Sanibel Communities for Clean Water Project

2024 Water Quality and Groundwater Monitoring Report

Post Hurricane Ian

Post Tropical Storm Debbie

Post Hurricane Helene

Post Hurricane Milton

SCCF
SANIBEL-CAPTIVA
CONSERVATION FOUNDATION

December 2024

For The City of Sanibel Natural Resources Department

Submitted by: Mark Thompson, M.S., Research Associate

Eric Milbrandt, Ph.D., Director

900A Tarpon Bay Rd, Sanibel, FL 33957

Description of the Project

Community-owned lakes and stormwater collection systems are the receiving waterbodies for much of Sanibel's stormwater runoff. These systems are designed to retain large volumes of stormwater runoff before discharging offsite. Through this process, stormwater is effectively dissipated through evapotranspiration or directed through the soil and into the groundwater system. Factors such as rainfall, tides, irrigation, insufficient vegetation, and poor system design can allow discharges to surrounding surface water. When discharges from these systems occur, stormwater is conveyed to the Sanibel Slough, a waterbody designated as impaired for nutrients by the Florida Department of Environmental Protection (FDEP), or to the estuarine and gulf waters surrounding Sanibel. The surficial groundwater aquifer on Sanibel is very shallow and effectively connected to most stormwater ponds through porous soils. In this way, groundwater quality and flow is affected by community stormwater systems and lakes. The discharge of groundwater from Sanibel into the estuary and Gulf is estimated to be of nearly equal or greater total annual volume than stormwater runoff. Knowledge of nutrient concentrations and potential loadings from community stormwater systems and lakes is essential for effective management of nutrient loading sources. Poor water quality can negatively impact our environment, wildlife, human health, property values, and overall quality of life; therefore, it is imperative that we educate citizens of Sanibel on the importance of improving water quality at the local scale.

The first goal of this study is to evaluate water quality trends and characterize current conditions for 50 sites to water quality criteria. Wet and dry season water quality sampling results will be supplied to the city so that it can be uploaded to the Sanibel Communities for Clean Water website. This website is accessible to the public to provide information on water quality conditions and changes in their community and provides a list of recommended Best Management Practices (BMPs) tailored to specific sites.

Hurricane Ian and its storm surge inundated Sanibel in September 2022. As a result, the freshwater systems on Sanibel instantly changed on September 28th, 2022, to marine/estuarine systems. *The second goal* of this study was to track water quality changes in the former freshwater lakes on Sanibel as they transition from post-Ian conditions. SCCF Marine Laboratory personnel have estimated it may take years for some of the lakes on Sanibel to transition back to freshwater systems with salinity below 3 PSU after Hurricane Ian. However, during the 2024 study period Sanibel experienced an additional 3 storm surge events due to Tropical Storm Debbie August 4th, Hurricane Helene September 26th, and Hurricane Milton October 9th. All three surge events had impacts on some or all of the freshwater systems on Sanibel. These storms occurred during the later part of this study and scheduled water quality sampling was already completed. Supplemental salinity sampling did occur to obtain an idea of impacts from these storms, however water quality characteristics of all Sanibel freshwater systems has changed since the last sampling event of this project.

The third goal of this year's study was to evaluate the relationship between groundwater and community lakes. Monitoring wells provide data showing how ground water characteristics affect 6 area waterbodies.

Methods

Surface water samples were taken at 50 unique sites on Sanibel in dry and wet seasons (Table 1; Figure 1). Sites include public and privately owned stormwater systems, ponds, lakes, and reservoirs which have possible interaction with Sanibel's surface water or groundwater. Sampling events were conducted in the dry season (February and May 2024) and wet season (August 2024). To help evaluate changes post hurricane Ian (goal 2), data previously collected in 2018, 2020, 2022 and 2023 is combined with the new 2024 data. Samples were analyzed for total phosphate (TP), total nitrogen (TN), nitrate-nitrite (NOx), ammonia (NH3), and total Kjeldahl nitrogen (TKN) using NELAC certified methods by Benchmark Laboratories in Palmetto Florida. In addition to the nutrient sampling, dissolved oxygen (DO), turbidity, colored dissolved organic matter (CDOM), chlorophyll *a*, pH, salinity and temperature data were collected using a portable YSI EXO data sonde at each sampling site. Chlorophyll *a* analyses were performed using EPA approved methodology at the SCCF Marine Laboratory.

After uploading all data into the SCCF water quality database, it was aggregated within an excel spreadsheet and manipulated for input to Minitab13® software for statistical analyses. Descriptive statistics were produced for each site. Median parameter values were compared to water quality criteria using the nonparametric 1-sample Wilcoxson test. A significance level of 0.05 was used in all comparative analyses.

The Trophic State Index (TSI) is based on chlorophyll *a*, total nitrogen, and total phosphorus levels, and was calculated for each of these study lakes following the procedures outlined on pages 86 and 87 of the Florida's 1996 305(b) report. Each waterbody was assigned a water quality grade based upon this study period's TSI values; values above 80 = F, 70-80 = D, 60-70 = C, 50-60 = B, and under 50 = A (Excellent). The grades are based upon TSI values ranging from oligotrophic (good) to hypereutrophic (bad) waterbodies (Carlson and Simpson 1996). Trends in TSI were evaluated for each site for 2016 through August 2023. If the trend in TSI was significant and increasing, the site was listed as having declining water quality while a decreasing TSI trend was identified as improving water quality (Table 2).

Sample sites were ranked based upon combined mean inorganic phosphorus, inorganic nitrogen, chlorophyll *a* concentrations and TSI scores from both sampling events. The mean value of each of these four parameters was used to assign a rank score to each sample site with rank 1 indicating the poorest score for each parameter. The four rank scores were then added together to produce a total rank for each site. Total scores were listed from lowest to highest with lowest scoring site having overall poorest water quality condition.

Groundwater monitoring stations were installed at 6 locations to provide insight into groundwater-lake interactions post-hurricane Ian (Figure 1, Table 1).

1. The Murex Lakes area has 4 groundwater stations and 2 lake elevation stations.
2. The Sea Oats area has 3 groundwater stations and 3 surface water elevation monitoring sites.
3. The Sanctuary Golf Course has 4 monitoring wells and 2 surface water elevation sites.
4. The Jordan Treatment Marsh area has 4 groundwater stations and 4 surface water elevation sites.
5. The Dunes Golf Course area has 4 wells and 2 surface water sites.
6. The Pond Apple Park area has 7 monitoring wells and 2 surface water sites.

Continuously recording water depth loggers (Onset Hobo) were installed in each of the 26 wells and at two surface water sites (Pond Apple Park and Sanibel Slough at Sea Oats). Several times during dry and wet season the data loggers were read out and surface water elevations were measured using a Trimble RTK GPS unit. The elevation data was downloaded and manipulated in an excel spreadsheet to assess groundwater flow directions at each of the sites. Salinity levels of the groundwater and surface water were measured during each data collection event. One wet season groundwater sample was taken at each of the 6 study areas and evaluated for nitrogen and phosphorus at a contracted NELAP laboratory.

Results and Discussion

Water Quality and the effects of Hurricane Ian and 2024 surge events.

For the two years after Hurricane Ian and before the Helene and Milton surge events of 2024, the mean salinity of the monitored lakes was significantly greater than the salinity before Hurricane Ian (Kruskal Wallis, $p < 0.01$, Figure 2). The salinity ranged from a mean of 30.9 PSU at North Murex Lake (SCL47) to 2.1 PSU at the Tradewinds North Lake (SCL64) and The Sanctuary Lake 7 (SCL71) before the inundation events of 2024. Twelve of the lakes monitored dropped to 5 PSU or less, a much-reduced salinity over the past two years. A significant downward trend in salinity ($p < 0.001$, $c = -0.45$) occurred between December 2023 and August 2024 (Figure 2). Monitoring showed that salinity remained higher in the deeper lakes compared to shallow lakes (Figure 3). During the dry season from October 2022 through May 2023 all lakes which were not artificially irrigated experienced increasing salinity due to evaporation and a lack of rain. After 2023, lakes generally decreased in salinity until the surge events in the summer of 2024. Most of the deeper lakes on Sanibel were man made and hold a relatively larger volume of water even though they may have small watersheds. The large volume of high salinity water in deep lakes coupled with small watersheds results in a longer period before they become fresh again. The deep lakes may also interact more significantly with the deepest portion of the surficial aquifer. The surge which inundated Sanibel during hurricane Ian temporarily replaced most of the freshwater in the shallow aquifer with higher salinity water. Most of the upper portion of that surficial aquifer become fresh again by August 2024 just before the 3 surge events of 2024 significantly changed its characteristics again. The surficial aquifer is stratified due to saline water intrusion from 4 surge events in 2 years. The deeper lakes on Sanibel are more likely to interact with the deeper, higher salinity groundwater than shallow lakes and wetlands.

Tropical Storm Debby passed near Sanibel in early August 2024 and produced a storm surge which affected several of the lakes on Sanibel. Looking at changes in salinity from dry season 2024 to wet season 2024, 12 of the 49 lakes which were sampled increased in salinity in this period. The wet season sampling occurred after TS Debby in late August. During 2024, Sanibel experienced 50% greater rainfall than the annual average. The salinity of all lakes should have decreased between the dry season and wet season sampling dates. Those waterbodies affected by the TS Debby surge had greater salinity during the wet season sampling (Figure 4).

In September 2024 Hurricane Helene inundated all six groundwater-lake monitoring sites for this project with water from the Gulf of Mexico (Figure 5). Again, in October 2024, Hurricane Milton brought an even greater surge inundation event which also covered all 6 research sites (Figure 6). Storm surge is calculated as the difference between predicted high tide elevation and the actual surge water elevation at a point and time. The storm surge depth was calculated from logger data at 6 groundwater monitoring sites which recorded the surge events (Figure 7). The actual storm surge ranged from 5.9 feet on Periwinkle Way at Pond Apple Park to 5.0 feet at the SCCF Sea Oats Preserve.

Supplemental surface water sampling for salinity was undertaken after Hurricanes Helene and Milton. A plot of the latest mean salinity in Sanibel lakes shows that salinity is once again almost as high as after Hurricane Ian (Figure 2). Sampling in the eastern and western basin of the Sanibel Slough revealed that these two central waterbodies with water control structures linked to Pine Island Sound currently have salinities comparable to the estuary (Figure 8). The reduced rain anticipated during the 2025 dry season will further increase the salinity in the Sanibel Slough delaying its return to a functioning freshwater ecosystem.

The Donax reclaimed water holding ponds (SCL05) in Pond Apple Park showed an increase in salinity after TS Debby, and Hurricane Helene and Milton (Figure 9). The ponds are surrounded by a berm and are continuously fed treated domestic wastewater and maintained at a water elevation significantly above sea level creating a groundwater flow gradient away from the ponds. Any increases in the salinity within the ponds treated wastewater are most likely due to increased salinity in the influent wastewater at the Donax plant. When storm surges occur such as TS Debby or Hurricane Helene and Milton, high salinity water from the Gulf and estuary can enter the wastewater conveyance system through manholes, floor drain connections, lift station vaults, and sewer system inflow/infiltration. Hurricane Ian produced a storm surge which completely inundated Sanibel with 2-15 feet of high salinity water. A comparison of mean and median salinity in the holding ponds before and after Hurricane Ian show a significantly greater salinity (Kruskal-Wallis, $p = 0.001$, mean = 6.7 PSU) in the 24 months after Ian than the 6 years before (mean = 1.3 PSU) (Figure 8). There is evidence that the wastewater treatment plant influent salinity has increased due to recent hurricane surge events. The effects of increased influent flow salinity on the operation of the City's wastewater treatment plant should be taken into consideration as well as the higher salinity water being supplied as an irrigation source.

The mean pH of lakes sampled in this study was significantly lower after hurricane Ian compared to before (Kruskal Wallis, $p = 0.011$, Figure 10). After hurricane Ian the pH rose to near pre-storm levels, but the storms of 2024 have once again lowered the average pH to be well below pre-Ian conditions. The current pH levels are not harmful to plants or animals, but they indicate that biochemical processes within the lakes are changed after storm surge events. The lower pH is an indirect result caused by lower algae/phytoplankton CO_2 uptake during photosynthesis in daylight hours because of changes in the microbe communities which consume CO_2 from the water column. Photosynthetic removal of CO_2 from the water column raises daytime pH in a waterbody. Anaerobic decomposition of large amounts of new organic matter within the lakes can also cause water column pH to be lowered.

Mean chlorophyll *a* (Chla) concentrations for the 2 monitoring events during 2024 ranged from 7.6 ug/l at Sundial East (SCL16), to 249.2 ug/l at Gulf Pines White Ibis (SCL60) (Table 2). The mean chlorophyll *a* concentration after Hurricane Ian was significantly greater for the monitored sites than previous to Ian (Kruskal-Wallis, $p=0.01$, Figure 11). Immediately after Ian, chlorophyll *a* values were generally as low or lower than before Ian. As new phytoplankton communities became established in the now higher-salinity lakes, the increased amounts of carbon and nutrients from hurricane runoff cultivated an increase in the chlorophyll *a*. The Florida DEP chlorophyll *a* water quality criteria for lakes is 20 ug/l while it is 11 ug/l for estuaries (which these lakes more closely resemble due to salinity). Ninety percent (45/50) of lakes monitored for this report have mean chlorophyll *a* values above the lake water quality criteria. This is an increase from the 70% of lakes which did not meet water quality criteria during the 2022 monitoring project.

