BENTHIC SEDIMENT SAMPLING REPORT
KING'S BAY RESTORATION AREAS

February 27, 2025

Prepared for:

Save Crystal River, Inc.
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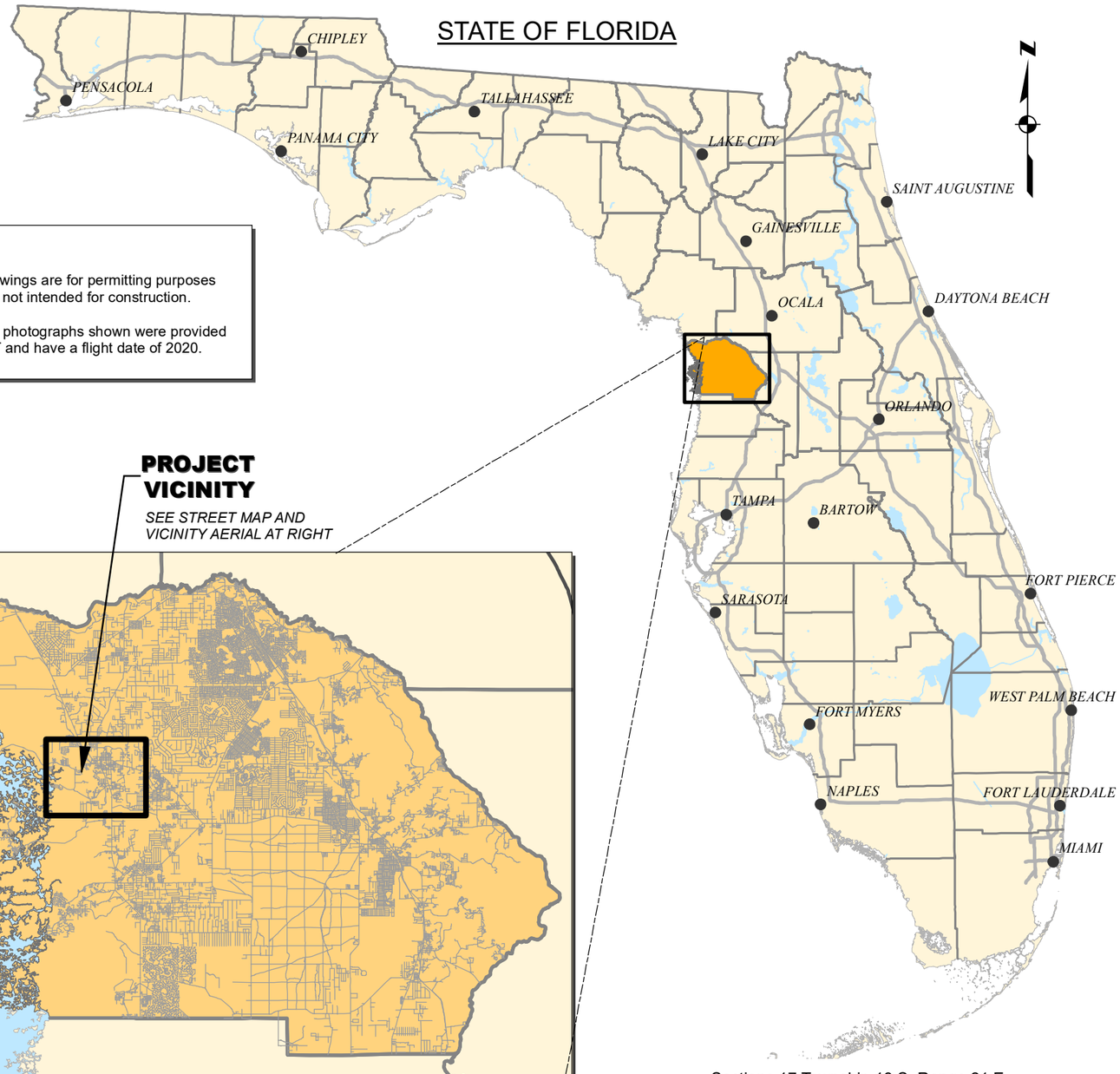
INTRODUCTION

Kings Bay is a tidally influenced spring-fed ecosystem located in Citrus County, Florida (**Figure 1**). A baseline benthic sediment assessment in Phase 5 of the Kings Bay Restoration Project was completed in June 2023 prior to the proposed habitat restoration, or de-mucking and planting of submerged aquatic vegetation (SAV) (Johnson Eng. Inc. & Ceilley Aquatic Science & Ecology 2023). Sediment profiles were collected from representative locations throughout Phase 5 and analyzed visually with tactile confirmation of composition of layers, photographed, and results recorded for graphing of sediment profiles. The primary goal of the baseline benthic sediment assessment was to document existing conditions across the bottom of Kings Bay prior to any de-mucking operations. Other Phases have also been sampled for sediment profiles with results reported in previous reports by Johnson Eng. All Phases of restoration are of concern after hurricanes Idalia in 2023 and Debby, Helene, and Milton in 2024. The repeated saltwater storm surges and silt deposits from these storms caused documented declines in SAV cover in all Phases (Sea and Shoreline personal communication). This rapid assessment of sediments was conducted to provide information on the suitability of sediments for SAV recovery in Kings Bay after the ecosystem endured hurricane Idalia in 2023, followed by three more hurricanes in 2024.

This follow-up report summarizes a post-hurricane(s) assessment of sediments within Phase 5 and other Phases of restoration in Kings Bay based upon a sampling of 30 representative locations (**Figure 2**). The primary purpose of this assessment was to identify benthic habitat conditions that remain suitable for SAV recovery. Another purpose was to identify areas that are not suitable for SAV recovery and will require additional de-mucking or maintenance dredging to remove flocculent organic material and *Lyngbya* that may have accumulated over time in various restoration areas.

The baseline sediment assessment in Phase 5 was completed approximately two months prior to the arrival of hurricane Idalia. Baseline sediment core data from Phase 5 are summarized in **Figure 3.** Baseline sediment core samples showed a range of sediment profiles with a consistent cover of flocculent fine organic material (shown in red) at each location (**Figure 3**). Baseline Phase 5 floc depths ranged from 1.5 cm to 10 cm, with an average depth of 4.1 cm. Area 5D had the deepest floc layers ranging from 3-10 cm with an average of 6.4 cm. The underlying sediments were quite variable from site to site with sand, sand/clay, and sand/mud layers considered to be suitable for SAV root establishment. Floc and mud/muck layers are less suitable for long-term establishment since plants may become uprooted by physical and biological disturbances.

STATE OF FLORIDA



NOTES

1. These drawings are for permitting purposes only and are not intended for construction.

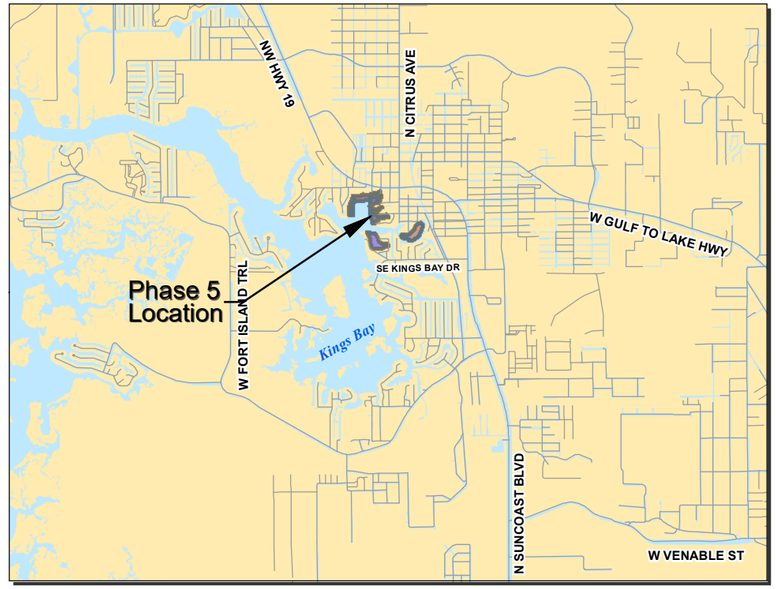
2. The aerial photographs shown were provided by the FDOT and have a flight date of 2020.

PROJECT VICINITY

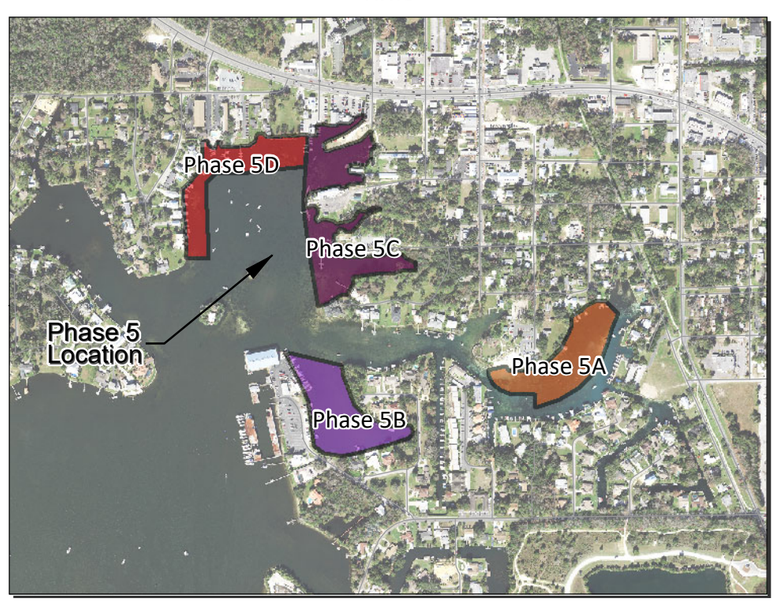
SEE STREET MAP AND VICINITY AERIAL AT RIGHT

CITRUS COUNTY
N.T.S

Sections 17 Township 18 S, Range 21 E
Latitude: 28° 53' 427" N; Longitude: 82° 35' 48" W



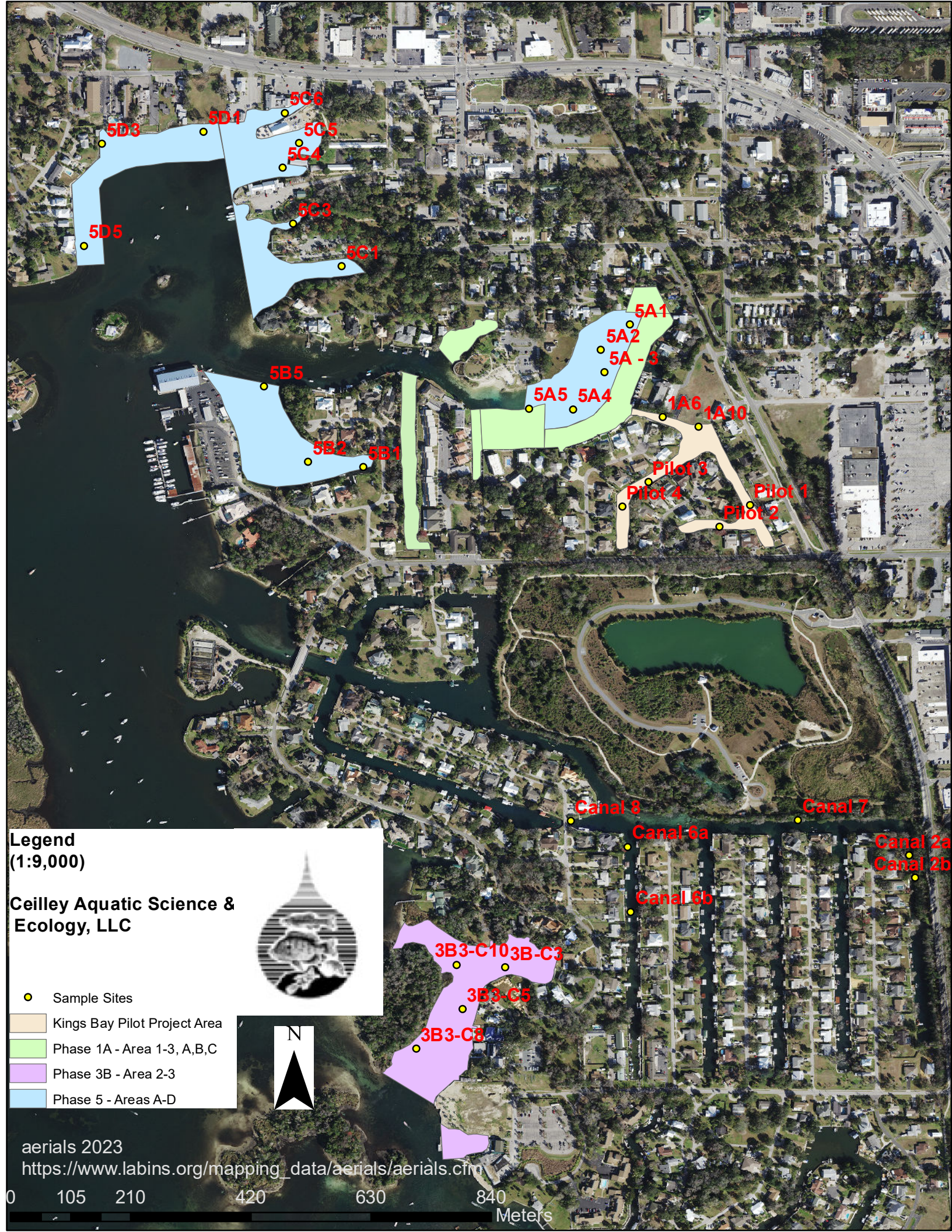
STREET MAP
N.T.S



VICINITY AERIAL
N.T.S

Homosassa River Restoration Project, Inc.	Homosassa River Restoration Phase 5 Citrus County, Florida	JOHNSON ENGINEERING	JOHNSON ENGINEERING, INC. 2122 JOHNSON STREET P.O. BOX 1550 FORT MYERS, FLORIDA 33902-1550 PHONE (239) 334-0046 FAX (239) 334-3661 E.B. #642 & L.B. #642	Project Location Map

