Appendix I

Geotechnical Instrumentation
and
Monitoring Report

ADAPTIVE
MANAGEMENT AND ENGINEERING

DATE: 6/8/2023

Mr. Bryan Harmon, P.E.
Vice President
Sigma Consulting Group, Inc.
10305 Airline Highway
Baton Rouge, LA 70816

DELIVERED VIA E-MAIL ONLY

SUBJECT: Geotechnical Instrumentation and Monitoring Final Report
Caminada Headlands Back Barrier Marsh Restoration Project (BA-171)
Jefferson and Lafourche Parish, Louisiana
File Number: 19A104

Dear Mr. Harmon:

Adaptive Management and Engineering, LLC (AME) is pleased to submit this Geotechnical Instrumentation and Monitoring Final Report for the Caminada Headlands Back Barrier Marsh Restoration Project (BA-171). Our services were conducted in general accordance with the original proposal submitted by S&ME, Inc. dated March 19, 2019, and as authorized by the Sigma Consulting Group, Inc. (SCG) on April 21, 2022. This report summarizes all of the geotechnical sampling, instrumentation and monitoring, and analyses conducted in support of this project.

AME appreciates the opportunity to collaborate with SCG and provide services for this project. Please do not hesitate to contact us with any questions you may have concerning this report.

Sincerely,

Adaptive Management and Engineering, LLC

STATE OF LOUISIANA
VENU TAMMINENI
License No. 36864
PROFESSIONAL ENGINEER

Gregory Mattson, II, P.E.
Project Lead Engineer

Venu Tammineni, P.E.
Principal

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ECD Priority Section Drive Point Piezometer Locations and Data Summary

Earthen Containment Dike Construction Monitoring at Bayou Moreau Caminada Headland Back Barrier Marsh Creation Project (BA-0171) Memorandum

1.0 EXECUTIVE SUMMARY

The instrumentation deployed on the Caminada Headlands Back Barrier Marsh Restoration Project (BA-171) was able to transmit data real-time, enabling Adaptive Management and Engineering, LLC (AME) and the Project Team to monitor the construction activities for the duration of the project; from the construction of the earthen containment dikes (ECDs) through the completion of filling operations. This was accomplished by installing four drive point piezometers, seventeen instrumented settlement plates (ISPs), and multiple cameras. Given below are some of benefits achieved from the instrumentation and monitoring effort of the project:

- <u>Removal of ECD Priority Section</u> – Based on the information available during the project design phase, it was determined that a sand base would be required at a section of the ECD to assist with slope stability. Due to the data collection from sampling and instrumentation, it was determined that the ECD Priority Section was not necessary. As a result, part of Change Order #3 removed the Priority Section which was a bid item of **$350,000.**

- <u>Reduction in construction time for ECD</u> – Based upon information available during the design phase, it was determined that 45 days was the required wait time between ECD lifts for the excess pore water pressure to dissipate, allowing enough strength gain to support the next lift of material. The instrumentation indicated that the excess pore water pressure in the foundation material was happening within approximately 14 days. An RFI was issued to reduce this wait time.

- <u>Notifications to prevent overtopping of ECDs (internal and external)</u> – At several times during construction, particularly during night pumping operations, the slurry levels within the cell would approach the top of the ECD. AME was able to track and notify the project team on several occasions which led to slowing or stopping of pumping operations to prevent overtopping of the ECD.

- <u>Monitoring of fill density</u> – The instrumentation allowed for the tracking of the density of the material that had been placed in the vicinity of each Instrumented Settlement Plate (ISP). The placement of dredged fill could then be adjusted to areas where less material had been placed.

- <u>Live monitoring using cameras</u> – Cameras were placed in each increment which allowed the Owner to check or verify data obtained from the ISPs (e.g. Overtopping of ECDs).

The following information in this report presents a synopsis of the timeline of the project, the data that was collected from the Drive Point Piezometers (DPs) in the ECDs, the data that was collected from the ISPs, and lessons learned. AME has been pleased to work with S&ME, Inc. (S&ME),

Sigma Consulting Group, Inc. (SCG), and the Coastal Protection and Restoration Authority (CPRA) on this project.

2.0 PROJECT BACKGROUND

The Caminada Headlands Back Barrier Marsh Restoration Project (BA-171) dredging contract was awarded to Great Lakes Dredge and Dock Company (GLDD) in 2020. AME received a task from CPRA through S&ME and SCG to install and monitor seventeen (17) Instrumented Settlement Plates (ISPs) across four (4) increments: four ISPs in each increment and one on the exterior of the project near the outfall of the weir boxes. A Task and several instrumentation and monitoring efforts were completed previously for this project by S&ME and AME. The Task was a lab-scale study of the instrumentation in an Instrumented Settling Tank (IST). The instrumentation and monitoring efforts were for the former Priority Section of the ECD and of the Access Channel (Bayou Moreau). The sampling performed and instrumentation installed in the former Priority Section of the ECD allowed for a Change Order to remove a bid item of **$350,000,** which saved the project over $300,000. The instrumentation data was also used to estimate the time taken for consolidation of foundation soil. This data was used to reduce the construction time between lifts for the ECDs from 45 days to approximately 14 days. The memorandums and data associated with these tasks and efforts are included in the Appendix.

Initial installation of instrumentation began in January 2020 and was completed in March 2020. However, multiple hurricanes and storm events led to numerous removals and damage of equipment culminating with Hurricane Ida in August 2021.

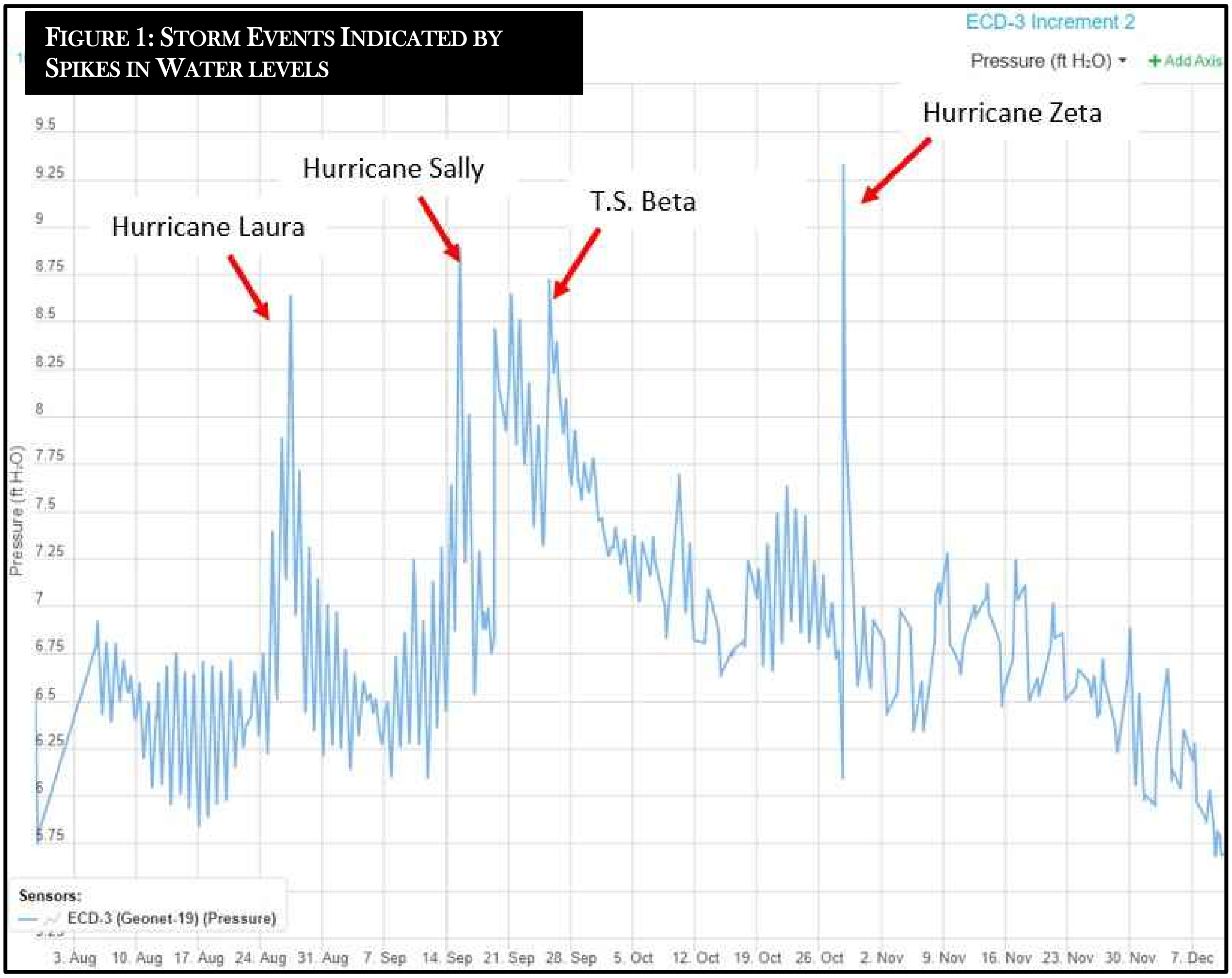

FIGURE 1: STORM EVENTS INDICATED BY SPIKES IN WATER LEVELS

After Hurricane Ida, the following ISPs were still standing and were checked for damages before the reinstallation of instrumentation: ISP-1, ISP-3, ISP-7, ISP-8, ISP-10, ISP-11, ISP-12, ISP-14, ISP-15, and ISP-16. The remainder of the ISPs were damaged or overturned during Ida and had to be replaced and re-set near their original locations. The final installation was completed in July 2022. The installation included the placement of 7 new ISPs nearby pre-Ida locations and outfitting all 17 ISPs with pressure plates, piezometers in sand-filled wells, data loggers, and antennas. Three Threads were installed on the ECD throughout the project to collect data from the loggers and to transmit the data to the Sensemetrics cloud via cellular network. An additional two Threads were installed to

FIGURE 2: DAMAGED ISP

promote communication of all instruments over the entire project to ensure all loggers collected and transmitted continuously in real-time. Field monitoring cameras were installed on the Threads and on the weir box to provide a visual of the placed marsh fill. Figure 3 below and Figure A-1 in the Appendix shows where the ISPs and Threads were located.

FIGURE 3: ISP LOCATIONS

3.0 DREDGE SEQUENCING

3.1. INCREMENT 1

After numerous hurricanes and storm events since the ECD construction began in 2020, GLDD dredging began on August 15, 2022. All material for this increment was dredged from the southwest borrow area. Initial plans were to begin dredge fill placement in the western most area of the project in Increment 1 near ISP-1 and advancing placement of fill to the east. However, GLDD encountered problems with the dredge pipeline and instead began pumping nearby ISP-4, in the eastern portion of Increment 1. The dredge pipe was placed primarily along the dune and the outfall was moved numerous times to facilitate even placement of the marsh fill throughout Increment 1. Clay balls were present at some of the discharge locations, as shown in Figure 4, and

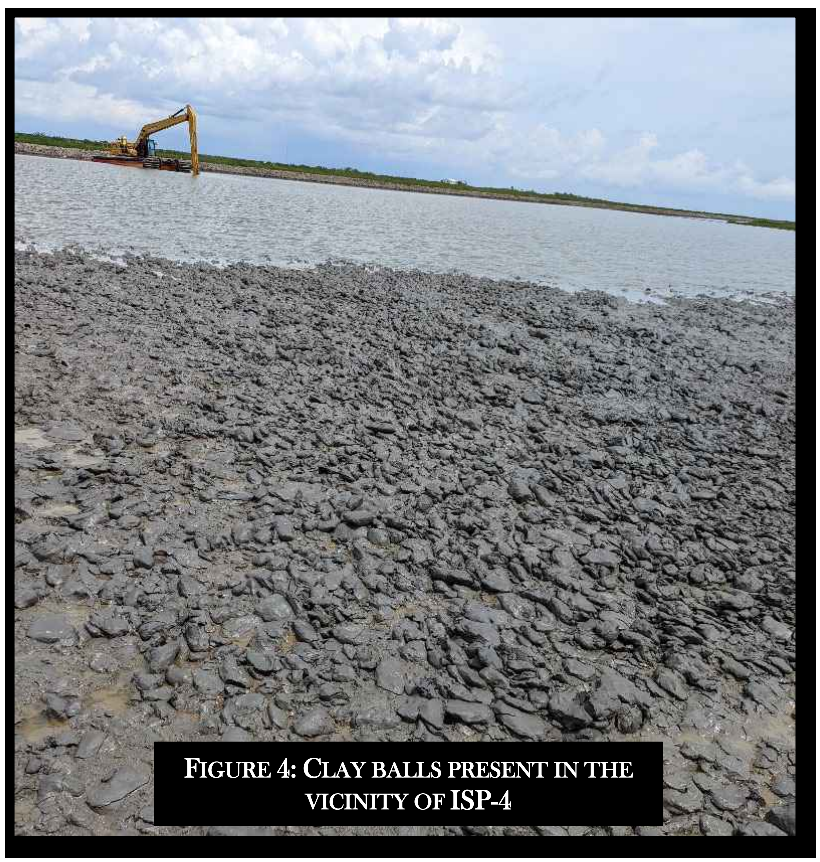

FIGURE 4: CLAY BALLS PRESENT IN THE VICINITY OF ISP-4

had to be mechanically spread to promote even placement. GLDD continued this advancement until reaching ISP-1 at which point placement continued back towards ISP-4 and the eastern boundary of Increment 1. It should be noted that the readings ISP-4 showed higher values immediately after placement and indicated higher concentration of soil being placed. This was communicated to the design team and based on the fill concentration, it was brought to CPRA's attention that the fill placement to the west of the Cell 1 needed more attention from GLDD and required additional time to fill. The ISP readings also indicated the dikes being overtopped or breached, and this was immediately brought to the attention of the design team. Calls were made to GLDD to check those locations in Cell 1 where potential overtopping of the dikes was occurring. GLDD moved the outfall from Increment 1 to Increment 2 on August 30, 2022. Increment 1 was filled to the required construction fill elevation in approximately 15 days.

3.2. INCREMENT 2

Dredge fill placement commenced in Increment 2 on August 30, 2022, with material still sourced from the southwest borrow area. It should be noted that readings at ISP-5 indicate that some material overtopped the training dike and was reaching this location prior to the outfall placement in this increment. Due to the presence of the Chevron pipeline canal that runs the length of the increment, GLDD anticipated the dredged fill would not flow evenly from one dredge pipeline discharge location along the dune to ECD to the north. For this reason, GLDD staggered dredge

FIGURE 5: DISCHARGE LOCATIONS ON EITHER SIDE OF CHEVRON PIPELINE CANAL

pipeline discharge locations, as shown in Figure 5, with one location near the dune to the south and the other close to the ECD to the north. Discharge locations advanced from west to east until arriving near the Louisiana Offshore Oil Port (LOOP) pipeline. At this point, GLDD mobilized the dredge to the northeast borrow area, started discharging east of the LOOP pipeline, and continued the same pattern of advancement to the east. Similar to Increment 1, clay balls were present at some of the outfall locations and had to be mechanically spread. GLDD moved the outfall from Increment 2 to Increment 3 on September 15, 2022. Increment 2 was filled to the required construction fill elevation in approximately 16 days.

3.3. INCREMENT 3

Dredge fill placement commenced in Increment 3 on September 15, 2022. Just as in Increment 2, GLDD staggered dredge pipeline discharge locations with one location south of the Chevron line and one north of the line. Discharge locations advanced from west to east and clay balls present at outfall locations were mechanically spread. GLDD moved the outfall from Increment 3 to Increment 4 on September 26, 2022. Increment 3 was filled to the required construction fill elevation in approximately 11 days.

FIGURE 6: CLAY BALLS PRESENT NEAR THE OUTFALL

3.4. INCREMENT 4

Dredging commenced in Increment 4 on September 26, 2022. Just as in Increments 2 and 3, GLDD staggered dredge pipeline discharge locations with one location south of the Chevron line and one north of the line. Discharge locations advanced from west to east and clay balls present at outfall locations were mechanically spread. GLDD removed the outfall from Increment 4 on October 15, 2022. Increment 4 was filled to the required construction fill elevation in approximately 19 days.

4.0 INSTRUMENTATION DATA

The ISPs have been developed based on the general principles of effective stress which state that the pressure is transmitted through grain-to-grain contact in a soil mass. Pore water pressure within the soil mass voids reduce the grain-to-grain pressure and hence is subtracted to provide the effective stress. The equation for effective stress is:

$$\sigma' = \sigma - u = TPC - PZ$$

Where: σ is total stress, σ' is effective stress, u is pore water pressure, TPC is the total pressure cell reading, and PZ is the vibrating wire piezometer reading. If the total pressure from the slurry (soil + water), the water pressure (water) and the soil properties are known, it is possible to back calculate the amount of soil solids placed in that particular area. <u>The amount of slurry (soil + water) needed in an area can vary greatly depending on the ratio of soil to water. Ultimately, the geotechnical design and marsh settlement curves are based upon a given amount of solids, not a slurry.</u>

Each of the 16 ISPs has a different target amount of solids, or effective stress, due to the varying mudline elevation. Shallower areas need less material whereas deeper areas need more material to achieve the target elevation. Effective stress targets were estimated using a combination of the design phase PSDDF calculations and an assumed existing healthy marsh density from nearby soil borings. Additionally, CPRA has learned from previous data collection efforts that the constructed marsh fill density is less likely to exceed the in-situ density in the borrow area unless the fill is in suspended state. The combination of these methods was used to provide an effective stress range. Table 2 below summarizes how the placed marsh fill relates to the target marsh fill as planned in design. Five of the sixteen ISPs were within their Theoretical Effective Stress ranges, while the remaining eleven were above the range indicating, a marsh platform above the design target elevation at TY-20 (20 years post-construction).

Table 1: Placed marsh fill vs. design target marsh fill

ISP	Theoretical Lower Bound Effective Stress Target (psf)	Theoretical Upper Bound Effective Stress Target (psf)	Measured Effective Stress from ISP (psf)	Effective Stress Outcome
1	64	88	85	Within Range
2	50	68	51	Within Range
3	46	62	78	Out of Range
4	33	45	95	Out of Range
5	61	83	138	Out of Range
6	65	89	107	Out of Range
7	48	65	78	Out of Range
8	52	71	63	Within Range
9	41	56	79	Out of Range
10	48	65	84	Out of Range
11	48	66	86	Out of Range
12	39	53	95	Out of Range
13	36	49	88	Out of Range
14	64	88	86	Within Range
15	61	84	61	Within Range
16	24	33	78	Out of Range

The following sections provide a summary of each increment's data. Snapshots of these plots are provided below, however, this data is provided as well as the individual ISP effective stress plots in the Attachments.

4.1. INCREMENT 1

The ISPs collected information on a regular basis each day. Shown in the plot below are the effective stress levels (Figure 7) obtained during the placement of marsh fill in Increment 1. ISP-4 was the first to register an effective stress above zero, followed by ISP-1, then ISP- 2, and lastly ISP-3. Increment 1 was the only increment in which the outfall movement didn't follow a west to east progression. Prior to fill being deposited on the ISPs, pressures tend to fluctuate, even below 0, as the total pressure cells are rapidly loaded and unloaded from the current of the dredge fill operations. Graphs tend to stabilize as filling operations are completed in a cell and the slurry stabilizes. This is true in all of the following graphs.

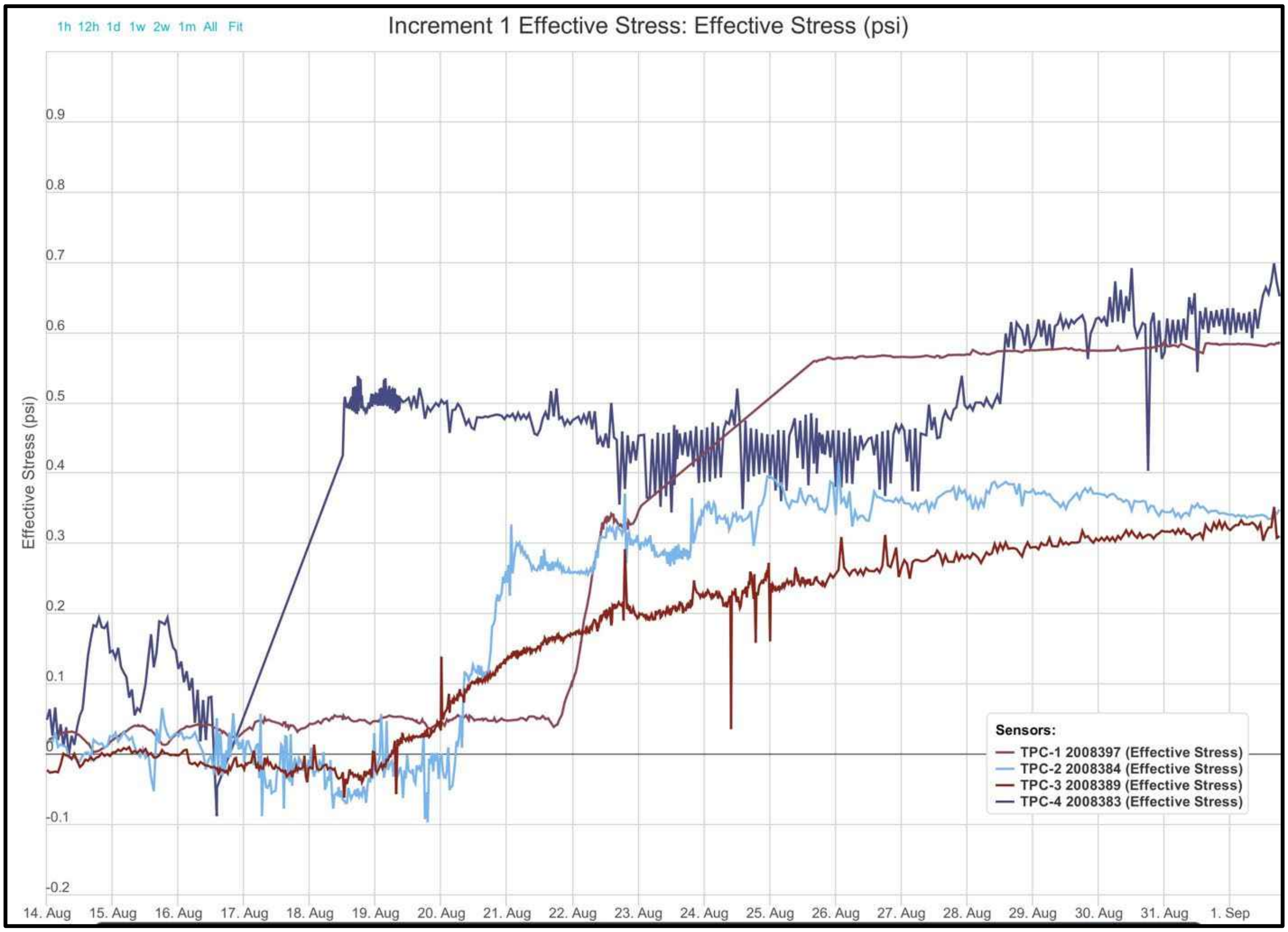

Figure 7: Increment 1, Effective Stress (y-axis) vs. Time (x-axis)

4.2. INCREMENT 2

Shown in the plot below are the effective stress levels (Figure 8) obtained during the placement of marsh fill in Increment 2. ISP-5 was the first to register an effective stress above zero, followed by ISP-6, then ISP- 7, and lastly ISP-8.