The median total phosphorus (TP) values for the period after Hurricane Ian compared to before could not be found to differ significantly (Kruskal Wallis, p = 0.756, Figure 12). Mean TP in the sampled lakes ranged from 0.024 mg/l at Sundial East (SCL16; high density residential) to 1.336 mg/l at the Sanibel Golf Club reclaimed water holding pond (SCL15; WWTP) (Table 2). Mean TP values at 80% of the lakes were above the FDEP water quality criteria (0.05 mg/l, Figure 12). Fifty percent (50%) were greater than the 90th percentile (0.092 mg/l) of Florida lakes (Hand 2008). At lower water column pH, TP is released from bottom sediments. Lower mean water column pH was observed after Hurricane Ian.

The median total nitrogen (TN) values for the period after Hurricane Ian compared to before were found to be significantly lower after the hurricane (Kruskal Wallis, p = 0.036, Figure 13). The lower TN after hurricane Ian was likely due to dilution with Gulf and estuary waters which have significantly lower nitrogen concentrations than most lakes. The mean TN concentration in lakes ranged from 7.27 mg/l at Annies Pond (SCL32, natural LU) to 1.305 mg/l at Tradewinds North Lake (SCL64, Medium Density LU) (Table 2). All (100%) of the sites had mean TN values above the Florida criteria for lakes (1.27 mg/l, Table 2). About 90% of sites had mean TN above the 90th percentile of all lakes in Florida (1.72 mg/l). During the 2024 project period, IN made up an average of 8% of the TN value. This is less than the 11% in 2023 and greater than 2022 (3.6%), 2020 (5%), 2018 (7%) and 2016 (5%). Increased IN since the Hurricanes (Figure 14) may be associated with wastewater discharges, and decomposition of other organic material washed into lakes.

TSI scores are meant to be an integrated look at the magnitude of eutrophication in a lake. Phosphorus, nitrogen and chlorophyll *a* are factors used to calculate a TSI value, so it is a good initial estimation of a lake's overall eutrophic condition. FDEP considers scores over 60 to indicate poor water quality and scores greater than 60 trigger evaluation of waterbodies for impairment. Forty-nine out of 50 (98%) lakes sampled this year had TSI scores greater than 60. Scores ranged from 53.3 at the Sundial East (SCL16, land use = medium density) to 94.6 at the Sanibel Golf Club reclaimed water pond (SCL13, golf course LU) (Table 2). No significant difference could be found for TSI scores after Hurricane Ian than before (Kruskal Wallis, p = 0.08, Figure 15).

The median fluorescent dissolved organic matter (FDOM) values of sampled lakes were found to be significantly greater for the period after Hurricane Ian compared to before (Kruskal Wallis, p < 0.01 and, Figure 16). Usually, FDOM is inversely related to salinity, however the colored organic matter which makes up FDOM was flushed into area waterbodies by saltwater surge instead of the usual freshwater precipitation.

Turbidity after Ian was significantly greater than the period before Ian (Kruskal Wallis, $p = 0.01$) (Figure 17). Potential drivers of the increase in turbidity include loss of aquatic vegetation within the lakes, suspended sediment associated with surge and stormwater, debris and altered biological and chemical characteristics of the waterbodies. Months after a hurricane surge event most added suspended solid will settle out, and lake clarity will mainly depend upon the phytoplankton stock (chlorophyll a) more than changes in turbidity or FDOM.

Grading Sanibel waterbodies based upon the TSI score, one waterbody (Sundial East SCL16) received a water quality grade of B; 12 received a C, 24 received a D and 13 received a grade of F (Table 2). Regardless of how an individual lake was ranked relative to other lakes on Sanibel, the water quality grade will give a better indication of its actual current health. If a lake has an F or D water quality grade – the water quality is very poor. A majority of Sanibel's formerly fresh waterbodies are eutrophic, and nutrient-enriched with high primary production leading to algal blooms. This statement was as true before the recent hurricanes as it is afterwards.

The water quality of lakes was ranked following procedures described in the methods section producing a prioritized list of lakes on Sanibel with water quality concerns (Table 2). Those with the highest rank are potentially most polluted and should be afforded the greatest resources in addressing their problems. The current ranked results are in a table with results from 2023, 2022, 2020, 2018 and 2016 (Table 2) to provide a sense of how water quality has changed in relationship to other Sanibel Lakes.

Interpolated maps of lake salinity in September 2024 (before Helene and Milton) and in October 2024 (after Helene and Milton) show salt concentrations were lower before the storm surges of late summer 2024 (Figure 18). Currently Sanibel has no fresh surface water sources. Dry season in 2025 will likely increase current salinity values before rains in the wet season of 2025 begin to lower values. An interpolated map of lake chlorophyll *a* across Sanibel is also shown (Figure 19).

Groundwater and Lake Relationships

Groundwater flow direction (hydraulic gradient) in the 6 study areas was generally toward the lakes. Evapotranspiration from a lake produces a virtual pump which carries water away from lake storage (Figures 20-25). However, areas which were adjacent to the Sanibel Slough could vary greatly in flow direction depending on the antecedent rain and water elevation of the Sanibel Slough. Water levels in the Slough can be held artificially high or low causing groundwater hydraulic gradients away or towards the slough instead of towards a nearby lake.

Similarly, the reclaimed water ponds at Pond Apple Park (Figure 21) are typically kept filled to an elevation significantly above the surrounding surficial aquifer. This creates a hydraulic gradient which causes water to flow continuously away from the ponds.

Groundwater at the 6 study sites was significantly greater in IN ($p = 0.029$, Paired t-test) and TP ($p = 0.05$, Paired t-test) than the nearby surface water (Figure 26). This is consistent with a previous study of groundwater nutrient loading done for the City of Sanibel Nutrient Management Plan (2015).

In October 2024, after Hurricane Milton, the mean salinity of groundwater (10.1 PSU) was significantly lower than the mean salinity of adjacent surface water (20.3 PSU) at the 6 study sites ($p = 0.004$, Paired t-test). This supports the findings we saw during the entire study period at our study sites (Figures 27-29). The salinity of groundwater monitored in this study was generally lower than the salinity of the adjacent surface water. The finding discounts the hypothesis that deep lakes were staying salty for long periods due to infiltration of saltier groundwater.

Less saline water is less dense than saltier water. Within the surficial aquifer, freshwater from precipitation floats on top of the more saline groundwater and forms a freshwater lens. The freshwater lens was certainly reduced in depth after saltwater surge events. In general, the surficial aquifer water table elevation is higher beneath a high elevation ground surface. Evaluation of groundwater salinity data collected during this study showed groundwater beneath a surface elevation greater than 1-meter NAVD88 was significantly lower than groundwater salinity beneath a surface elevation of less than 1 meter (Kruskal Wallis, $p < 0.01$, Figures 28-29). This supports what is known about the freshwater lens of a barrier island surficial aquifer.

After rain events, the surficial aquifer water table elevation becomes greater than an adjacent surface water body and the hydraulic gradient toward the surface water becomes greater (Figure 30). As a result, rain events cause greater groundwater flow into adjacent lakes. This was found at all sites except for the Pond Apple Park Site where reclaimed water is held at a considerably greater elevation by earthen dikes.

Additional Findings

Having depth loggers installed during the storm surges of 2024 allowed evaluation of storm surge data at the 6 sites where equipment was installed. In addition, the continuously recording depth loggers provided rare and valuable information regarding the surficial aquifer on Sanibel. Appendix I includes plots of the continuous groundwater depth data and shows the effects of large precipitation and surge events at these sites.

Using the White (1932) method, evapotranspiration rates at a monitoring well can be estimated. The diurnal drawdown and rise in groundwater elevation over a day shows how vegetation pumps groundwater from the ground during the daylight hours, losing much of the water to evapotranspiration and storing some in the biomass (Figure 31).

Estimates were made at two sites to compare evapotranspiration rates from differing landscapes; 1. A preserve which is covered with dense young buttonwood which has been recovering since Hurricane Ian and 2. An undeveloped home site which was recently cleared of non-native vegetation, producing a partially sparsely vegetated landscape. Evaluation of data collected in September 2024 from the site with dense young buttonwoods (Jordan Marsh GW13) produced an estimated evapotranspiration potential of 10.5 inches of water for the month of September. For the same period the sparsely vegetated site had an estimated evapotranspiration potential of 6.9 inches for the month. This finding confirms abundant literature which describes vegetation as a primary mover of stormwater from a watershed. Land types with abundant healthy vegetation remove and store more water in a watershed than those with sparse or unhealthy vegetation.

The USGS provides a satellite tool, the Normalized Difference Vegetation Index (NDVI), to evaluate changes in vegetation coverage and health after natural or human induced events. NDVI values range from +1.0 to -1.0. Areas of barren rock, sand, or snow usually show very low NDVI values (for example, 0.1 or less). Sparse vegetation such as shrubs and grasslands or senescing crops may result in moderate NDVI values (approximately 0.2 to 0.5). High NDVI values (approximately 0.6 to 0.9) correspond to dense vegetation such as that found in temperate and tropical forests. Johnson Engineering (2024) did an aerial-based NDVI assessment of Sanibel before Ian and compared it to the NDVI after Ian. The results showed the pre-Ian NDVI was 0.7 corresponding to healthy, dense vegetation, while the post-Ian index was 0.4 typical of a sparsely or unhealthy vegetated watershed. The USGS (2024) further explains that the lower the NDVI score, the less evapotranspiration potential in the watershed.

As confirmed in the Johnson Engineering analysis, Sanibel has lost much of its healthy vegetation since Hurricane Ian. While the White Method can sometimes result in an overestimation of evapotranspiration rates, when coupled with NDVI it helps to illustrate the importance of vegetation cover and stormwater management. A majority (estimated up to 90%) of the annual precipitation which falls on Sanibel is moved from the island through vegetative evapotranspiration. Vegetation also stores water within its biomass which provides a source of water during dry periods. The loss of vegetation through hurricane damage and post-hurricane clearing resulted in less evapotranspiration. Therefore, more runoff and pooling of water during the wet season can be partially explained by the loss of vegetative cover on the island.

Conclusions

Hurricanes Ian, Helene and Milton had significant water quality impacts on the community lakes and groundwater of Sanibel. On September 28, 2022, the fresh lakes, wetlands and ponds of Sanibel were instantaneously converted to saline waterbodies. Freshwater ecosystems were destroyed, and transient saline-water ecosystems have now developed. Some lakes and ponds were showing a significant decrease in salinity due to the precipitation during 2024, however the additional storm surge events of 2024 has now converted them back to conditions similar to post Ian. It may be many years before the deeper lakes of Sanibel can support freshwater flora and fauna again. However freshwater wetlands and the Sanibel Slough have the ability to become nearly fresh again with another 100 inches of rainfall (as seen post Ian). Salinity will be reduced fastest in the lakes which receive inputs of reclaimed wastewater directly or through irrigation. Deep lakes with small watersheds will continue to have salinities closer to the Gulf of Mexico than to freshwater lakes for the foreseeable future (2+years).

Lakes were ranked from poorest (ranked 1) overall water quality to those with the least impairment (ranked 50). The lakes with poorest water quality can be targeted for lake management plan development and other pertinent BMPs once the source of poor water quality is identified. In general, lakes on Sanibel are eutrophic to hyper-eutrophic with relatively high nitrogen and phosphorus concentrations and abundant phytoplankton. The storm surges from recent hurricanes may have changed the salinity characteristics of the lakes, but the persistent phytoplankton blooms and low dissolved oxygen problems during cloudy days continues. The lakes are now populated by estuarine fish replacing the freshwater cichlids, bass and sunfish which were present pre-hurricane. Salinity-tolerant killifish and gambusia are the most common fish currently seen. Low dissolved oxygen conditions which occasionally develop in Sanibel lakes due to their eutrophic state, will be more likely to kill the estuarine fish which are now in these lakes due to their low tolerance to low oxygen conditions.

In general, groundwater on Sanibel currently has lower salinity but higher nutrient concentrations than adjacent surface water. Groundwater normally flows towards lakes and this can help lower lake salinity but can also be detrimental because it will increase nutrient concentrations (and eutrophication) in the lakes. Evapotranspiration rates of vegetation were estimated from monitoring well drawdown using accepted methods. Evapotranspiration from healthy trees can equal rainfall during the wet season. An analysis by Johnson Engineering (2024) found that Sanibel's vegetation index (NDVI) decreased significantly after hurricane Ian, suggesting its vegetation coverage is significantly reduced. Reduced vegetation coverage would reduce evapotranspiration and thus reduce the rate of stormwater removal from the island. This can result in more standing water for longer periods of time in areas which have reduced vegetation.

Attached file: ComLakesDat_2024.xlsx

Figures and Tables

Table 1. Location of lake and groundwater sampling sites for this project.