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
June 2023	20170047-008		NTS	1


5C6
5D1
5D3
5C5
5C4
5C3
5D5
5C1
5A1
5A2
5A - 3
5B5
5A5
5A4
1A6
1A10
5B2
5B1
Pilot 3
Pilot 4
Pilot 1
Pilot 2
Canal 8
Canal 7
Canal 6a
Canal 2a
Canal 2b
Canal 6b
3B3-C10
3B-C3
3B3-C5
3B3-C8
Legend
(1:9,000)
Ceilley Aquatic Science & Ecology, LLC
Sample Sites
Kings Bay Pilot Project Area
Phase 1A - Area 1-3, A,B,C
Phase 3B - Area 2-3
Phase 5 - Areas A-D
N
aerials 2023
https://www.labins.org/mapping_data/aerials/aerials.cfm
0
105
210
420
630
840
Meters

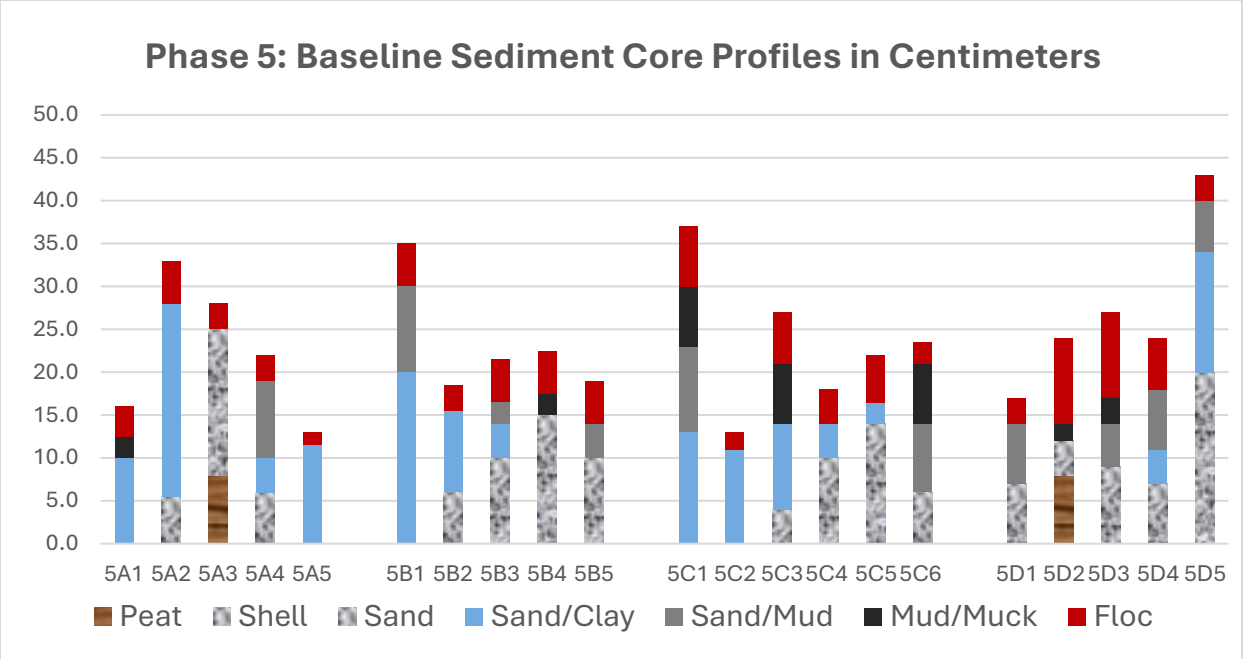


Figure 3. Baseline sediment core sample profiles collected in June 2023 from Phase 5 (5A-5D).

Hurricane Impacts

Figure 4. shows the paths, strength categories, and landfall dates of five hurricanes that made landfall in the United States in 2024. Prior to that, hurricane Idalia made landfall as a Category 3 storm on August 30, 2023. Kings Bay was inundated with a storm surge between 9 to 12 feet resulting in severe coastal flooding in Crystal River, Florida (**Figure 5).** The impacts of Idalia's saltwater storm surge on *Vallisneria* were still being assessed by Sea and Shoreline biologists when the hurricane season of 2024 produced Hurricanes Debby, Helene, and Milton that also impacted Kings Bay.

Debby was a named tropical storm that strengthened to a Category 1 hurricane when it made landfall on August 5, 2024, near Cedar Key, Florida. Kings Bay and Crystal River were on the southeast side of the storm known as the "dirty side' due to the duration and strength of onshore winds and heavier rainfall that normally accompanies tropical storms and hurricanes. Three weeks later, on August 26, 2024, hurricane Helene made landfall as a Category 4 storm with 140 mph winds and heavy rainfall near Perry Florida. Coastal flooding from storm surge and rainfall in Crystal River Florida is shown in **Figure 6.** During the first week of October 2024 hurricane Milton was strengthening in the Gulf of Mexico from a tropical storm to a Category 5 hurricane in less than 24 hours. Milton lost strength before making landfall at Siesta Key, FL as a Category 3 storm but the storm surge from Milton (**Figure 7**) also caused coastal flooding and

saltwater intrusion into Kings Bay. Together, these storms had severe negative impacts on the Kings Bay SAV restoration project, in addition to the damage to the communities along the Gulf Coast.

Quantifying the impacts of individual storm events on the restoration project was not feasible. However, this report represents a rapid assessment method for monitoring changes in benthic sediments following all these storm events. Additional sediment sampling will be needed to identify all locations and amounts of fine organic floc and surficial sediments were deposited by hurricane storm surges.

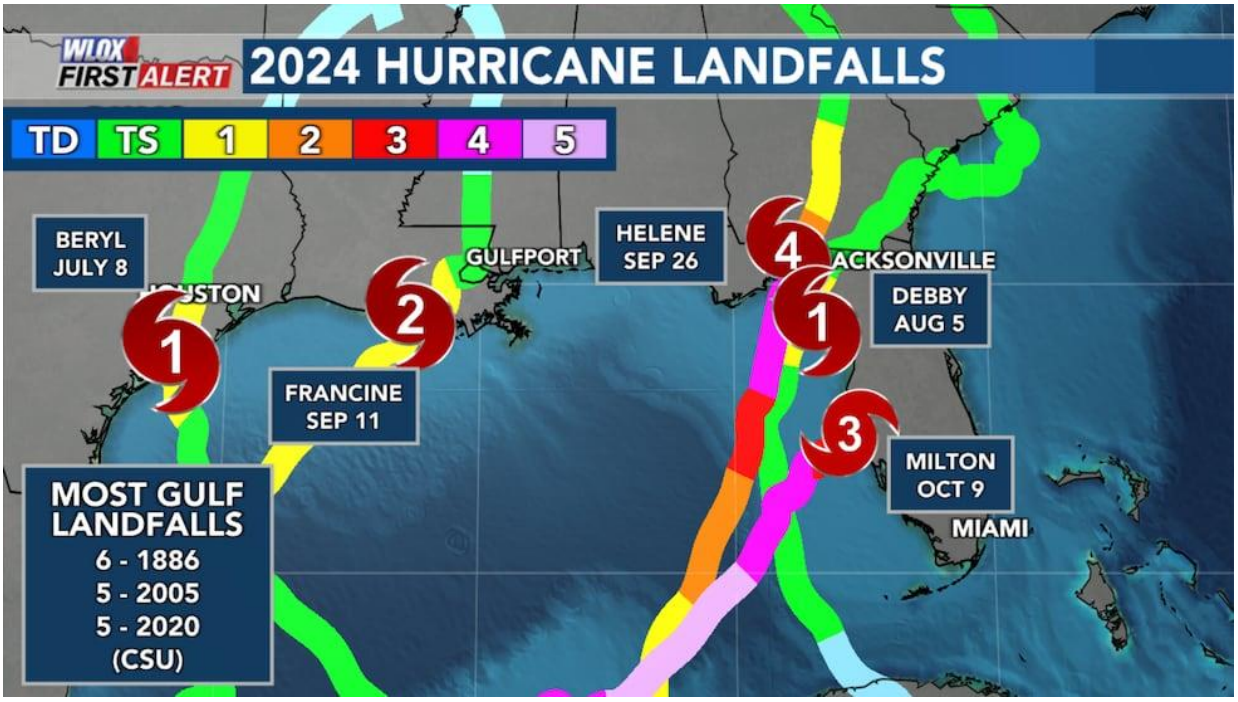


Figure 4. Hurricane tracks for all five hurricanes that made landfall in the Gulf of Mexico in 2024.

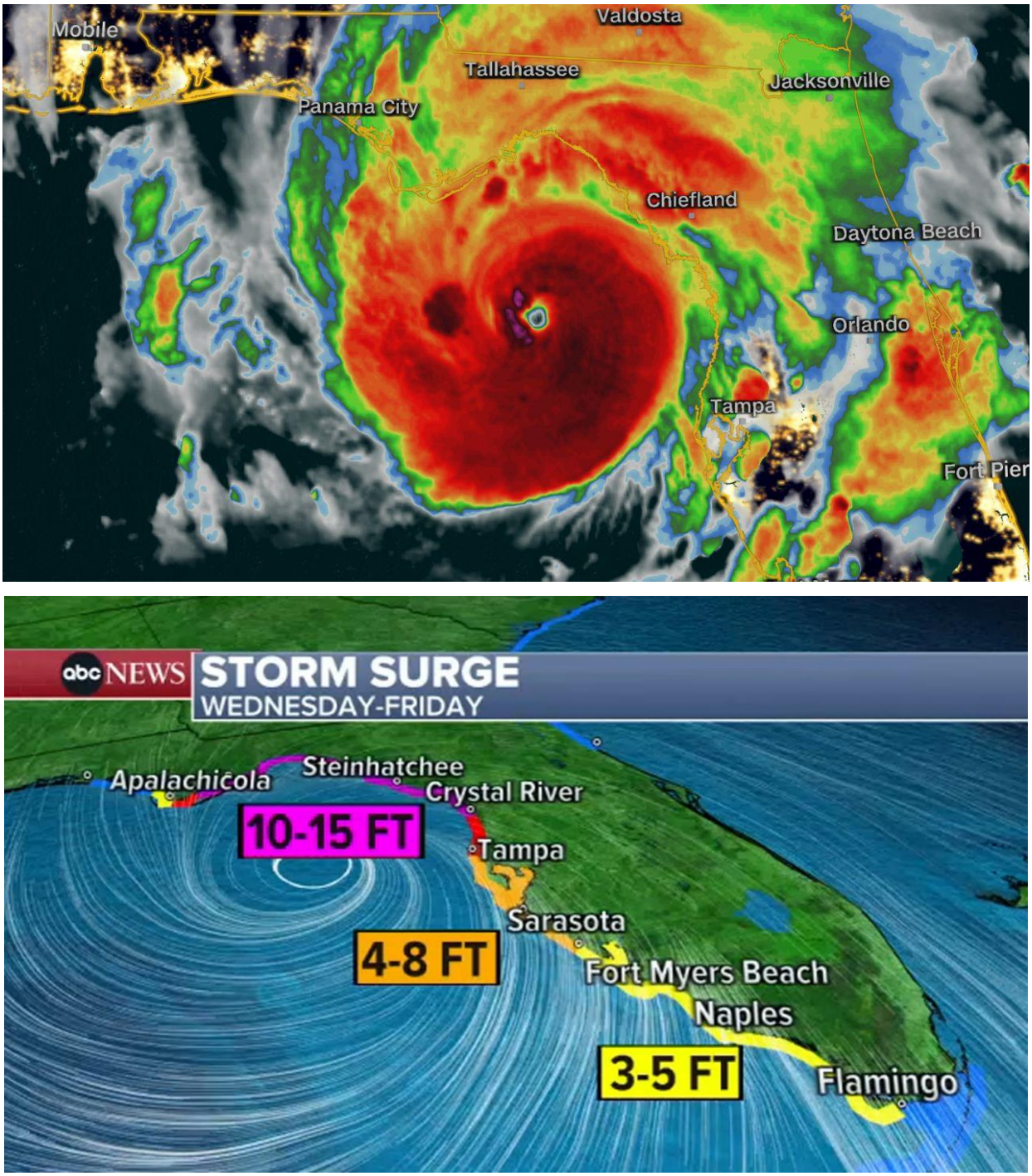


Figure 5. Hurricane Idalia 2023 satellite infrared image (top) and storm surge map (bottom) showing areas of impact with Crystal River, Fl on the "dirty" side of Idalia where winds increase storm surge.