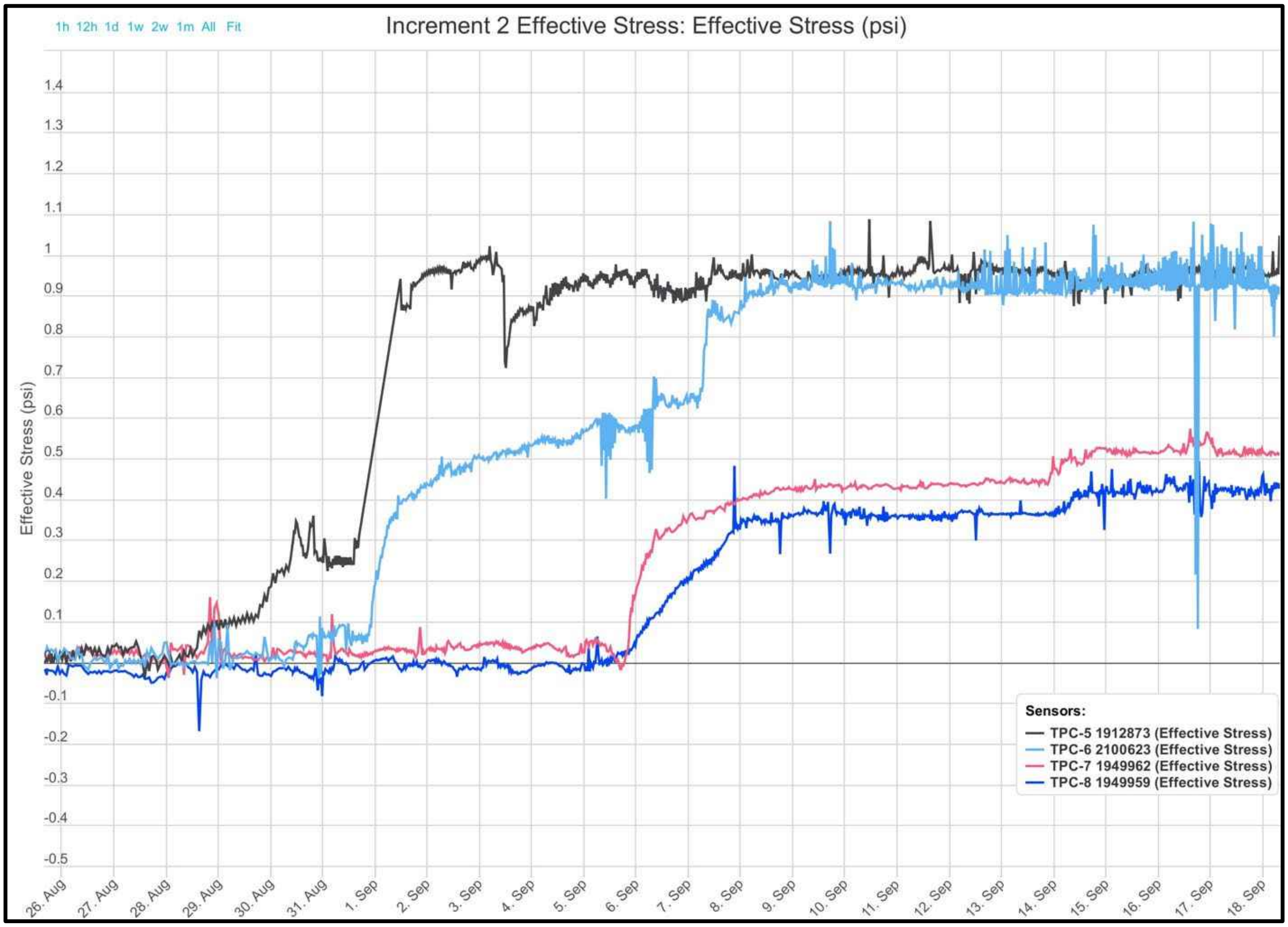

Figure 8: Increment 2, Effective Stress (y-axis) vs. Time (x-axis)

4.3. INCREMENT 3

Shown in the plot below are the effective stress levels (Figure 9) obtained during the placement of marsh fill in Increment 3. ISP-9 was the first to register an effective stress above zero, followed by ISP-10, then ISP- 11, and lastly ISP-12.

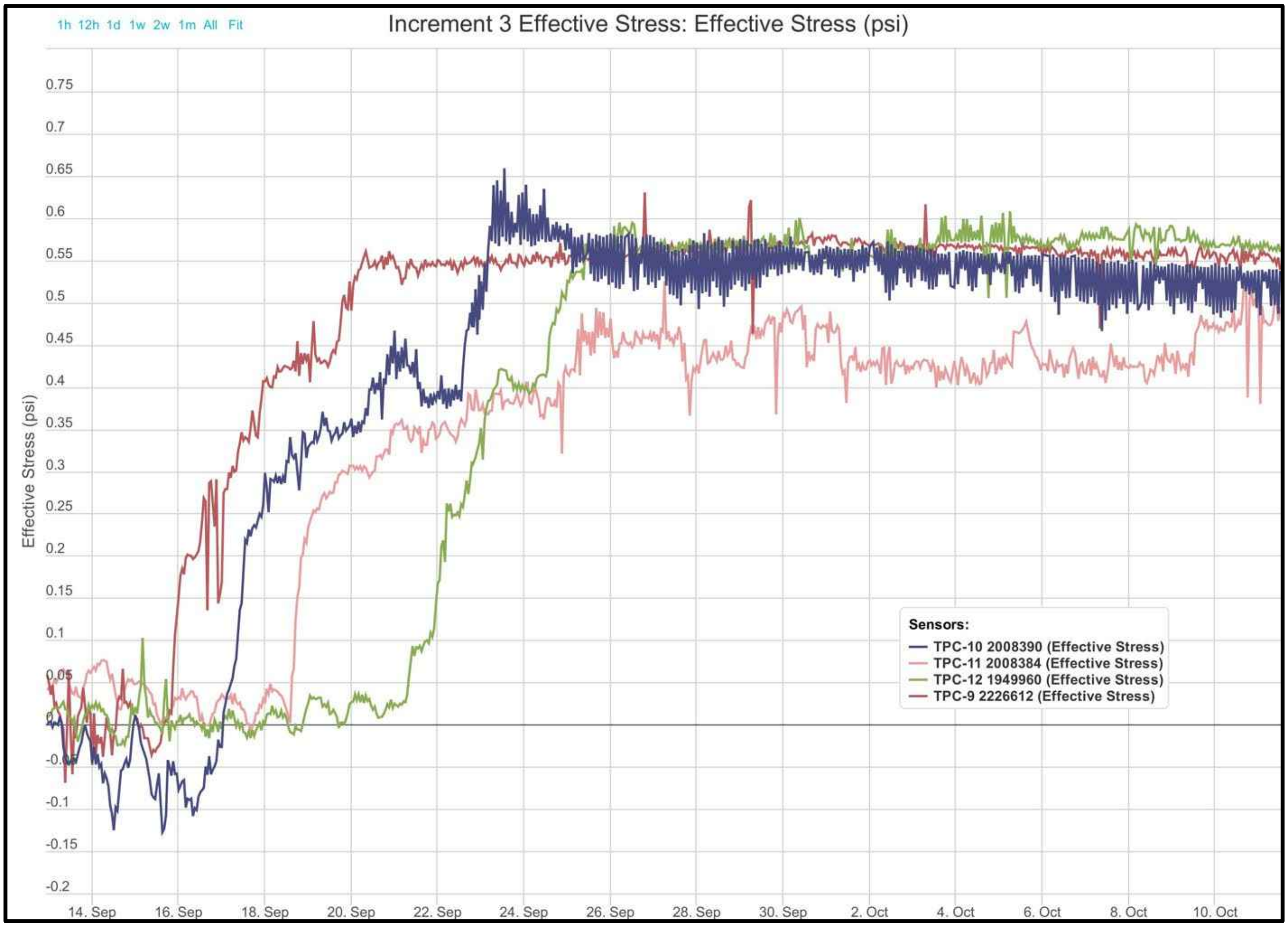

Figure 9: Increment 3, Effective Stress (y-axis) vs. Time (x-axis)

4.4. INCREMENT 4

Shown in the plot below are the effective stress levels (Figure 10) obtained during the placement of marsh fill in Increment 4. ISP-13 was the first to register an effective stress above zero, followed by ISP-14, then ISP- 15, and lastly ISP-16.

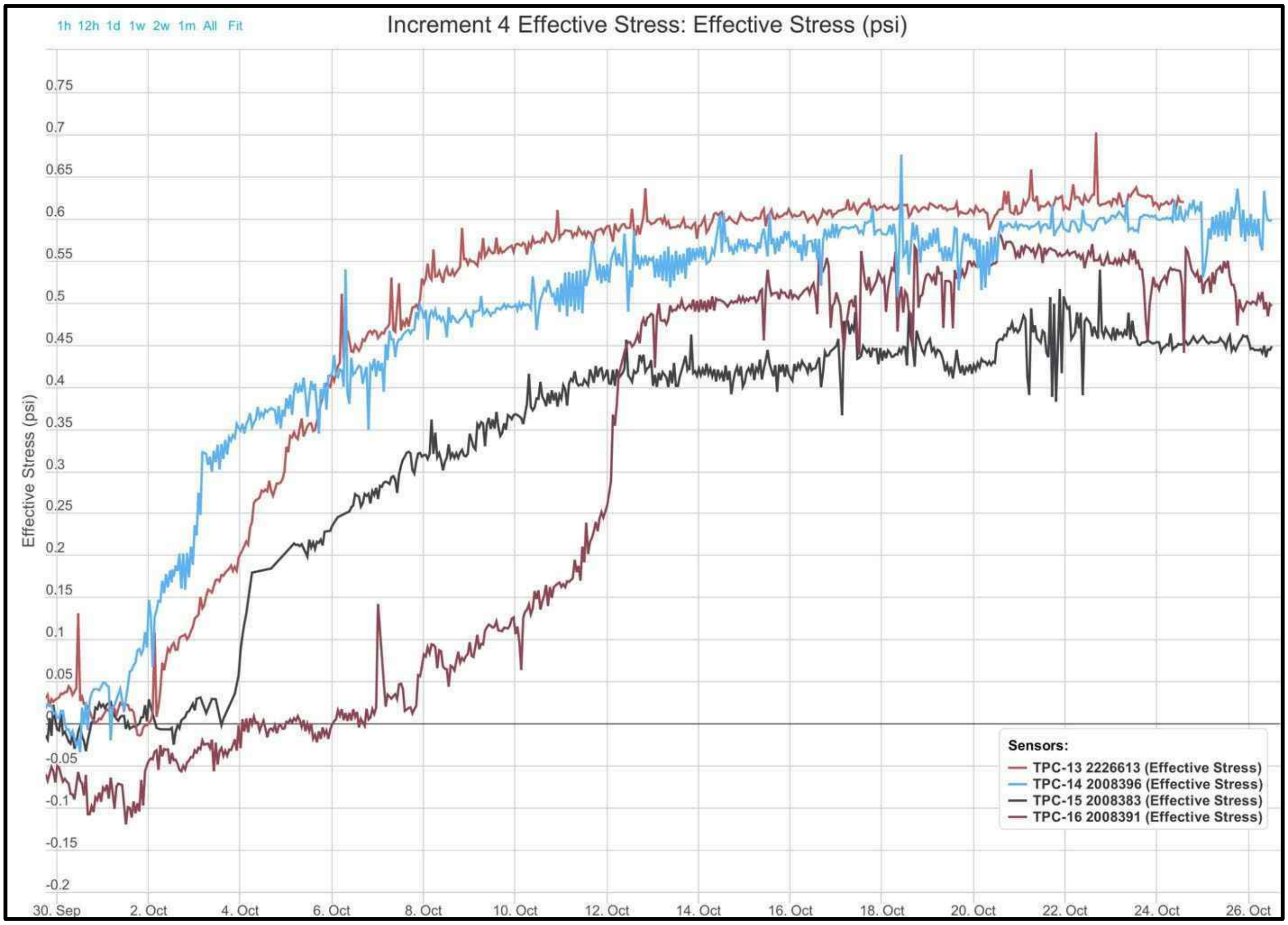

Figure 10: Increment 4, Effective Stress (y-axis) vs. Time (x-axis)

5.0 FIELD CAMERAS

AME installed cameras along the project to visually monitor the placement and movement of the placed marsh fill. Cameras were installed to the same mounts as the Threads, and to the railing on the center weir box at the far east edge of the project. Figures 11 and 12 below show snapshots from the cameras during construction of the project.

Figure 11: Snapshot from Field Camera in Increment 1 Showing Material Near Top of ECD

Figure 12: Snapshot from field Camera in Increment 1 Showing Material Being Discharge

6.0 MARSH FILL SAMPLING AND LABORATORY TESTING

Marsh fill samples were obtained at each of the ISPs in Increment 1, at ISP-5, and at select locations between ISPs on September 1, 2022. On September 23, 2022, samples were obtained at ISP-6 through ISP-10. On October 20, 2022, samples were obtained at ISP-11 through ISP-17. The samples were obtained using a handheld vibratory coring device to push a 3-inch diameter, aluminum thin-walled tube into the slurry. Samples were extruded in the field into 5-gallon buckets, sealed, and labeled for transportation to a geotechnical laboratory for testing.

Once at the laboratory, the samples were thoroughly mixed prior to testing. This mixing was conducted in an effort to homogenize the sample and to obtain the average properties of the slurry column near each ISP. Listed below is the suite of laboratory testing performed on the samples to classify the material and to obtain pertinent soil properties:

- Concentration by Mud Balance
- Moisture Content (ASTM D2216)
- Atterberg Limits (ASTM D4318)
- Hydrometer Analysis (ASTM D7928)
- Specific Gravity (ASTM D854)
- Low Stress Consolidation Testing

Laboratory testing results are available in the Appendix.

7.0 DATA COMPARISON

Laboratory testing was assigned to confirm the marsh fill data the ISPs were collecting was accurate. The soil solids concentration was tested by mud balance testing.

Table 2: Effective Stress Calculation Obtained from Physical Sampling vs. ISP Readings

ISP	Effective Stress from Physical Sample (psf)	Effective Stress from ISP (psf)	Percent Difference (%)
1	92	85	8
2	79	51	43
3	72	78	8
4	132	95	33
5	140	138	1
6	101	107	6
7	78	78	0
8	78	63	20

ISP	Effective Stress from Physical Sample (psf)	Effective Stress from ISP (psf)	Percent Difference (%)
9	82	79	4
10	86	84	3
11	92	86	6
12	95	95	0
13	92	88	5
14	94	86	8
15	86	61	34
16	78	78	0

8.0 LESSONS LEARNED

Over the course of the project, there were many lessons learned due to logistical, environmental, and technical challenges. Select lessons learned are described.

- Communications – Careful care must be taken to avoid interference when setting up equipment. Raising antennas and maintaining line of sight are key.
- Dredge Pipeline Discharge Locations – Working with the Contractor to avoid placing instrumentation in high traffic and dredge discharge locations is key.
- Environmental – Salt water and stagnant water within marsh creation cells can lead to corrosion and algae growth. Installing instrumentation as close to the dredge arrival date to minimize standing time is recommended. Additionally, using corrosion resistant and anti-fouling mechanisms can help prevent issues.

FIGURE 13: DAMAGED ISP-5

APPENDIX A

Figure A-1 Project Instrumentation Locations

NOTES

1. BACKGROUND SATELLITE IMAGERY, DATED 2022, WAS OBTAINED FROM GOOGLE EARTH PRO ON 11/11/2022.

LEGEND

⊕ APPROXIMATE ISP LOCATION

◎ APPROXIMATE THREAD LOCATION

0 2500 5000

GRAPHIC SCALE (IN FEET)

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DRAWN BY: RAW

CHECKED BY: GAM

PROJECT INSTRUMENTATION MAP - INCREMENTS 1 AND 2

CAMINADA HEADLANDS BACK BARRIER MARSH RESTORATION PROJECT (BA-171)

LAFOURCHE PARISH, LOUISIANA

SCALE: 1"=2500'

DATE: 11/11/2022

PROJECT NUMBER 19A104

FIGURE NO. 1A

NOTES
1. BACKGROUND SATELLITE IMAGERY, DATED 2022, WAS OBTAINED FROM GOOGLE EARTH PRO ON 11/11/2022.

LEGEND
⊕ APPROXIMATE ISP LOCATION
◎ APPROXIMATE THREAD LOCATION

0 2500 5000
GRAPHIC SCALE (IN FEET)

ADAPTIVE MANAGEMENT AND ENGINEERING

DRAWN BY: RAW
CHECKED BY: GAM

PROJECT INSTRUMENTATION MAP - INCREMENTS 3 AND 4

CAMINADA HEADLANDS BACK BARRIER MARSH RESTORATION PROJECT (BA-171)
LAFOURCHE PARISH, LOUISIANA

SCALE: 1"=2500'
DATE: 11/11/2022
PROJECT NUMBER 19A104
FIGURE NO. 1B

APPENDIX B

Figures B-1 to B-21: Effective Stress Plots (Individual and by Increment)

Figure B-1: ISP-1, Effective Stress (y-axis) vs. Time (x-axis)

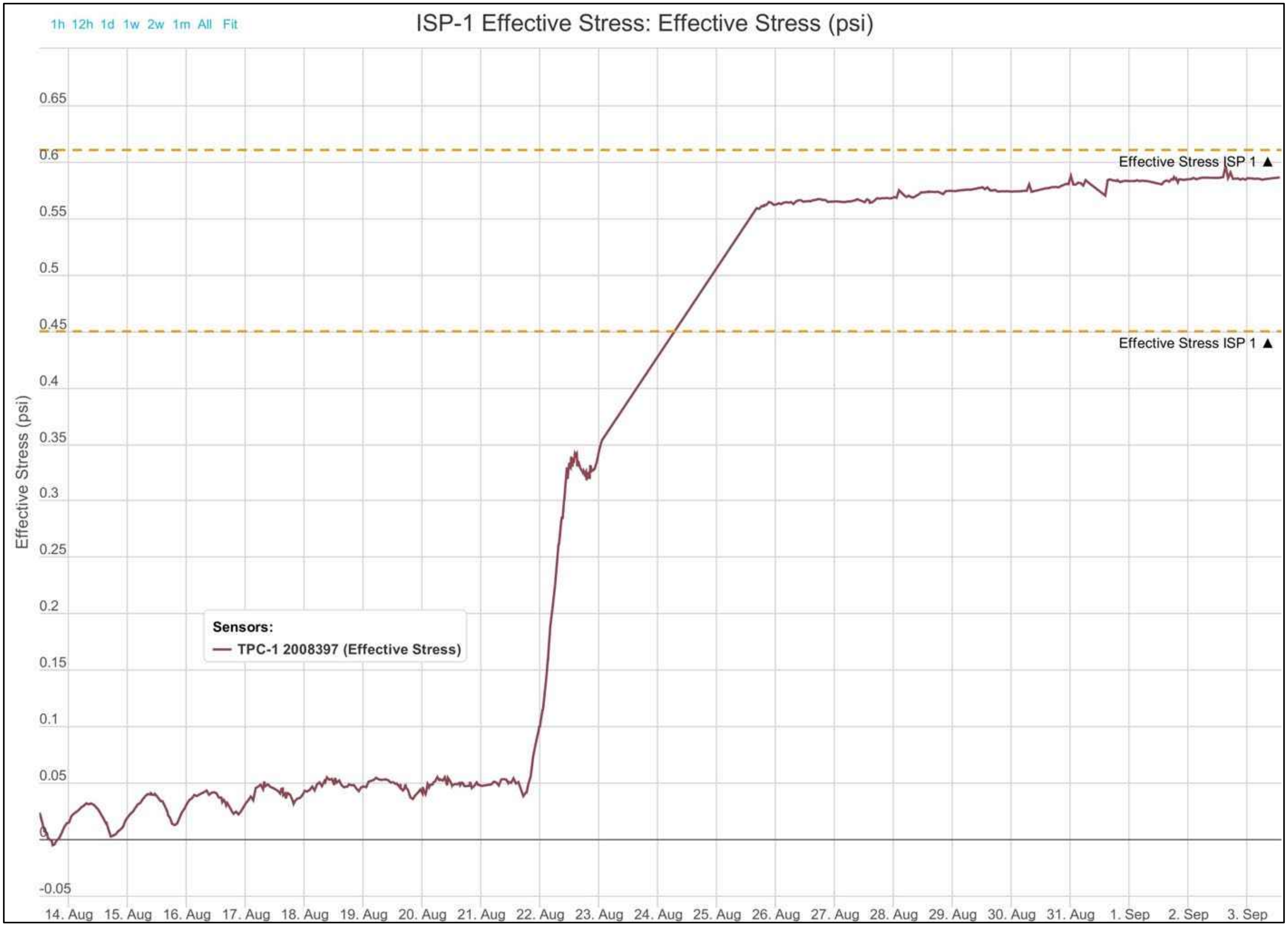

Figure B-2: ISP-2, Effective Stress (y-axis) vs. Time (x-axis)

Figure B-3: ISP-3, Effective Stress (y-axis) vs. Time (x-axis)

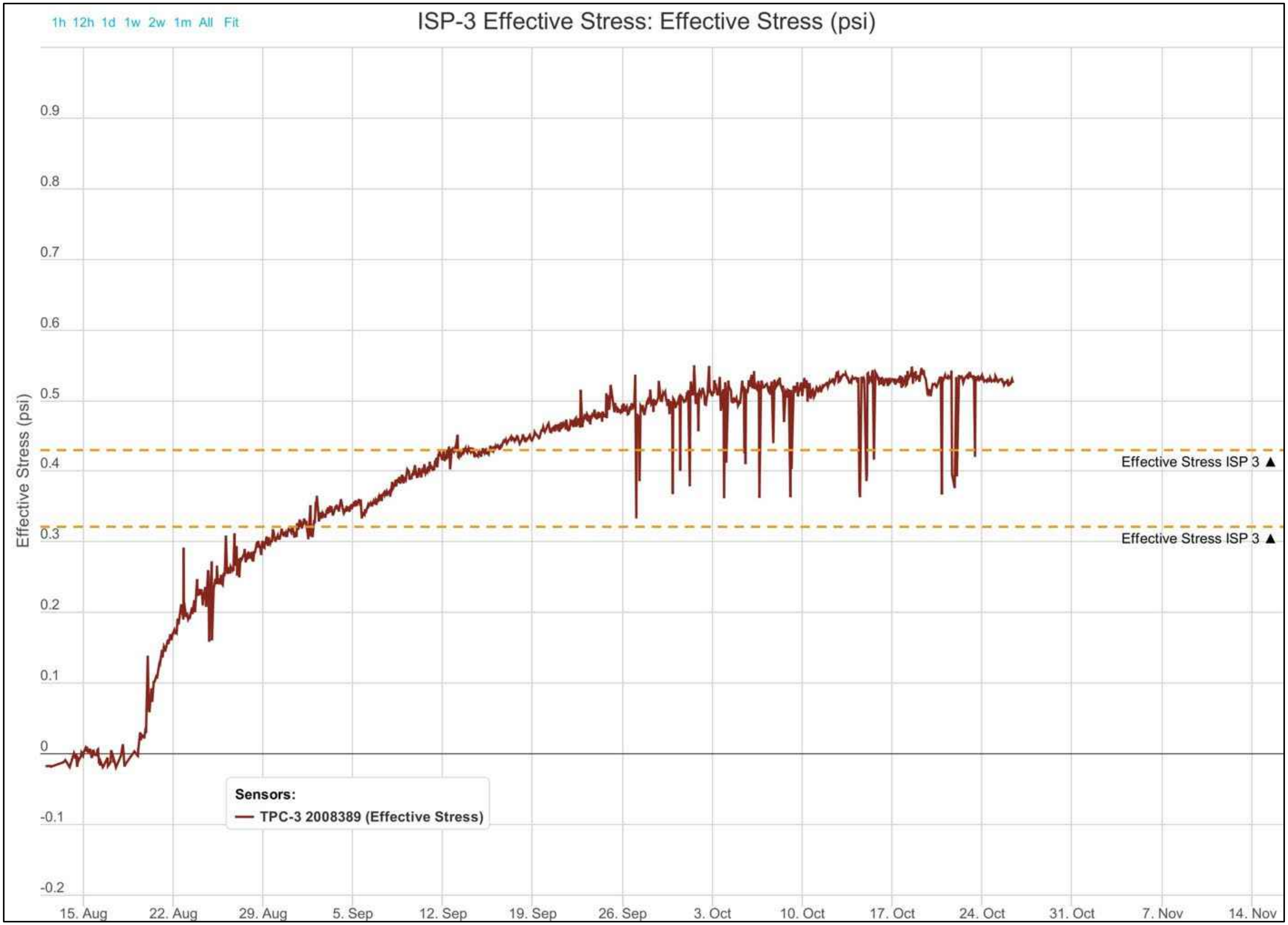

Figure B-4: ISP-4, Effective Stress (y-axis) vs. Time (x-axis)