Site ID	Site Type	Description	Lat	Long
Devitt01	Lake	Pond at SCCF Homestead	26.44440	-82.04939
JM02	Lake	Jordan Marsh Effluent	26.43862	-82.05810
SCL02	Lake	BeachRdVillasPnd	26.44554	-82.04058
SCL05	Lake	CityReclaimDschrge	26.44571	-82.04570
SCL07	Lake	DunesLake5	26.45300	-82.04227
SCL08	Lake	DunesLake4	26.45515	-82.05254
SCL11	Lake	GumboLimboEast	26.44465	-82.05816
SCL13	Lake	SanGolfReclmPnd	26.43910	-82.05151
SCL15	Lake	PanamaCanal	26.42978	-82.05942
SCL26	Lake	CasaYbel	26.42493	-82.07111
SCL27	Lake	CityHall	26.44124	-82.07408
SCL30	Lake	Pointe Santos	26.42268	-82.07734
SCL31	Lake	BaileysPond	26.43361	-82.07880
SCL36	Lake	SandPointe	26.42337	-82.08674
SCL37	Lake	SmithLkBaileyTrct	26.43112	-82.08708
SCL43	Lake	PalmLake	26.42626	-82.09312
SCL48	Lake	SLakeMurex	26.43137	-82.09683
SCL50	Lake	StIsabelCathChrch	26.44117	-82.10718
SCL55	Lake	ERockWestEndCoquina	26.43773	-82.11592
SCL56	Lake	WRockEastEndCoquina	26.43802	-82.11892
SCL62	Lake	ChateauSurMerLake	26.45264	-82.13939
SCL64	Lake	TradewindsNLake	26.45389	-82.14111
SCL71	Lake	SanctuaryLake7	26.49135	-82.17098
SCL74	Lake	Herons Landing Lake	26.47001	-82.15974
SCL82	Lake	Behind Jacaranda	26.44404	-82.04640
SCL04	Lake	PrwnklePrkRVPond	26.44405723	-82.04404297
SCL10	Lake	WhsperwdPond	26.44542201	-82.05533903
SCL16	Lake	SundialEast	26.43265501	-82.05008639
SCL18	Lake	SanibelLakeEst 1806_IbisLn_or_1995_Roseate	26.4360386	-82.06534666
SCL19	Lake	GulfsidePark_1 Off Parking Lot	26.4261864	-82.06460605
SCL21	Lake	OceansReachCondo	26.42559423	-82.0675629
SCL23	Lake	PeriwinklePlaceSW	26.43734917	-82.06837736
SCL25	Lake	PeriwinklePinesSW	26.43915036	-82.07039688
SCL28	Lake	SanComAssPark In Park Behind Sanibel ComHouse	26.43587429	-82.07434664
SCL32	Lake	AniPondBailyTract	26.42813349	-82.08198178
SCL35	Lake	SeagullEstates - Daniel Lane _ western small lake	26.42519685	-82.08647547
SCL41	Lake	HurricaneLane at Dock	26.4265256	-82.09170041
SCL45	Lake	NPoincianaPond Poinciana off Island Inn	26.43066475	-82.0943386
SCL46	Lake	Brghtwter_IslandInn	26.4289865	-82.0962015
SCL47	Lake	NlakeMurex	26.433161	-82.096812
SCL51	Lake	NBikePathlake	26.43916321	-82.10848682
SCL52	Lake	SBikePathLake	26.43733707	-82.10889297
SCL53	Lake	SeaOatsDrSmlLake	26.43259396	-82.10993543
SCL57	Lake	GulfPines Near Tennis Courts	26.44434064	-82.12827171
SCL60	Lake	WhiteIbisGulfPines	26.44600475	-82.13462191
SCL66	Lake	Bayous Middle Lake (Ladyfinger Lake)	26.4661995	-82.15658218
SCL69	Lake	SanctuaryLake4	26.47680143	-82.1666622
SCL70	Lake	BluCrabLake	26.47856434	-82.17064221
SCL80	Lake	East Hollys Pond	26.469667	-82.159048

Site ID	Site Type	Description	Lat	Long
GW01	Monitoring Well	South of Reclaim PondsPond Apple	26.445252	-82.045822
GW02	Monitoring Well	West of Reclaim PondsPond Apple	26.446874	-82.046014
GW03	Monitoring Well	North of Reclaim Ponds w BarometricPond Apple	26.447986	-82.045064
GW04	Monitoring Well	East of Reclaim PondsPond Apple	26.446953	-82.043791
GW05	Monitoring Well	Farther East of Reclaim PondsPond Apple	26.447039	-82.042662
GW06	Monitoring Well	NE Corner of Murex LakesLake Murex	26.434401	-82.096562
GW07	Monitoring Well	NE Corner of Murex LakesLake Murex	26.434725	-82.09679
GW08	Monitoring Well	SW Corner of Murex LakesLake Murex	26.430139	-82.103857
GW09	Monitoring Well	SW Corner of Murex LakesLake Murex	26.429453	-82.104676
GW10	Monitoring Well	SW Corner Jordan MarshJordan Marsh	26.438558	-82.057874
GW11	Monitoring Well	Mid JMarsh SouthsideJordan Marsh	26.439291	-82.056822
GW12	Monitoring Well	SW Jmarsh Just N of Sanibel SloughJordan Marsh	26.43779	-82.057742
GW13	Monitoring Well	Mid Sanibel Slough and JMarsh East Jordan Marsh	26.438805	-82.056074
GW14	Monitoring Well	Pond Apple Park just off Bailey RdDunes/PondApple	26.448805	-82.040337
GW15	Monitoring Well	South of Lake 7 in TreesSanctuary	26.489616	-82.170759
GW16	Monitoring Well	West of Lake 7 in MangrovesSanctuary	26.490618	-82.173315
GW17	Monitoring Well	The ShackPond Apple	26.444776	-82.046063
GW18	Monitoring Well	Bailey Rd East of Dunes Lake 5Dunes	26.451082	-82.039014
GW19	Monitoring Well	Bay Rd North of Lake 5Dunes	26.455438	-82.041668
GW20	Monitoring Well	NE Lake 5 near Tennis CourtsDunes	26.453699	-82.040941
GW21	Monitoring Well	S of Lake 5 behind house on SandcastleDunes	26.451326	-82.041229
GW22	Monitoring Well	East of Lake 7 off Wulfert RdSanctuary	26.490834	-82.169861
GW23	Monitoring Well	NE Lake 7 off Wulfert RdSanctuary	26.491958	-82.170398
GW24	Monitoring Well	Southern Well Between Sea Oats and Sanibel SloughSea Oats	26.437196	-82.110271
GW25	Monitoring Well	Middle Well Between Sea Oats and Sanibel SloughSea Oats	26.43762	-82.110539
GW26	Monitoring Well	Northern Well Between Sea Oats and Sanibel SloughSea Oats	26.438274	-82.110956

Figure 1. Sampling locations for this study. Lake were sampled at 50 representative sites (green circles) and 26 groundwater monitoring wells were installed at 6 sites (red stars).

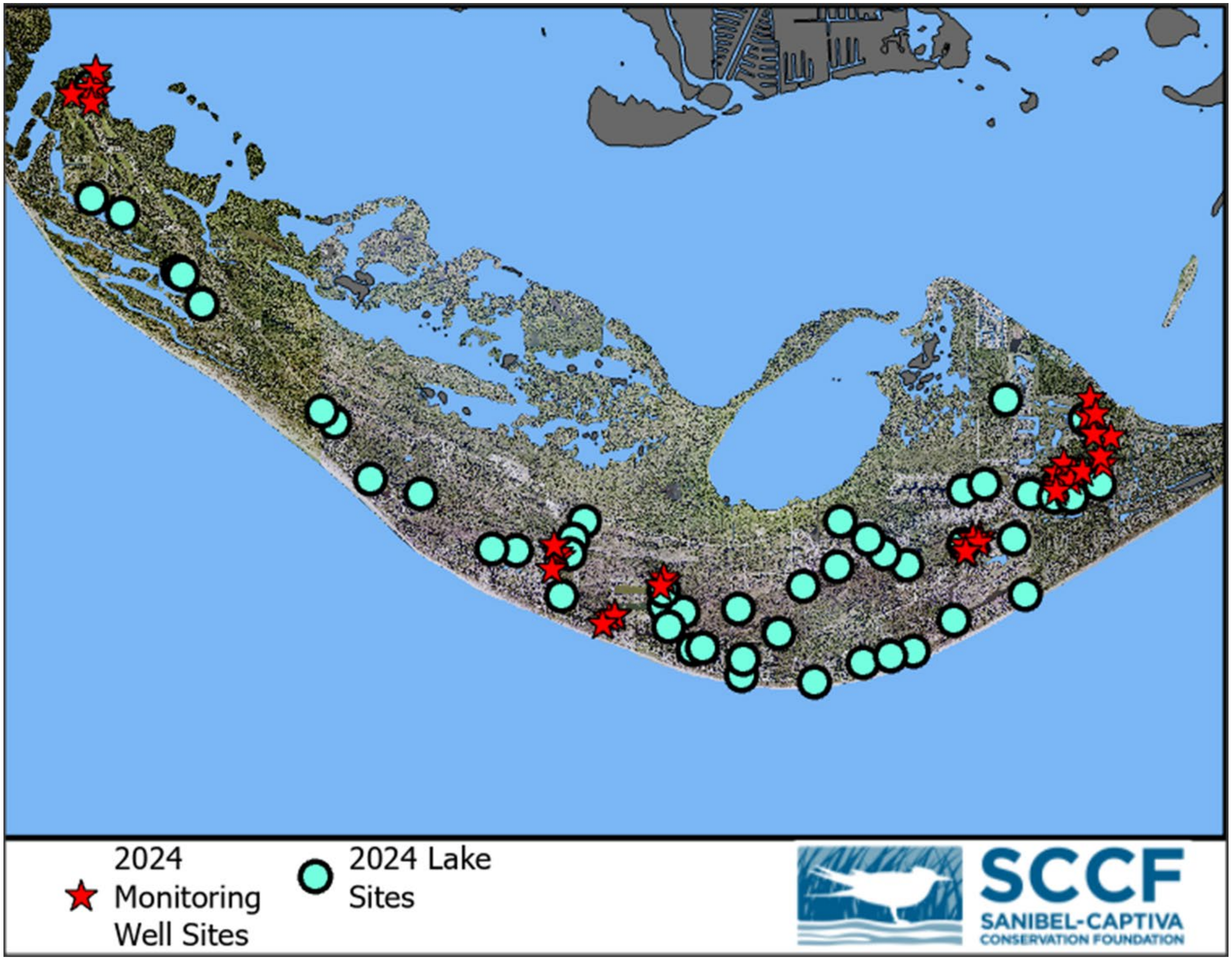


Table 2. Ranking of sample sites from poorest to better water quality showing mean water quality data for 2024. All parameter values shown are averages of wet and dry season results.

