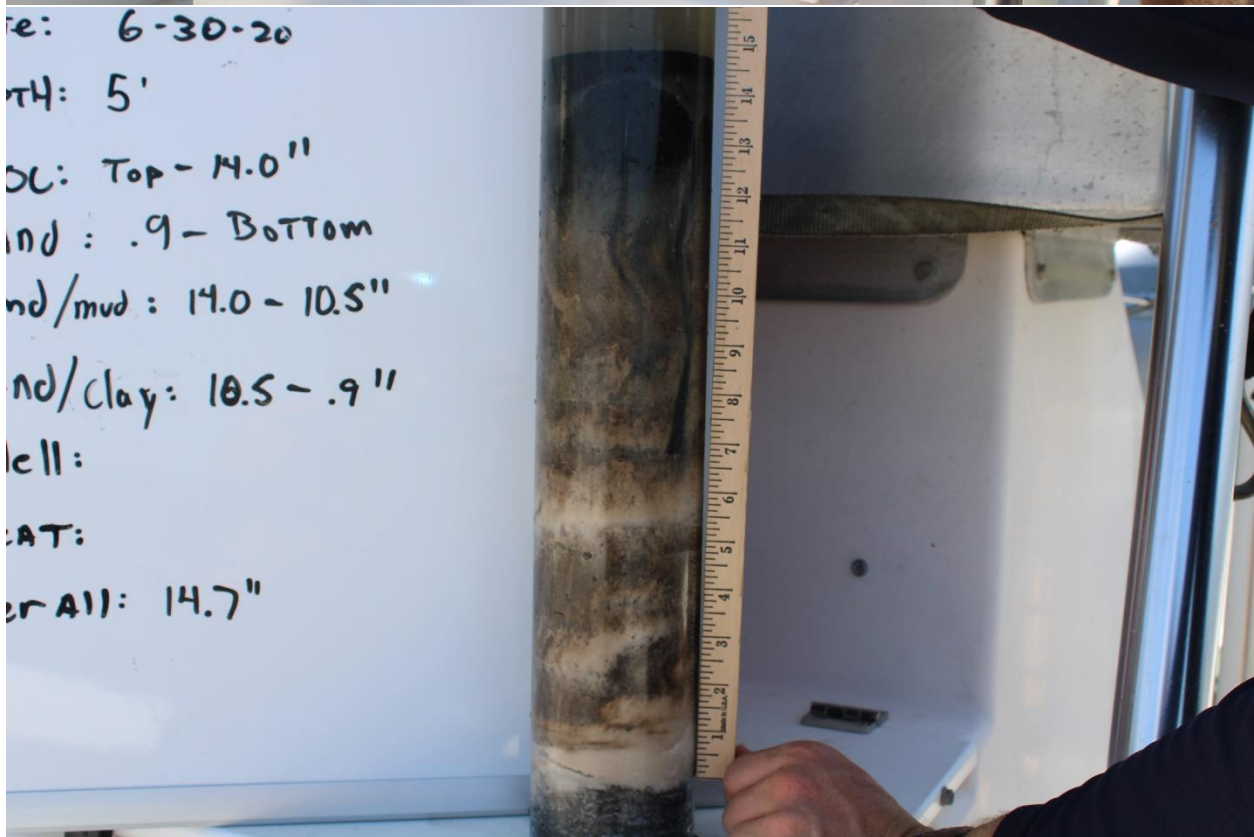
Phase 2-B: Core Sample 4 with 1.0 cm floc and 19.3 cm sand/mud layers.