Figure B-5: ISP-5, Effective Stress (y-axis) vs. Time (x-axis)

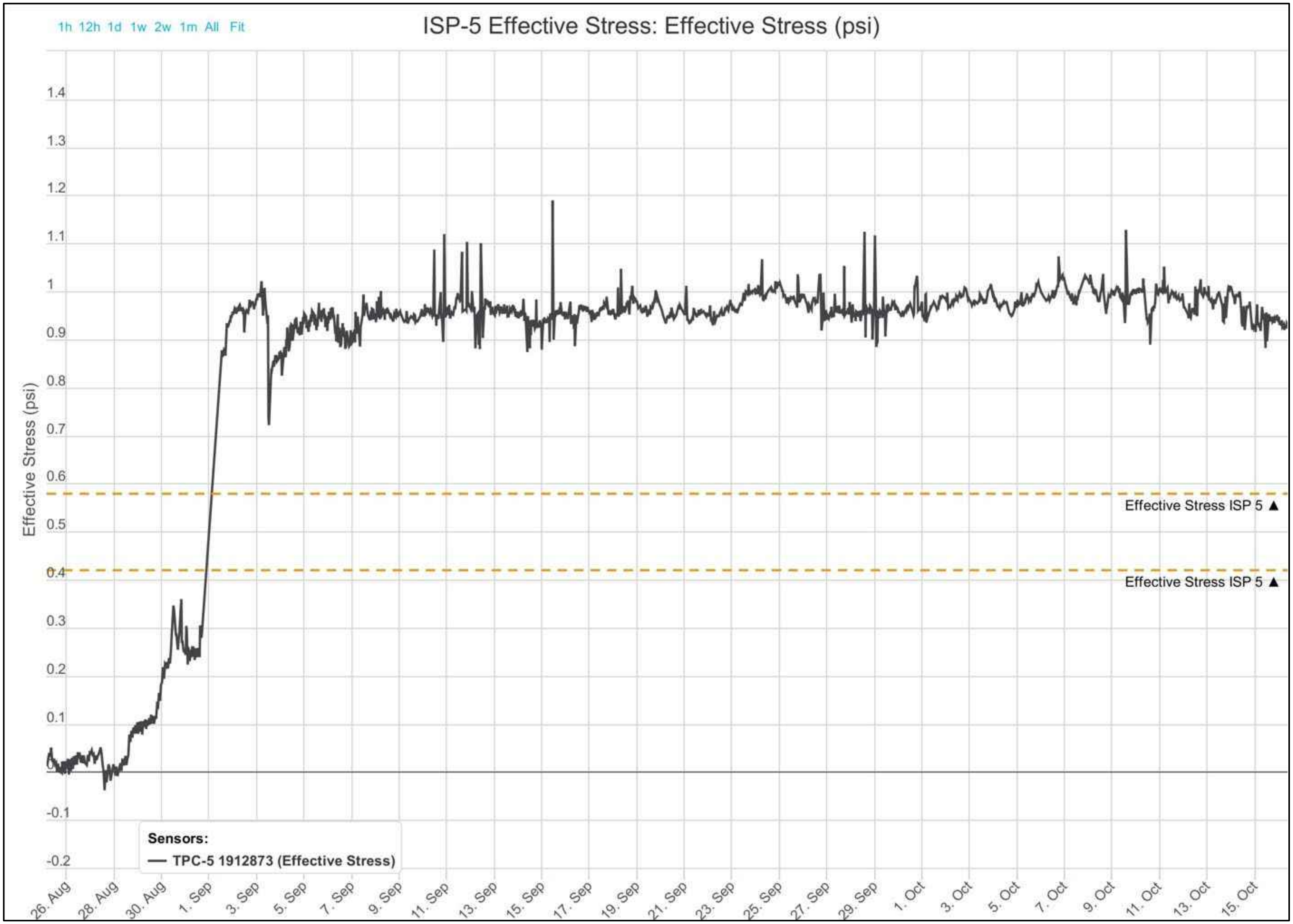

Figure B-6: ISP-6, Effective Stress (y-axis) vs. Time (x-axis)

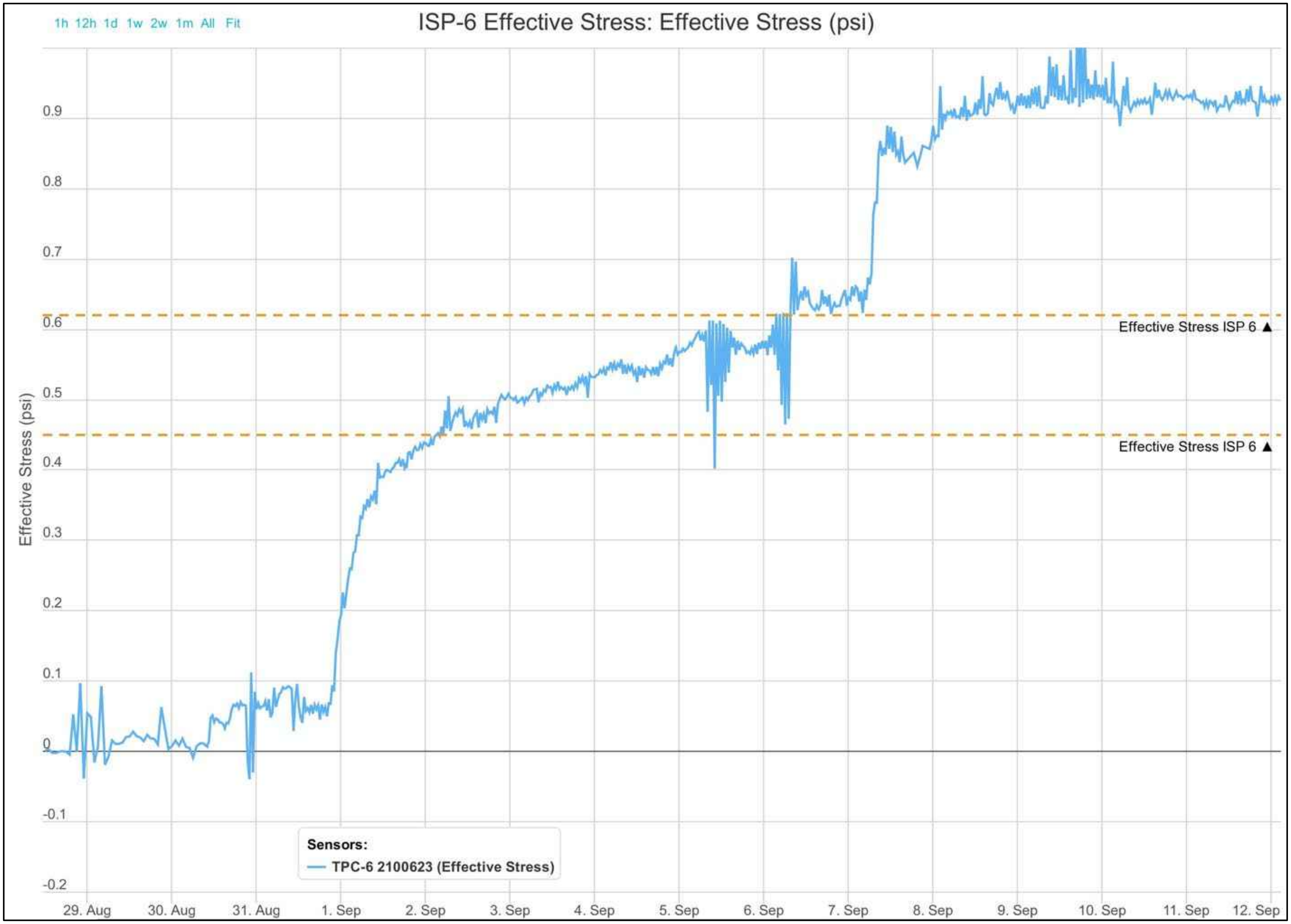

Figure B-7: ISP-7, Effective Stress (y-axis) vs. Time (x-axis)

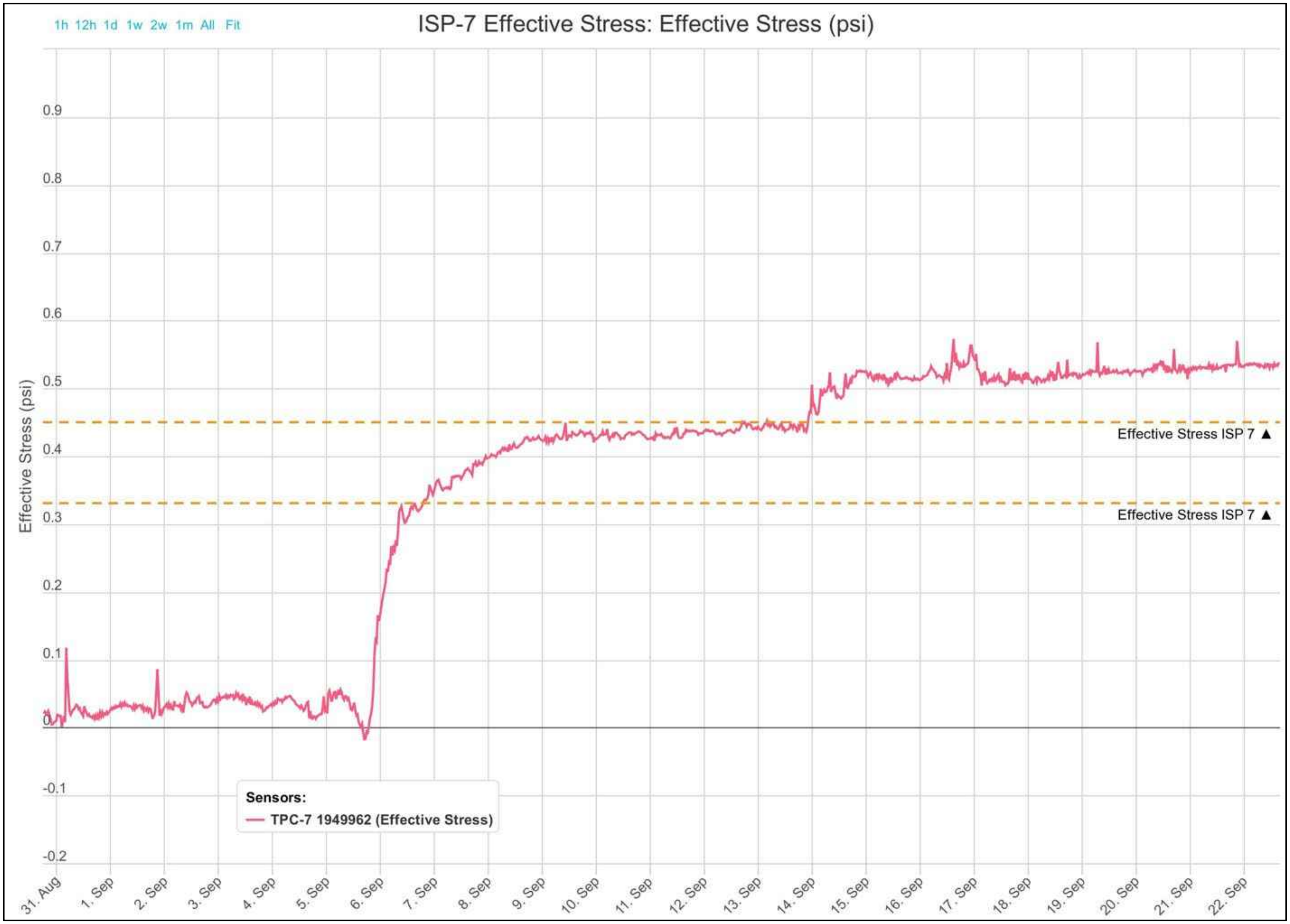

Figure B-8: ISP-8, Effective Stress (y-axis) vs. Time (x-axis)

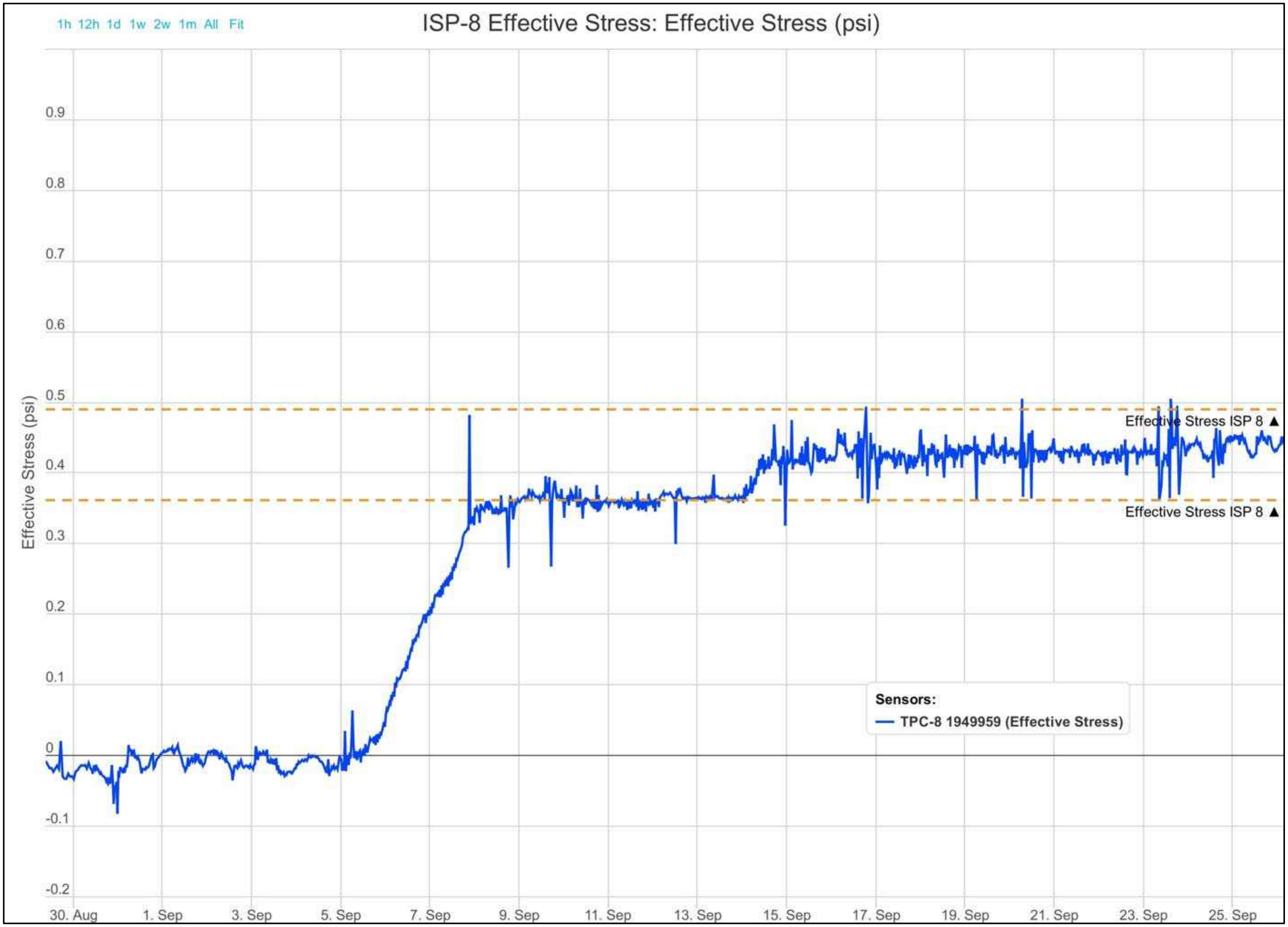

Figure B-9: ISP-9, Effective Stress (y-axis) vs. Time (x-axis)

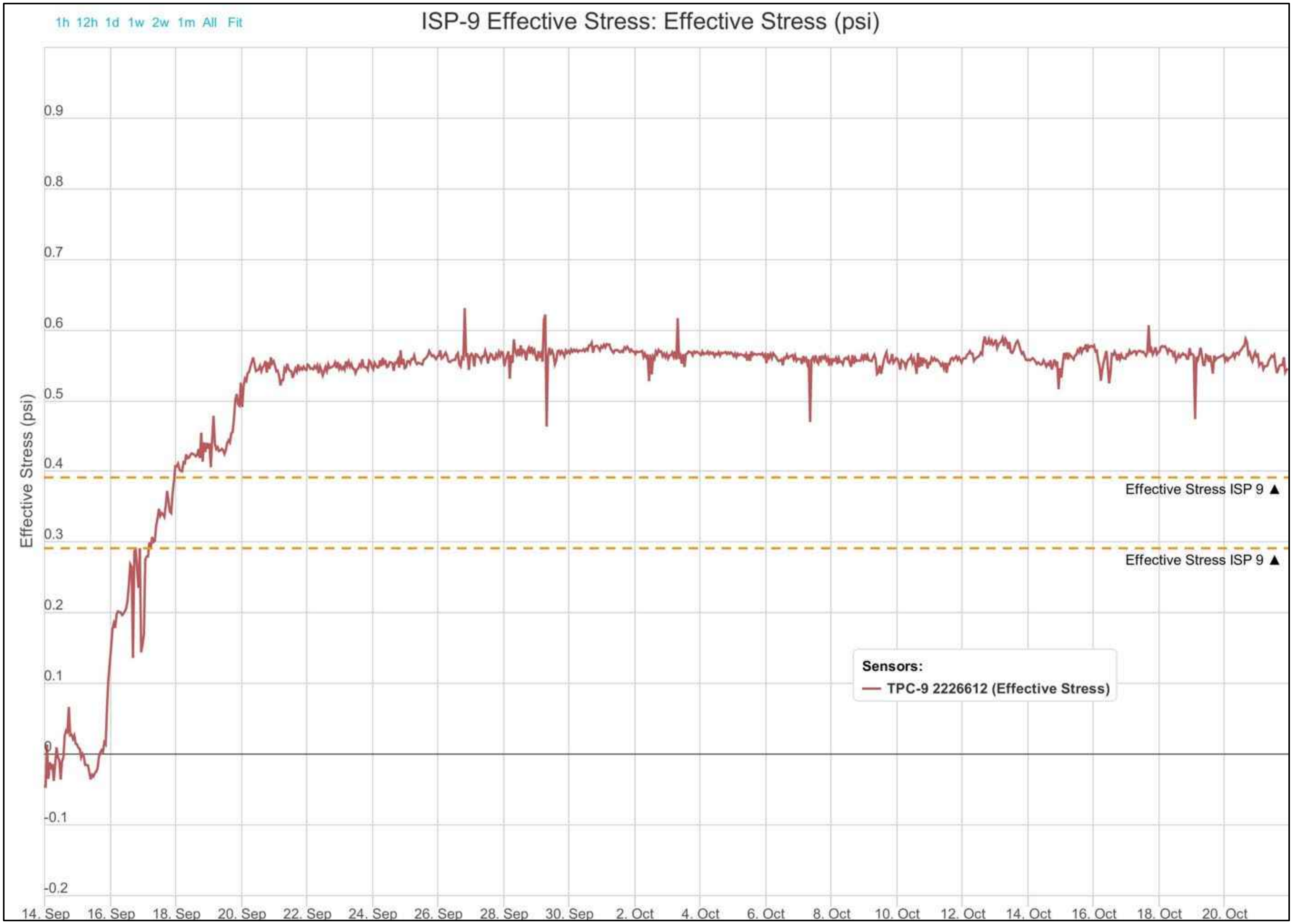

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Figure B-10: ISP-10, Effective Stress (y-axis) vs. Time (x-axis)

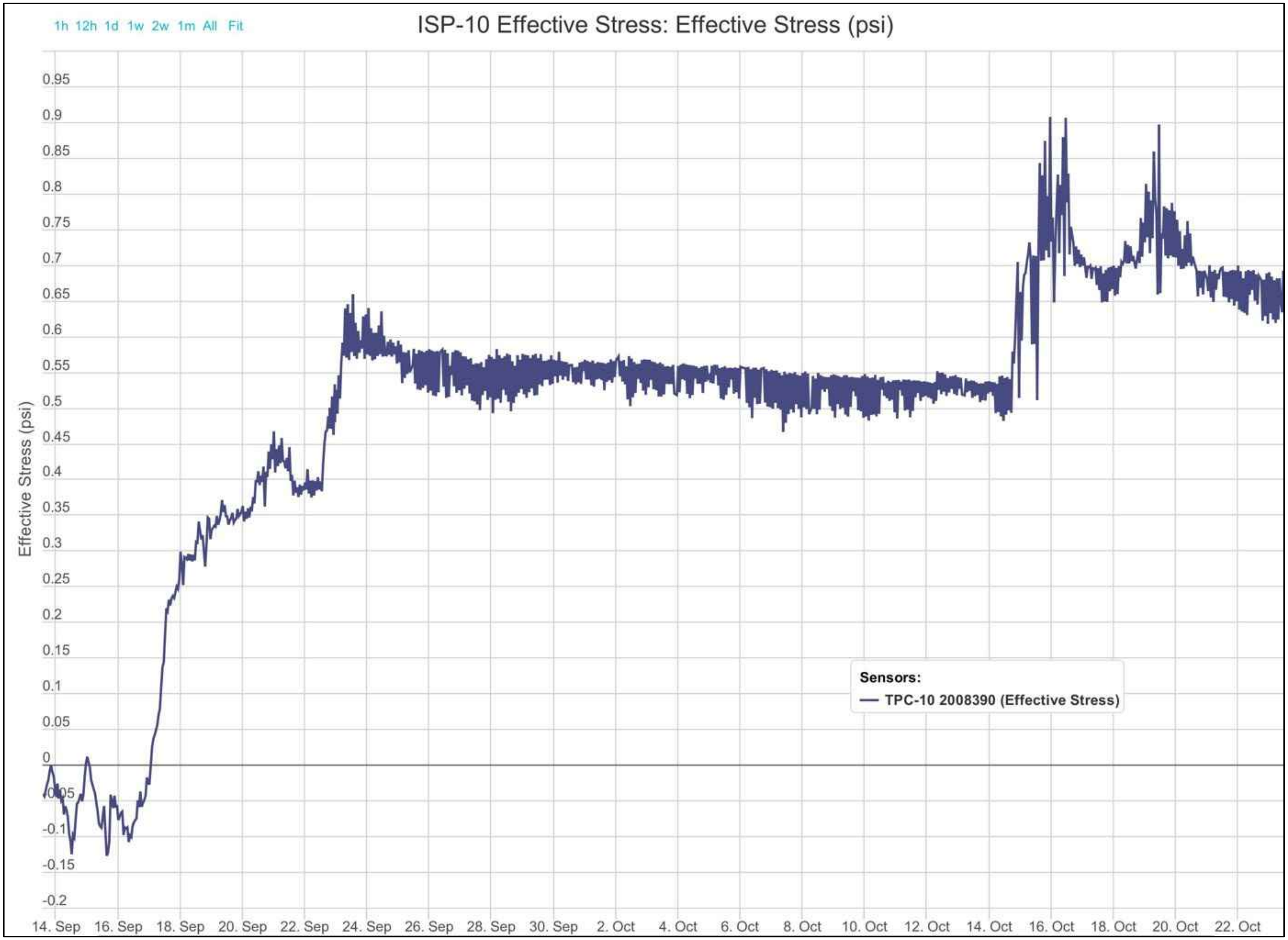

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Figure B-11: ISP-11, Effective Stress (y-axis) vs. Time (x-axis)