Prority Rank	Station	Description	IN (mg/l)	TN (mg/l)	OP (mg/l)	TP (mg/l)	Chla (ug/l)	TSI Score	NH3 (mg/l)	NOx (mg/l)	TKN (mg/l)	Salinity (PSU)	FDOM QSE	DO %	DO mg/l	Turbidity NTU	pH	Water Temp °C	IN Rank	OP Rank	Chla Rank	TSI Rank	Total Rank Score	WQ Trend	2024 Grade	2023 Grade	2020 Grade	2018 Grade	2016 Grade
1	SCL74	Herons Landing Lake	0.608	2.825	0.862	0.708	70.6	91.7	0.538	0.070	2.76	20.2	289.3	38.3	3.1	54.0	7.74	25.4	2	1	19	2	24	Better	F	F	F	F	NR
2	SCL13	SanGolfReclmPnd	0.455	2.480	0.047	1.336	88.4	94.6	0.097	0.358	2.12	2.9	153.9	171.8	13.0	10.1	8.59	27.5	4	15	7	1	27	No Change	F	F	F	F	F
3	SCL60	WhiteIbisGulfPines	0.222	4.360	0.114	0.151	249.2	90.9	0.184	0.038	4.33	7.4	372.4	43.3	3.0	23.5	8.15	30.7	18	5	1	4	28	Worse	F	NR	D	D	C
4	SCL80	East Hollys Pond	0.228	4.770	0.079	0.209	158.7	91.6	0.191	0.038	4.73	15.6	298.4	72.5	4.9	201.7	8.21	31.7	16	8	2	3	29	No Change	F	NR	F	F	NR
5	SCL07	DunesLake5	0.306	3.635	0.126	0.206	78.5	86.6	0.286	0.020	3.62	16.0	250.1	56.0	4.0	7.1	7.93	28.4	9	4	14	8	35	No Change	F	D	F	D	D
6	SCL57	GulfPines Near Tennis Courts	0.171	3.520	0.108	0.112	142.3	82.4	0.137	0.035	3.49	9.9	431.1	31.3	2.2	52.6	8.06	30.7	27	6	3	12	48	Worse	F	NR	D	D	C
7	SCL26	CasaYbel	0.2465	2.305	0.033	0.196	86.4	83.2	0.227	0.020	2.29	16.9	150.5	92.6	6.3	32.5	8.09	27.8	12	21	8	11	52	No Change	F	C	D	D	D
8	West SanSlough	West Basin Sanibel Slough monthly data	0.290	3.121	0.038	0.110	81.7	78.0	0.255	0.035	3.08	13.7		26.4	2.0	29.8	8.0	26.9	10	17	11	17	55	No Change	D	F	D	D	C
9	SCL19	GulfsidePark_1 Off Parking Lot	0.346	2.890	0.015	0.426	106.4	90.4	0.317	0.029	2.87	26.7	369.2	10.5	0.7	21.1	7.74	29.7	8	37	6	5	56	Worse	F	NR	C	C	C
10	SCL05	CityReclaimDschrge	0.3995	1.930	0.028	1.028	73.5	88.0	0.085	0.315	1.62	5.6	130.6	141.6	10.5	21.3	8.17	28.8	6	27	17	6	56	No Change	F	F	F	F	F
11	SCL69	SanctuaryLake4	0.5105	2.515	0.055	0.238	38.3	80.7	0.490	0.021	2.49	4.2	282.4	33.3	2.4	10.6	7.83	31.5	3	11	33	15	62	No Change	D	NR	F	F	F
12	SCL41	HurricaneLane at Dock	0.1345	3.290	0.100	0.090	109.7	80.3	0.086	0.049	3.24	7.8	189.0	102.1	7.2	21.8	8.49	31.9	35	7	5	16	63	No Change	D	NR	C	C	C
13	SCL08	DunesLake4	0.4045	2.690	0.033	0.167	56.4	81.4	0.375	0.030	2.66	17.7	225.3	61.1	4.9	9.0	7.89	24.9	5	20	27	13	65	No Change	F	F	D	F	D
14	SCL45	NPoincianaPond Poinciana off Island Inn	0.1915	2.060	0.062	0.063	83.2	75.7	0.175	0.017	2.04	9.7	337.9	19.2	1.4	51.6	7.95	31.2	24	9	10	23	66	No Change	D	NR	C	C	C
15	SCL71	SanctuaryLake7	0.16	2.690	0.048	0.235	74.4	84.1	0.141	0.020	2.67	2.1	259.4	106.5	8.2	13.0	8.61	29.4	29	14	16	9	68	No Change	F	D	F	F	F
16	Devitt01	Pond at SCCF Homestead	0.1175	2.94	0.053	0.192	84.0	83.45	0.099	0.019	2.92	4.5	299.1	56.4	4.75	31.2	7.80	24.1	40	13	9	10	72	Worse	F	F	D	D	C
17	SCL15	PanamaCanal	0.1965	2.400	0.054	0.100	72.5	76.7	0.172	0.025	2.38	14.9	200.4	54.4	4.1	14.9	7.88	26.2	23	12	18	20	73	No Change	D	C	F	D	D
18	SCL32	AniPondBailyTract	0.166	7.270	0.019	0.123	113.5	86.8	0.127	0.040	7.20	17.9	369.1	68.7	4.8	116.4	8.38	30.3	28	35	4	7	74	No Change	F	NR	D	F	D
19	East SanSlough	East Basin Sanibel Slough monthly data	0.223	2.040	0.057	0.123	66.2	75.30	0.201	0.022	2.02	10.6		36.7	2.8	17.5	8.0	27.5	17	10	23	25	75	No Change	D	F	D	D	D
20	SCL35	SeagullEstates - Daniel Lane _ western small lake	0.15	2.280	0.038	0.079	80.7	77.1	0.134	0.017	2.26	19.3	312.4	177.2	11.2	11.7	8.32	34.5	32	18	12	19	81	No Change	D	NR	F	F	F
21	SCL62	ChateauSurMerLake	0.2685	2.405	0.022	0.081	68.6	77.4	0.249	0.020	2.39	6.1	315.3	66.8	5.1	16.3	8.17	27.3	11	34	21	18	84	Worse	D	D	D	D	C
22	SCL43	PalmLake	0.237	2.345	0.025	0.051	74.8	74.6	0.211	0.026	2.32	14.4	164.3	98.0	7.5	10.4	8.20	26.0	13	32	15	26	86	No Change	D	D	C	C	C
23	SCL82	Pond Behind Jacaranda	0.0905	1.720	0.203	0.214	61.0	80.7	0.069	0.022	1.70	9.1	191.2	47.7	4.1	16.6	7.51	30.7	44	3	26	14	87	No Change	D	D	F	A	NR
24	SCL27	CityHall	0.8225	1.870	0.287	0.212	10.4	72.0	0.750	0.073	1.80	24.5	309.4	39.2	3.1	13.0	7.53	25.1	1	2	49	35	87	No Change	D	D	C	C	C
25	SCL02	BeachRdVillasPnd	0.157	2.300	0.047	0.074	68.2	75.65	0.137	0.020	2.28	13.2	204.10	43.4	3.6	11.8	7.8	26.8	31	16	22	24	93	Worse	D	D	B	C	B

Table 2 (cont.). Ranking of sample sites from poorest to better water quality showing mean water quality data for 2024. All parameter values shown are averages of wet and dry season results.

Prority Rank	Station	Description	IN (mg/l)	TN (mg/l)	OP (mg/l)	TP (mg/l)	Chla ug/l	TSI	NH3 (mg/l)	NOx (mg/l)	TKN (mg/l)	Salinity (PSU)	CDOM Lab QSE	DO %	DO mg/l	Turbidity NTU	pH	Water Temp C	IN Rank	OP Rank	Chla Rank	TSI Rank	Total Rank Score	WQ Trend	WQ Grade	2023 Grade	2020 Grade	2018 Grade	2016 Grade
26	SCL70	BluCrabLake	0.176	2.455	0.027	0.094	66.1	76.4	0.163	0.014	2.44	27.6	265.0	113.5	7.0	16.6	9.42	33.4	26	29	24	21	100	No Change	D	NR	D	F	F
27	SCL48	SLakeMurex	0.3785	2.480	0.022	0.076	35.3	74.0	0.362	0.017	2.47	23.7	138.2	107.4	7.2	5.8	8.52	29.1	7	33	37	31	108	Worse	D	D	D	C	C
28	SCL56	WRockEastEndCoquina	0.1215	2.360	0.037	0.077	40.3	74.3	0.101	0.021	2.34	12.8	219.8	56.7	4.1	18.6	8.17	26.1	37	19	31	30	117	Worse	D	D	C	D	C
29	SCL21	OceansReachCondo	0.055	1.980	0.030	0.143	69.8	74.3	0.038	0.017	1.97	24.7	170.3	79.6	5.2	154.1	8.09	31.0	50	26	20	28	124	No Change	D	NR	B	C	C
30	SCL23	PeriwinklePlaceSW	0.1115	1.810	0.027	0.104	64.9	74.3	0.070	0.042	1.77	4.7	189.1	55.6	4.1	19.7	7.92	30.8	41	30	25	29	125	No Change	D	NR	C	C	B
31	SCL10	WhsperwdPond	0.124	2.225	0.031	0.078	37.2	73.3	0.112	0.012	2.22	21.9	199.2	42.2	2.7	7.4	7.35	32.2	36	24	35	33	128	No Change	D	NR	D	C	D
32	SCL53	SeaOatsDrSmlLake	0.14	1.670	0.032	0.047	44.2	69.4	0.126	0.015	1.66	5.4	163.4	70.4	5.0	27.1	8.30	31.3	34	22	30	42	128	No Change	C	NR	C	C	C
33	SCL50	StIsabelCathChrch	0.121	2.505	0.013	0.094	51.0	76.4	0.100	0.022	2.49	11.2	193.6	68.0	5.0	25.0	8.50	27.5	38	43	28	22	131	No Change	D	F	F	F	D
34	SCL28	SanComAssPark In Park Behind Sanibel ComHouse	0.204	4.540	0.014	0.050	27.5	73.4	0.191	0.013	4.53	10.0	409.9	37.8	2.7	3.5	7.70	30.2	22	40	42	32	136	Worse	D	NR	D	C	C
35	SCL04	PrwnklePrkRVPond	0.1045	2.070	0.005	0.078	79.3	72.60	0.084	0.021	2.05	6.2	271.00	46.3	3.3	17.4	7.6	31.1	42	47	13	34	136	No Change	D	NR	F	F	D
36	SCL37	SmithLkBaileyTrct	0.1765	3.475	0.028	0.036	27.5	69.2	0.155	0.022	3.45	18.4	414.6	36.6	3.0	13.4	8.06	25.5	25	28	41	43	137	No Change	C	C	C	D	C
37	SCL18	SanibelLakeEst 1806_IbisLn_or_1995_Roseate	0.2175	2.030	0.010	0.051	37.8	69.6	0.195	0.023	2.01	17.0	354.9	36.5	2.5	8.8	7.55	30.3	20	45	34	40	139	No Change	C	NR	C	C	C
38	SCL51	NBikePathlake	0.2205	2.315	0.010	0.047	35.6	69.5	0.210	0.011	2.31	24.8	208.6	56.7	3.7	9.7	7.67	32.3	19	44	36	41	140	No Change	C	NR	F	D	D
39	DL09	Dunes Lake 9 Pelican Dr	0.157	2.6	0.031	0.0545	17.9	68.7	0.146	0.011	2.59	20.2	200.1	74.3	4.9	3.5	7.83	31.9	30	23	46	44	143	No Change	C	NR	NR	NR	NR
40	SCL30	Pointe Santos	0.0775	2.135	0.019	0.102	33.5	74.4	0.056	0.022	2.11	8.5	91.4	59.6	4.7	9.3	7.85	26.8	45	36	39	27	147	Worse	D	D	C	D	C
41	SCL55	ERockWestEndCoquina	0.237	2.050	0.009	0.034	24.7	66.2	0.218	0.020	2.03	8.7	332.6	60.5	4.9	39.2	8.08	25.2	14	46	45	45	150	No Change	C	D	C	D	C
42	SCL11	GumboLimboEast	0.1425	1.790	0.015	0.031	39.3	65.2	0.111	0.032	1.76	12.4	232.1	43.3	3.4	6.5	7.62	27.8	33	38	32	48	151	Better	C	C	D	D	D
43	SCL31	BaileysPond	0.076	1.685	0.014	0.056	50.5	71.2	0.059	0.018	1.67	11.5	225.8	36.6	3.0	27.6	7.46	26.0	46	41	29	37	153	No Change	D	D	C	C	C
44	SCL36	SandPointe	0.208	2.010	0.003	0.221	14.5	71.6	0.174	0.035	1.98	28.0	150.1	138.1	9.7	8.3	8.50	27.6	21	50	47	36	154	Better	D	C	F	F	F
45	JM02	Jordan Marsh Effluent	0.0735	2.51	0.031	0.054	26.3	69.9	0.055	0.019	2.50	4.2	192.13	106.7	7.95	10.9	8.461	29.1	48	25	43	38	154	No Change	C	D	NR	NR	NR
46	SCL52	SBikePathLake	0.121	2.310	0.015	0.050	27.8	69.8	0.107	0.015	2.30	24.5	191.9	83.7	5.4	2.7	7.93	32.3	39	39	40	39	157	No Change	C	NR	F	F	D
47	SCL64	TradewindsNLake	0.2335	1.305	0.004	0.076	11.7	63.5	0.219	0.015	1.29	2.1	211.8	115.4	9.8	37.8	8.54	24.2	15	49	48	49	161	Better	C	C	D	D	D
48	SCL47	NlakeMurex	0.0755	2.365	0.027	0.027	33.9	65.4	0.061	0.015	2.35	30.9	108.4	97.7	6.1	43.8	8.23	31.2	47	31	38	46	162	Better	C	NR	D	D	D
49	SCL25	PeriwinklePinesSW	0.098	1.960	0.005	0.032	24.7	65.4	0.087	0.011	1.95	6.6	226.6	52.6	3.8	5557.0	7.73	30.5	43	48	44	47	182	No Change	C	NR	C	D	C
50	SCL16	SundialEast	0.0625	1.381	0.014	0.024	7.6	53.3	0.048	0.015	1.37	6.8	90.7	113.1	7.9	23.4	8.83	30.9	49	42	50	50	191	Better	B	NR	D	F	D

Figure 2. Boxplot of mean salinity values for lakes sampled for the Sanibel Communities for Clean Water project during the period 2016 through 2024. Hurricane Ian immediately changed freshwater systems to marine systems. The mean salinity dropped significantly in the 2 years post Ian but storm surges from TS Debbie, and Hurricanes Helene and Milton have increased salinity again.