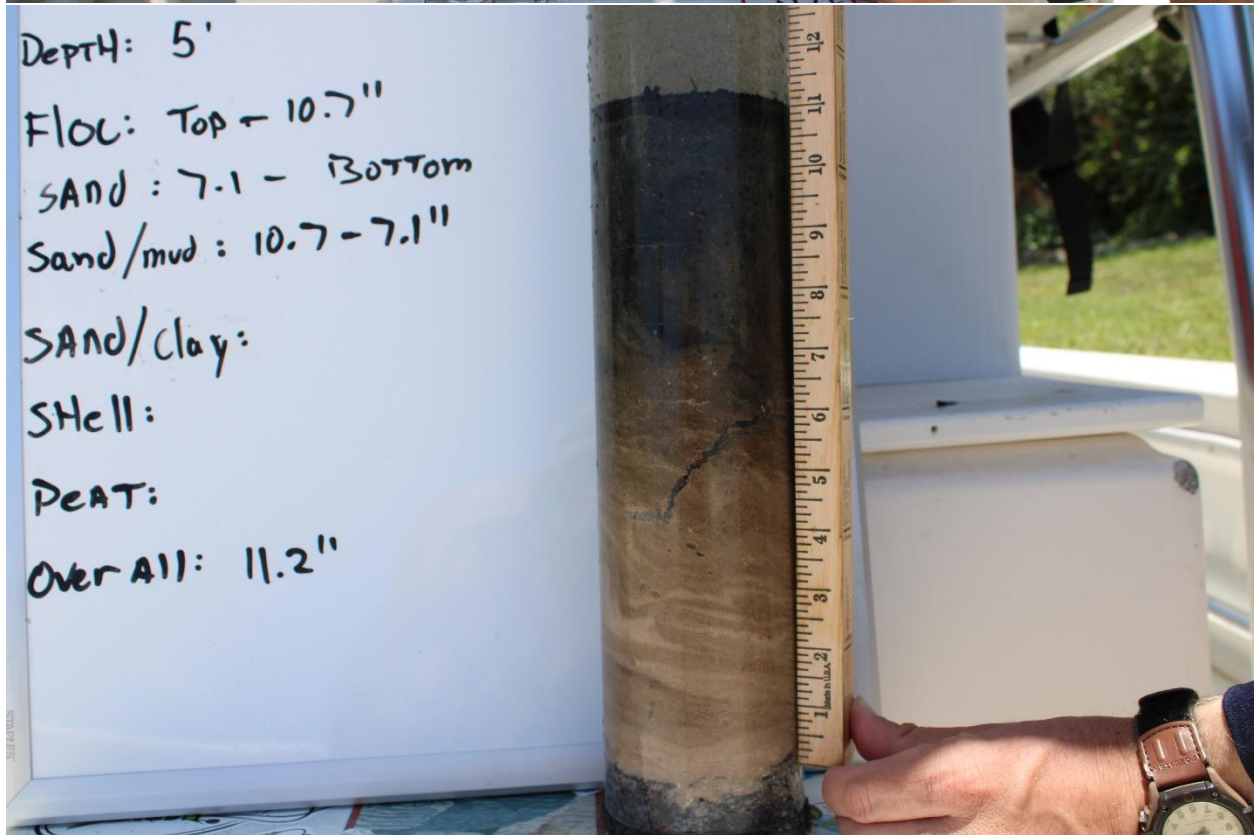
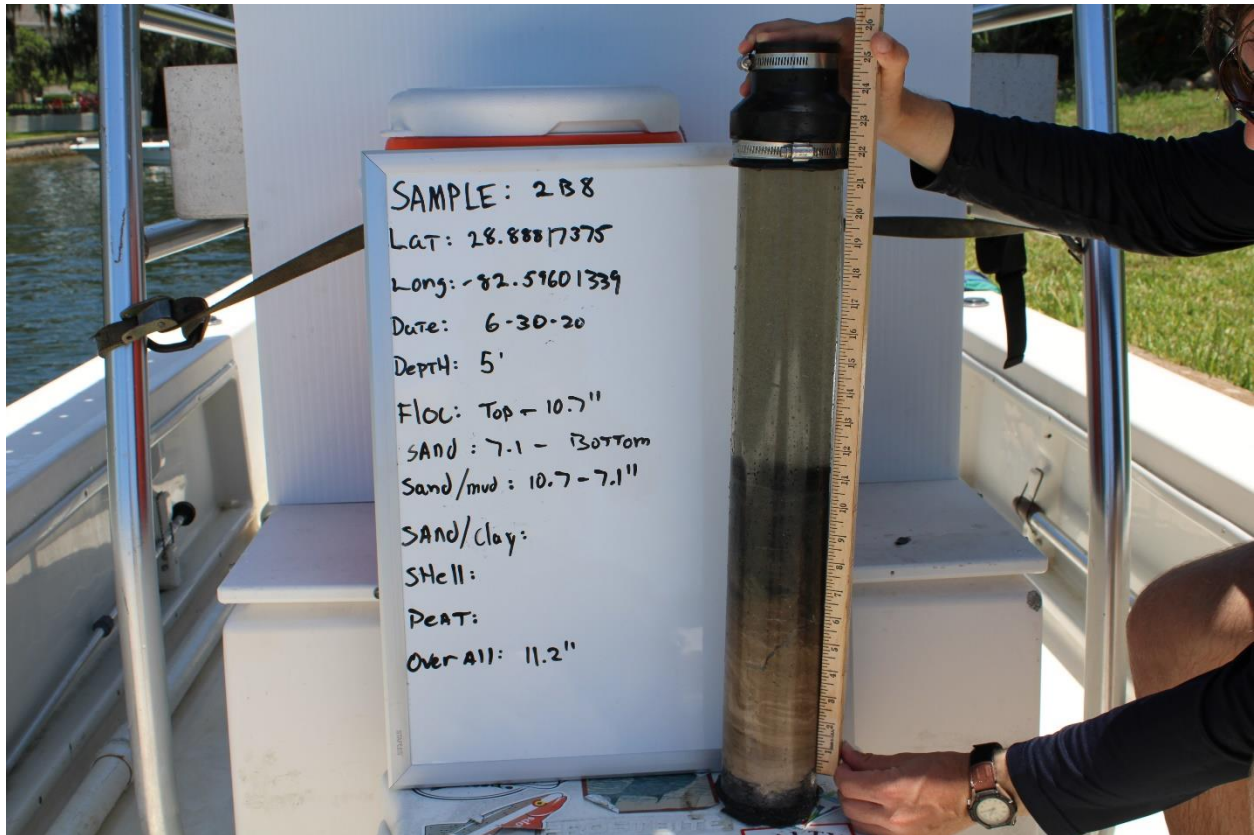
Phase 2-B: Core Sample 5 with 2.3 cm floc and 14.0 cm sand/mud layers with shell.