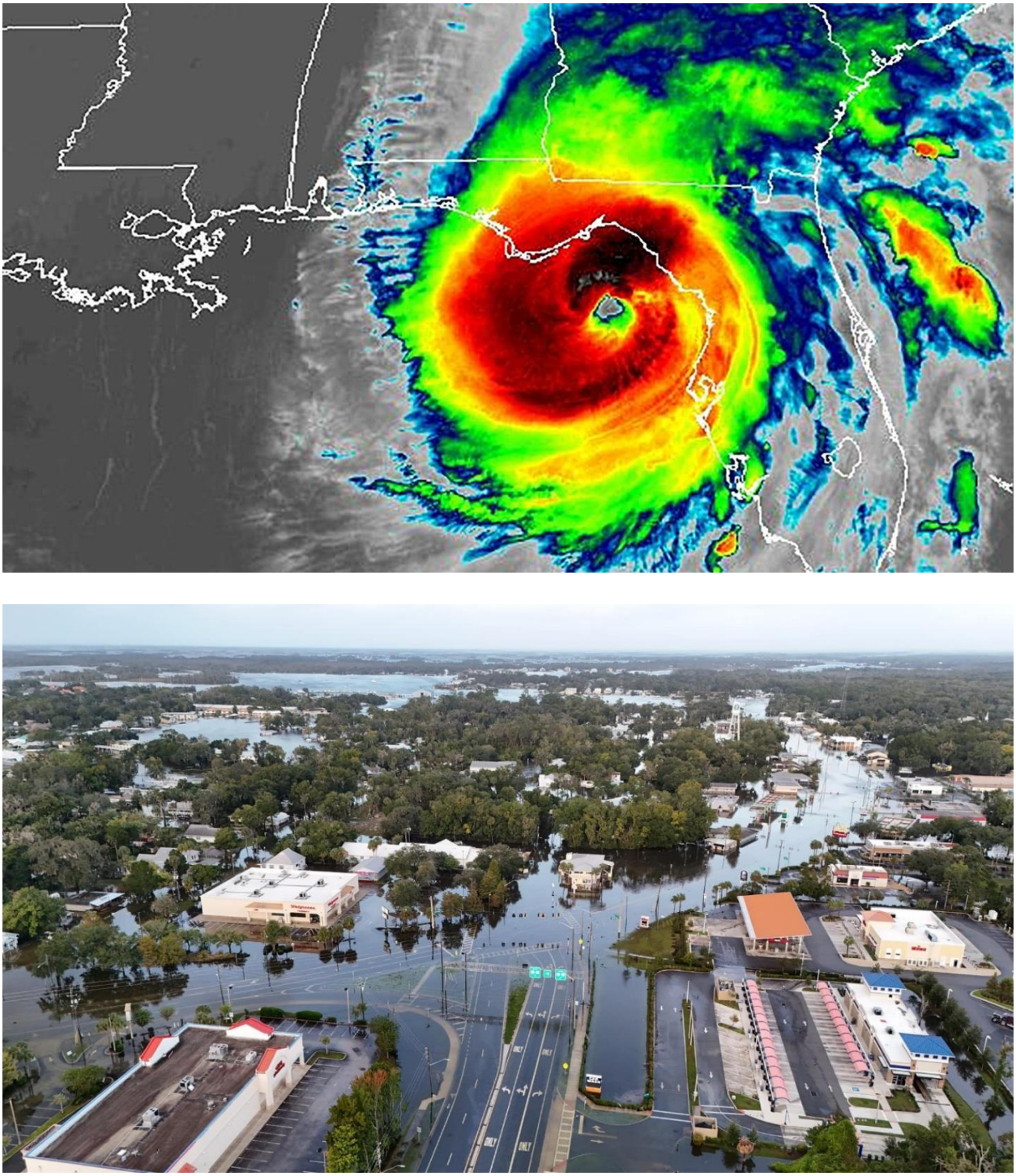


Figure 6. Hurricane Helene satellite image at landfall (top) storm surge flooding of Crystal River, FL on August 26-27, 2024 (bottom).

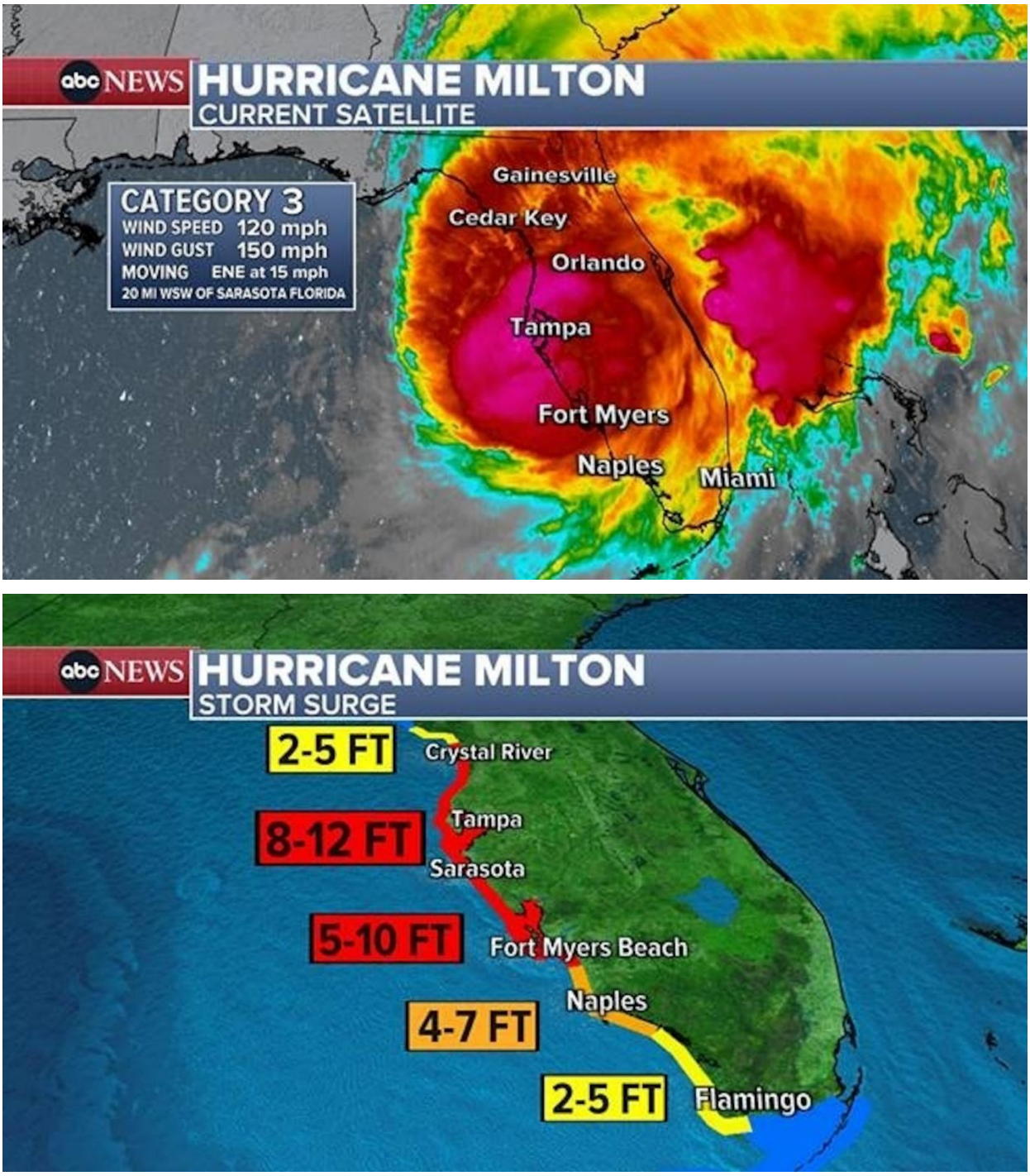


Figure 7. Hurricane Milton satellite image (top) just after landfall on October 9, 2024, with storm surge range estimates for the west coast of Florida.

METHODS

A total of 30 sediment cores were collected over a two-day period in areas as agreed by Save Crystal River and their representatives at Sea and Shoreline, LLC. Sampling locations and names were based on the Phase 5 Baseline sediment study and previous sampling locations from Phase 1A, Phase 2 canals, Phase 3B, and the Pilot Project area (**Figure 2**). Sediment cores were collected using a customized benthic sampler with a 10 cm x 50 cm clear PVC cylinder for visual assessment of sediment profile (cover photo). 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. Sediment profiles were assessed and photographed against a white board with location and date for archival and later comparison with post-restoration sediment profiles. Sediment core profiles will be categorized as floc (including live and dead filamentous algae), mud/muck, sand/mud, sand/clay, sand, peat, shell, and peat. The focus will be on the depth of upper layers of flocculent (floc) organic material (unconsolidated fine organics) and of mud/muck that are less suitable for long-term survival and growth of *Vallisneria americana* and other native SAV species. Other consolidated layers will be characterized and measured to the nearest centimeter (cm). Baseline sediment core sampling results from Phase 5 are presented in **Figure 3.**

RESULTS

A total of 30 sediment core samples were collected for this initial assessment with a focus on Phase 5 habitats, at the direction of Save Crystal River and Sea and Shoreline, LLC. The results from Phase 5 are presented in **Table 1** and illustrated in **Figure 8** that depicts the sediment core profiles. Photographs of sediment core samples are included in the Appendix. The floc layers in Phase 5 ranged from 0.5 to 10.0 cm with a mean depth of 3.1 cm. Area 5A was in overall good condition with sand bottom and thin layers of floc at two locations (5A1, 5A2). The 5A4 location had a 7.5 cm floc layer and 22.5 cm deep layer of sand/mud/clay mix. The core from 5A5 had a 4.0 cm layer of floc over 6.0 cm layer of clay. Area 5B was also in relatively good condition with two of three sites having a sandy substrate with a thin 0.25 cm layer of floc. Area 5C was highly variable with floc layers ranging from 0.5 to 5.0 cm thick (**Table 1, Figure 8**).

Table 1. Phase 5: Sediment Core Sampling Results from January 27, 2025.

Site Code	Latitude	Longitude	Sand	Clay	Sand/Mud/Clay	Peat/Mud	Mud/Muck	Flocc	Lyngbya	Total (cm)
5A1	28.89572	-82.5904	6.5					0.5		7
5A2	28.89532	-82.5909	4					0.5		4.5
5A4	28.89439	-82.5913			22.5			7.5		30
5A5	28.8944	-82.5920		6				4		10
5B1	28.89349	-82.5946		3.5			3.5	4		11
5B2	28.89356	-82.5955	10.3					0.25		10.55
5B5	28.89475	-82.5962	6				6	0.25		12.25
5C1	28.89664	-82.5950		2	22			5		29
5C3	28.89731	-82.5957				10.5	6	4.5		21
5C4	28.89819	-82.5959	5					0.5		5.5
5C5	28.89858	-82.5956	4.5					0.5		5
5C6	28.89905	-82.5958				26		4		30
5D1	28.89875	-82.5971	0				14	7		21
5D3	28.89856	-82.5987	4				10	7		21
5D5	28.89696	-82.5990	10				15	10		35