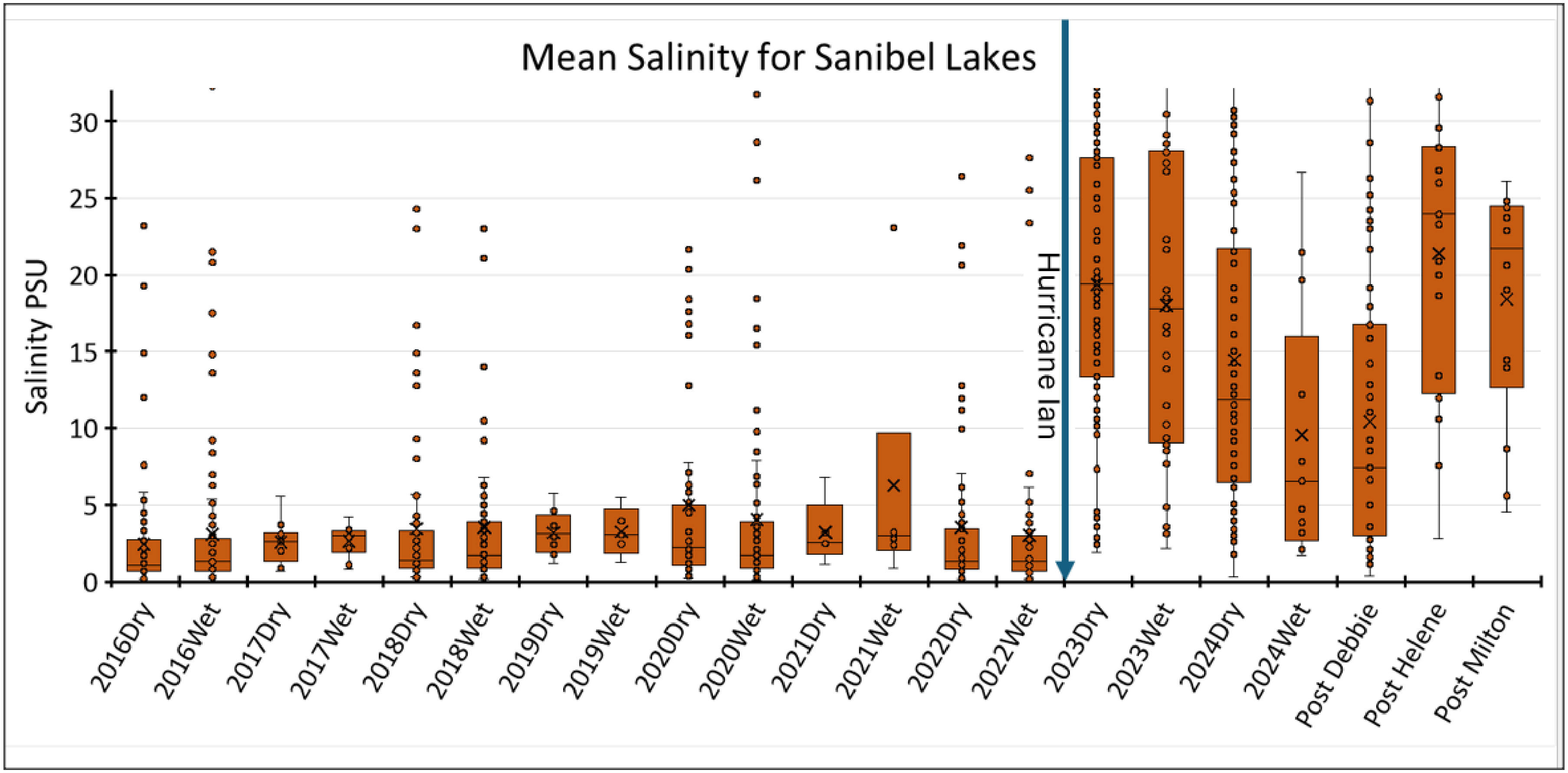
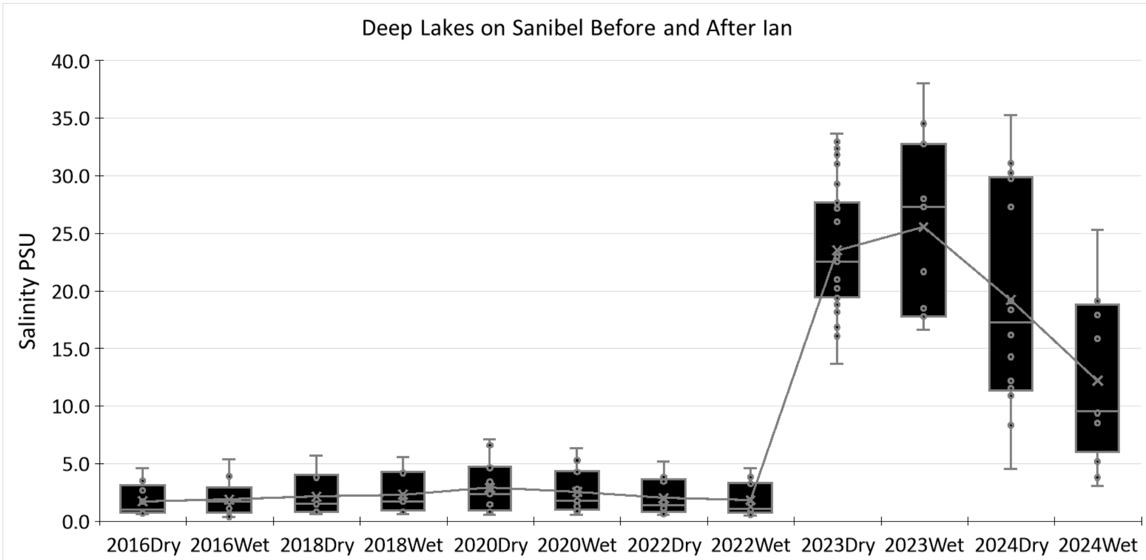


Figure 3. Change in salinity for deep lakes, shallow lakes and lakes which have reclaimed water irrigation in watershed.



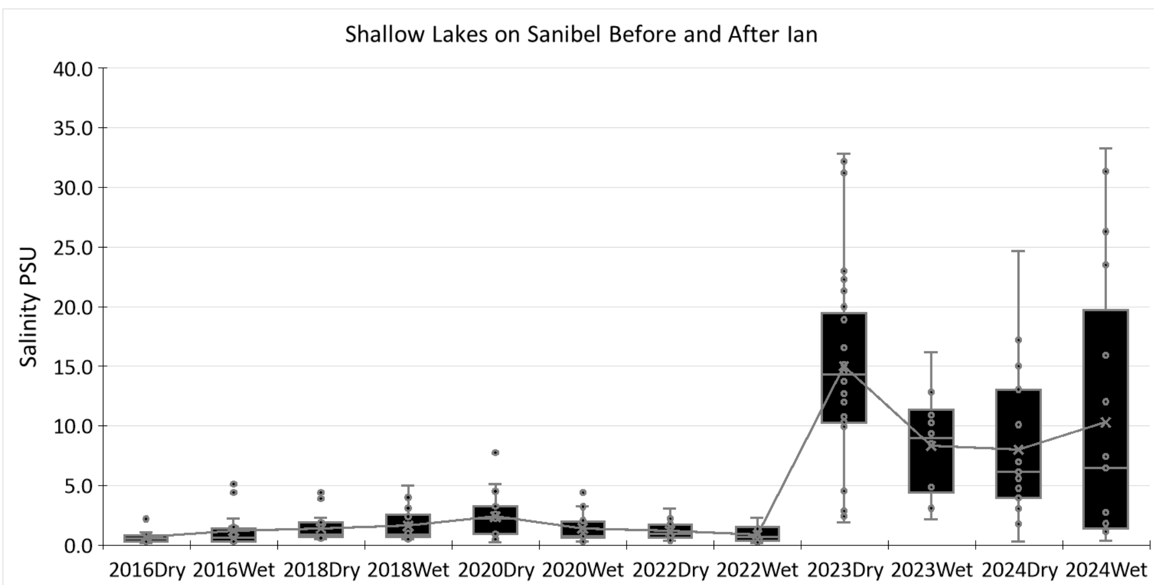
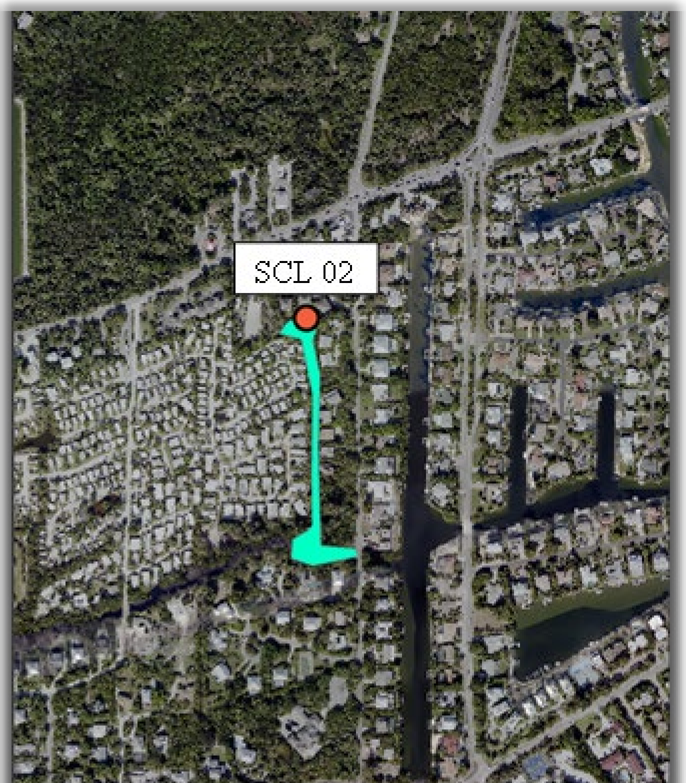


Figure 4. Sites and areas where salinity increased after Hurricane Debby Surge. Red dots are sites with relative % increase in salinity shown by size. Green polygon is estimated minimum surge area using salinity change in lakes to estimate range.



SiteID	Site	Lat	Long	% Increase In Salinity From Dry To Wet Season
SCL02	BeachRdVillasPnd	26.44554	-82.04058	90
SCL05	CityReclaimDschrge	26.44571	-82.04570	19
SCL15	PanamaCanal	26.42978	-82.05942	14
SCL16	SundialEast	26.43266	-82.0501	360
SCL19	GulfsidePark_1 Off Parking Lot	26.42619	-82.0646	16
SCL21	OceansReachCondo	26.42559	-82.0676	360
SCL26	CasaYbel	26.42493	-82.07111	550
SCL30	Pointe Santos	26.42268	-82.07734	87
SCL35	SeagullEstates - Daniel Lane _ western small lake	26.4252	-82.0865	57
SCL36	SandPointe	26.42337	-82.08674	27
SCL74	Herons Landing Lake	26.47001	-82.15974	16
SCL80	East Hollys Pond	26.46967	-82.159	5

Figure 5. Water level above ground surface at 6 monitoring sites during Hurricane Helene. All six sites were inundated with surge water from the Gulf.

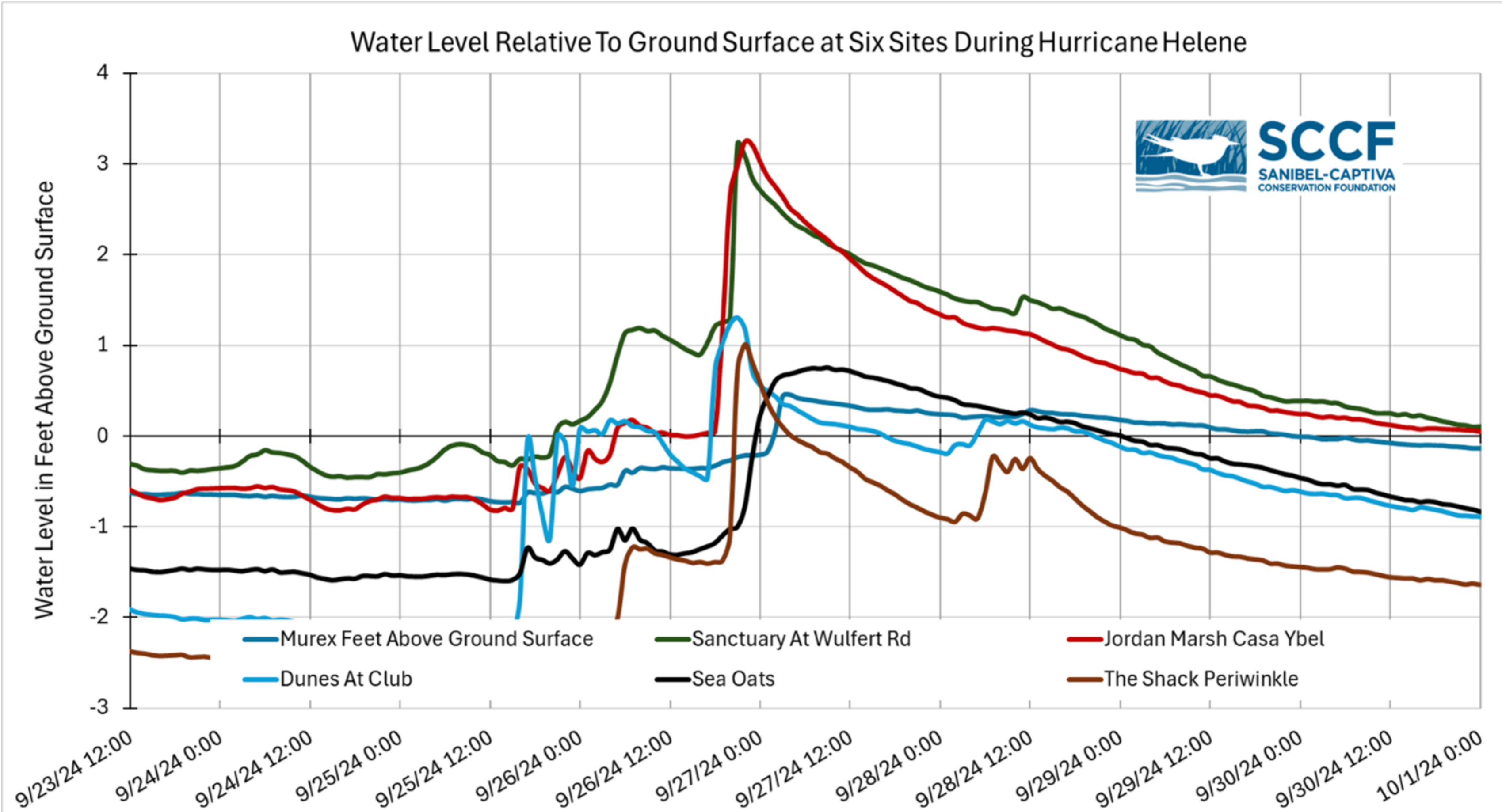


Figure 6. Water level above ground surface at 6 monitoring sites during Hurricane Milton. All six sites were inundated with surge water from the Gulf.