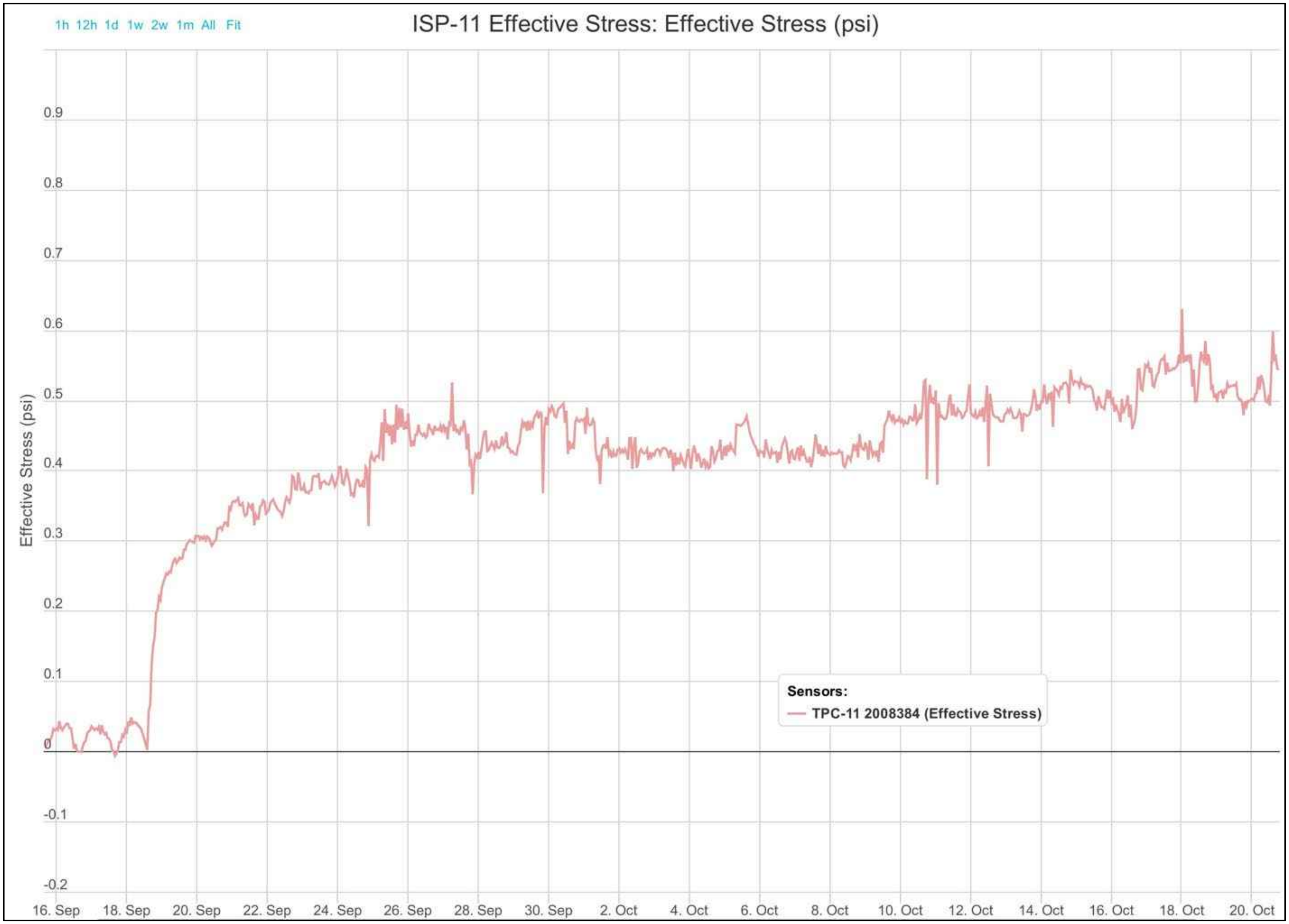


Figure B-12: ISP-12, Effective Stress (y-axis) vs. Time (x-axis)

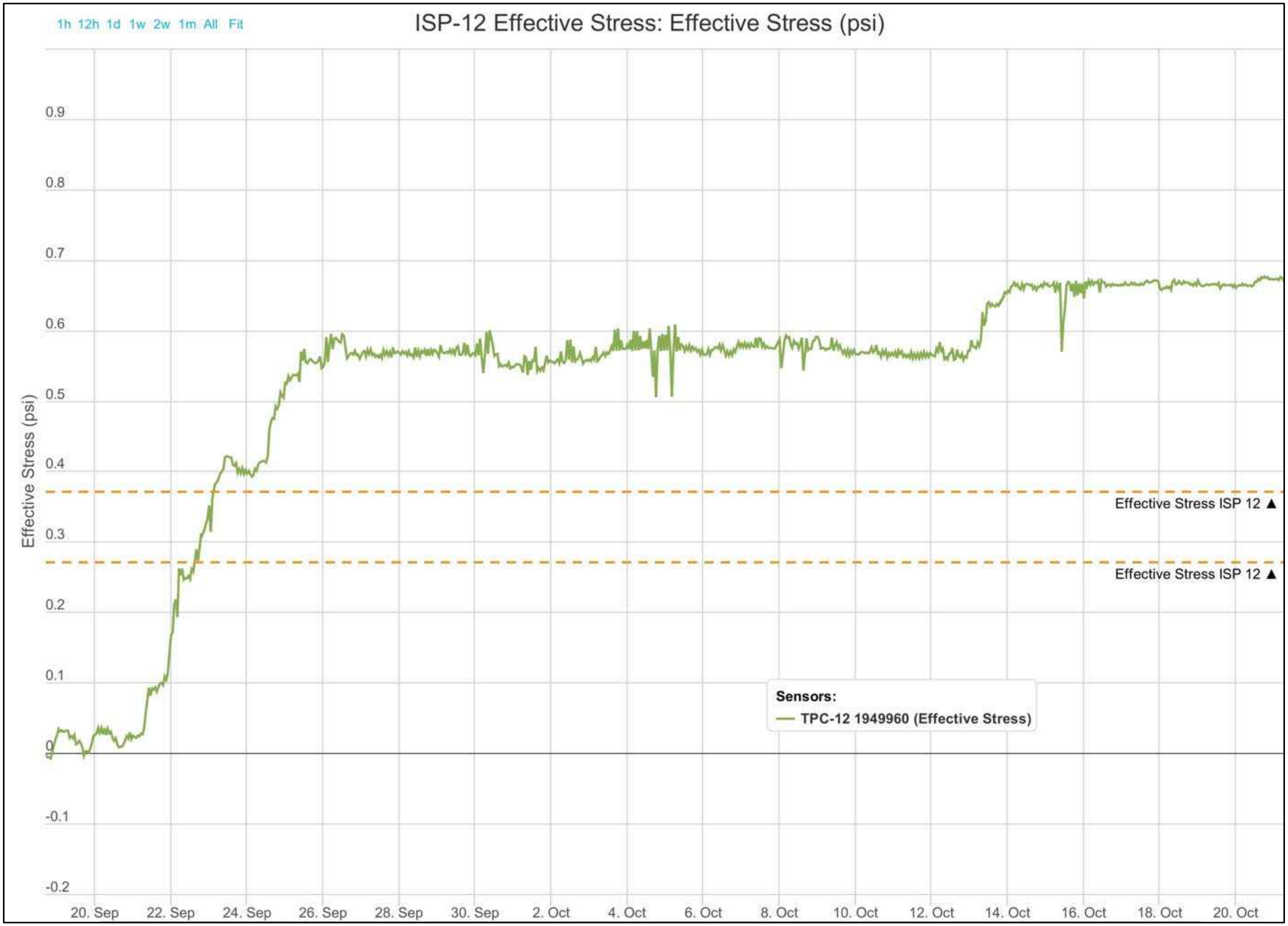


Figure B-13: ISP-13, Effective Stress (y-axis) vs. Time (x-axis)

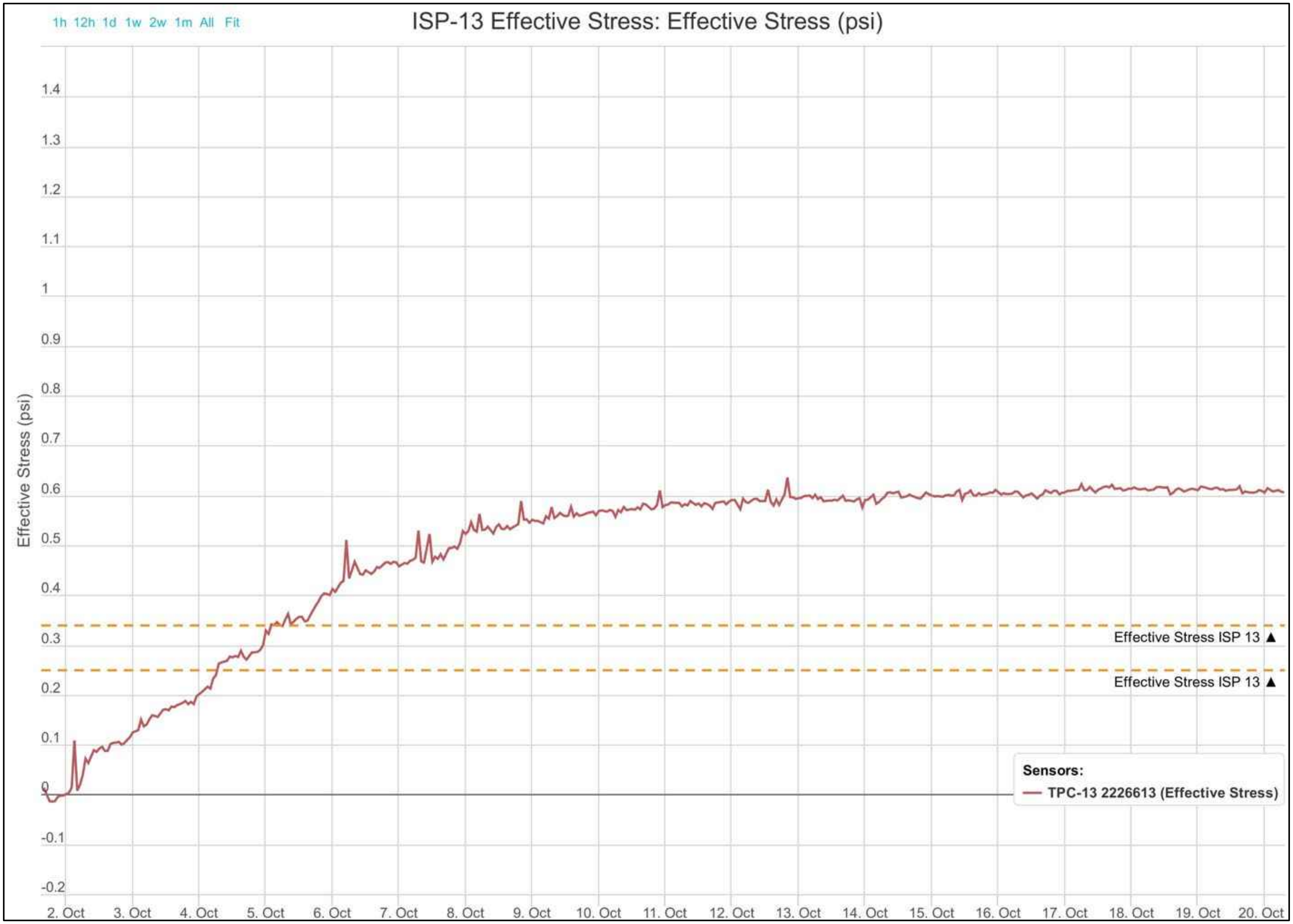


Figure B-14: ISP-14, Effective Stress (y-axis) vs. Time (x-axis)

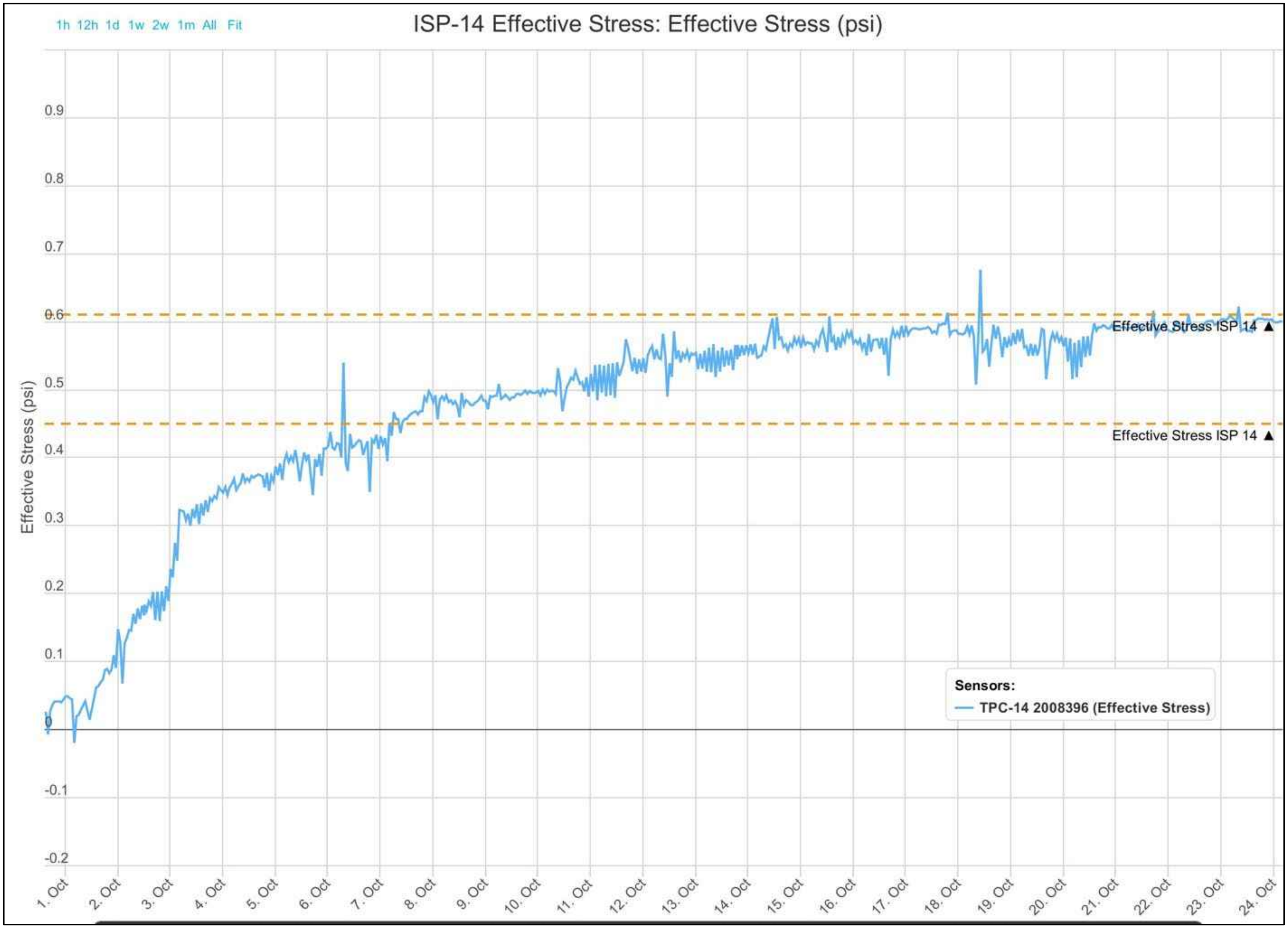


Figure B-15: ISP-15, Effective Stress (y-axis) vs. Time (x-axis)

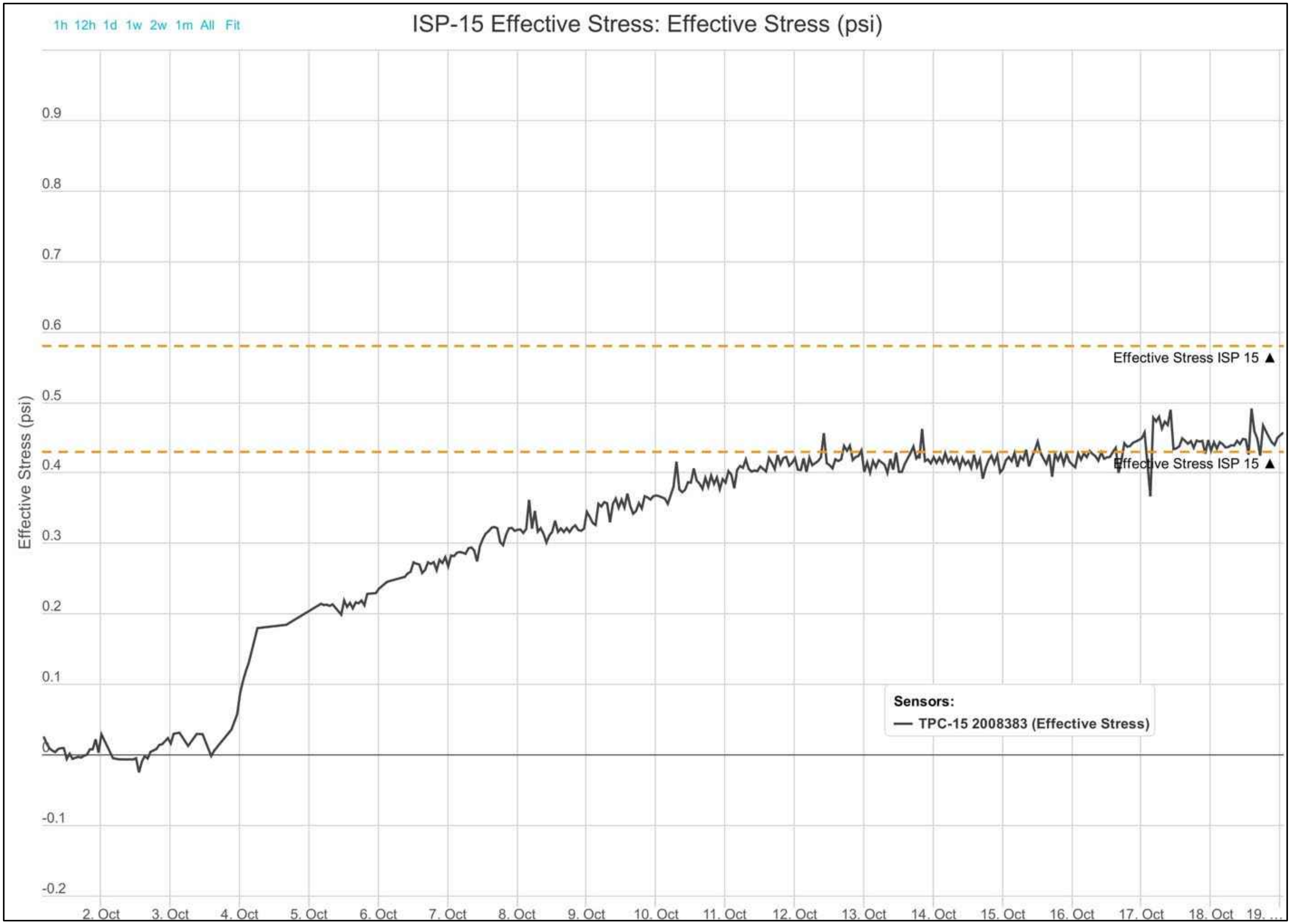


Figure B-16: ISP-16, Effective Stress (y-axis) vs. Time (x-axis)

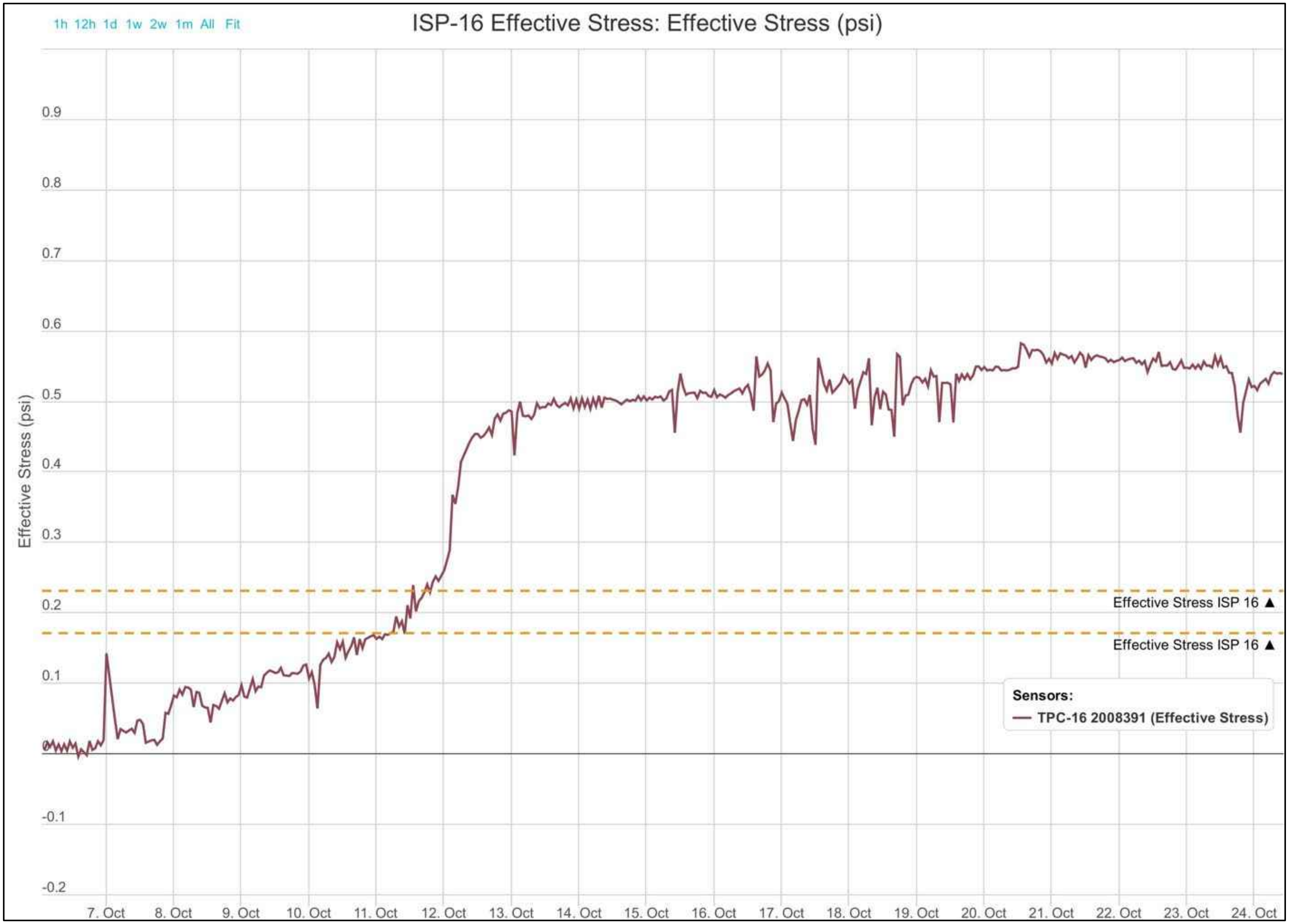


Figure B-17: ISP-17, Effective Stress (y-axis) vs. Time (x-axis)