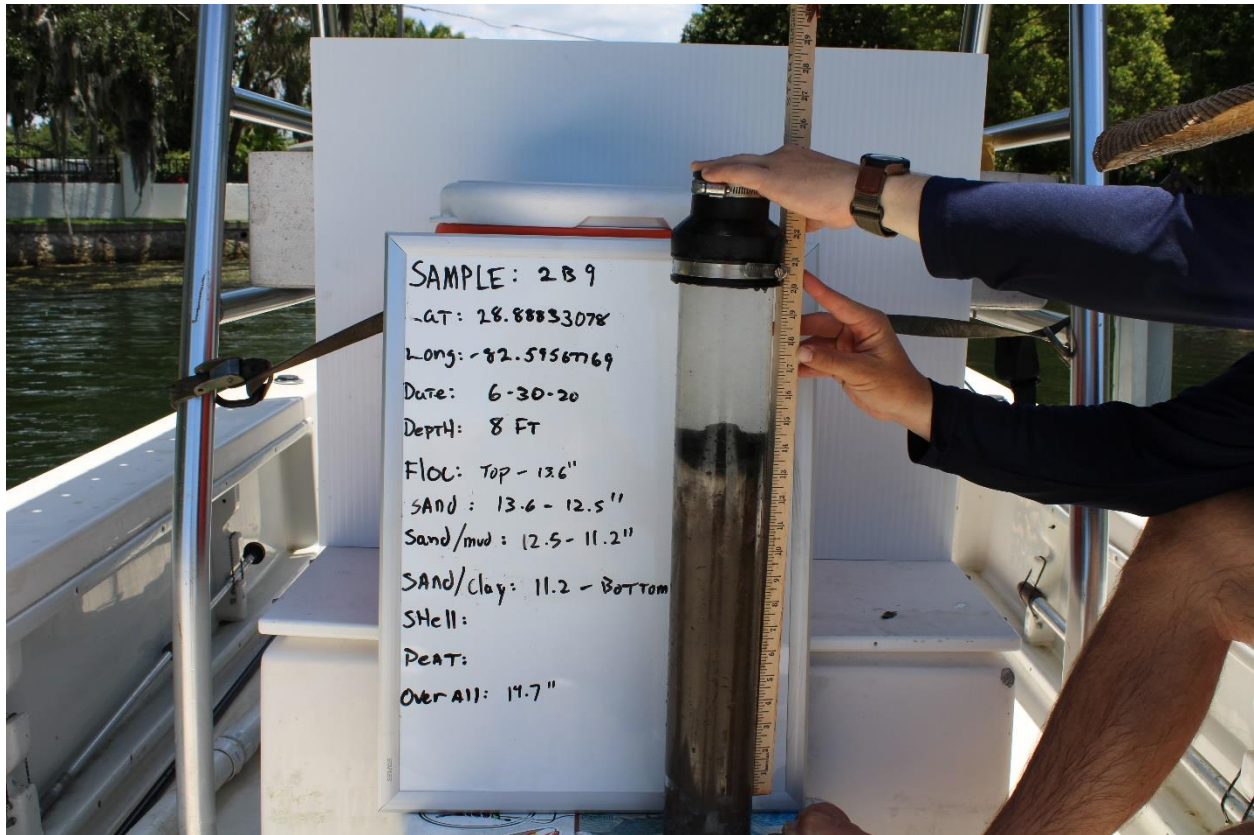
Phase 2-B: Core Sample 6 with 3.3 cm floc and 23.6 cm sand/mud/clay.