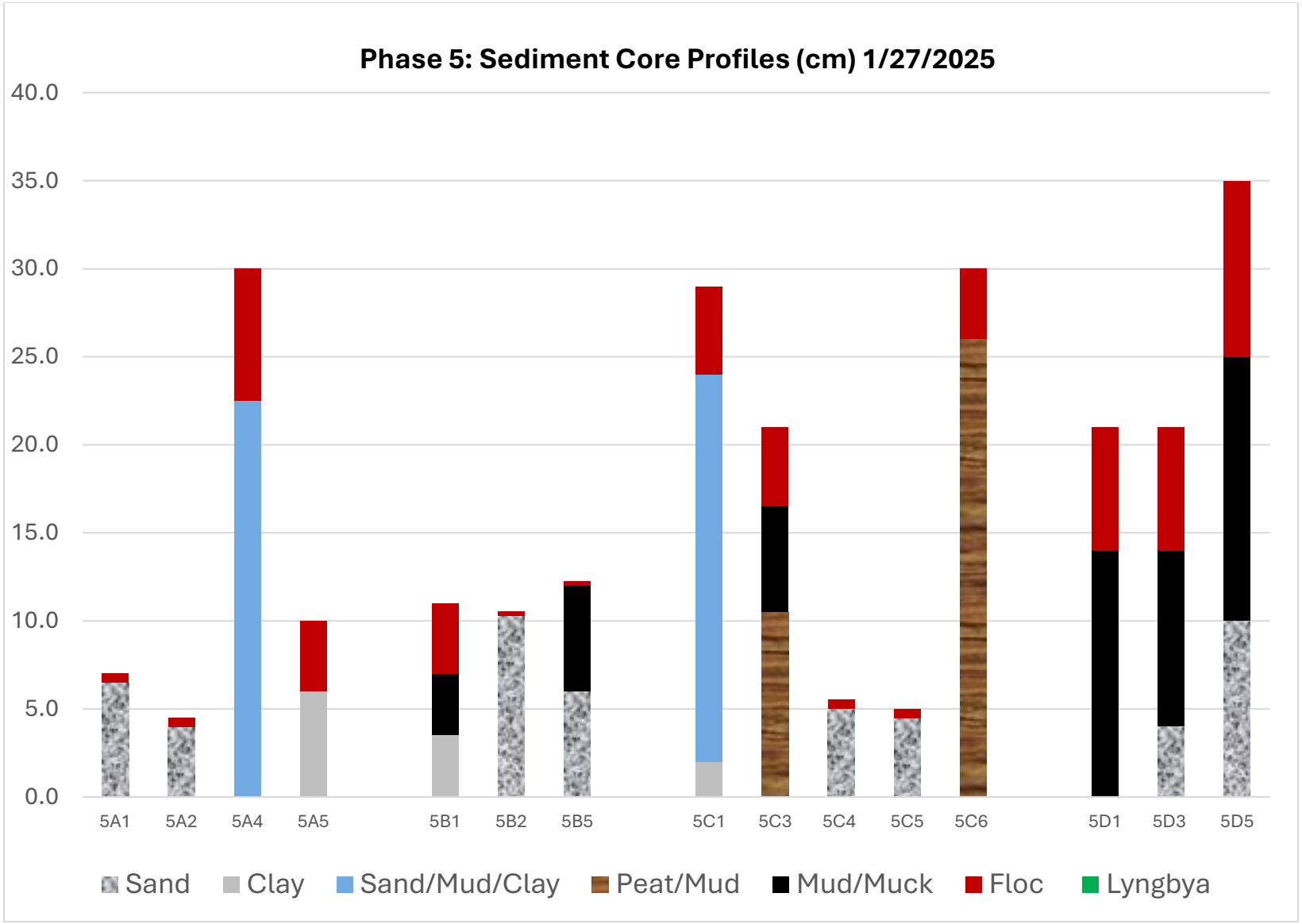


Figure 8. Sediment core profiles collected 1/27/2025 from restoration areas in Phase 5 of Kings Bay in Citrus County, Florida

Area 5C3 had a 5.0 cm layer of floc over a 22.0 cm layer of sand/mud/clay which represents a suitable substrate for SAV if the floc layer is removed. Area 5C6 had a 4.0 cm layer of floc over 26.0 cm of peat/mud. Peat layers indicate a history of wetland conditions that are acidic and anerobic that allow for the accumulation of partly decayed vegetative material. Samples from 5C3 and 5C6 had mud/peat deposits of 10.5 and 26.0 cm respectively, indicating wetland like conditions previously existed there or possibly deposited in runoff from tributaries.

Area 5D had the deepest layers of floc, ranging from 7.0 to 10.0 cm with a mean depth of 8.0 cm and the deepest deposits of mud/muck with a range from 10.0 to 15.0 cm and an average depth of 13.0 cm. The upper layers were consistent in Area 5D, with thick mud/muck topped with 7-10 cm of flocculent organic matter. Samples from the 5D area may represent sloughing of material from adjacent shallows outside of the de-mucking footprint because of hurricanes wind driven currents and storm surge(s).

The Pilot project restoration area consists of dead-end canal habitats that were de-mucked in 2017. Two samples collected at Pilot 1 and Pilot 2 (**Figure 2**) contained deposits of mud/muck of 10.5 and 11.5 cm respectively (**Table 2, Figure 9**). Both samples contained a floc layer and a layer of the filamentous blue-green algae or cyanobacteria, *Lyngbya wollei*. Pilot 3 contained a similar profile with shallower layers of each constituent. Pilot 4 consisted entirely of *Lyngbya* over a hard bottom of rock or gravel that could not be collected by the vacuum core sampler. Samples from Phase 1A also had a layer of *Lyngbya* but underneath was a thick layer of sand that is considered ideal for *Vallisneria* establishment. A biological assessment conducted by Johnson Engineering (2018) documented dense *Vallisneria* beds throughout this area that were lost from the repeated hurricane storm surges in 2023 and 2024 (**Figures 4, 5, 6 and 7**).

Four sediment core samples were collected from Phase 3B, and each core contained a lower layer of sand/mud/clay that is suitable SAV habitat (**Figure 9**). Sediment cores 3B-C3 and 3B-C5 contained a mud/muck layer on top of the sand/mud/clay (**Table 2, Figure 9**). Cores from 3B-C5 and 3B-C10 had 0.5 and 1.0 cm layers of floc respectively.

The canal sites are all situated near Three Sisters Spring (**Figure 2**). Canal 2 is located to the east and runs north and south. Both samples collected here consisted entirely of sand with no floc or mud/muck layers. Canal 6a and 6b samples contained 6.5 cm of floc on top of mud/muck layers of 5.5 and 11.0 cm respectively. Sample 6b contained a lower layer of peat/mud which was indicative of historic wetlands at this location. Canal 7 is the main east-west canal that is connected to Three Sisters Spring and its' sediment core sample contained at least 4.0 cm of sand with a thin layer (1.0 cm) of floc on the surface.

Table 2. Kings Bay Sediment Core Sampling Results:1/28/2025										
Site Code	**Latitude**	**Longitude**	**Sand**	**Clay**	**Sand/Mud/Clay**	**Peat/Mud**	**Mud/Muck**	**Floc**	**Lyngbya**	**Total (cm)**
Canal 2a	28.887377	-82.586030	5							5
Canal 2b	28.887024	-82.585940	5							5
Canal 6a	28.887512	-82.590452					5.5	6.5		12
Canal 6b						6.5	11	6.5		24
Canal 7	28.887934	-82.587774	4					1		5
Canal 8	28.887919	-82.591352	7.5							7.5
3B-C3	28.885613	-82.592378			4.5		3.5			8
3B3-C5	28.884959	-82.593051			10		10	0.5		20.5
3B3-C8	28.884333	-82.593775			3.5					3.5
3B3-C10	28.885659	-82.593144			9.5			1		10.5
1A6	28.894266	-82.589902	4						3.5	7.5
1A10	28.894117	-82.589345	4						3.5	7.5
Pilot 1	28.892884	-82.588535					10.5	5.5	4.5	20.5
Pilot 2	28.892544	-82.589016					11.5	4.5	4	20
Pilot 3	28.893244	-82.590129					6	2	2	10
Pilot 4	28.892864	-82.590541							5	5

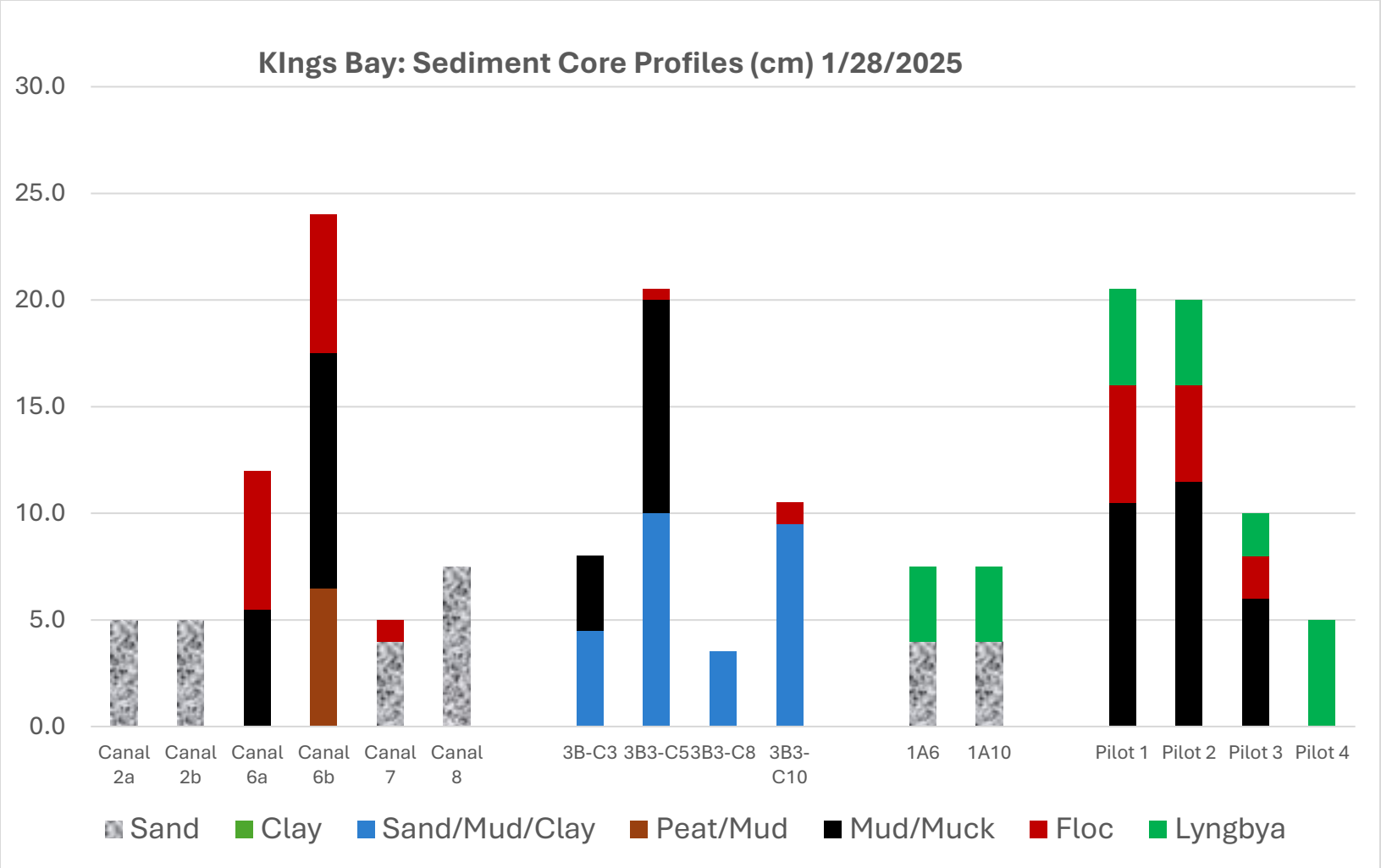


Figure 9. Sediment core profiles collected 1/28/2025 from various restoration areas in Kings Bay in Citrus County, Florida.