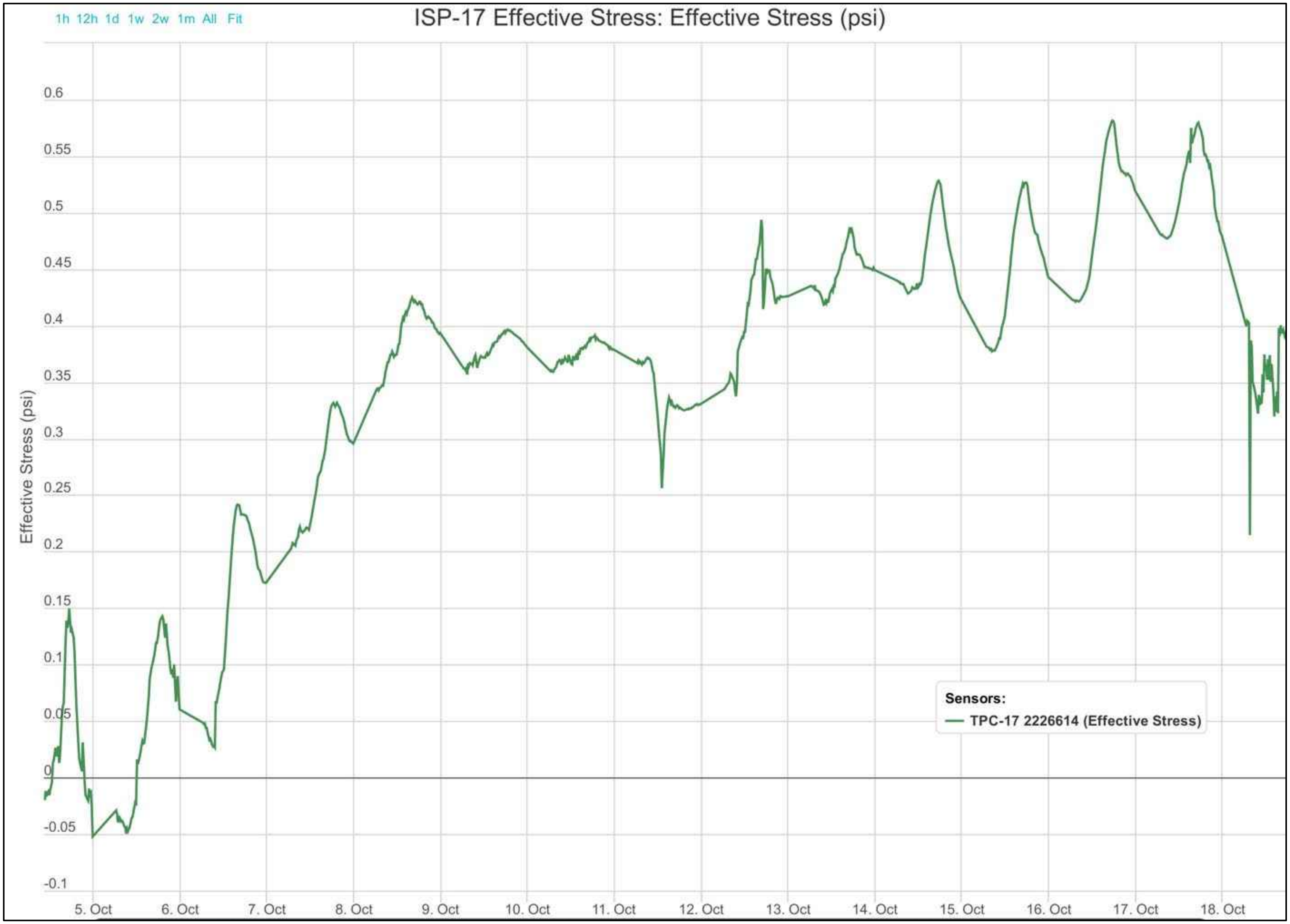


Figure B-18: Increment-1, Effective Stress (y-axis) vs. Time (x-axis)

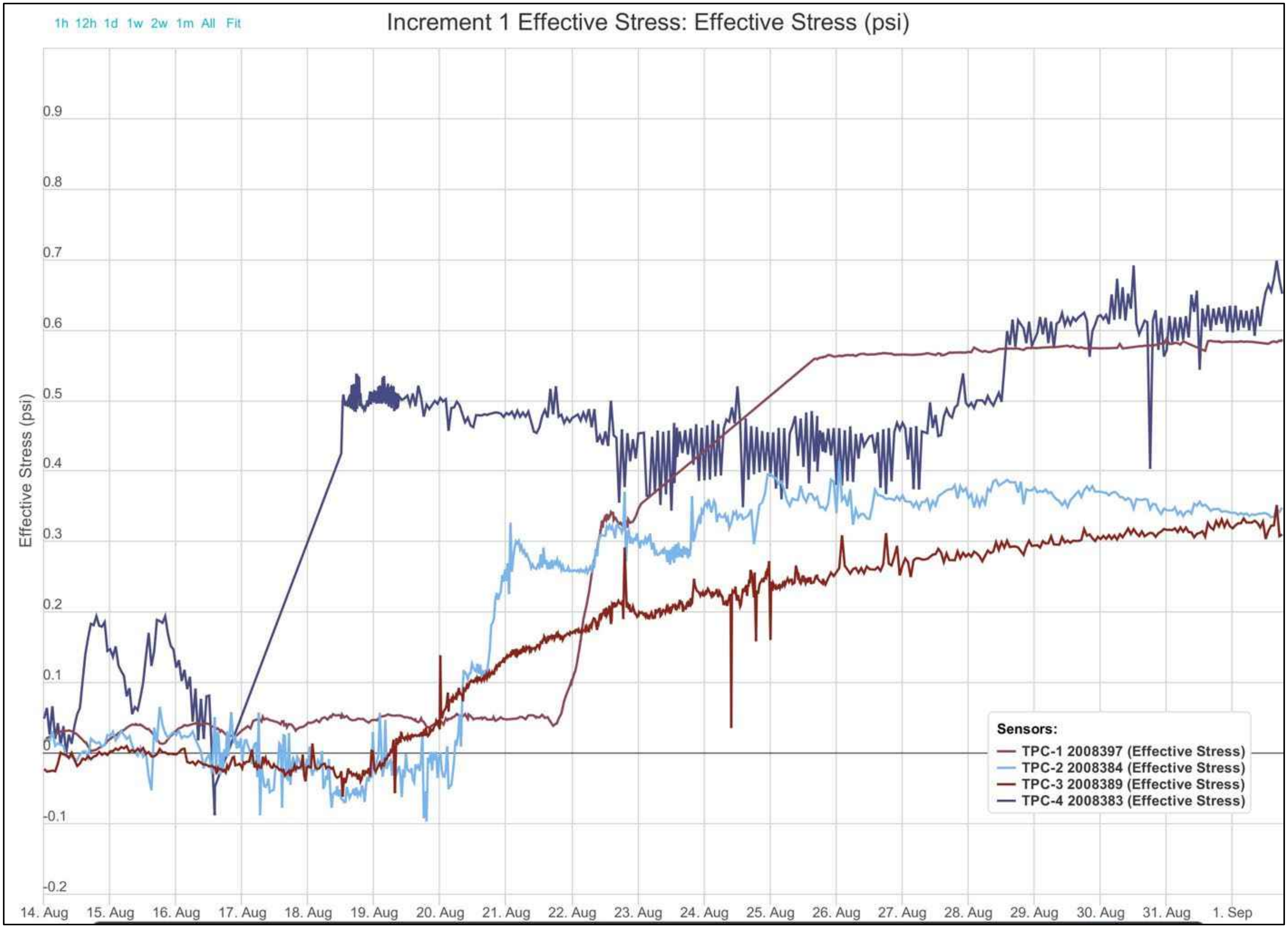


Figure B-19: Increment-2, Effective Stress (y-axis) vs. Time (x-axis)

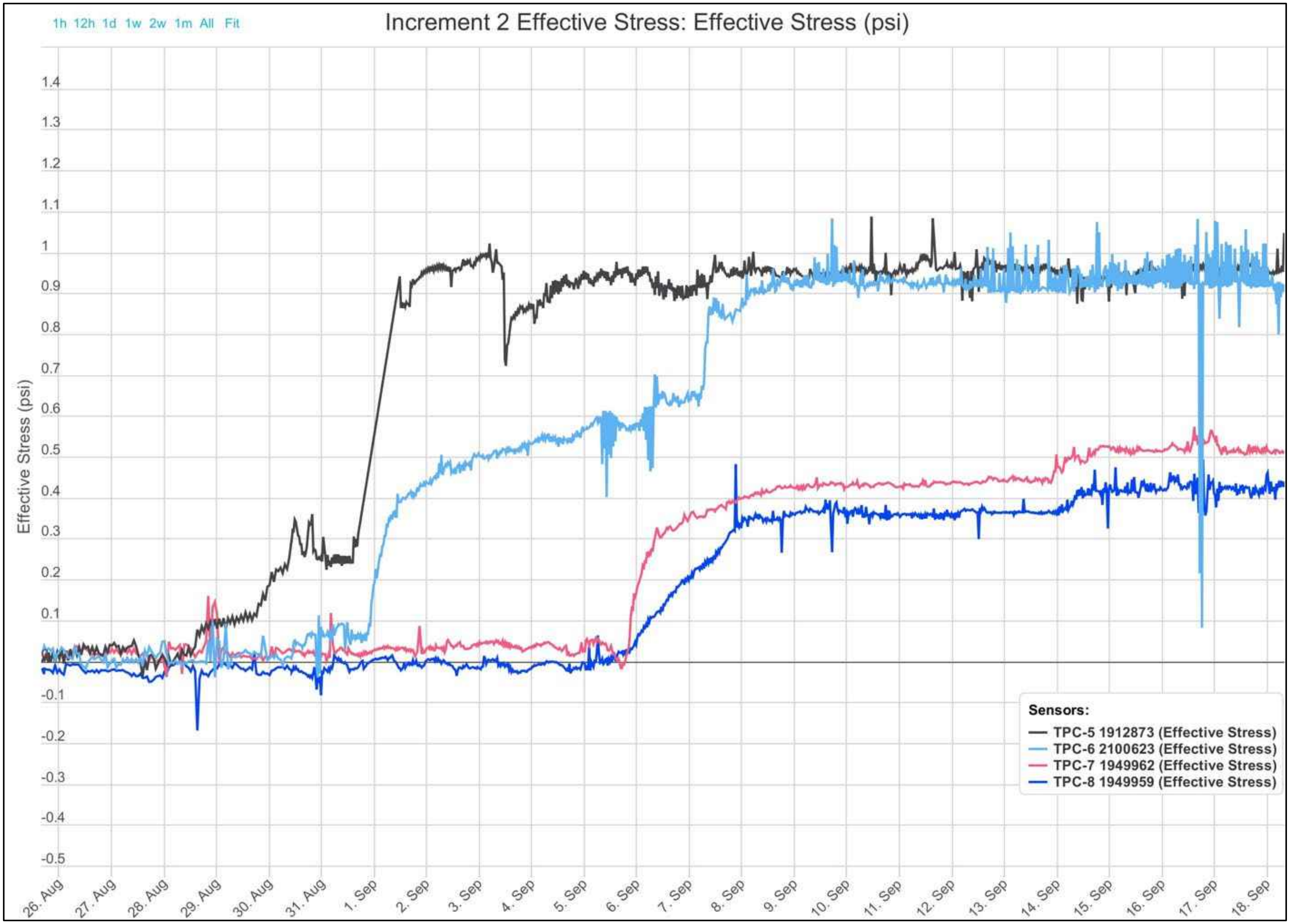


Figure B-20: Increment-3, Effective Stress (y-axis) vs. Time (x-axis)

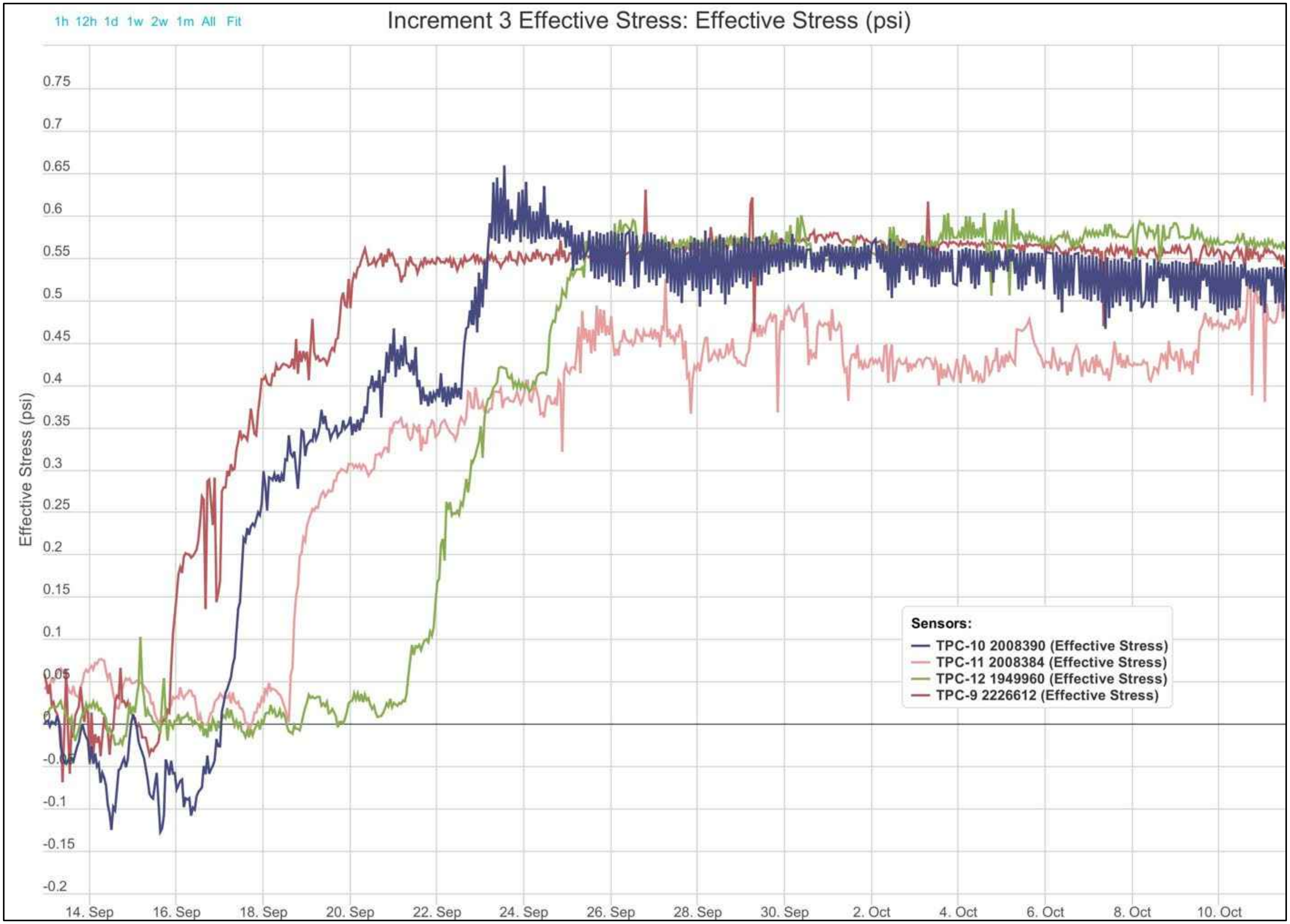
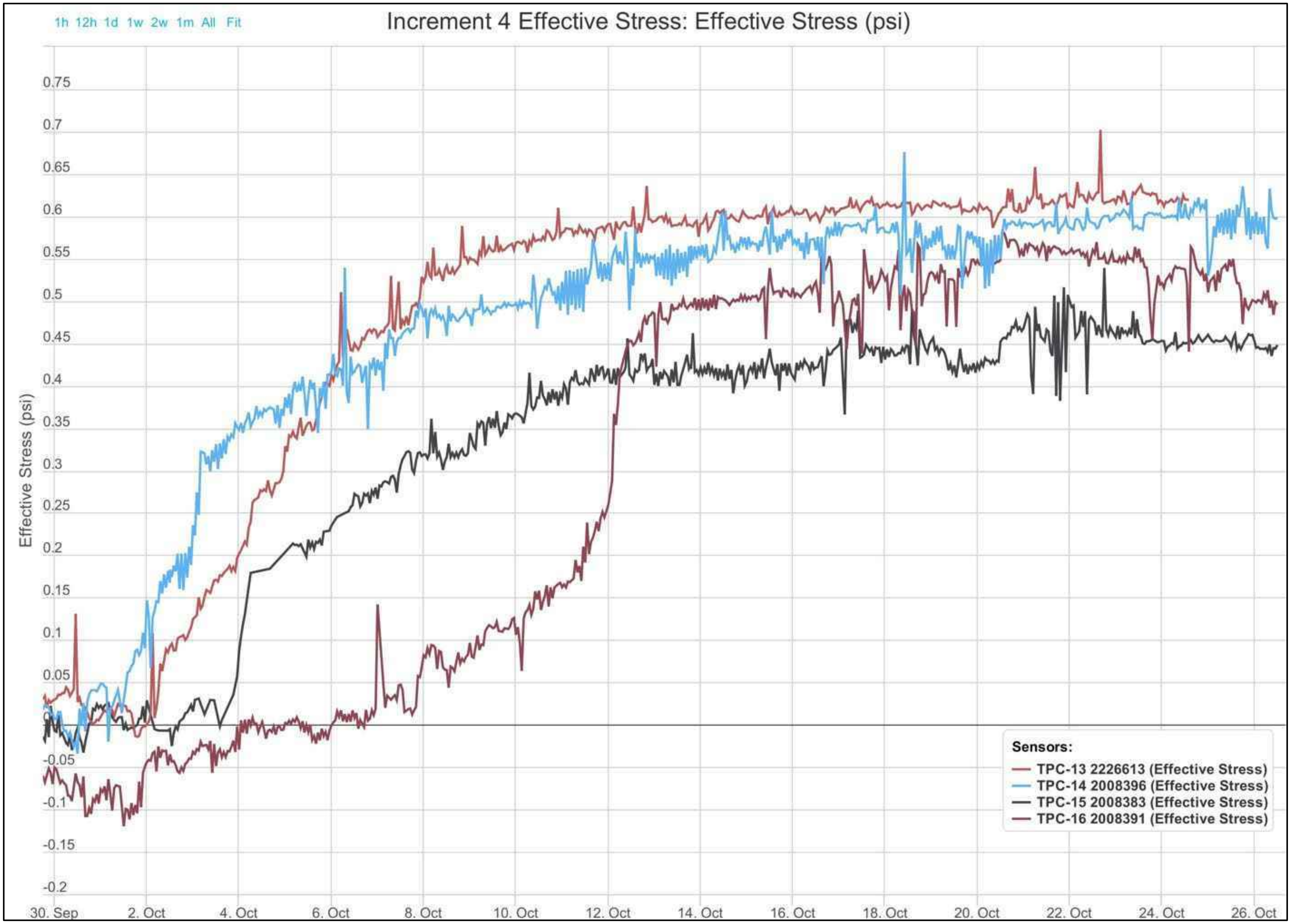


Figure B-21: Increment-4, Effective Stress (y-axis) vs. Time (x-axis)



APPENDIX C

Lab Summary – Fill Area Testing
Laboratory Testing Summary

Summary of Lab Results

CLIENT CPRA
PROJECT NUMBER 19A104
PROJECT NAME Caminada Instrumentation
PROJECT LOCATION Caminada, Louisiana

Soil Boring ID	Depth Interval (ft)	D2488	D2216	D2166/D2850		D4318			D422/D1140 /D6913	D2166/D2850				D4648	D2974	D854	Comments
		Visual Description	Moisture (%)	Unit Weight (PCF)		Atterberg Limits			%<#200 Sieve	Shear Strength (PSF)	Failure Strain (%)	Confining Pressure (PSI)	Failure Type	Mini Vane Shear Strength (PSF)	Organic (%)	Specific Gravity	
				Wet	Dry	LL	PL	PI									
ISP-1	0.0 -	Gray fat clay (CH)	149.6													1.339	
ISP-2	0.0 -	Gray fat clay (CH)	185.1			67	21	46								1.285	
ISP-3	0.0 -	Gray fat clay (CH)	136.1													1.366	
ISP-4	0.0 -	Gray fat clay (CH)	83.4			74	19	55									
ISP-5	0.0 -	Gray fat clay (CH)	90.1														
ISP-6	0.0 -	Gray fat clay (CH)	136.9			62	19	43								1.360	
ISP-7	0.0 -	Gray fat clay (CH)	139.7													1.340	
ISP-8	0.0 -	Gray fat clay (CH)	157.6			58	19	39								1.320	
ISP-9	0.0 -	Gray fat clay (CH)	141.6													1.350	
ISP-10	0.0 -	Gray fat clay (CH)	151.5			54	20	34								1.320	
ISP-11	0.0 -	Gray fat clay (CH)	120.5													1.402	
ISP-12	0.0 -	Gray fat clay (CH)	119.8			54	21	33								1.404	
ISP-13	0.0 -	Gray fat clay (CH)	142.3													1.448	
ISP-14	0.0 -	Gray fat clay (CH)	143.5			57	22	35								1.351	
ISP-15	0.0 -	Gray fat clay (CH)	141.0													1.356	
ISP-16	0.0 -	Gray fat clay (CH)	132.7			59	23	36								1.373	

Disclaimer: The results presented relate only to those samples tested.
Note: ASTM standard identification numbers shown above each test description.

Multiple Shear = MS Vertical Shear = VS Angle Shear = AS
Slickensided = SLS Bulge = B Crumble = C

Tested By: Justin Ator

Checked By: Venu Tammineni, P.E.

ADAPTIVE MANAGEMENT AND ENGINEERING

Summary of Lab Results

CLIENT CPRA
PROJECT NUMBER 19A104
PROJECT NAME Caminada Instrumentation
PROJECT LOCATION Caminada, Louisiana

Soil Boring ID	Depth Interval (ft)	D2488	D2216	D2166/D2850		D4318			D422/D1140 /D6913	D2166/D2850				D4648	D2974	D854	Comments
		Visual Description	Moisture (%)	Unit Weight (PCF)		Atterberg Limits			%<#200 Sieve	Shear Strength (PSF)	Failure Strain (%)	Confining Pressure (PSI)	Failure Type	Mini Vane Shear Strength (PSF)	Organic (%)	Specific Gravity	
				Wet	Dry	LL	PL	PI									
ISP-17	0.0 -	Gray lean clay with sand (CL)	83.1			36	20	16	79.1							1.528	

Disclaimer: The results presented relate only to those samples tested.
Note: ASTM standard identification numbers shown above each test description.