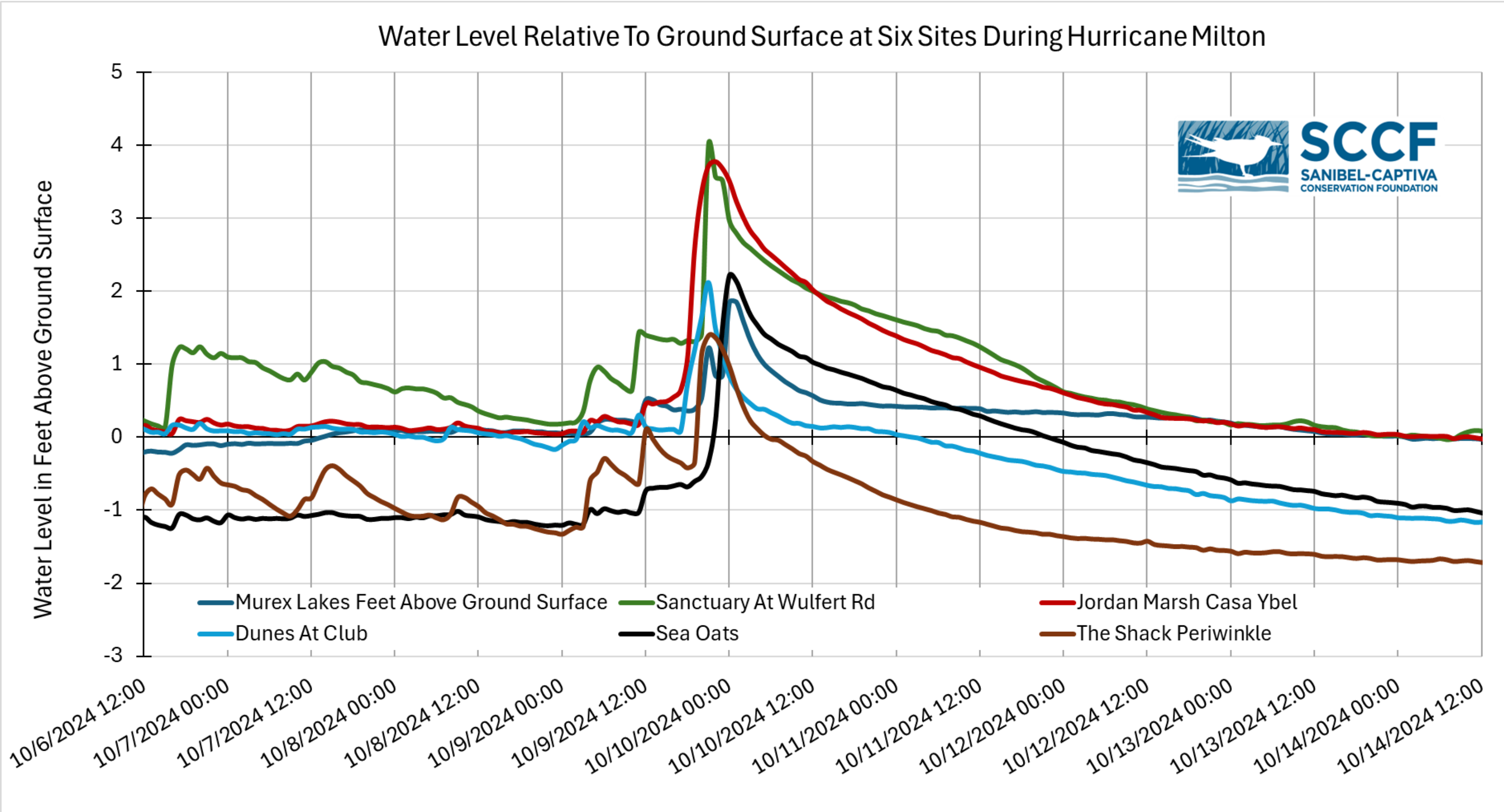
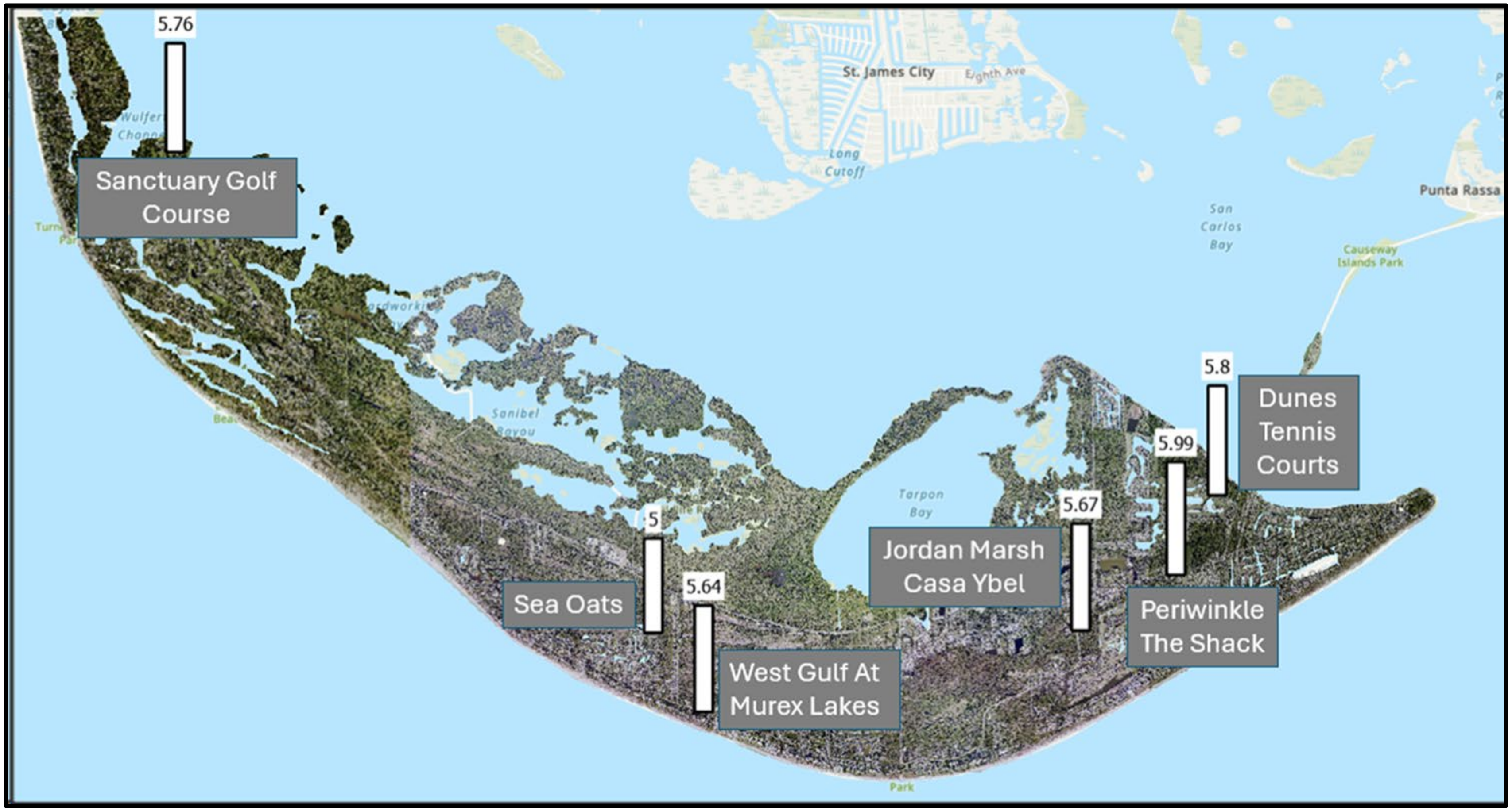
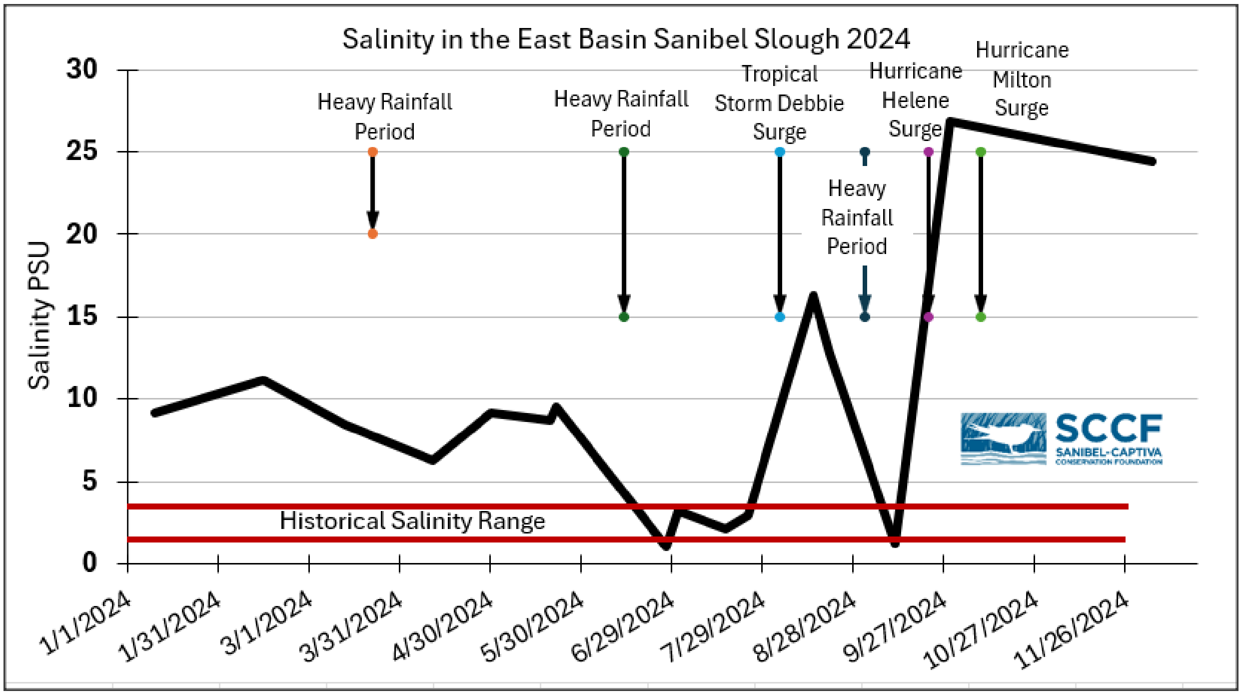


Figure 7. Figure shows storm surge depths during Hurricane Milton in **feet** calculated from depth logger readings at 6 sites located across Sanibel. Storm surge is the depth above the predicted tide at the time and location of the surge. Table shows data used in calculation.



Site	Date	Time	Milton Max Water Elevation (m) NAVD88	Milton Max Water Elevation (m) MLLW	Description	Lat	Long	Predicted Tide m MLLW	Estimated Depth Above Predicted Tide at Location m	Estimated Depth above Predicted Tide at Location ft	Water Depth above Ground Level ft
GW26	10/9/2024	23:00	1.61	2.193	Sea Oats	26.438274	-82.110956	0.67	1.52	5.00	2.5
GW10	10/9/2024	22:00	1.76	2.368	Jordan Marsh	26.438558	-82.057874	0.64	1.73	5.67	3.82
GW20	10/9/2024	21:00	1.813	2.377	Dunes Tennis Courts	26.453699	-82.040941	0.61	1.77	5.80	2.12
GW09	10/9/2024	21:00	1.742	2.328	West Gulf Road Murex Lakes	26.429453	-82.104676	0.61	1.72	5.64	-0.39
GW23	10/9/2024	21:00	1.8333	2.365	Sanctuary GC Path at Wulfertt Rd.	26.491958	-82.170398	0.61	1.76	5.76	4.01
GW17	10/9/2024	21:00	1.837	2.437	Periwinkle Drive At "The Shack"	26.444776	-82.046063	0.61	1.827	5.99	1.4

Figure 8. Salinity in the eastern and western basins of the Sanibel Slough. After hurricanes Ian, Helen and Milton the salinity of these waterbodies increased to well above the historical salinity range (red lines).