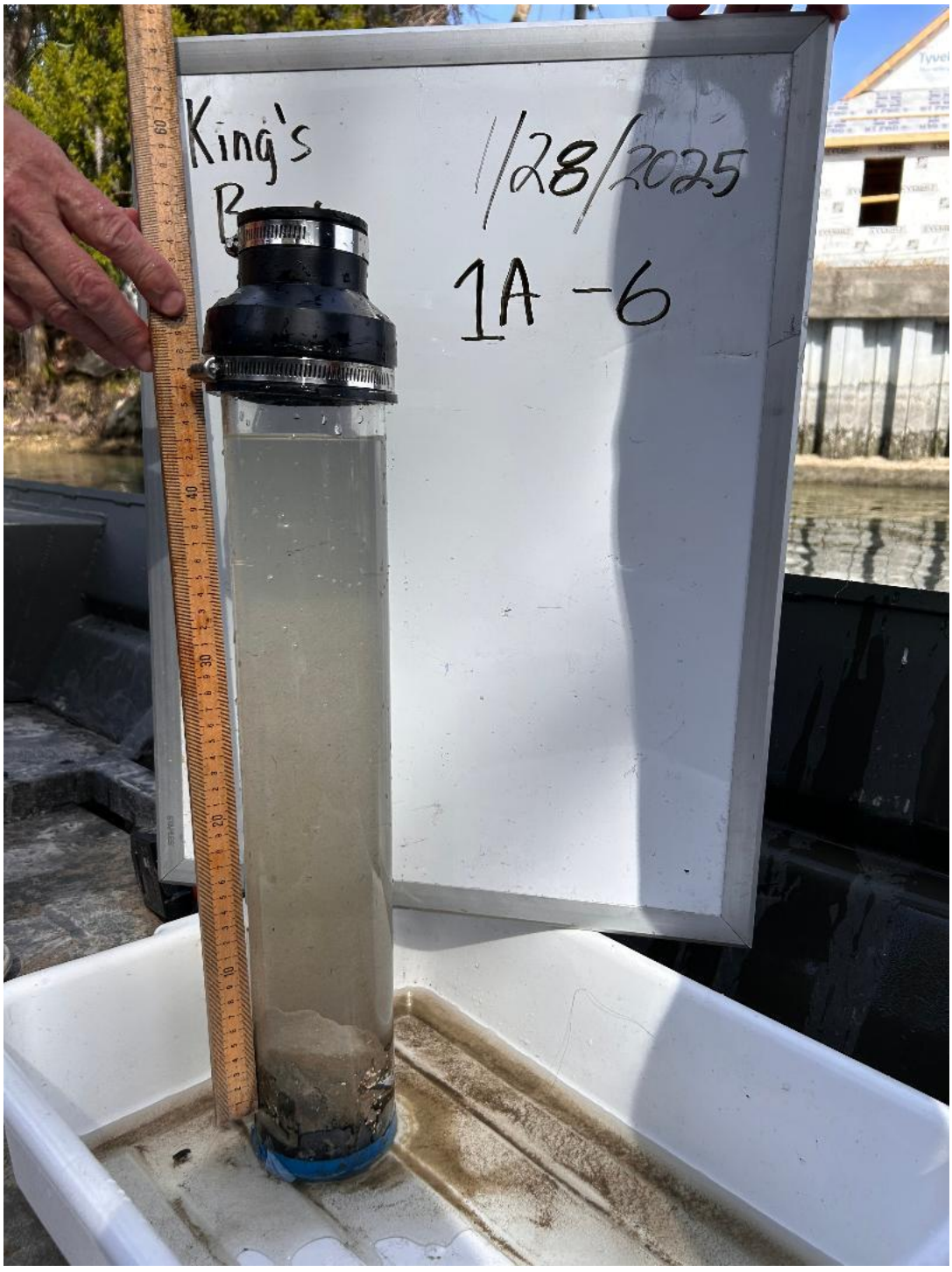
The Canal 8 sediment sample was collected just east of the low bridge over Canal 8 and consisted entirely of sand. Canal 8 is open at both ends and allows for continuous flushing of water from Three Sisters Spring and daily tidal exchange.

SUMMARY AND CONCLUSIONS

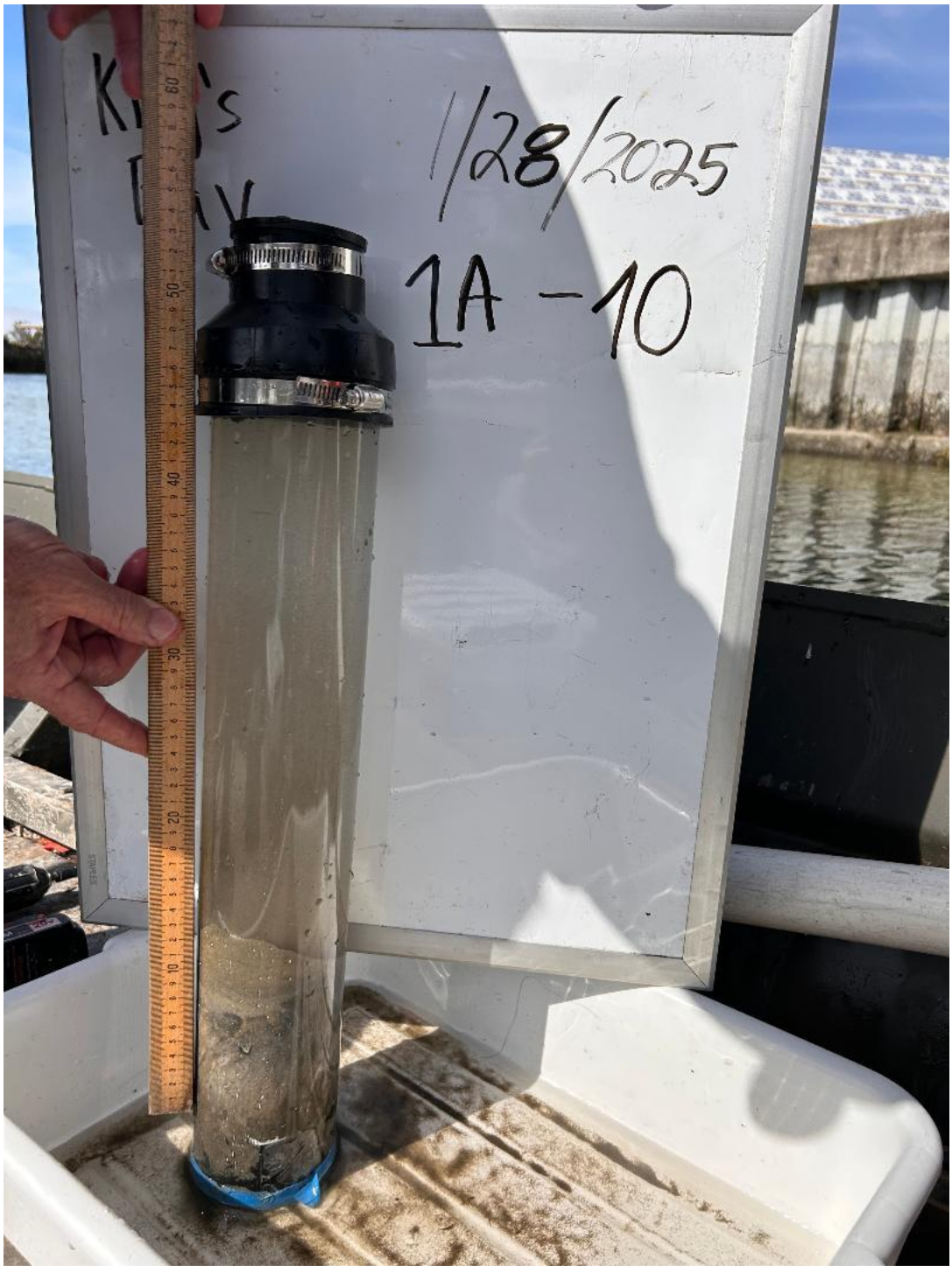
- Sediment cores identified several areas of Phase 5 and other locations that had suitable sediment types to support growth, survival and spread of native SAV, i.e. *Vallisneria americana* (*neotropicalis*). These locations had sand substrates and/or thin layers of floc. In Phase 5 there was an overall 25% reduction in flocculent organic layers from the baseline conditions documented in June 2023.
- Phase 5D sites had deep deposits of floc and soft mud/muck that are unsuitable for long-term survival of native SAV. The floc and mud/muck layers in 5D may have been deposited from adjacent open water habitats of Kings Bay that were not de-mucked. Other sites in Phase 5 that contained excessive floc were 5A4, 5B1, 5C1, 5C3, and 5C6.
- Canal samples 6a and 6b (Phase 2) contained deep floc and mud/muck layers that are unsuitable for SAV growth and survival. It is possible that these deposits were pre-existing, or they were deposited by one or more hurricanes that impacted the region.
- The Pilot Project canal contained a nearly contiguous layer of *Lyngbya* on top of the sediments. Cores from Pilot 1, 2, and 3 contained layers of floc and mud/muck layers that may reflect deposition from one or more of the hurricanes that impacted Kings Bay in 2023-24. To ensure the recovery of SAV beds, the Pilot Project area needs de-mucking and removal of the *Lyngbya* layer.
- The sediment sampling indicated that areas with flowing water from springs and/or tidal flushing had suitable habitats for SAV growth, spread, and survival due to sand or other consolidated sediments that will hold rooted SAV.
- Hurricanes appear to have transported fine organic materials from open areas of Kings Bay and downstream mud flats into restored habitats that have limited flushing by freshwater springs and tidal exchange. These areas include the Pilot Project, Canal 6 (Phase 2), and portions of Phase 5 where maintenance de-mucking would be beneficial prior to replanting native SAV (i.e. *Vallisneria*).
- Areas with good flushing such as Canals 2, 7 and 8 had good habitat for *Vallisneria* establishment and are likely to recover quickly if replanted or if a seed bank is established. Seed production will be critical for the recovery of *Vallisneria* beds after prolonged saltwater storm surge events that kill mature plants. Seeds can lay dormant in the sediment until conditions are favorable for growth.

APPENDIX

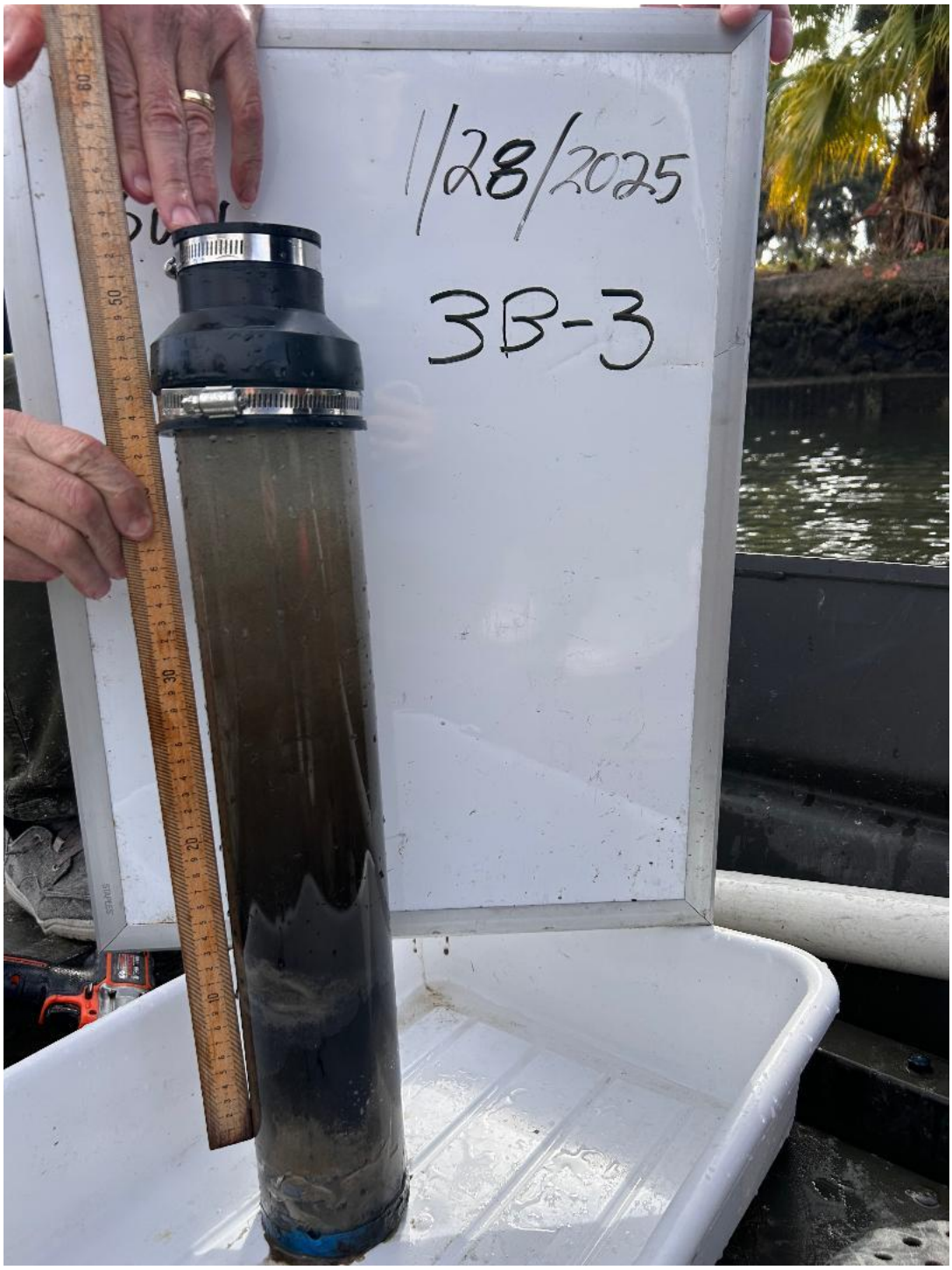
PHOTOGRAPHS OF SEDIMENT CORES
January 27-28, 2025



Kings Bay sediment core sample collected from Phase 1A-6.