Multiple Shear = MS Vertical Shear = VS Angle Shear = AS
Slickensided = SLS Bulge = B Crumble = C

Tested By: Justin Ator

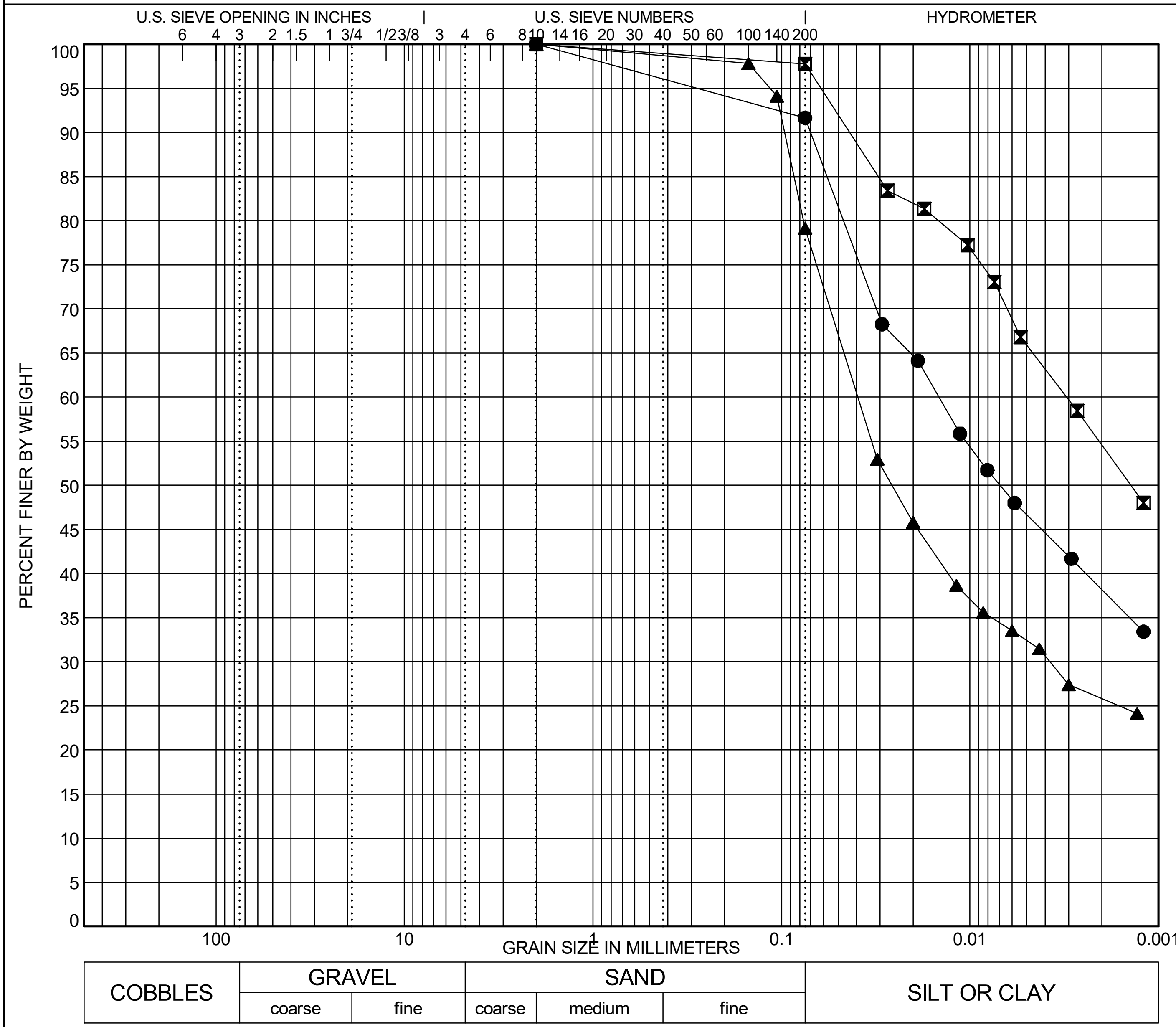
Checked By: Venu Tammineni, P.E.

AASHTO ACCREDITED

GRAIN SIZE DISTRIBUTION

ADAPTIVE
MANAGEMENT AND ENGINEERING

CLIENT CPRA
PROJECT NUMBER 19A104
PROJECT NAME Caminada Instrumentation
PROJECT LOCATION Caminada, Louisiana



	Borehole	Top Depth	Classification	LL	PL	PI	Cc	Cu
●	**ISP4-1**	**0.0**	**Gray fat clay (CH)**	**58**	**23**	**35**		
⊠	**ISP4-2**	**0.0**	**Gray fat clay (CH)**	**78**	**29**	**49**		
▲	**ISP-17**	**0.0**	**Gray lean clay with sand (CL)**	**36**	**20**	**16**		

* There is a possibility these percents contain shells or other material instead of the listed percent.

	Borehole	Top Depth	D100	D50	D30	D10	%Gravel*	%Sand*	%Silt	%Clay
●	**ISP4-1**	**0.0**	**2**	**0.007**			**0.0**	**8.3**	**45.0**	**46.6**
⊠	**ISP4-2**	**0.0**	**2**	**0.001**			**0.0**	**2.2**	**31.9**	**65.9**
▲	**ISP-17**	**0.0**	**2**	**0.026**	**0.004**		**0.0**	**20.9**	**46.7**	**32.4**

APPENDIX D

Caminada Headlands Back Barrier Marsh Creation Project (BA-0171) Geotechnical Investigation and Engineering Services, Task 6- Development of an Instrumented Settlement Plate (ISP) Web- based Data Monitoring Program Memorandum

ECD Priority Section Sampling and Laboratory Testing Memorandum

ECD Priority Section Drive Point Piezometer Locations and Data Summary

Earthen Containment Dike Construction Monitoring at Bayou Moreau Caminada Headland Back Barrier Marsh Creation Project (BA-0171) Memorandum

Memorandum

To: Ms. Renee Bennett, P.M.P.

State of Louisiana
Coastal Protection and Restoration Authority
(Email: renee.s.bennett@la.gov; Tel: 225-342-4592)

STATE OF LOUISIANA
ROBERT J. WERNER
License No. 36633
PROFESSIONAL
ENGINEER
IN
CIVIL ENGINEERING
10/18/19

From: Gregory Mattson II, P.E. | Robert J. Werner, P.E.

Date: October 18, 2019

Subject: Caminada Headlands Back Barrier Marsh Creation Project (BA-0171) Geotechnical Investigation and Engineering Services, Task 6 – Development of an Instrumented Settlement Plate (ISP) Web-based Data Monitoring Program, Lafourche and Jefferson Parishes, Louisiana. S&ME Project No. 148919010.

S&ME, Inc. appreciates the opportunity to provide geotechnical engineering services for the Caminada Headland Back Barrier Marsh Creation Project (BA-0171) in Lafourche and Jefferson Parishes, Louisiana. Our services are being provided pursuant to S&ME's Proposal No. 141900416, authorized by the State of Louisiana - Coastal Protection and Restoration Authority (CPRA) on June 20, 2019 as "Task 6" under the Geotechnical Services for Coastal Protection and Restoration Authority Contract No. 4400012425, dated August 11, 2017.

The purpose of these services is to review previously collected data, predict magnitudes and rates of undrained shear strength gain in the natural ground soils supporting the proposed earthen containment dikes (ECDs) and re-evaluate design ECD crest elevations, and collaborate with CPRA on developing an Instrumented Settlement Plate (ISP) Web-based Data Monitoring Program to be utilized during construction of the BA-0171 project.

The BA-0171 project involves the creation or nourishment of 1,061 acres of back barrier marsh using hydraulically dredged and placed material from a borrow area approximately 1.5 miles offshore in the Gulf of Mexico. The fill areas will be fully confined with ECDs along the west, north, and east sides, and to the south by the previously-constructed Caminada beach and dune projects (BA-45 and BA-143).

This Memorandum report was prepared to summarize results of or analyses performed as "Task 3" of the work order, which encompasses the following activities:

- Collaborate with CPRA to determine the appropriate type of instrumentation needed, estimate costs, and identify locations of ISPs throughout the BA-0171 project site.
- Develop an ISP Instrumentation and Monitoring Plan including: installation methodology, data acquisition rates, data download and upload intervals, data reading thresholds to activate alarms, and a physical sampling schedule to confirm data readings.
- Collaborate with CPRA in developing an ISP Web Based Data Monitoring Program to be utilized during construction for remote monitoring of dredge slurry placement and dewatering.

Background

CPRA encourages the use of geotechnical monitoring instrumentation on coastal marsh creation projects to assist with evaluating the performance of hydraulically placed fill material in marsh creation areas (MCAs). A template for this instrumentation is illustrated in the Marsh Creation Design Guidelines, Version 1.0 (MCDG 1.0). The scope of this task involves evaluating the appropriate instrumentation and developing a web-based data monitoring program to be used during construction.

Traditionally, dredged fill surface elevation has been the benchmark target specified for CPRA marsh creation projects, with target fill elevations established through geotechnical analyses during the project design phase. In particular, classical consolidation analyses are performed to estimate the magnitude of in situ fill area foundation settlement and the large-strain finite difference model Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill (PSDDF) program is used to predict long-term post-construction consolidation and desiccation of the hydraulically-placed fill. Soil parameters used in these models are normally estimated through extensive field sampling and laboratory testing, including settling column and low-stress one-dimensional consolidation tests. Although these testing and analytical methods have often proven useful in characterizing the long-term state of the created marsh in terms of void ratio or density years after construction, CPRA experience suggests that the initial and early post-construction behavior can vary significantly from expectations due to numerous variables, including the contractors' means and methods, dredge discharge rates, and slurry solids content.

Fundamentally, it is generally accepted that fine-grained soils used as borrow materials for marsh creation projects in the Louisiana Gulf Coast tend to exhibit fairly predictable virgin compression behavior such that the vertical effective stress corresponding to the predicted long-term post-construction void ratio can be established using the traditional testing and analytical methods. Accurately estimating the initial conditions during and shortly after filling has proven much more of a challenge. Thus, selecting a target fill elevation needed to achieve the desired long-term outcome has been problematic, particularly when construction conditions deviate from those assumed during the geotechnical design phase. Recognizing that the mass of soil solids in the slurry "column" in the marsh creation area ultimately dictates long-term vertical effective stresses, an alternative approach to specifying targets for marsh creation contracts is being contemplated by CPRA. Based on observed performance of previously constructed projects and results of geotechnical field monitoring using instrumented settlement plates (ISPs), the feasibility of measuring the vertical effective during fill placement stress appears promising. This approach allows dredging contractors to control their means and methods, including slurry density and fill height, while enabling CPRA to control the quantity of solids placed via direct real-time measurement of effective stress. This new approach is expected to improve project performance, while also reducing the overall cost of the project.

The BA-0171 project was selected by CPRA for demonstration of this alternative monitoring and adaptive management approach. Development of the monitoring system plan, along with verification of the ability to reliably measure "target" vertical effective stresses in a subaqueous depositional environment for dredged soil in southern Louisiana were primary objectives of Task 3.

Instrumented Settling Tank (IST)

In order to validate that a target vertical effective stress measurement is achievable using contemporary geotechnical monitoring field instrumentation, S&ME set up a large-scale controlled laboratory experiment. This was achieved by setting up a 4'x3'x3' (LxWxH) instrumented settling tank (IST) and filling it with a homogenized marsh slurry similar to what would be dredged in the field. We obtained instrumentation used in past CPRA projects as well as instrumentation loaned from GEOKON to install in the IST. This instrumentation included a data transmitter (node), a data logger (supervisor), total pressure cell, and multiple vibrating wire piezometers.

In previous projects, CPRA has installed the instrumentation on instrumented settlement plates (ISPs) placed within marsh creation cells. A total pressure cell is mounted to the base of the ISP and a vibrating wire piezometer is placed at the base of a vented and screened PVC pipe encased in sand with both instruments located at approximately the same elevation. For this experiment, we mounted the total pressure cell at the base of the IST to simulate being installed at the base of the ISP. Two different vibrating wire piezometer installation methods were investigated: installation in a sand-packed, vented monitoring well screen and then encased with 1 foot of sand and sealed in with bentonite; and installation directly in the marsh slurry. The two installation methods were chosen to determine which method would provide the most accurate and timely response to the piezometric head of the slurry. Two additional sand-packed vented, monitoring well screens were placed at the corners of the tank to assist with dewatering.

Pictured Above: IST filled with water during instrument calibration

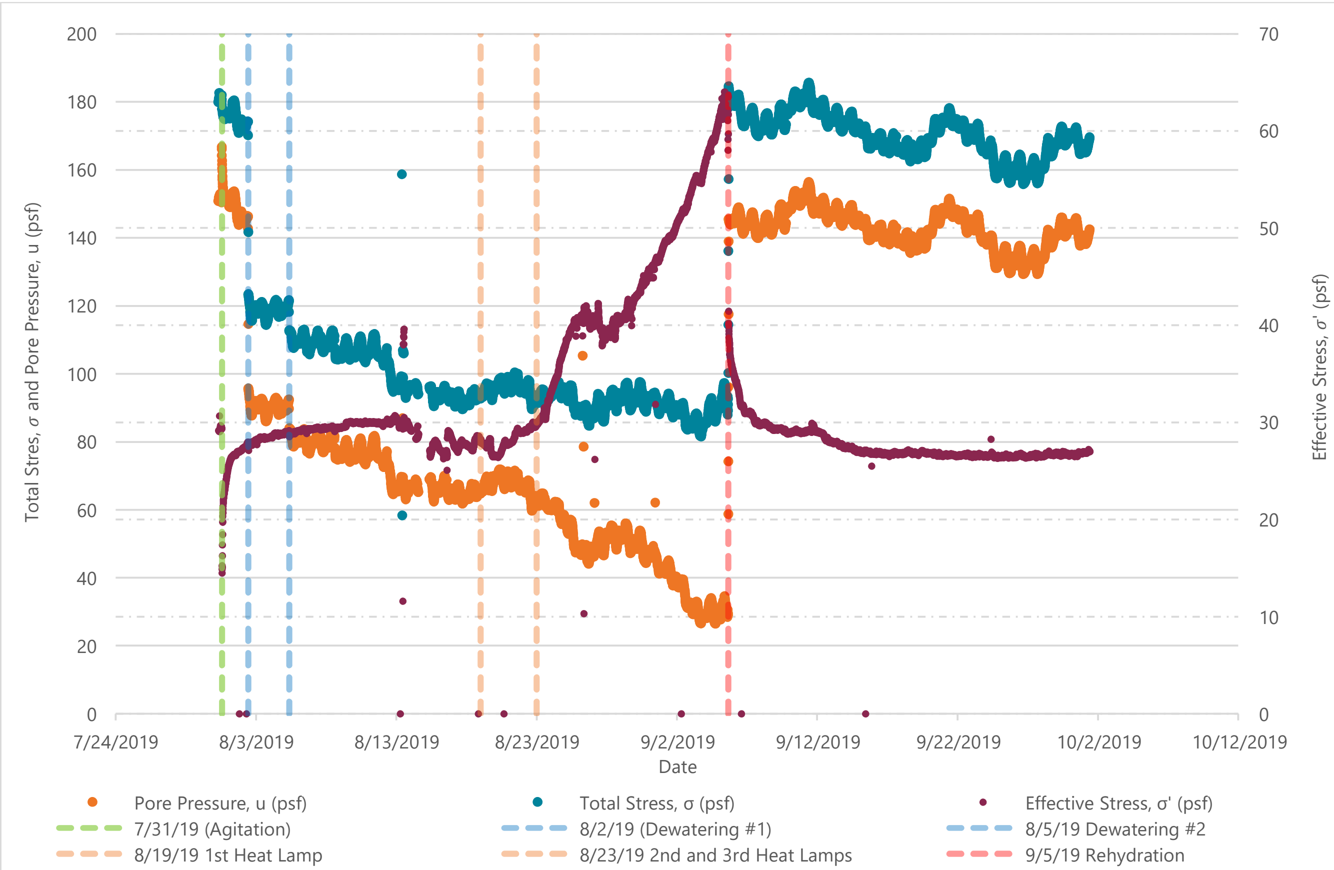
Laboratory Testing

Prior to the commencement of testing, all instrumentation was calibrated and the GEOKON data logger was set to obtain data readings every 10 minutes. Initial readings measuring various depths of water in the IST were recorded to verify accuracy. To simulate the placement of dredged marsh fill, samples from a previous project were homogenized and mixed with water to a concentration of approximately 348 g/l or a specific gravity of 1.22 and pumped into the IST to a depth of 30 inches. The slurry was continuously agitated to maintain suspension of the coarser particles prior to commencement of the test.

As the slurry began to settle and the water interface began to form, the free water was slowly decanted until the slurry no longer settled. At this point, water was extracted from the well screens and heat lamps were installed above the tank to simulate and expedite evaporation and desiccation. Monitoring continued until the crust was fully desiccated and water levels beneath the desiccated crust stabilized. The slurry was then rehydrated by pumping water to the original 30-inch height.

Results and Analyses

Data was downloaded daily and plotted in both the GEOKON software and Excel. The Excel plot is show below and a full-scale plot is included in Attachment A.



To summarize here are the major milestones of the experiment:

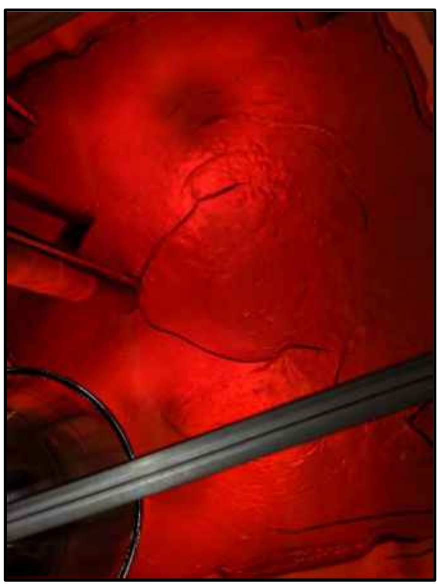
- 7/31/19 – Agitation – Tank pumped to 30 inches and agitated
- 8/02/19 – Dewatering #1 – Water pumped off the surface
- 8/05/19 – Dewatering #2 – Additional water pumped off the surface
- 8/19/19 – 1st Heat Lamp – One heat lamp was installed to increase evaporation
- 8/23/19 – 2nd and 3rd Heat Lamps – Two additional heat lamps were installed
- 9/05/19 – Rehydration – Water was filled back to the original 30-inch level

The milestone sequencing was chosen to simulate the life-cycle of a marsh creation project. The dewatering simulates the opening of the weirs, thereby lowering water levels, the heat lamps simulate the evaporation induced by the sun and wind, and the rehydration represents the marsh slowly becoming re-saturated as the slurry and foundation soils consolidate and sea levels continue to rise. These milestone events exhibited very distinct trends in the monitoring data. To assist with the discussion, below is an equation and terms:

$$\sigma' = \sigma - \mathrm{u} = TPC - PZ$$

Where: σ is total stress, σ' effective stress, u is pore pressure, TPC is the total pressure cell reading, and PZ is the vibrating wire piezometer reading.

When the slurry in the IST is initially agitated, there is very little (nearly zero) effective stress as there is limited particle-to-particle contact. This changes quickly as energy dissipates, particle-to-particle contact is established, and the slurry begins to settle. This can be seen in the steep increase in the effective stress curves at or near the beginning of the test. The effective stress then stabilized at approximately 27-30 pounds per square foot (psf). The next milestones are the dewatering events. The total pressure cell and vibrating wire piezometer readings both show a decrease by the amount of water that is removed, meaning the effective stress is still the same (27-30 psf). This trend remains true through the next milestone where the first heat lamp was added. At this point the slurry was still saturated, so the total pressure and vibrating wire piezometer readings continue to decrease, but the difference in the readings, effective stress, remains roughly constant. The next milestone is when the second and third heat lamps are added. At this point the slurry begins to desiccate. The water level continues to drop but the amount of soil remains constant. However, since soil has a higher unit weight than water, the effective stress increases. This increase continues and briefly stabilizes before the desiccated crust forms and then continues to increase again. This increase continues throughout this phase of the test, with the effective stress measuring as high as 64 psf before beginning to stabilize. The next step (and final milestone) was to rehydrate the material, thereby re-saturating the material, to test if the effective stress would return to the level it was pre-desiccation. The data shows a steep increase in the total pressure cell and vibrating wire piezometer readings, however the effective stress readings immediately drop from around 64 to 40 psf. From this point the effective stress slowly decreases to around 27-28 psf, approximately the same readings recorded prior to the drying and desiccation phase.




Pictured Left; Right: Slurry surface after first heat lamp added; Slurry surface prior to rehydration

Pictured Above: Instrumentation panel on back of IST

Target Metric

Based upon the IST data above, analysis of previous ISP data, and discussion with CPRA, we believe that the use of measured effective stress as the target metric for marsh creation control is appropriate and achievable. As shown by the IST results, effective stress can be calculated by subtracting the pore water pressure readings recorded by the vibrating wire piezometer (PZ) from the total stress recorded by the total pressure cell (TPC). When in a saturated state the effective stress reading remains constant despite the water level in the marsh creation cell fluctuating. It is also reasonable to assume that the created marsh platform will become re-saturated towards the end of its 20-year project life as the material consolidates, and sea levels rise. Assuming zero losses, effective stress at the beginning of the project should equal effective stress at the end of the project.

Web-based Data Platform

As part of this task, we coordinated with GEOKON and sensemetrics, INC (sensemetrics), a sensor data management company, to discuss a web-based data monitoring program that would allow data to be transmitted wirelessly through cellular network and monitored real-time from any location. GEOKON is primarily an instrumentation manufacturer and has limited software capabilities. However, they have partnered with sensemetrics to provide seamless integration of the data output from their instrumentation with sensemetrics' software platform. This is done by swapping the GEOKON data logger with a sensemetrics THREAD, a data logger with an integrated 4G/LTE cellular modem and battery pack in a weather resistant enclosure. Due to the power required to transmit data via the 4G/LTE cellular mode, the thread also comes equipped with a solar panel to keep the battery pack charged.

The sensemetrics' platform provides numerous options to generate graphs, export data to Excel, set alarms, generate reports, set viewing and editing permissions, and edit calibration factors, all from a desktop or remote laptop computer. Alarms can be configured such that as an instrumentation reading approaches a set value an alarm is triggered. Up to four alarms can be set: yellow, orange, red, and purple, with colors corresponding to different intensities. The ability to have varying viewing and editing permissions allows for only certain members of the Project team to have access to only what is deemed necessary by the Project Engineer.

Sensemetrics traveled to S&ME's office and provided S&ME and CPRA with a demonstration of the software. They were able to connect the THREAD to the instruments in the Instrumented Settling Tank and display live data. Both GEOKON and sensemetrics provide on-site troubleshooting if required.

Monitoring Plan

Marsh Creation Areas

CPRA determined that sixteen (16) ISPs would be specified in the contract. Each ISP should include a GEOKON node with antenna and lightning protection, a total pressure cell mounted at the base, and a vibrating wire piezometer located at the same elevation as the total pressure cell. Three THREAD data loggers should be placed throughout the MCA to allow for adequate data communication coverage and provide a degree of redundancy. The ISPs should be placed at locations which will accurately measure the material being placed, i.e. open water areas. Areas surrounded by existing marsh should be avoided since there may be a greater tendency for segregation of coarser and finer fill materials. The primary objective in ISP site locations is to promote collection of data most representative of the dredge slurry properties within MCA increment.

Data outputs should include total stresses from the total pressure cells and pore water pressures from the vibrating wire piezometers plotted versus time. A third graph should be generated that displays the target metric, vertical effective stress, being equal to the difference between the total pressure cell and corresponding vibrating wire piezometer readings. Data acquisition intervals can be as rapid as every 10 minutes; however, this may only be necessary when an increment is active. With the ability to set multiple alarms as outlined above, it is possible that an alarm could trigger changing the acquisition interval. For example, when the effective stress reading measures 30 psf the acquisition interval could be changed from 4 hours to 1 hour and when the reading measures 40 psf the acquisition interval could be changed from 1 hour to 10 minutes.

Earthen Containment Dike

A detailed analysis of staged earthen containment dike (ECD) construction was provided in the Task 2 memorandum. It was highly recommended that those analyses be verified during construction using instrumentation to verify that target degrees of consolidation, and hence anticipated undrained shear strength gains in the ECD foundation soils are achieved prior to raising the dike to its final design crest elevation.

After discussion with CPRA, it was recommended that four vibrating wire piezometers be installed at varying depths in the foundation soils to measure pore water pressures as the fill is placed and as consolidation progresses during the idle period between ECD staged construction lifts.

Data outputs should include pore water pressure from the vibrating wire piezometers. Data acquisition intervals can be as rapid as every 10 minutes; however, for this application an acquisition rate of once an hour should suffice. Based upon the pre-construction surveys and baseline readings, alarms could be configured such that target pressures could trigger the ability to place additional lifts.