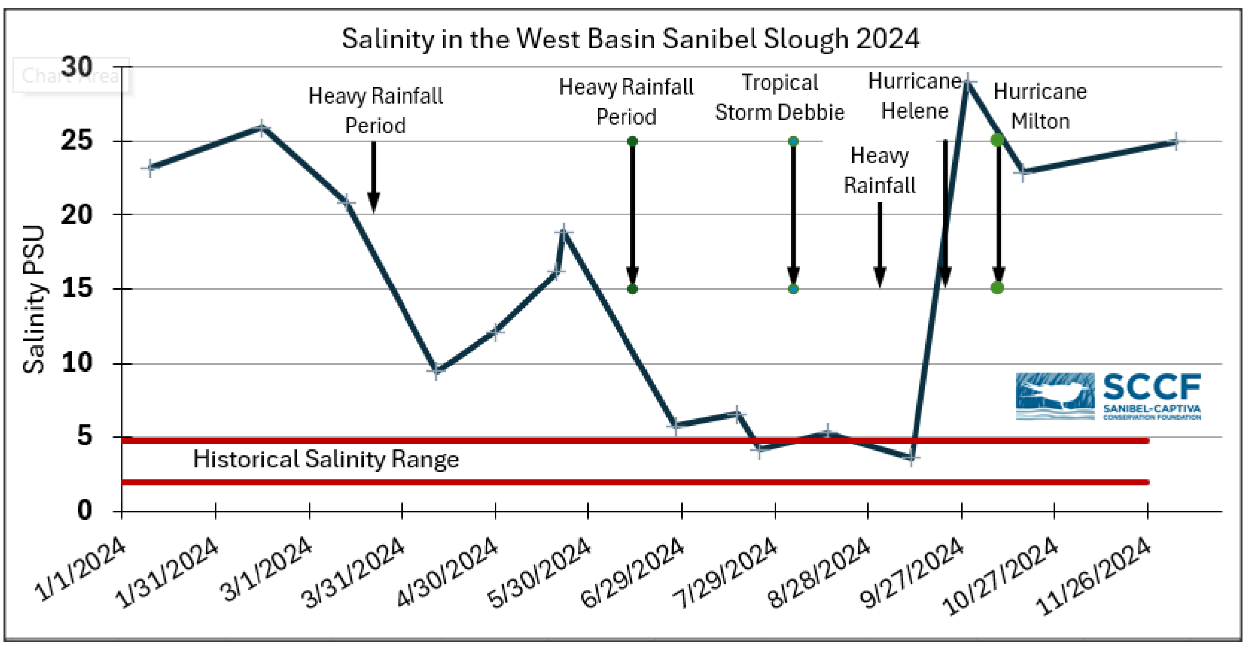


Figure 9. Salinity in the Donax WWTP reclaimed wastewater ponds at Pond Apple Park. A salinity under 2 PSU is considered freshwater (red line). After hurricanes Ian, Helen and Milton the salinity of the reclaimed water increased to levels well above freshwater. The dots are samples taken at the wastewater treatment facility influent and effluent lines.

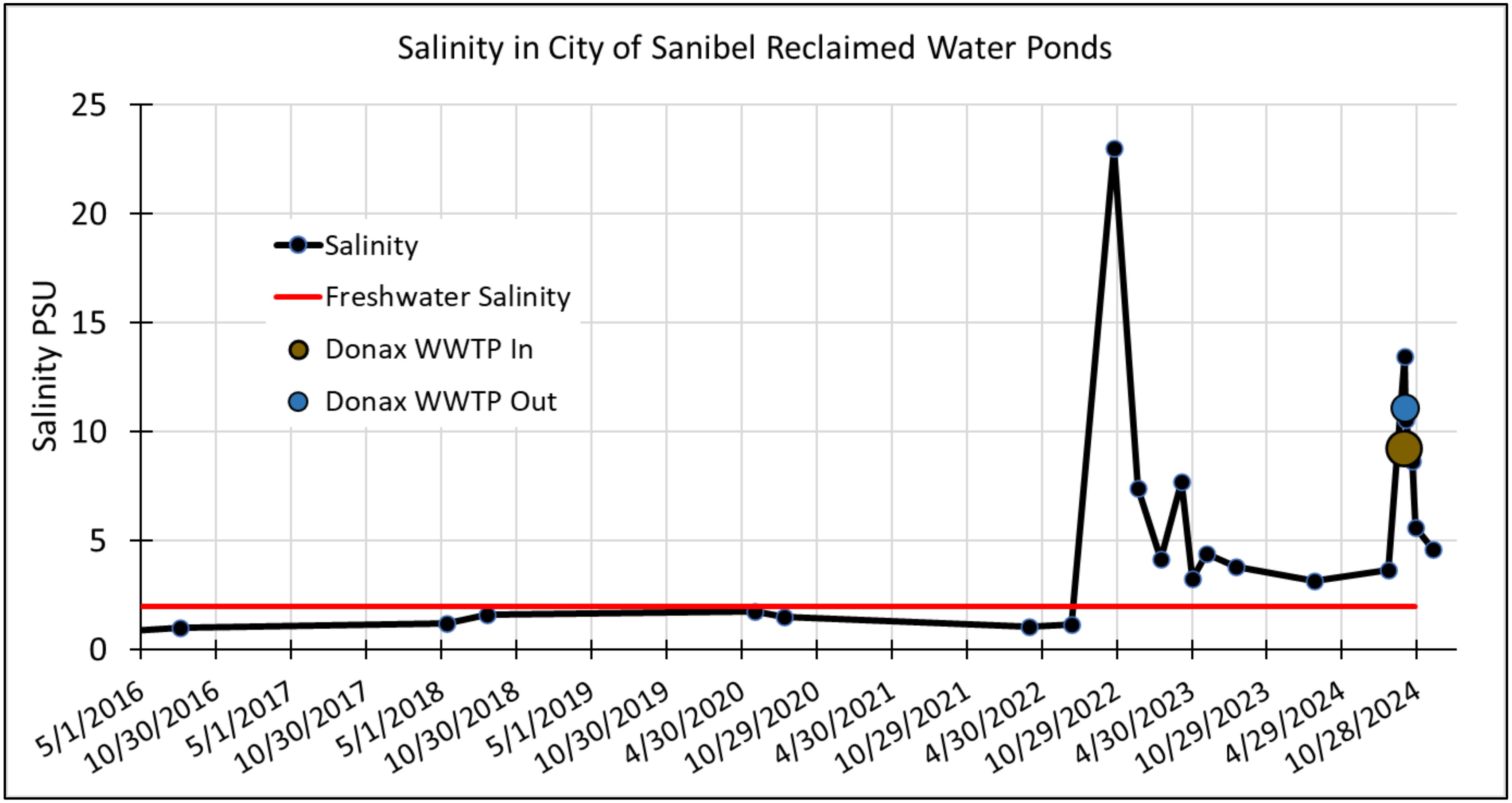


Figure 10. Time series of average pH for monitored lakes showing effects of storm surges in 2022 and 2024.

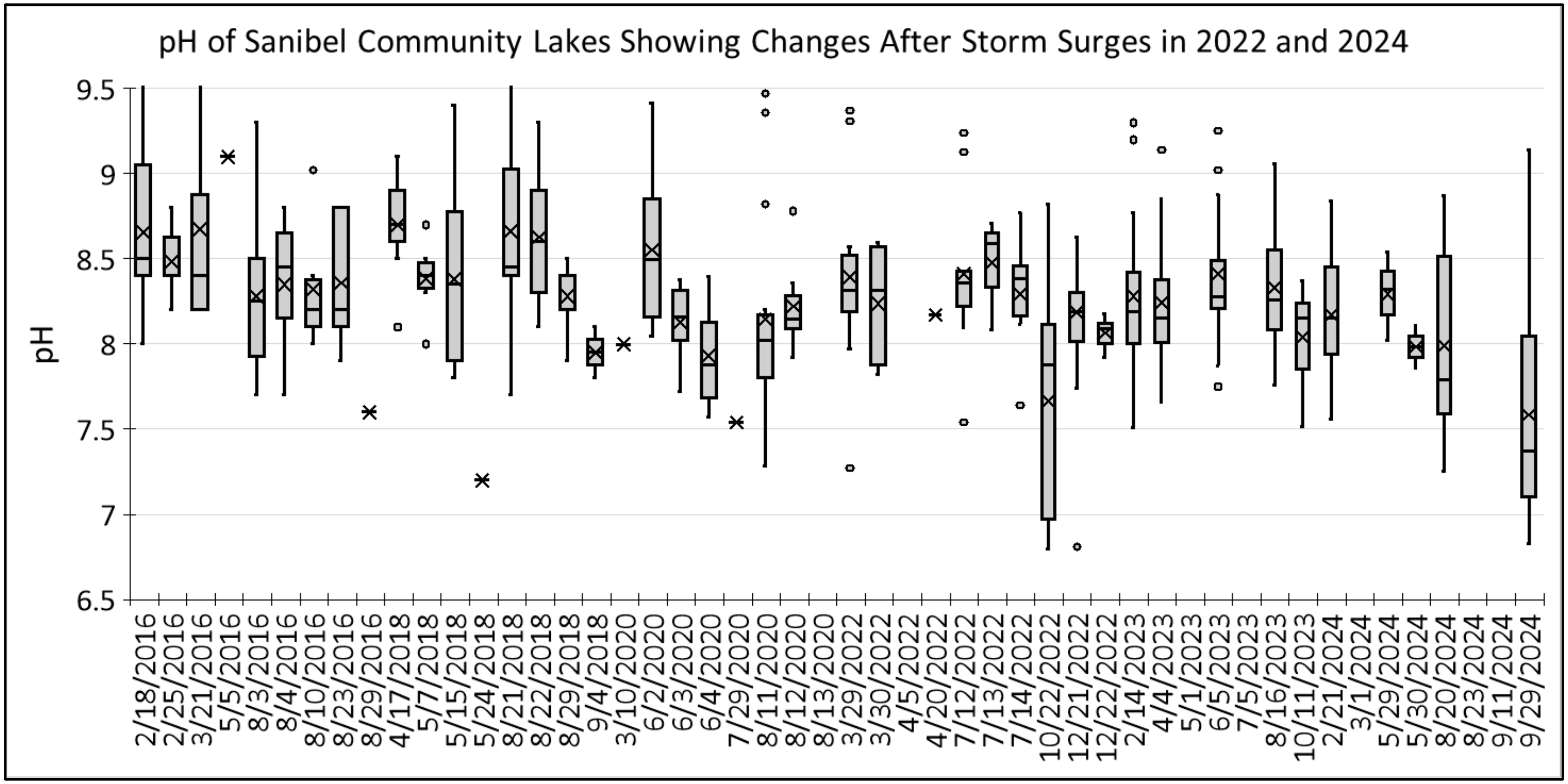


Figure 11. Boxplot of mean chlorophyll *a* concentration per season for the lakes sampled during the Sanibel Communities for Clean Water project.

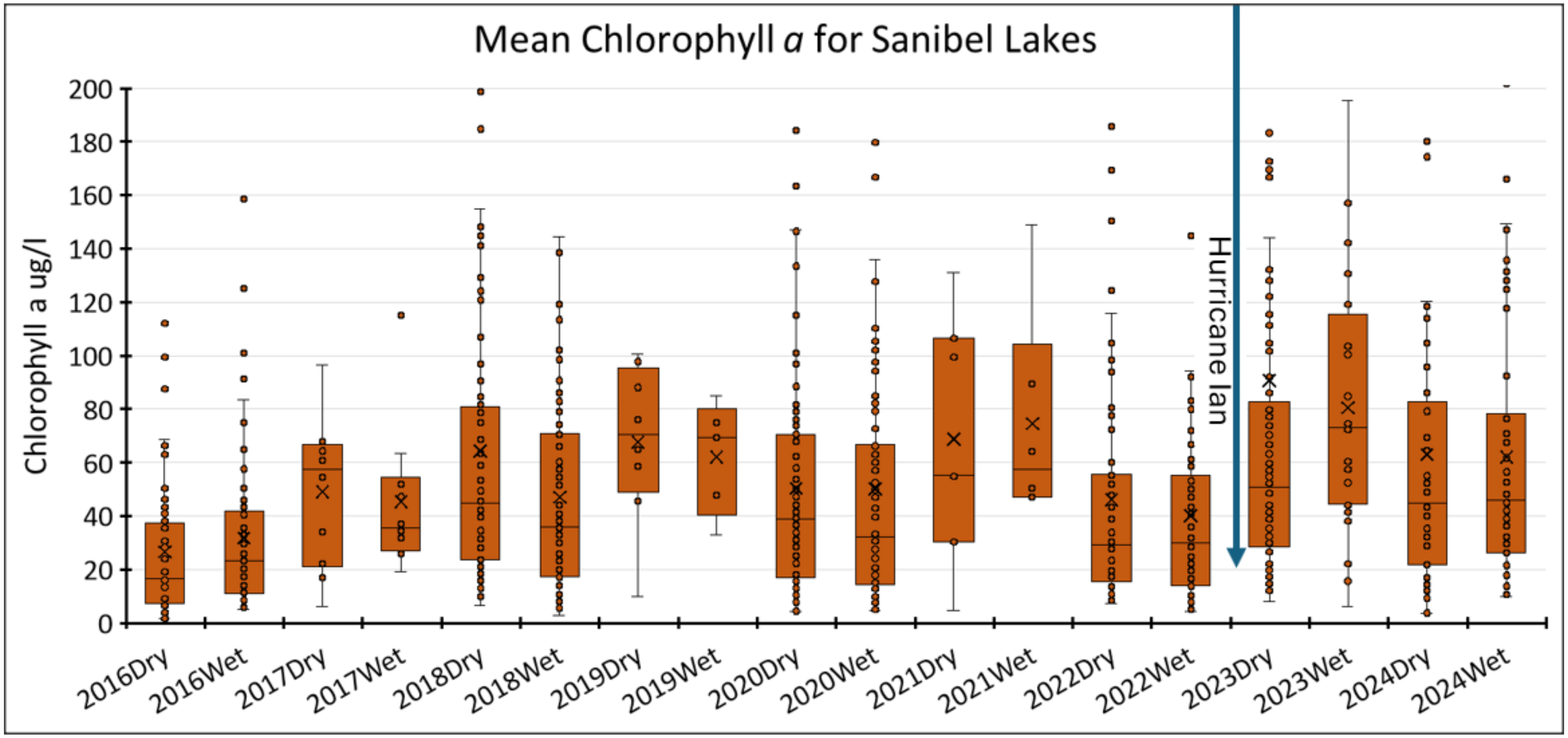


Figure 12. Boxplot of mean total phosphorus concentration per season for the lakes sampled during the Sanibel Communities for Clean Water project.