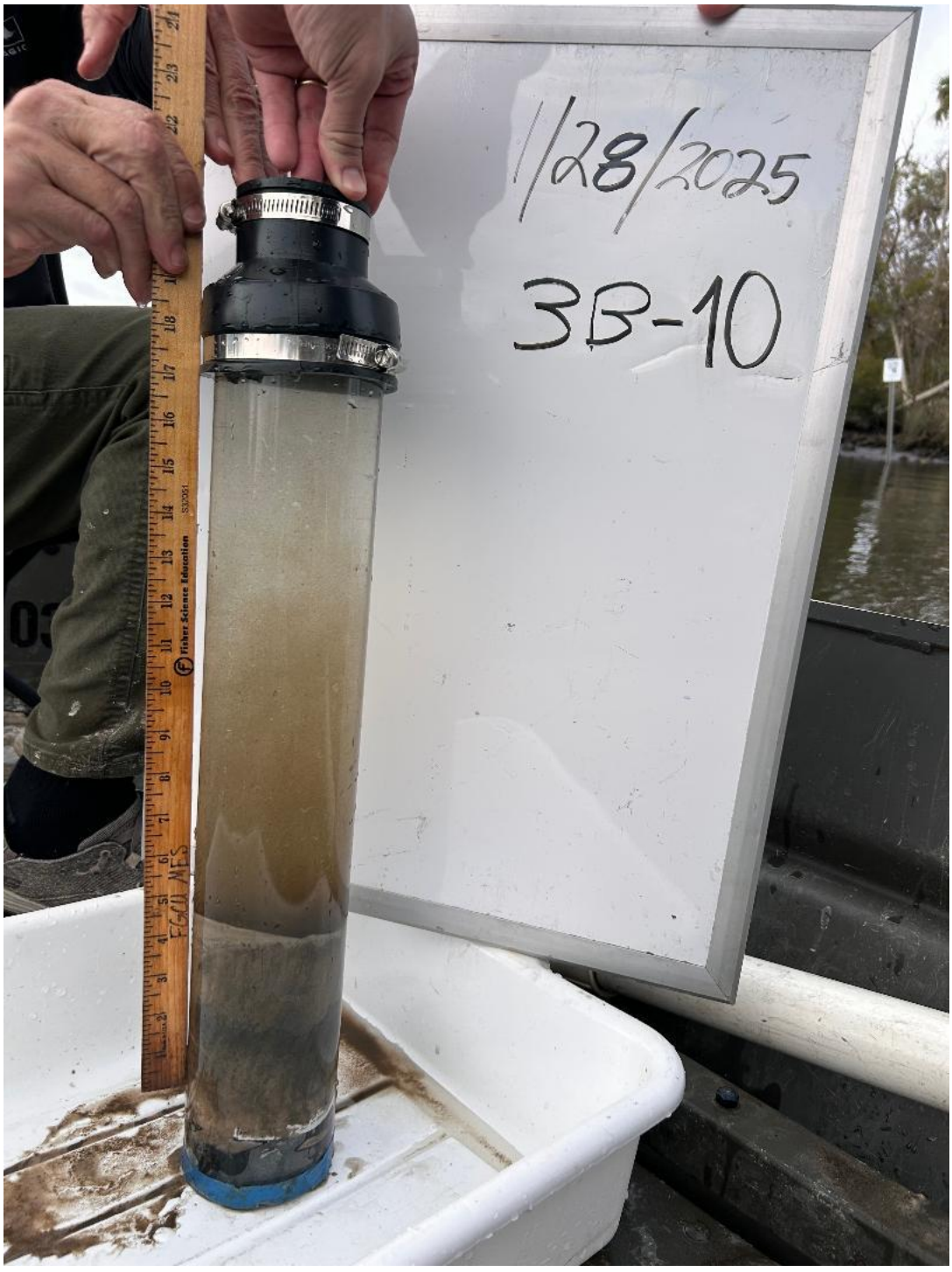
Kings Bay sediment core sample collected from Phase 1A-10.



Kings Bay sediment core sample collected from site 3B-3.

Kings Bay sediment core sample collected from site 3B-5.

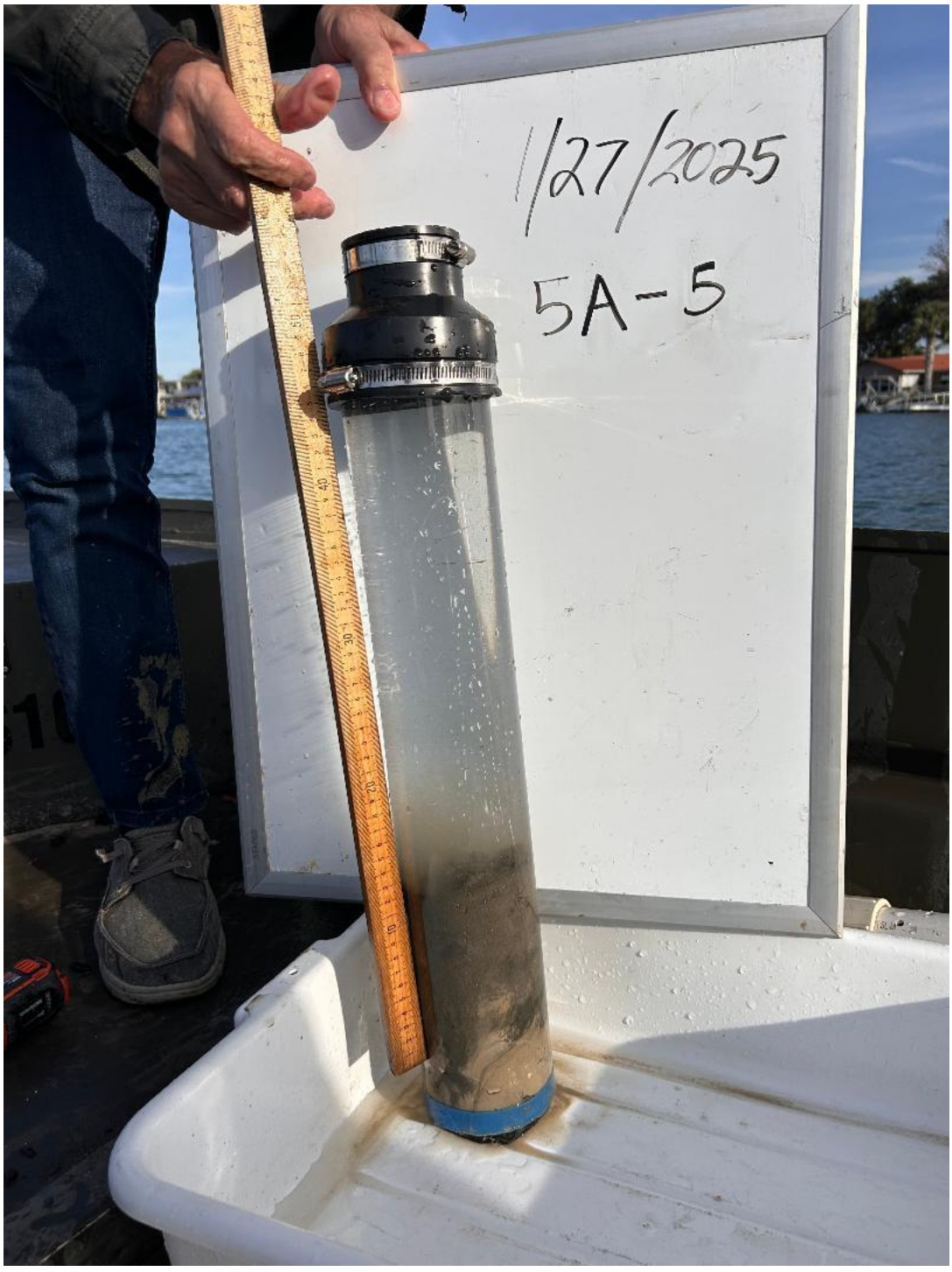
Kings Bay sediment core sample collected from site 3B-8.



Kings Bay sediment core sample collected from site 3B-10.

Kings Bay sediment core sample collected from Phase 5A-1.

Kings Bay sediment core sample collected from Phase 5A-4.

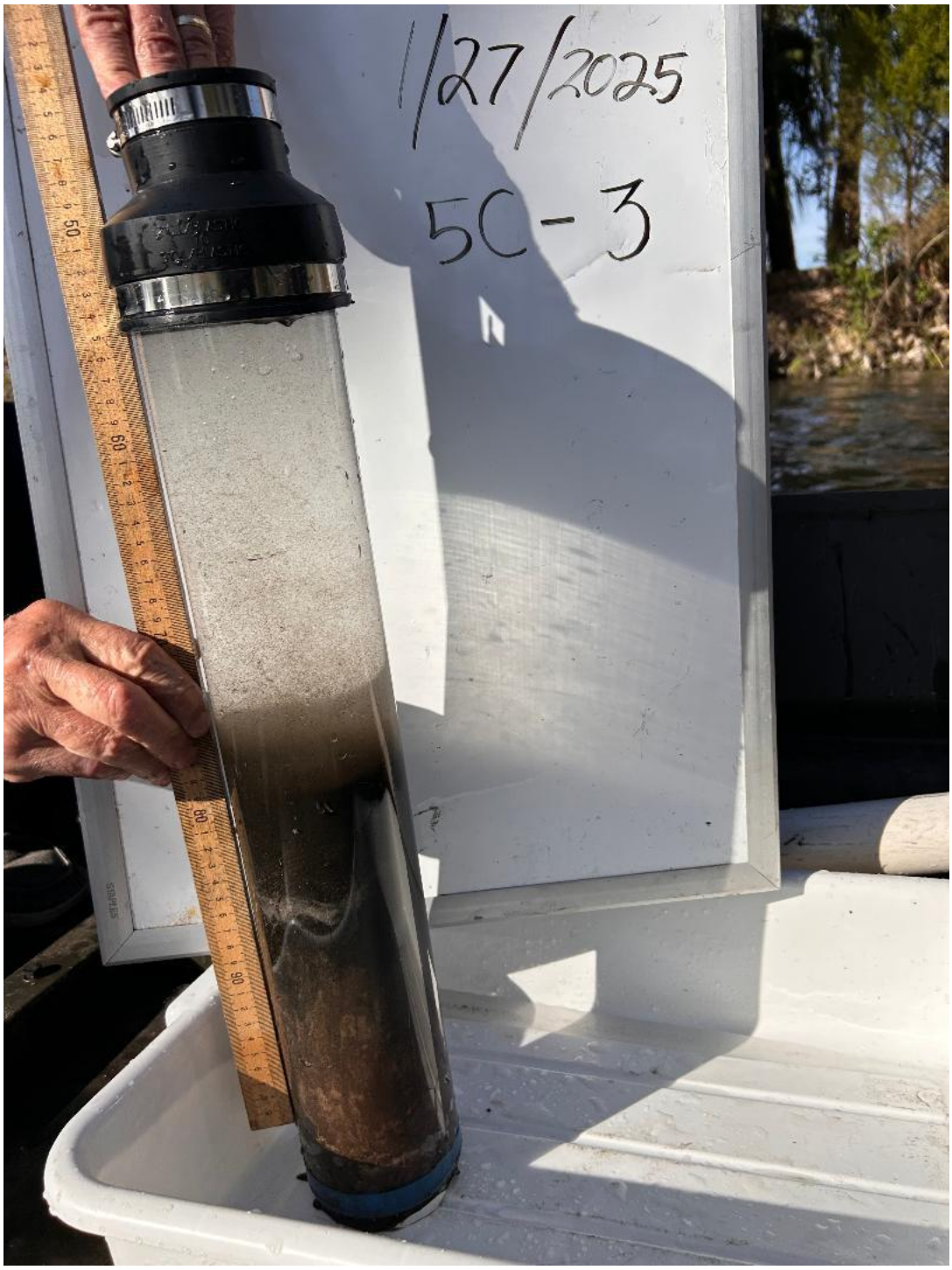


Kings Bay sediment core sample collected from Phase 5A-5.