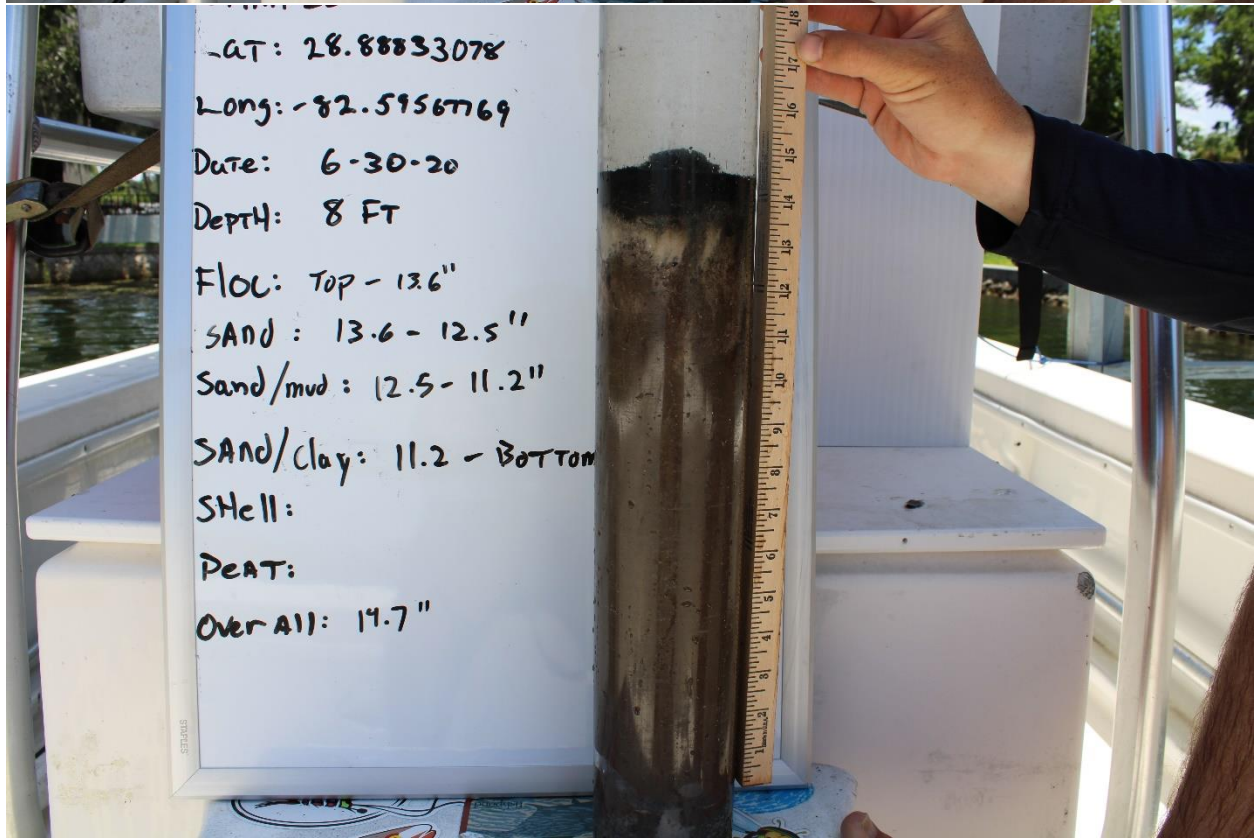
Phase 2-B: Core Sample 7 with 1.8 cm floc and 35.5 cm sand/mud/clay layers.