Monitoring Reports

Typical CPRA construction contracts include daily monitoring reports. These can be generated by the software and automatically sent directly to the appropriate Project team members. A more detailed weekly or bi-weekly report can be prepared if necessary.

Instrumentation Cost Estimate

After discussion with CPRA, GEOKON, and sensemetrics, and considering results of the laboratory testing program described above, cost estimates for instrumentation and supplies needed are summarized below. A full breakdown of instrumentation costs can be found in Attachment B.

Table 1: Instrumentation Cost Estimate

Type	Cost
sensemetrics	$42,125[(1)]
GEOKON	$73,481[(1)]
Miscellaneous	$13,680
TOTAL	**$129,286**

(1) Quotes valid for 90 days

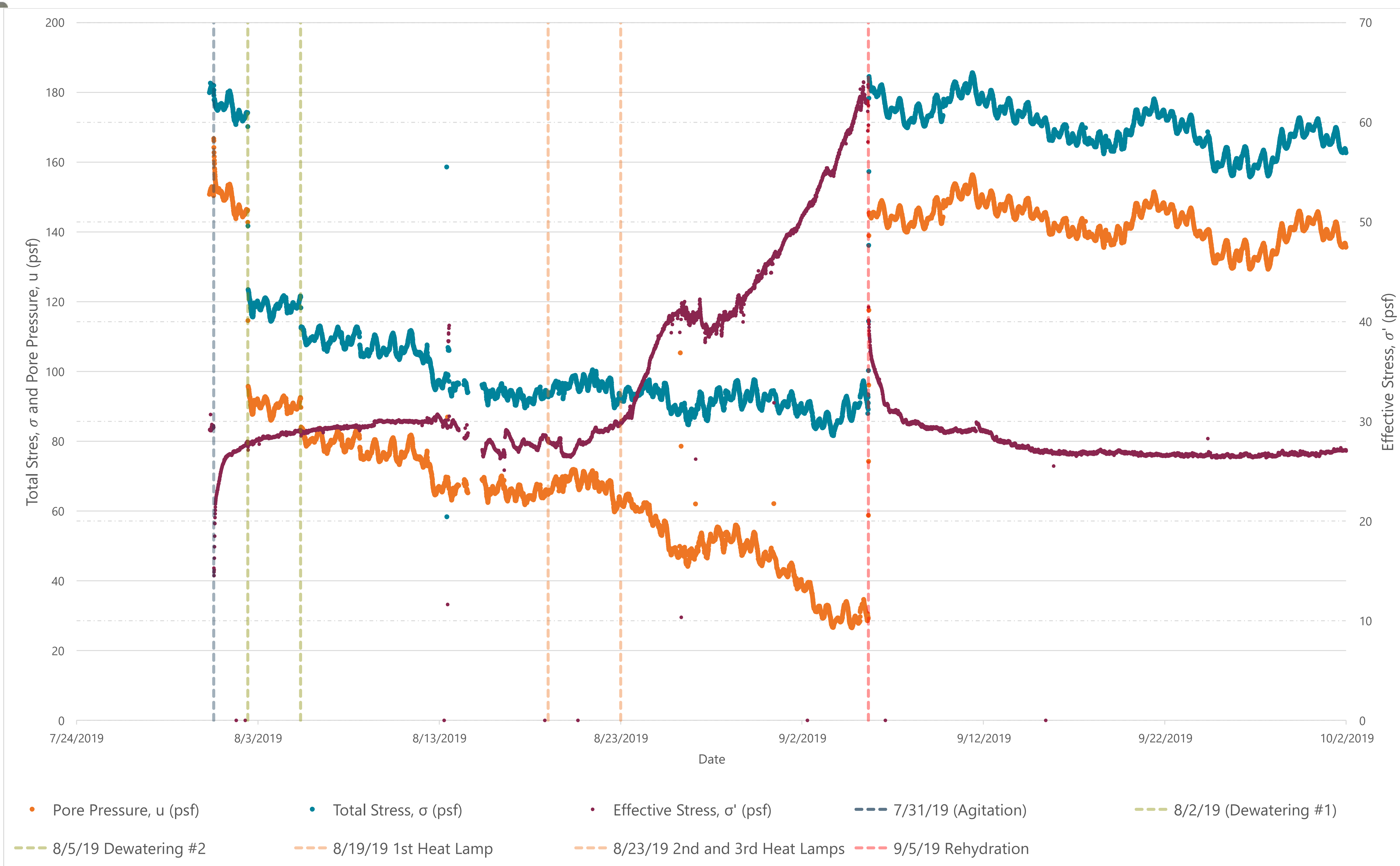
Conclusions and Recommendations

Based upon the results of the IST, a demonstration data provided by sensemetrics, ISP data obtained from previous projects, and discussions with CPRA, the outlined Instrumented Settlement Plate (ISP) Web-based Data Monitoring Program should allow CPRA to use ISPs as construction control. Sixteen ISPs using the sensemetrics data acquisition platform to monitor effective stress in each increment should allow for the construction of a stable marsh platform. Additionally, the installation of drive point vibrating wire piezometers in the weaker sections of the ECD should provide the Project Engineer and Contractor with confidence in constructing subsequent lifts.

Attachments

A – Instrumented Settling Tank Graphical Results

B – BA-0171 Instrumentation Cost Estimate



200
180
160
140
120
100
80
60
40
20
0
70
60
50
40
30
20
10
0
Total Stres, σ and Pore Pressure, u (psf)
Effective Stress, σ' (psf)
7/24/2019
8/3/2019
8/13/2019
8/23/2019
9/2/2019
9/12/2019
9/22/2019
10/2/2019
Date
Pore Pressure, u (psf)
Total Stress, σ (psf)
Effective Stress, σ' (psf)
7/31/19 (Agitation)
8/2/19 (Dewatering #1)
8/5/19 Dewatering #2
8/19/19 1st Heat Lamp
8/23/19 2nd and 3rd Heat Lamps
9/5/19 Rehydration

S&ME COST ESTIMATE

GEOTECHNICAL CONSTRUCTION MONITORING

BA-0171 INSTRUMENTATION COST ESTIMATE

I. UNIT RATE SERVICES	*QTY.*	*RATE*	*COST*
A. Sensemetrics			
Sensemetrics 1-year Subscription	1	$16,125.00	$16,125
Sensemetrics Field Tech	2	$5,000.00	$10,000
Thread	4	$4,000.00	$16,000
		Subtotal	**$42,125**
B. Geokon			
Single-Channel Node (for Drive Point PZ)	4	$738.00	$2,952
Single-Channel Node w/10-Pin	16	$810.00	$12,960
8-CH Multiplexer	16	$882.00	$14,112
Multiplexer Cable	16	$162.00	$2,592
Lithium Batteries	80	$40.50	$3,240
Antenna Tip	19	$117.00	$2,223
Antenna Patchcord (Node to High Gain)	19	$33.00	$627
Antenna High Gain	19	$38.00	$722
Antenna Lightning Protector	19	$30.00	$570
Antenna Mount	19	$30.00	$570
Total Pressure Cell	16	$693.00	$11,088
VW Piezometer	32	$477.00	$15,264
Drive Point Piezometer for Containment Dike	4	$531.00	$2,124
5' Drive Point Rod	25	$157.50	$3,938
Insrumentation Wiring	704	$0.71	$500
		Subtotal	**$73,481**
B. Miscellaneous			
Prototype Settlement Plate	1	$1,000.00	$1,000
5' Sand Packed Well	32	$150.00	$4,800
Camera + Cell Service	16	$350.00	$5,600
Solar Panel (for cameras)	16	$80.00	$1,280
Miscellaneous Supplies	1	$1,000.00	$1,000
		Subtotal	**$13,680**
		SUBTOTAL =	**$129,286**

Memorandum

To: Shannon Haynes, P.E., CPRA

From: Gregory A. Mattson, II, P.E. | Ryan Williamson, E.I.

Date: July 8, 2020

Subject: Caminada Headland Back Barrier Marsh Creation Project (BA-171)

S&ME has completed soil sampling and laboratory testing for the proposed priority earthen containment dike section of the Caminada Headland Back Barrier Marsh Creation Project in Lafourshe and Jefferson Parishes, Louisiana. Our services were provided pursuant to S&ME's Proposal No. 141900797, authorized by the State of Louisiana - Coastal Protection and Restoration Authority (CPRA) on December 2, 2019 as "Task 2" under Sigma Consulting Group's (SCG) "General Engineering Services for CPRA" Contract No. 4400015376, dated August 31, 2018.

Field Sampling

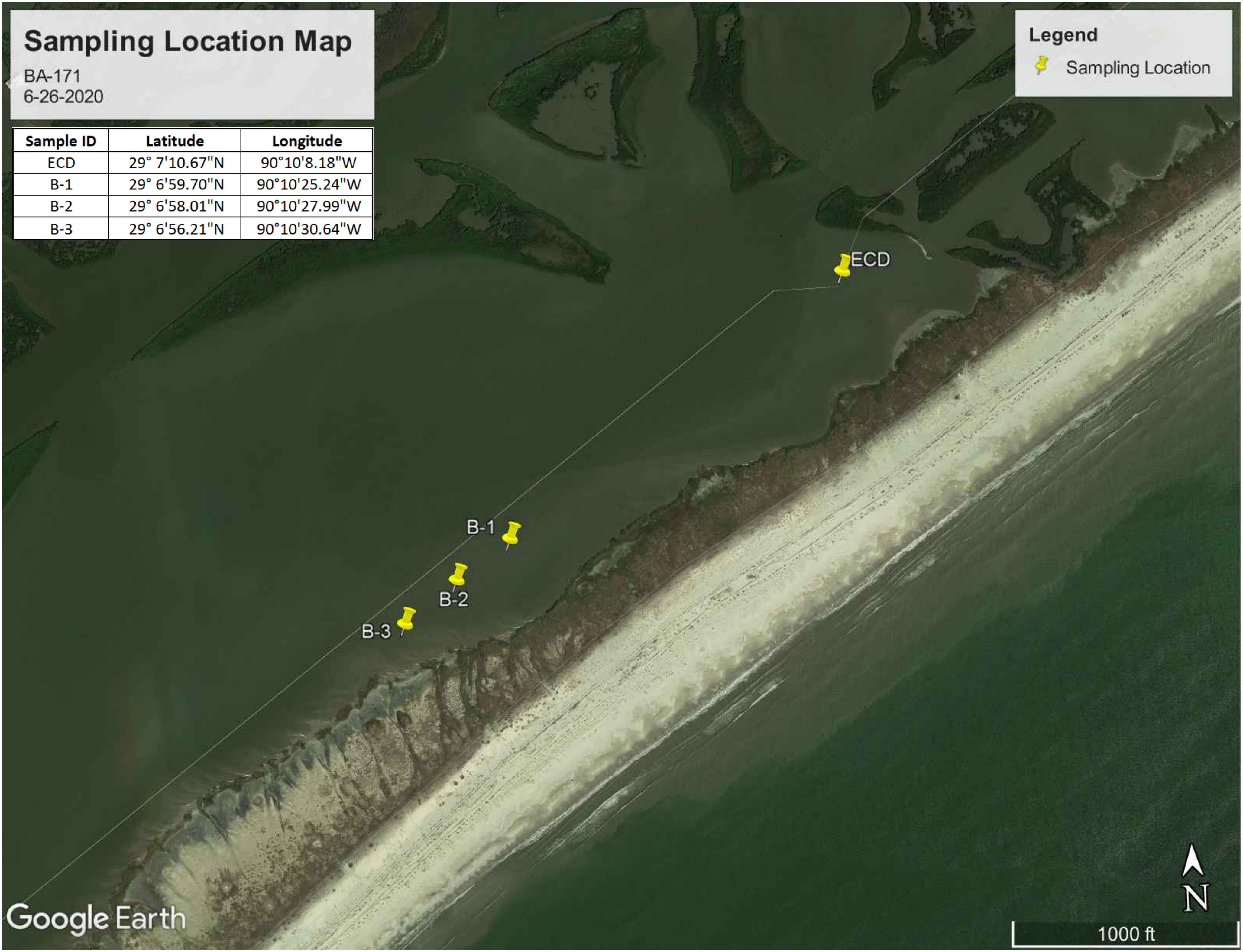
A site visit was conducted on June 6, 2020 to obtain soil samples from four locations, denotated as ECD, B-1, B-2, and B-3 on the attached Sampling Location Map. The ECD sample was obtained from the footprint of the earthen containment dike at the priority section and the three other samples were obtained from a potential sand borrow source for the priority section. Sampling was completed by using a handheld Vibracore to push 5-foot long, 3-inch diameter, aluminum, thin-walled tubes. Water depth and coordinates were obtained at each sampling location. Samples were sealed, labeled, and prepared for transportation to S&ME's geotechnical laboratory in Baton Rouge.

Laboratory Testing

Upon arrival at S&ME's geotechnical laboratory, the samples were extruded and classified visually in general accordance with the Unified Soil Classification System (ASTM D2488). Laboratory testing assignments included moisture content determination (ASTM D2216), wet/dry unit weight determination (ASTM D2166/D2850), and washover #200 tests (ASTM D1140). A laboratory test summary is attached.

Attachments

Soil Sampling Locations
Laboratory Test Summary Sheets



Sampling Location Map
BA-171
6-26-2020

Sample ID	Latitude	Longitude
ECD	29° 7'10.67"N	90°10'8.18"W
B-1	29° 6'59.70"N	90°10'25.24"W
B-2	29° 6'58.01"N	90°10'27.99"W
B-3	29° 6'56.21"N	90°10'30.64"W

Legend
Sampling Location
ECD
B-1
B-2
B-3
Google Earth
N
1000 ft

Summary of Lab Results

CLIENT CPRA
PROJECT NUMBER 1489-20-002
PROJECT NAME Caminada Headland Back Barrier
PROJECT LOCATION Port Fourchon, Louisiana

Soil Boring ID	Depth Interval (ft)	D2488 Visual Description	D2216 Moisture (%)	D2166/D2850 Unit Weight (PCF) Wet	Dry	D4318 Atterberg Limits LL	PL	PI	D422/D1140/D6913 %<#200 Sieve	D2166/D2850 Shear Strength (KSF)	Remolded Strength (KSF)	Failure Strain (%)	Confining Pressure (PSI)	Failure Type	D4648 Mini Vane Shear Strength (KSF)	D2974 Organic (%)	D854 Specific Gravity	Comments
ECD	0.0 - 1.0	Gray sandy clay ()	62.4	122.2	75.2				65.8									
ECD	1.0 - 2.0	soft Gray organic clay, with sand ()	76.3	90.2	51.2													
ECD	2.0 - 3.0	Gray organic clay, with a 4 inch peat layer ()	249.8	80.4	23.0													
ECD	3.0 - 4.0	Gray clay, with a 3.5 inch peat layer ()	232.2	89.9	27.1													
ECD	4.0 - 5.0	Gray clay, with trace root ()	83.4	91.6	49.9													

Disclaimer: The results presented relate only to those samples tested.
Note: ASTM standard identification numbers shown above each test description.

Multiple Shear = MS Vertical Shear = VS Angle Shear = AS
Slickensided = SLS Bulge = B Crumble = C

Value next to failure type is angle which the sample failed if measured.
Organics: refers to a organic component of soil consisting of plant residues, decomposing or stable organic matter (humus).

Prepared By: ____________________ Reviewed By: ____________________

Date: 7/1/2020 Date: 7/1/2020

Summary of Lab Results

CLIENT CPRA
PROJECT NUMBER 1489-20-002
PROJECT NAME Caminada Headland Back Barrier
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B-1	0.0 - 1.0	Gray soft, sandy clay ()	47.9	92.4	62.5				66.0									
B-1	1.0 - 2.0	Gray sandy clay, with shell fragments ()	49.0	99.3	66.6				67.9									
B-1	2.0 - 3.0	Gray clay with trace sand ()	70.2	97.3	57.2				91.5									
B-1	3.0 - 4.0	Gray clay ()	74.6	96.0	55.0													
B-1	4.0 - 5.0	Gray clay ()	80.6	98.0	54.2													

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Prepared By: ______________________ Reviewed By: ______________________

Date: 7/1/2020 Date: 7/1/2020

Summary of Lab Results

CLIENT CPRA
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B-2	0.0 - 1.0	Gray sand with clay and trace roots ()	26.9	120.6	95.0				5.2									
B-2	1.0 - 2.0	Gray sand with shell fragments ()	23.4	132.8	107.6													
B-2	2.0 - 3.0	Gray sand with shell fragments ()	25.2	128.6	102.8				2.1									
B-2	3.0 - 4.0	Gray clayey sand with shell fragments ()	25.7	108.8	86.6													
B-2	4.0 - 5.0	Gray clay with sand and trace shell fragments ()	53.6	102.2	66.5				74.7									

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Slickensided = SLS Bulge = B Crumble = C

Value next to failure type is angle which the sample failed if measured.
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Prepared By: ______________________ Reviewed By: ______________________

Date: 7/1/2020 Date: 7/1/2020

LAB SUMMARY LANDSCAPE WITH CLASS 1489-20-002_CPRA CAMINADA HEADLAND BACK MARRIER MC_PORT FOURCHON.GPJ BTR TMPL.GDT 7/1/20

Summary of Lab Results

CLIENT CPRA
PROJECT NUMBER 1489-20-002
PROJECT NAME Caminada Headland Back Barrier
PROJECT LOCATION Port Fourchon, Louisiana

Soil Boring ID	Depth Interval (ft)	D2488 Visual Description	D2216 Moisture (%)	D2166/D2850 Unit Weight (PCF) Wet	Dry	D4318 Atterberg Limits LL	PL	PI	D422/D1140 /D6913 %<#200 Sieve	D2166/D2850 Shear Strength (KSF)	Remolded Strength (KSF)	Failure Strain (%)	Confining Pressure (PSI)	Failure Type	D4648 Mini Vane Shear Strength (KSF)	D2974 Organic (%)	D854 Specific Gravity	Comments
B-3	0.0 - 1.0	Gray and dark gray sand with shell fragments ()	25.4	121.6	97.0				4.3									
B-3	1.0 - 2.0	Gray and dark gray sand with shell fragments ()	23.9	126.1	101.7													2 cracks
B-3	2.0 - 3.0	Gray sand, with shell fragments and a 2 inch sandy clay layer ()	24.1	125.0	100.8				2.8									
B-3	3.0 - 4.0	Gray sand, withshell fragments ()	34.9	120.2	89.1													
B-3	4.0 - 5.0	Gray sand with a 2 inch clay layer ()	26.3	119.8	94.8				7.0									
B-3	5.0 - 6.0	Gray clay ()	56.9	109.5	69.8													

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Organics: refers to a organic component of soil consisting of plant residues, decomposing or stable organic matter (humus).

Prepared By: ______________________

Date: 7/1/2020

Reviewed By: ______________________

Date: 7/1/2020

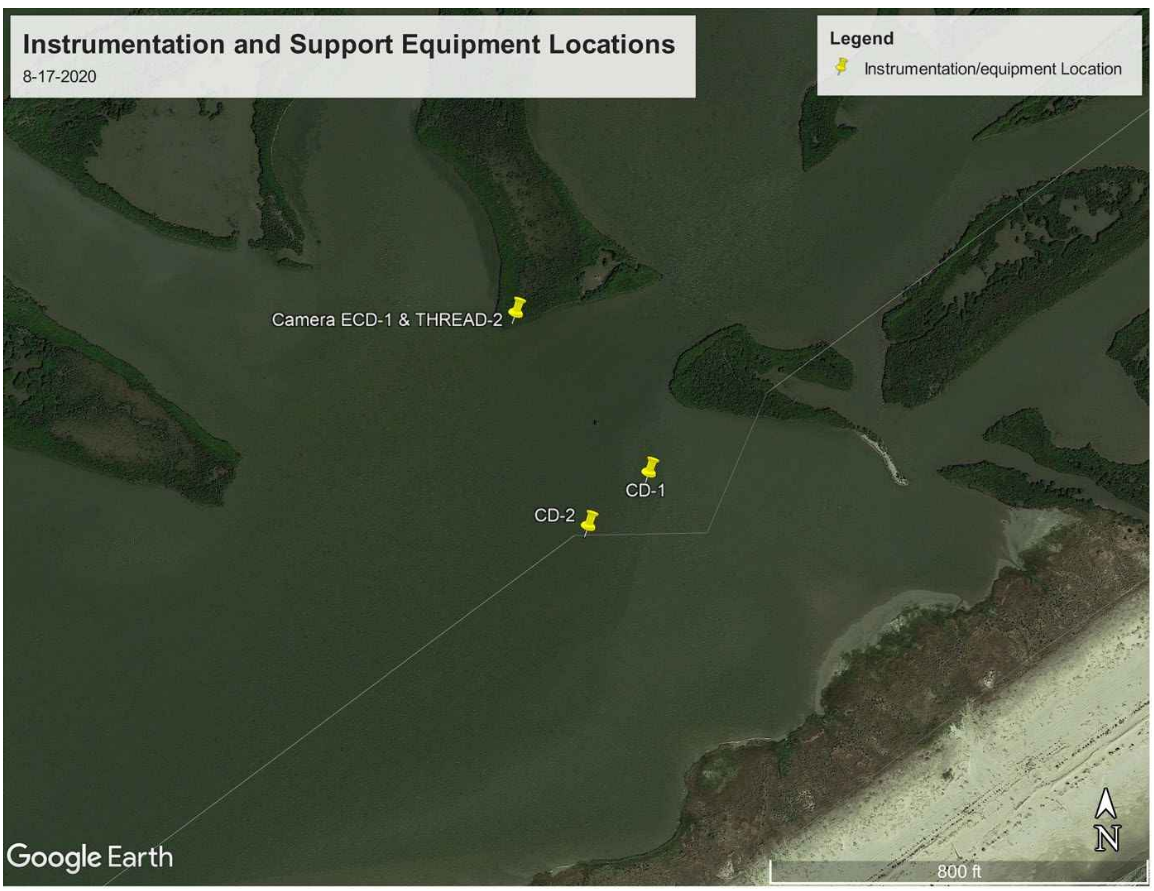
ECD PRIORITY SECTION DRIVE POINT PIEZOMETER LOCATIONS AND DATA SUMMARY

S&ME completed the installation of ECD monitoring instrumentation for the Caminada Headland Back Barrier Marsh Creation Project in Lafourche and Jefferson Parishes, Louisiana. Previously, S&ME completed soil sampling and laboratory testing for the proposed priority earthen containment dike section as outlined in a Memorandum dated July 8, 2020.

MONITORING INSTRUMENTATION

The following geotechnical instrumentation and supporting equipment have been installed at the project site to monitor the construction of the ECD:

- Three Drive Point Piezometers
- Three Single-Channel GeoNet Nodes (Data loggers)
- Two Sensemetrics Threads
- Two 4G LTE Monitoring Cameras



INSTALLATION

Site Visit 6-26-20

During S&ME's site visit on June 26, 2020, the subgrade under the proposed priority section footprint of the ECD was probed for stiffness/material type, water depths were measured, and a vibracore sample was obtained. This information was used to determine the feasibility and placement of the Drive Point Piezometers. See S&ME's Memorandum dated July 8, 2020 for more information on soil sampling and subsequent laboratory testing completed during this site visit.

Site Visit 7-10-20

On the July 10, 2020 site visit, S&ME installed two Drive Point Piezometers in the proposed priority section footprint of the ECD in increment 1 of the project. Both Piezometers were fixed to the bottom of 15 feet of steel rod, pushed into the subgrade by hand, and wired to a GeoNet Node for data storage and transmission. A photo of the Drive Point apparatus post-installation in available in Figure 1. The Drive Point Piezometers, denoted as 'CD-1' and 'CD-2', were installed to collect pore water pressure data in the subgrade soils during construction of the ECD. The pore water pressure dissipation can then be monitored to determine the strength gain in the subgrade, and therefore determine the timing of second lift construction.