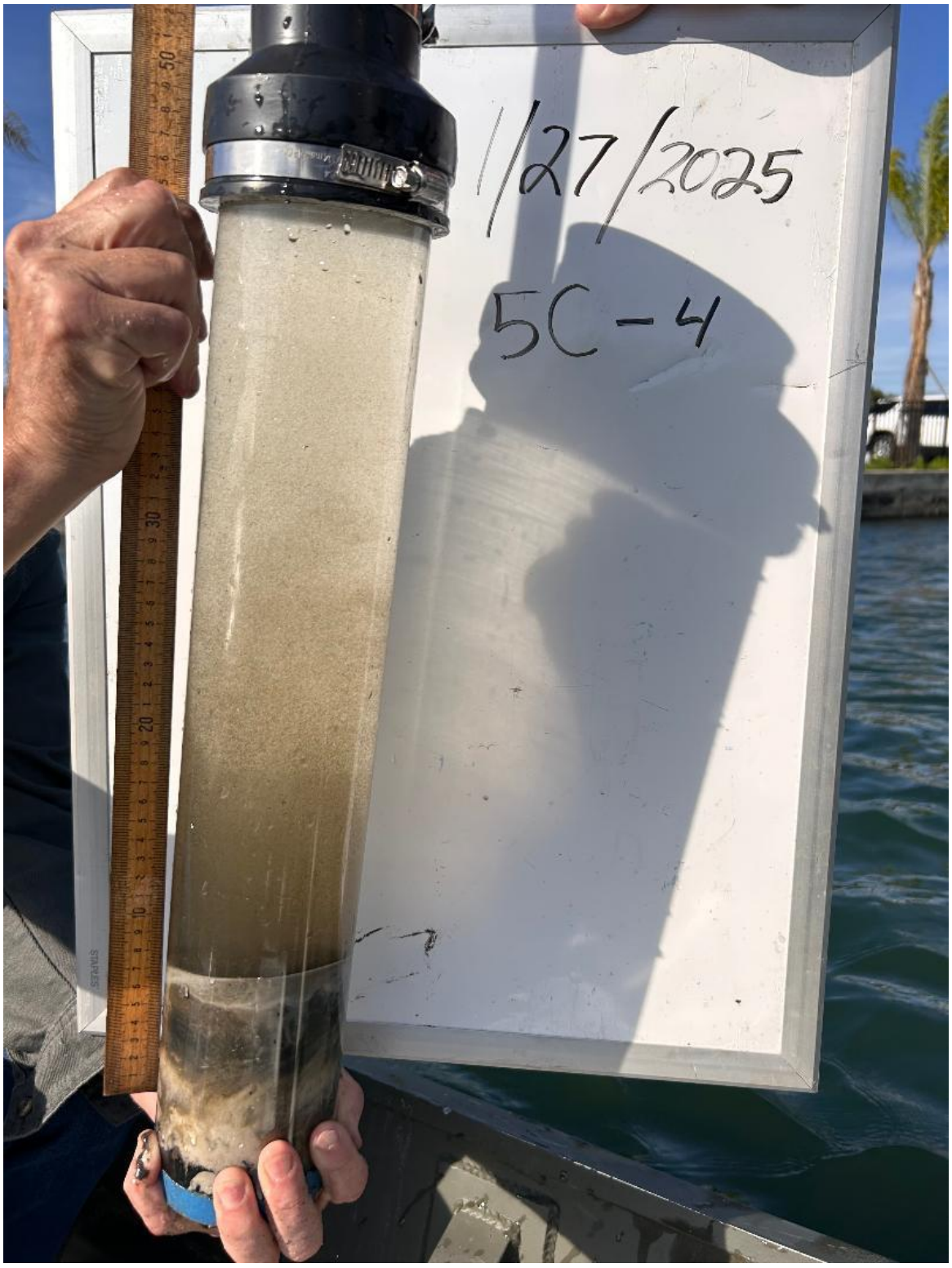
Kings Bay sediment core sample collected from Phase 5B-1.

Kings Bay sediment core sample collected from Phase 5B-2.

Kings Bay sediment core sample collected from Phase 5C-1.



Kings Bay sediment core sample collected from Phase 5C-3.



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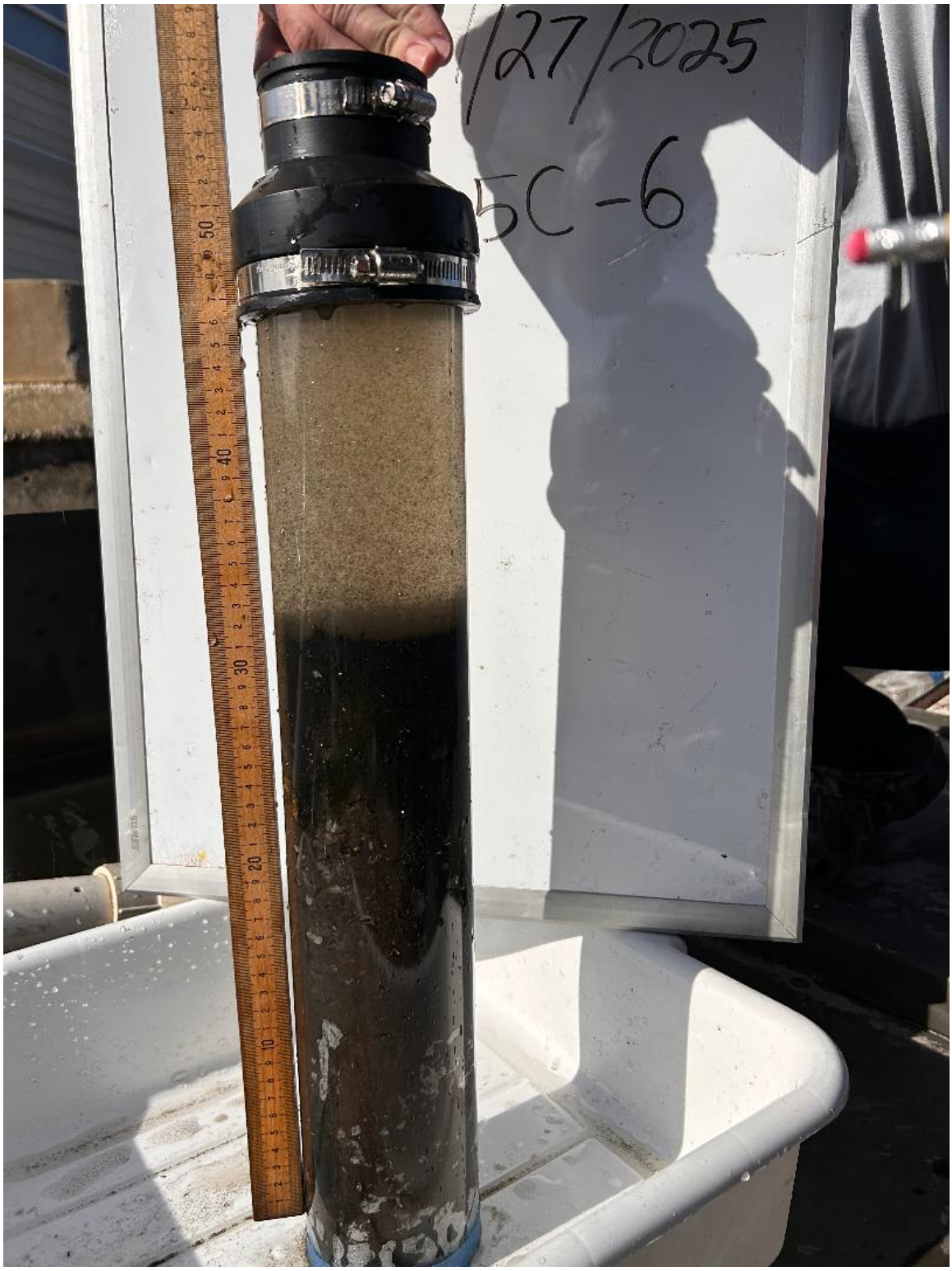

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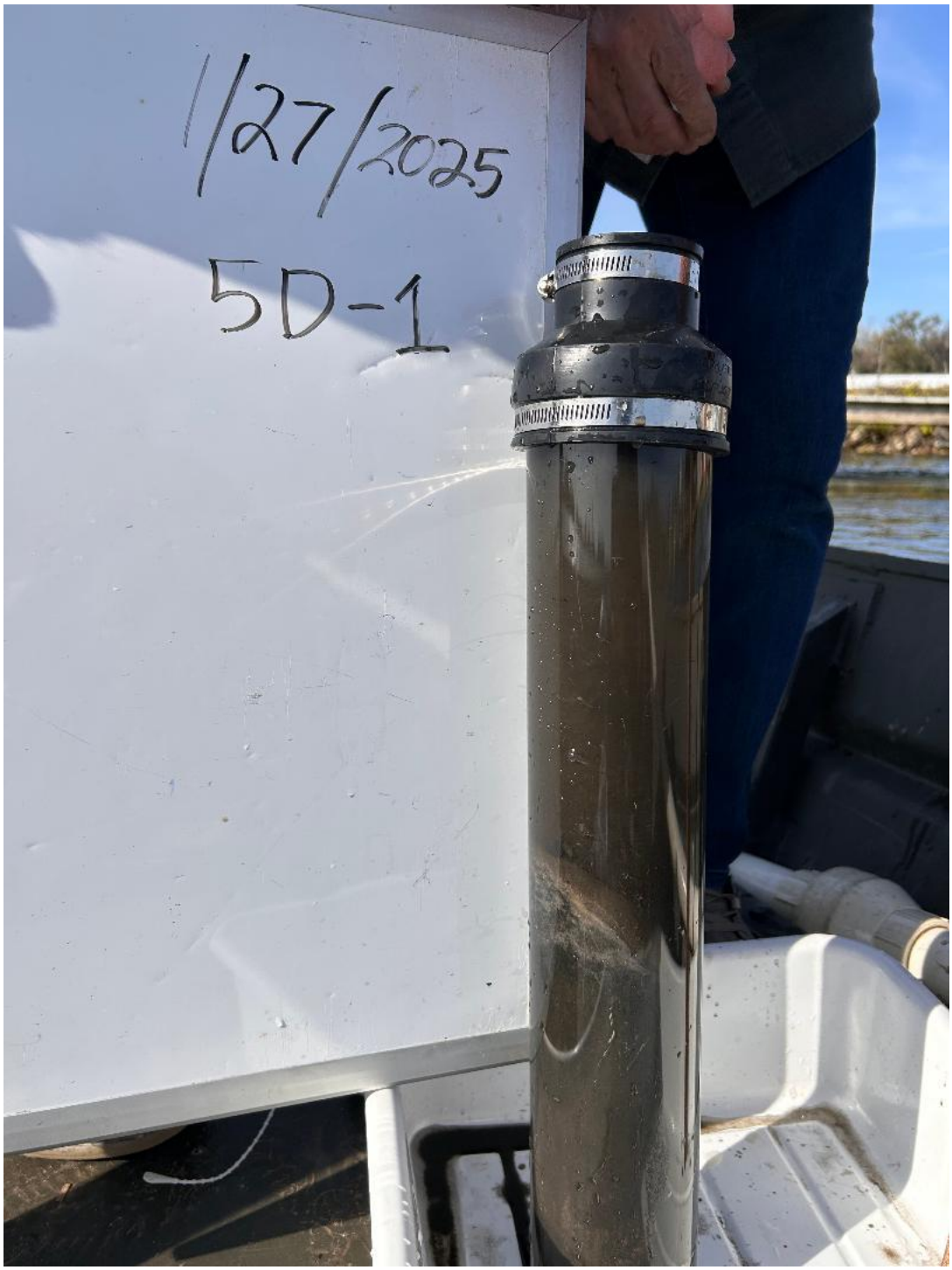
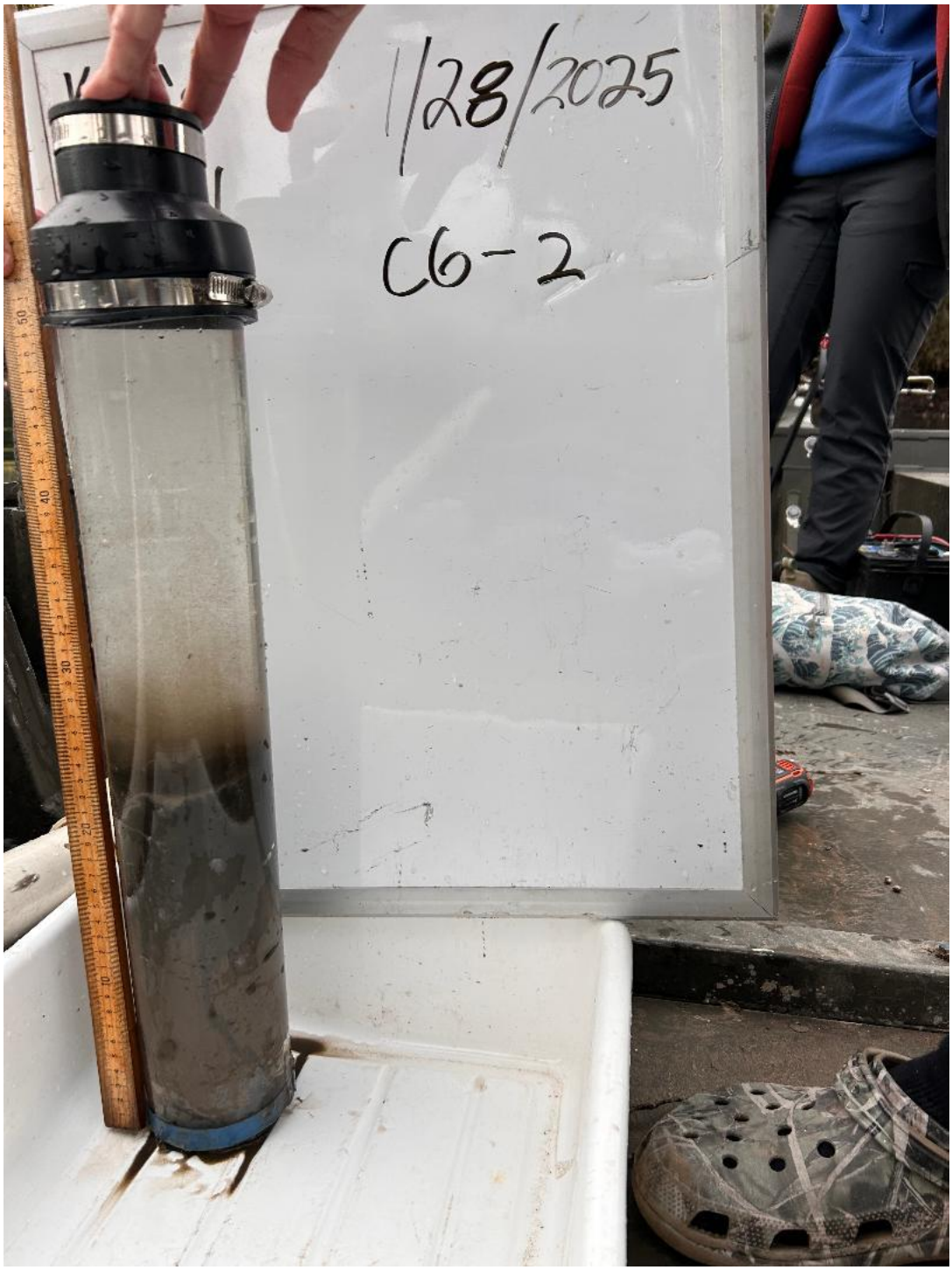