Phase 2-B: Core Sample 8 with 1.3 cm floc and 27.1 cm sand and mud layers.

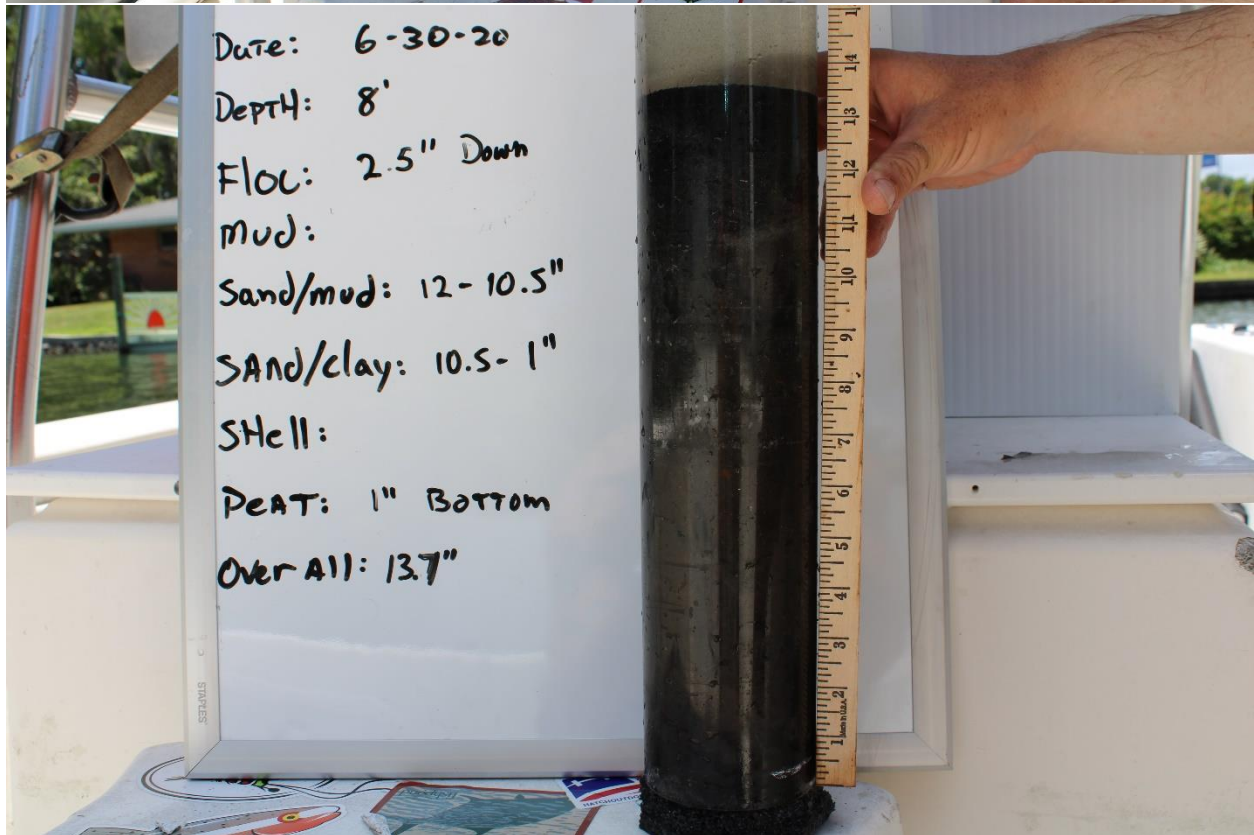


SAMPLE: 2B9
-AT: 28.88833078
Long: -82.59567769
Date: 6-30-20
Depth: 8 FT
Floc: Top - 13.6"
SAND: 13.6 - 12.5"
Sand/mud: 12.5 - 11.2"
SAND/clay: 11.2 - BOTTOM
Shell:
Peat:
Overall: 11.7"



-AT: 28.88833078
Long: -82.59567769
Date: 6-30-20
Depth: 8 FT
Floc: Top - 13.6"
SAND: 13.6 - 12.5"
Sand/mud: 12.5 - 11.2"
SAND/clay: 11.2 - BOTTOM
Shell:
Peat:
Overall: 11.7"

Phase 2-B: Core Sample 9 with 2.8 cm with 34.5 cm of sand/mud and clay layers.



Phase 2-B: Core Sample 10 with 4.3 cm of floc over 30.5 cm of sand/mud/clay and peat layers.