Figure 1: Typical Drive Point Piezometer post-installation

To support the Drive Point Piezometer installation, a Sensemetrics Thread, 'Thread-3', was installed nearby to receive data from the GeoNet Node and send it to the Sensemetrics cloud.

Additionally, a 4G LTE camera was installed next to the Thread to monitor activity around the Drive Point Piezometers. Both the Thread and the camera were fixed to a 4-inch by 4-inch, 8-foot long piece of lumber driven into the subgrade. Two solar panels were also fixed to the lumber to support the Thread and the camera. See Figure 2 for a visual of the supporting apparatus. A map of installation locations is available in the Attachments.

Figure 2: Typical Thread and camera post-installation

Site Visit 7-13-20

During a site visit on July 13, 2020, Thread-3 was replaced by Thread-2 because Thread-3 was failing to transmit data to the cloud. Thread-1 was confirmed to be transmitting before S&ME departed the site. Additionally during this site visit, the first lift of ECD construction was observed around the location of CD-1 and CD-2 as shown in Figure 3 below.

Figure 3: Typical Thread and camera post-installation

Site Visit 7-29-20

On the July 29, 2020 site visit, S&ME installed an additional Drive Point Piezometer, 'CD-3' within the ECD footprint of increment 2 of the project. Installation was performed similar to that of CD-1 and CD-2. An extended antenna was installed on all of the Drive Point Piezometers and on Thread-1 to improve the quality of data transmission. See Figure 4 for a visual of CD-3 with the antenna extension installed.

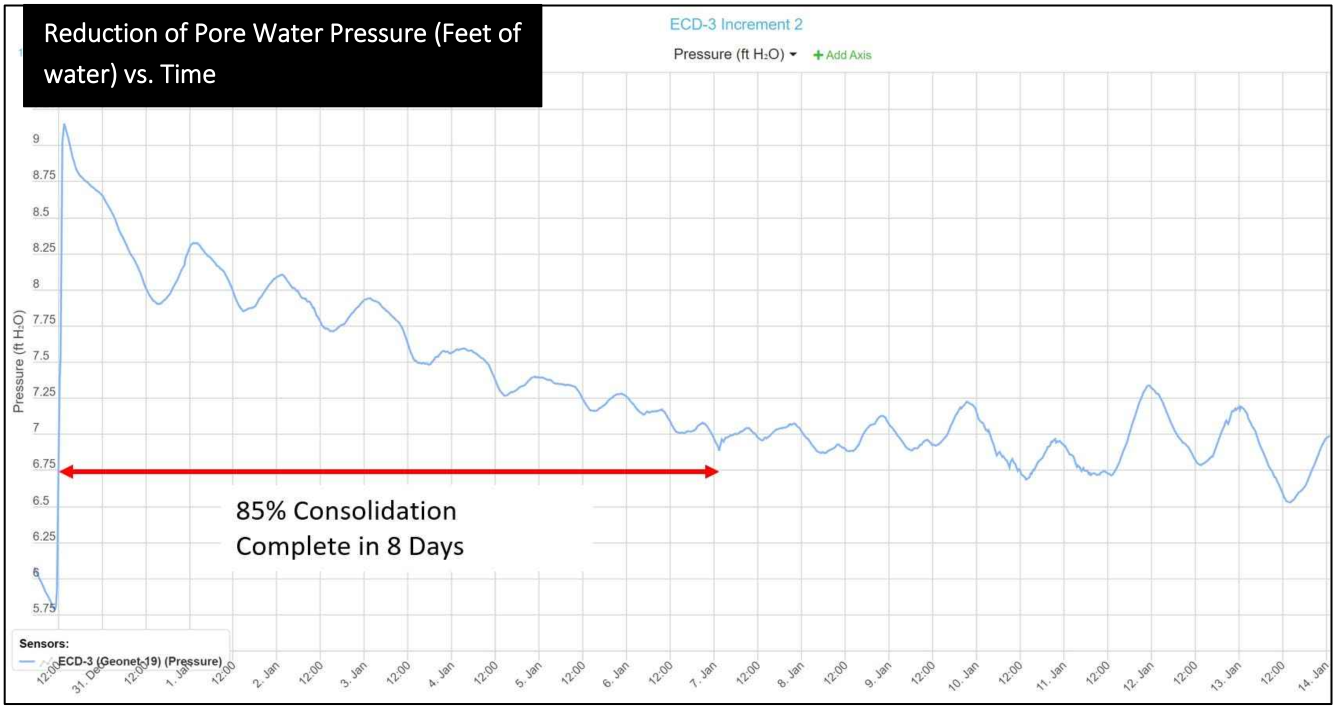
Figure 4: Typical Drive Point Piezometer with antenna extension post-installation

To support the CD-3 installation, another Thread, 'Thread-3', was installed nearby to receive data from the GeoNet Node and send it to the Sensemetrics cloud. Additionally, a second 4G LTE camera was installed next to the Thread to monitor activity around the CD-3. The installation was similar to the installation shown in Figure 2.

MONITORING DATA AND CHANGE ORDER

The data from the three piezometers was collected over the course of the first lift of construction of the ECD. The data obtained displayed a clear dissipation in pore water pressure within the first 10 days post construction. Previous recommendations with the available design data suggested a wait time of 45 days. Additionally, the soil samples collected, and pre-construction survey data indicated that the mudline was both shallower and the material stiffer.

The combination of the geotechnical laboratory testing and instrumentation and monitoring data led to the removal of the priority section of the dike and reduced the wait time between lifts from 45 days to 15 days. A sample of the data showing the pore water dissipation and CD-3 is shown below.



Reduction of Pore Water Pressure (Feet of water) vs. Time
ECD-3 Increment 2
Pressure (ft H₂O)
+ Add Axis
Pressure (ft H₂O)
85% Consolidation Complete in 8 Days
Sensors:
ECD-3 (Geonet-19) (Pressure)

ADAPTIVE
MANAGEMENT AND ENGINEERING

Memorandum

To: Mr. Shannon Haynes, P.E. | CPRA

From: Venu Tammineni, P.E. | Gregory A. Mattson II, P.E. | Adaptive Management and Engineering, LLC

Date: August 6th, 2021

Subject: Earthen Containment Dike Construction Monitoring at Bayou Moreau Caminada Headland Back Barrier Marsh Creation Project (BA-0171)

Adaptive Management and Engineering, LLC (AME) completed the installation of Earthen Containment Dike (ECD) monitoring instrumentation at Bayou Moreau for the Caminada Headland Back Barrier Marsh Creation Project (BA-0171) in Lafourche and Jefferson Parishes, Louisiana. Our services were provided as a subconsultant to S&ME, Inc. (S&ME) through Sigma Consulting Group (SCG) as authorized by the State of Louisiana - Coastal Protection and Restoration Authority (CPRA) on December 2, 2019 as "Task 2" under SCG's "General Engineering Services for CPRA" Contract No. 4400015376. This memorandum describes the geotechnical instrumentation and monitoring of the ECD crossing at Bayou Moreau completed to date. This memorandum will be updated as data collection efforts continue.

BACKGROUND AND KEY PROJECT EVENTS

Previously, S&ME completed soil sampling, laboratory testing, and instrumentation and monitoring for the proposed priority ECD section as outlined in a Memorandum dated August 18, 2020. This included installing drive point piezometers, data loggers, and cameras to monitor the installation of the first and second lifts of the ECD at three locations as shown in the Photo 1 below. Based on the data collected from the priority section geotechnical instrumentation and monitoring program, the contractor was able to reduce the wait time between the first and second lifts of the ECD construction from 30 days to 14 days in most areas with undisturbed foundation soil.

After multiple tropical events in 2020, the existing dune that lines the southern border of the project eroded considerably. Storm surge from hurricane Zeta caused a major damage to the dune that was intended to serve as the containment berm for the project, so a decision was made to repair the dune. The opening at Bayou Moreau was chosen as an access point for the equipment needed to repair the dune. This caused considerable disturbance to the foundation soils along the ECD alignment at Bayou Moreau. In addition

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Baton Rouge, La 70809

to equipment movement, Bayou Moreau served as a major funnel for storm surge and tidal interchange that eroded the disturbed the ECD foundation soils.

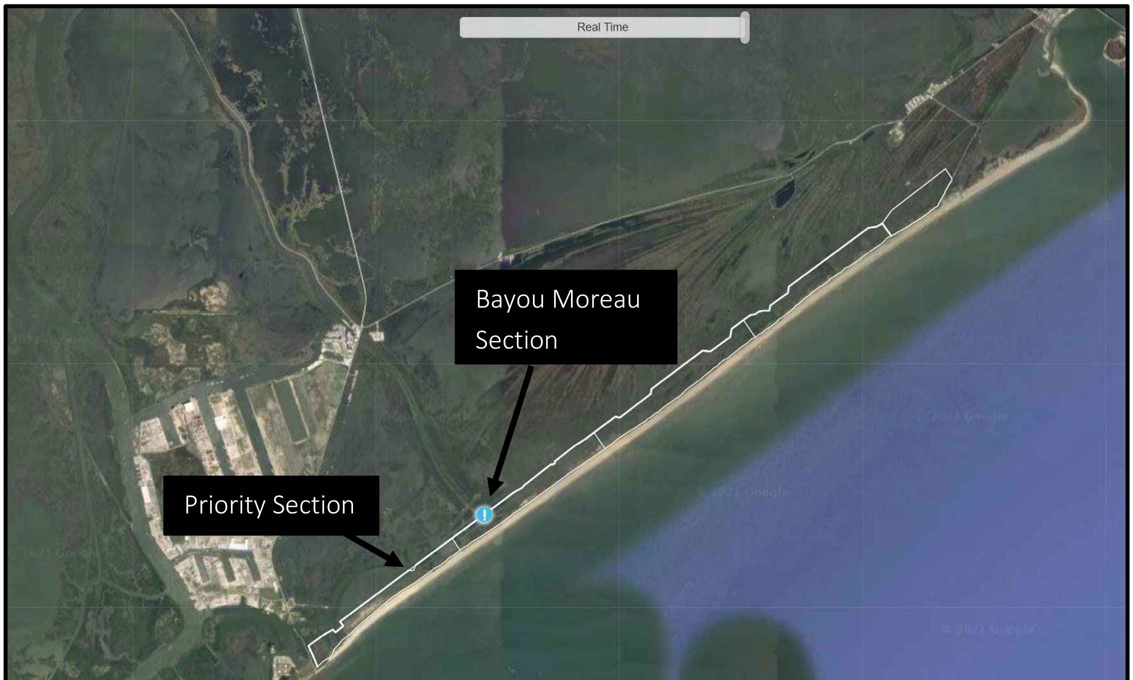


Photo 1: Drive Point Piezometer installation areas

On June 8th, at the bi-weekly project meeting, it was brought to the Project Team's attention that Wilco Marsh Buggies & Draglines (Wilco) was having issues constructing the ECD across Bayou Moreau. After continued issues, CPRA brought AME onboard to evaluate possible solutions, including haybale placement to decrease ECD core weight, sheetpile installation to replace the ECD, and traditional earthen material construction with increased wait periods between lifts to allow pore water dissipation and material consolidation. CPRA requested that AME conduct slope stability analyses for the proposed solutions.

On June 16th, a meeting was held with Great Lakes Dredge and Dock (GLDD), Wilco, and CPRA to discuss a path forward amongst the three options (haybale, sheetpile, or ECD with increased wait periods). AME's slope stability results were presented to assist with the discussion. Based on the discussions during the meeting and Wilco's experience, GLDD decided to construct the ECD at Bayou Moreau using existing material with longer wait times (30 to 45 days) as the disturbed foundations soils needed additional time to consolidate. At this meeting CPRA, requested AME to install drive point piezometers to assist GLDD and Wilco with estimating the degree of consolidation after placement of each lift. AME monitored the pore-water dissipation data and provided the information to CPRA, GLDD and Wilco during the Bayou Moreau ECD construction.

MONITORING INSTRUMENTATION

The following geotechnical instrumentation and supporting equipment are currently installed at the Bayou Moreau ECD crossing to monitor construction activities:

- Two Drive Point Piezometers
- Two Data Loggers
- One Monitoring Camera

INSTALLATION AND SITE VISITS

Site Visit 7-1-21

On the July 1, 2021 site visit, AME installed two Drive Point Piezometers in the Bayou Moreau ECD. Both Piezometers were fixed to the bottom of 15 feet of steel rod, pushed into the subgrade by hand and then driven to the targeted depth with the assistance of a marsh buggy. The drive point piezometers were then wired to a Data Logger, which was mounted to the top of the steel rods, for data storage and transmission. Photos 2 and 3 show the Drive Point apparatus post-installation. The Drive Point Piezometers, denoted as 'DP E' (for Drive Point East) and 'DP W' (for Drive Point West), were installed to collect pore water pressure data in the subgrade soils during the placement of additional lifts of material

Photo 2: Drive Point Piezometer 'DP E' – installed in the area of concern in Bayou Moreau.

Photo 3: Drive Point 'DP W' - installed in control section where ECD is

upon the ECD. Based on survey results obtained from GLDD, the ground surface elevation at the DP E and DP W was approximately El. +1.9 feet and El. +4.65 feet, respectively, at the time of installation. The top of the steel pipe was at El. +9.5 feet and +10.75 feet, respectively. Two soil samples were collected in the ECD and tested in a geotechnical laboratory for ECD soil properties. DP W was installed in a section near the edge of Bayou Moreau that was performing as expected (no excessive settlement or sloughing) and was to be used as a control point. DP E was installed at the area of concern in the Bayou Moreau ECD. The pore water pressure dissipation was monitored to determine the consolidation in the subgrade soil.

Site Visit 7-13-21

During a site visit on July 13, 2021, Geonet DP-E was reset, and the main data loggers were exchanged to ensure continuous data transmission.

Site Visit 7-26-21

Since installation of the drive point piezometers was performed, additional two lifts had been placed upon the dike. The pore-water dissipation in DP W and DP E were occurring at different rates. On the July 26, 2021 site visit, CPRA and AME traveled to the Bayou Moreau ECD section to observe construction progress and check the monitoring instrumentation.

OBSERVATIONS AND MONITORING DATA

After installation of the drive point piezometers and cameras, the placement of first lift occurred on July 5th in the area of concern in Bayou Moreau near DP E. This was both captured in the instrumentation data and on the camera footage. Pore water pressure began to dissipate at both the piezometer locations until an additional lift was placed on July 10th. The lift placed on July 10th was constructed along the entire section across Bayou Moreau. Pore water pressures increased at both DP E and DP W with the placement of the additional material. After approximately 7 days of fill placement, pore water pressure at DP W began to plateau indicating the majority of the pore water dissipation had occurred and therefore the subgrade soils had experienced the majority of consolidation. However, DP E showed continued pore water dissipation occurring for 12 days without any plateau in the data. On July 22nd an additional lift was placed across the entire Section of Bayou Moreau. Pore water pressures quickly dissipated and plateaued at DP W. At DP E, as of August 4th, pore water dissipation appeared to be trending towards plateauing. During a call on August 4th, with CPRA, GLDD and Wilco, the drive point piezometer data was presented by AME and the concerns about insufficient foundation soil consolidation was reiterated. GLDD assured CPRA during the August 4th call that dry soil would be placed on the Bayou Moreau ECD around DP E prior to placing any saturated soil from the borrow area. Wilco was onboard with placing dry soil from the dike first prior to placing the saturated soil. Wilco started placing additional saturated soil from the borrow area on August 4th at around 3:30 PM.

See the Attachments to this Memorandum for drive point piezometer locations along Bayou Moreau ECD and sample pore water pressure vs. time plots for the drive point piezometers. Additional information can be found on the sensemetric's web dashboard.

ASSUMPTIONS & LIMITATIONS

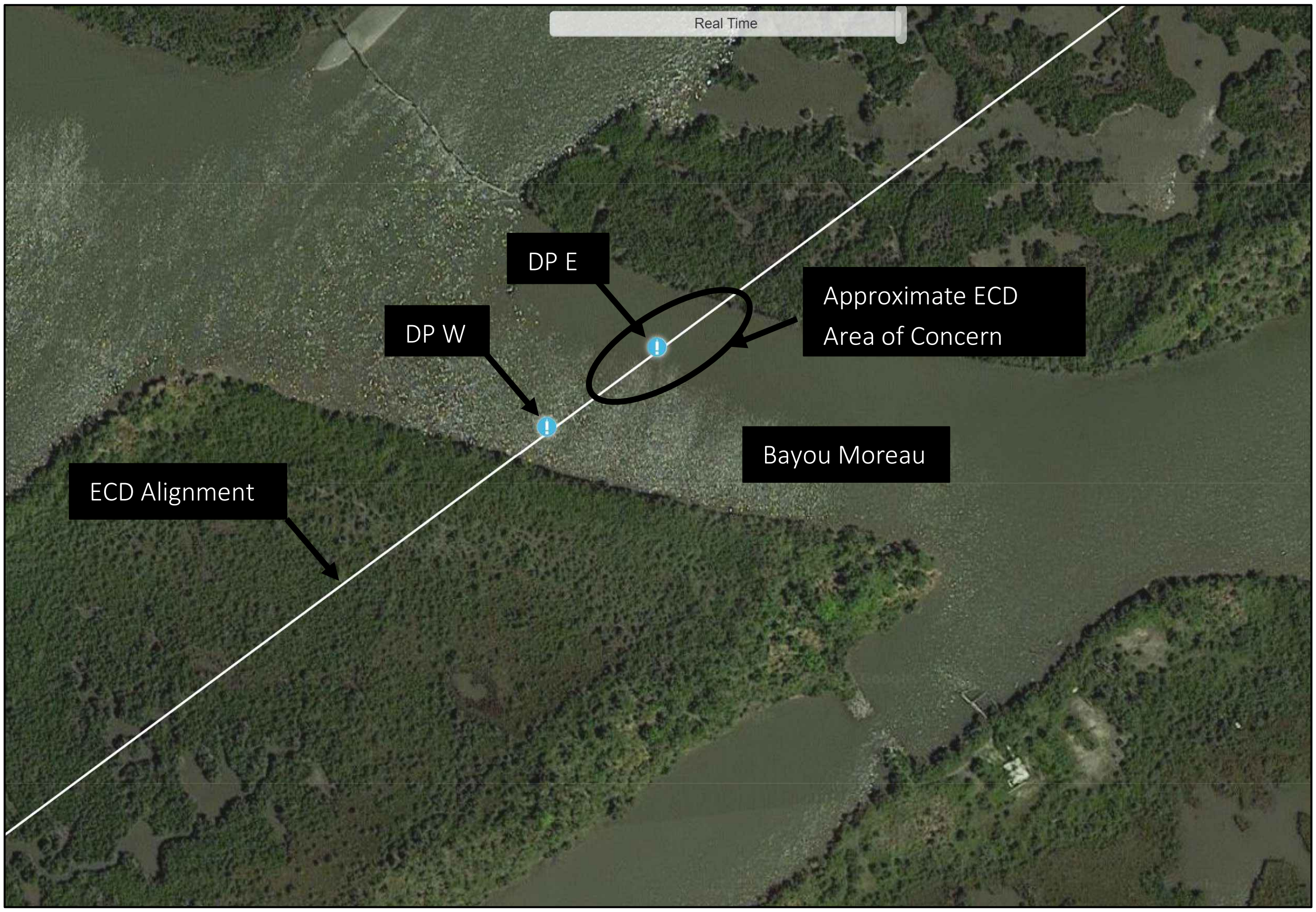
The following assumptions and limitations apply:

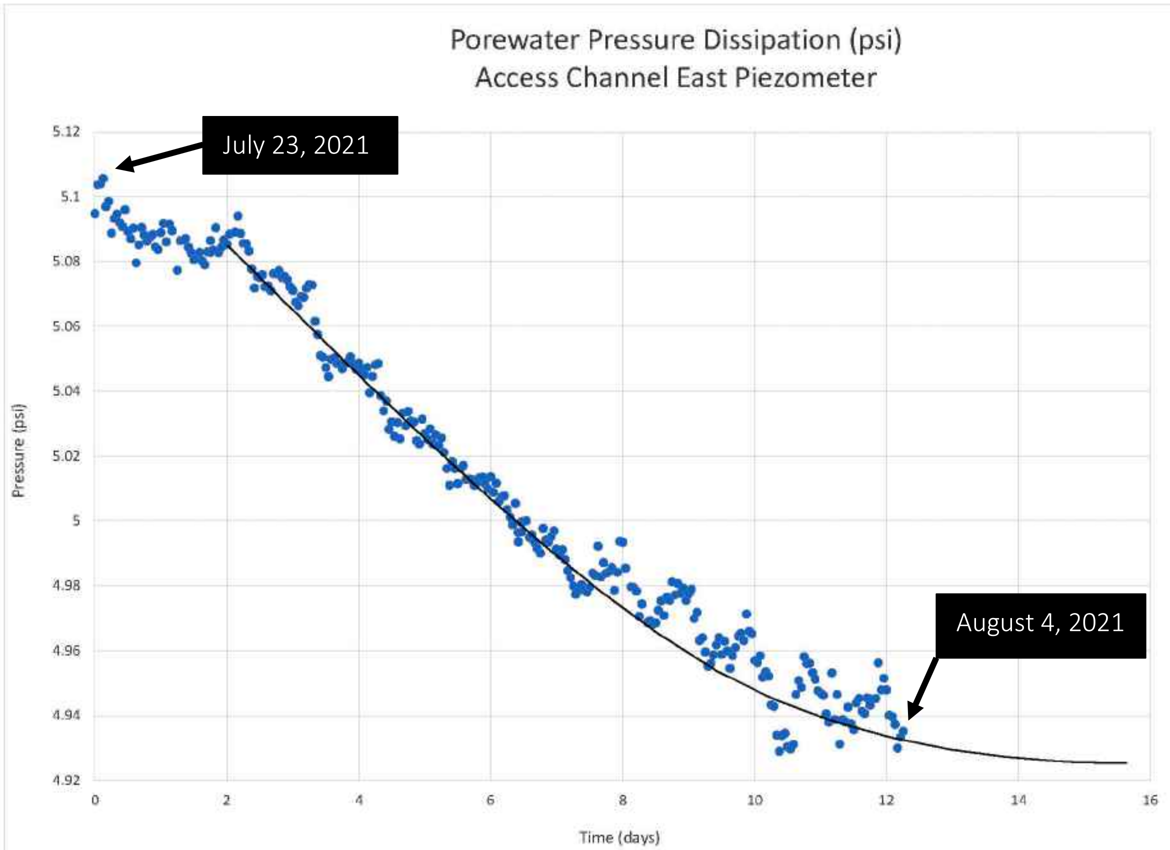
- No geotechnical data is available in the Bayou Moreau ECD section.
- No survey data showing mudline elevation is available for the Bayou Moreau ECD section post-Hurricane Zeta.
- The control point section of ECD where DP W is installed has similar pore water dissipation rates as the previous sections that were monitored.
- Consolidation is occurring vertically, and no lateral spreading is occurring.
- Pore water recharge due to rain events cannot be measured.
- Any vertical or horizontal movement of the drive point piezometers must be recorded and reported by the Contractor.

ATTACHMENTS

Instrument and Equipment Locations

Sample Data Plots


Real Time
DP E
DP W
Approximate ECD
Area of Concern
Bayou Moreau
ECD Alignment


Porewater Pressure Dissipation (psi)
Access Channel East Piezometer
July 23, 2021
August 4, 2021
Pressure (psi)
5.12
5.1
5.08
5.06
5.04
5.02
5
4.98
4.96
4.94
4.92
0
2
4
6
8
10
12
14
16
Time (days)

Appendix J

As-Built Drawings