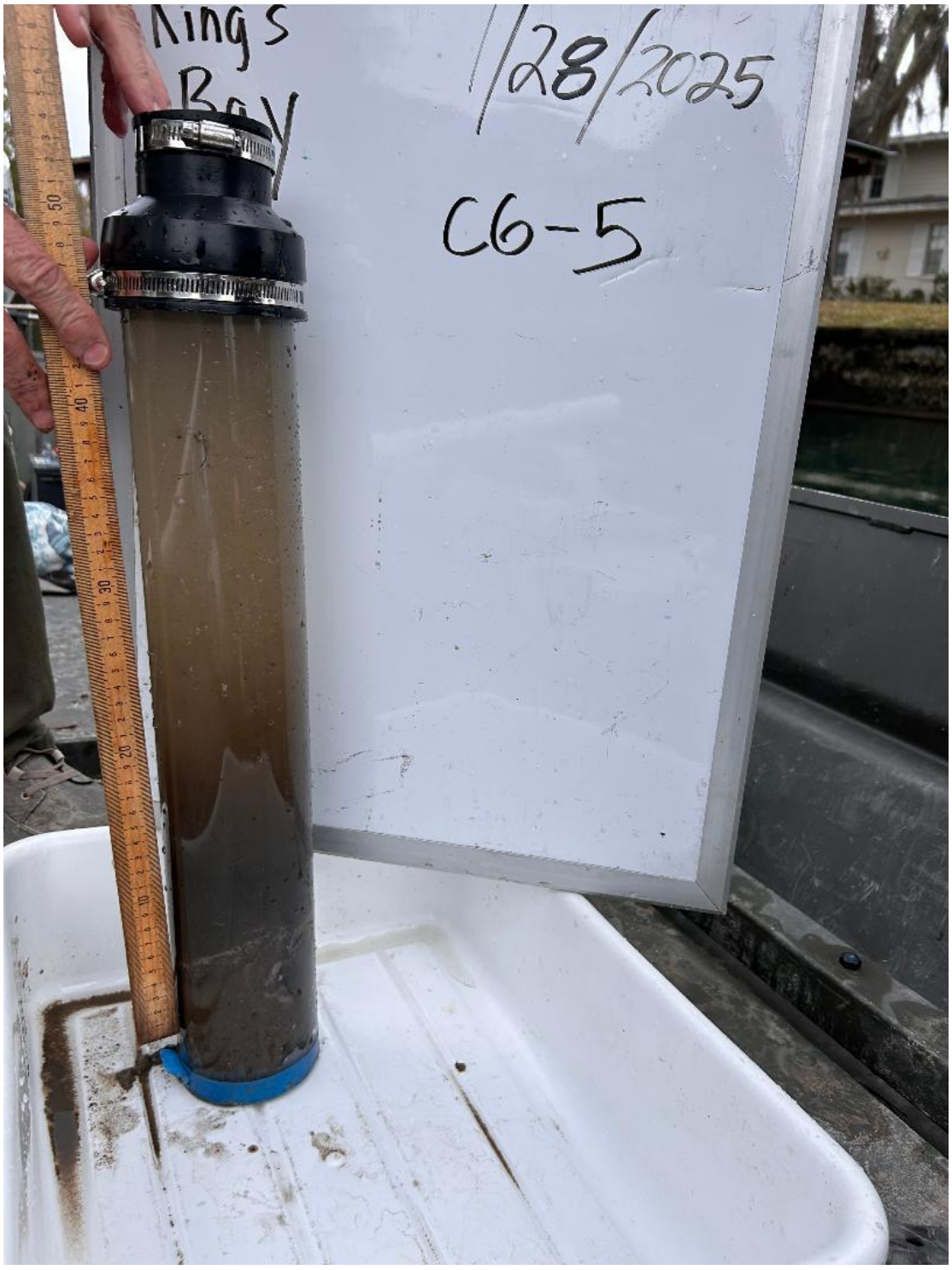
Kings Bay sediment core sample collected from Phase 5D-1.

Kings Bay sediment core sample collected from Phase 5D-3.

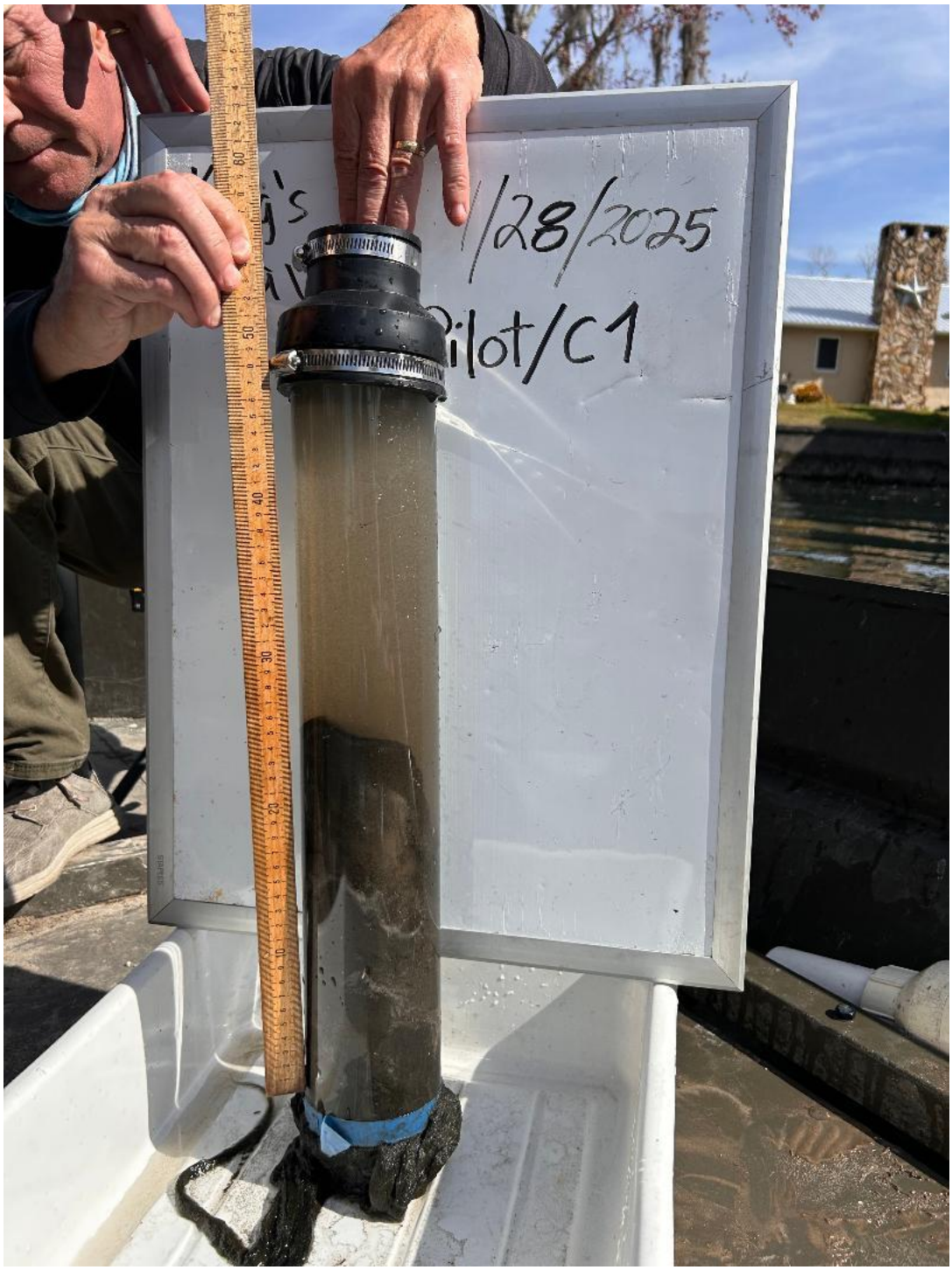
Kings Bay sediment core sample collected from Phase 5D-5.



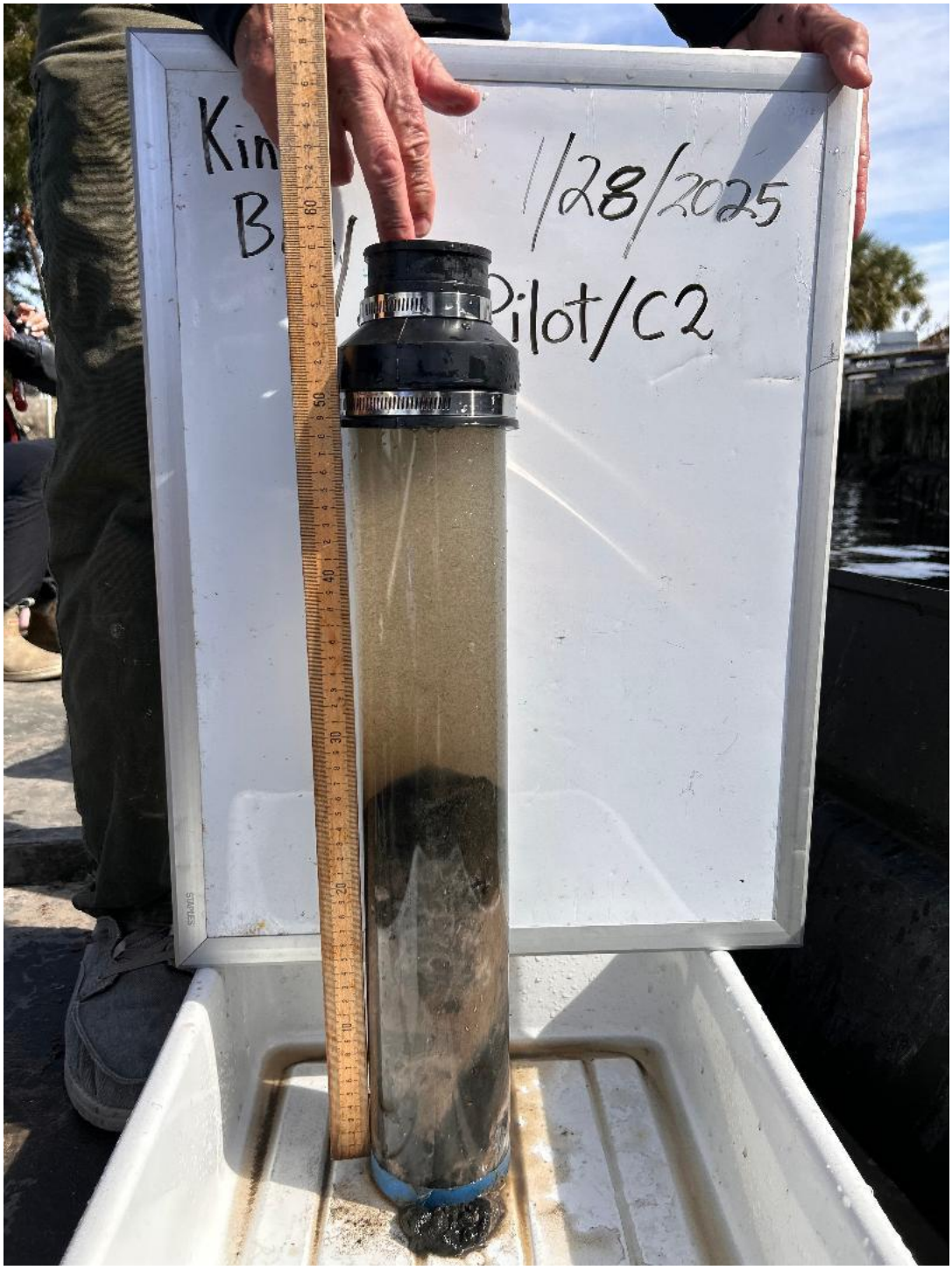
Kings Bay sediment core sample collected from Canal 6-2.



Kings' Bay sediment core sample collected from Canal 6-5.



PILOT C1
Kings Bay sediment core sample collected from Pilot Project area.



PILOT C2
Kings Bay sediment core sample collected from Pilot Project area.

PILOT C3
Kings Bay sediment core sample collected from Pilot Project area.

PILOT C4
Kings Bay sediment core sample collected from Pilot Project area.