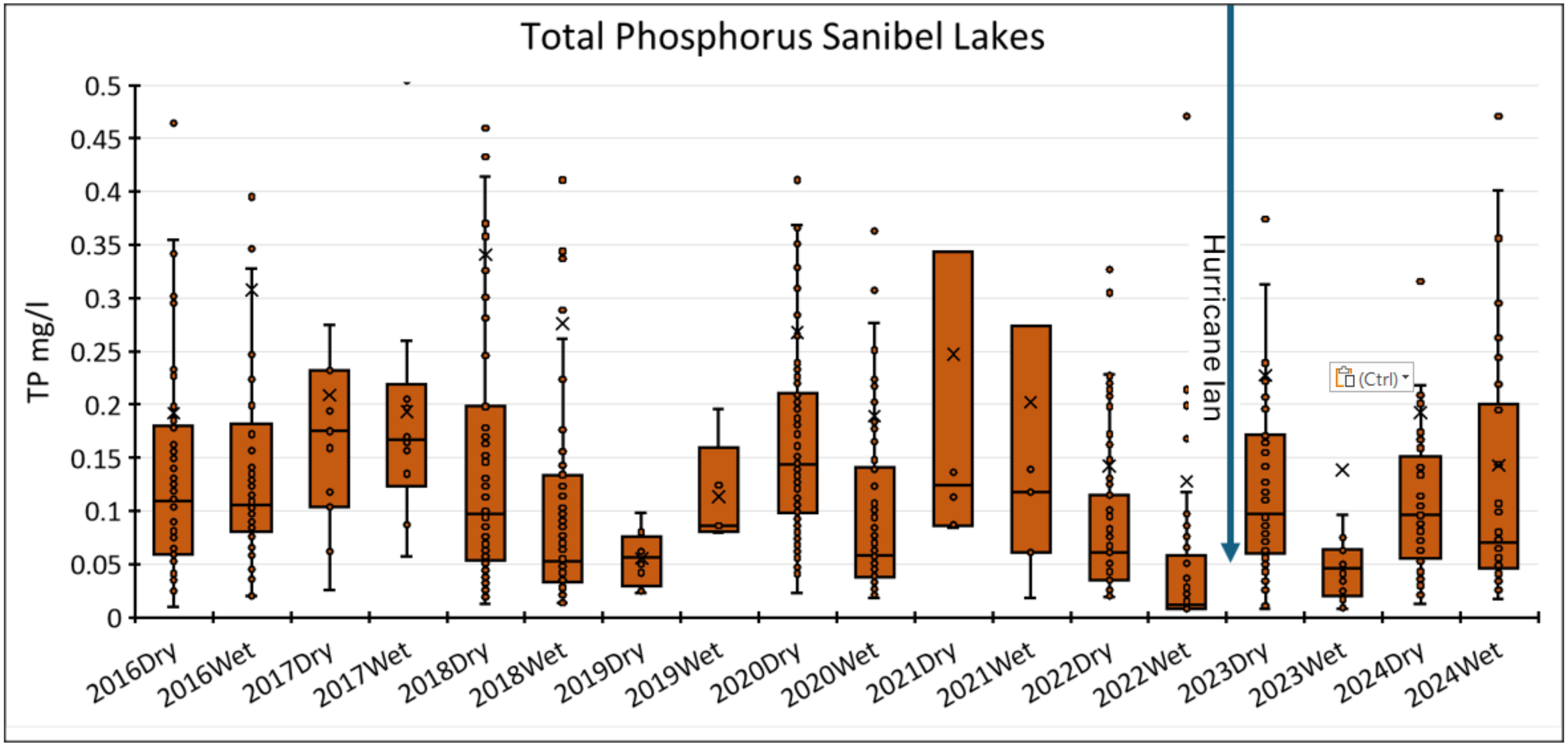


Figure 13. Boxplot of mean total nitrogen concentration per season for the lakes sampled during the Sanibel Communities for Clean Water project.

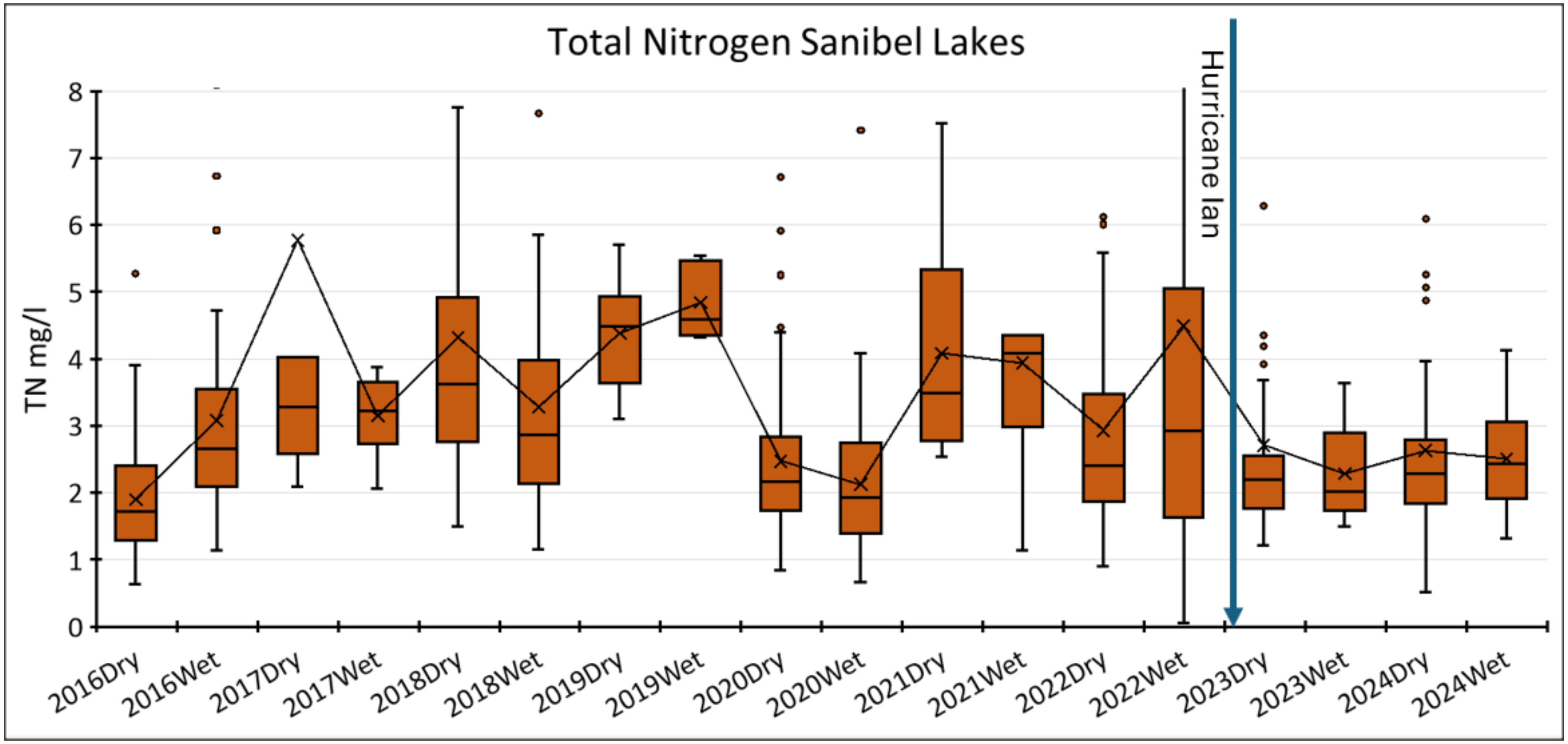


Figure 14. Boxplot of mean inorganic nitrogen concentration per season for the lakes sampled during the Sanibel Communities for Clean Water project.

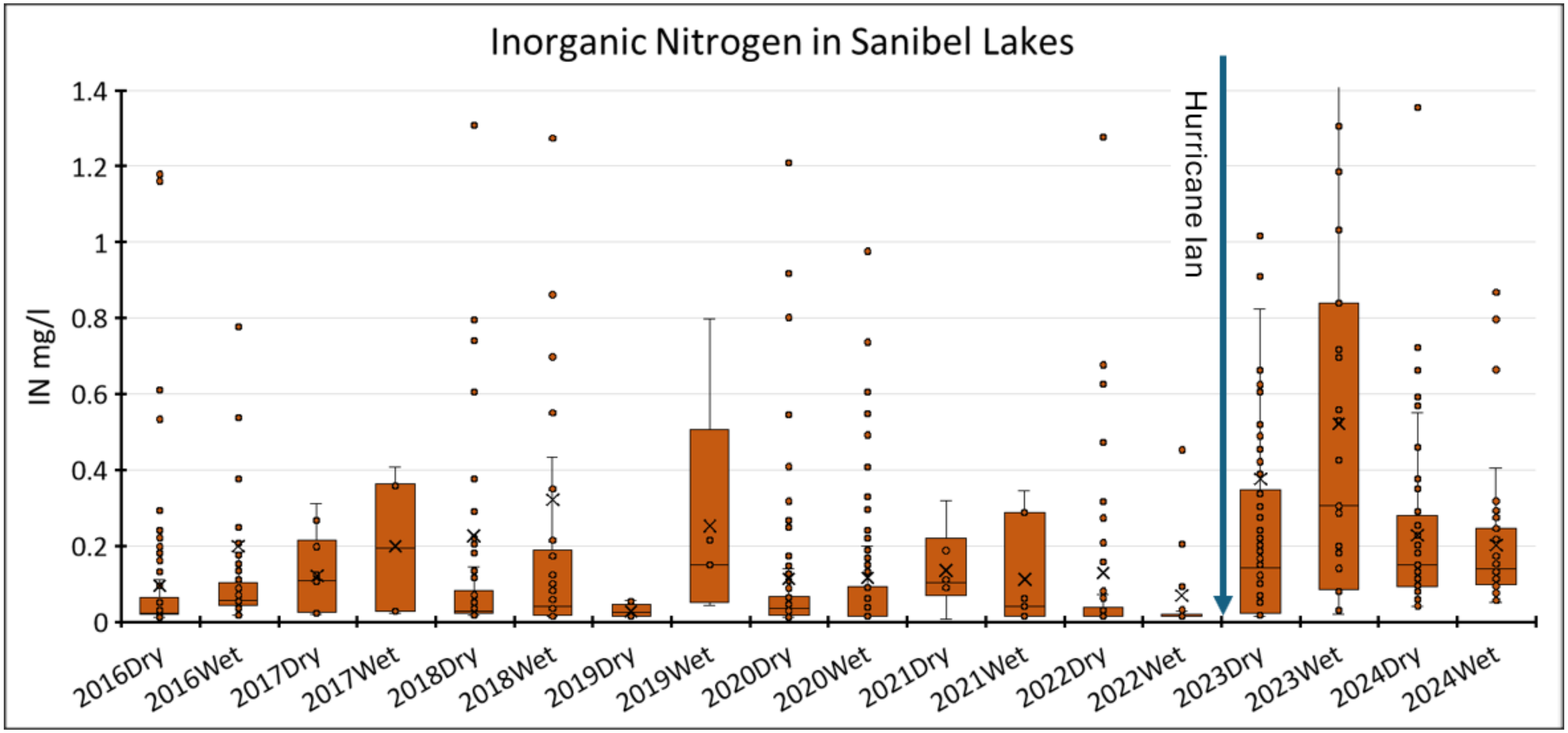


Figure 15. Boxplot of mean trophic state index (TSI) per season for the lakes sampled during the Sanibel Communities for Clean Water project.

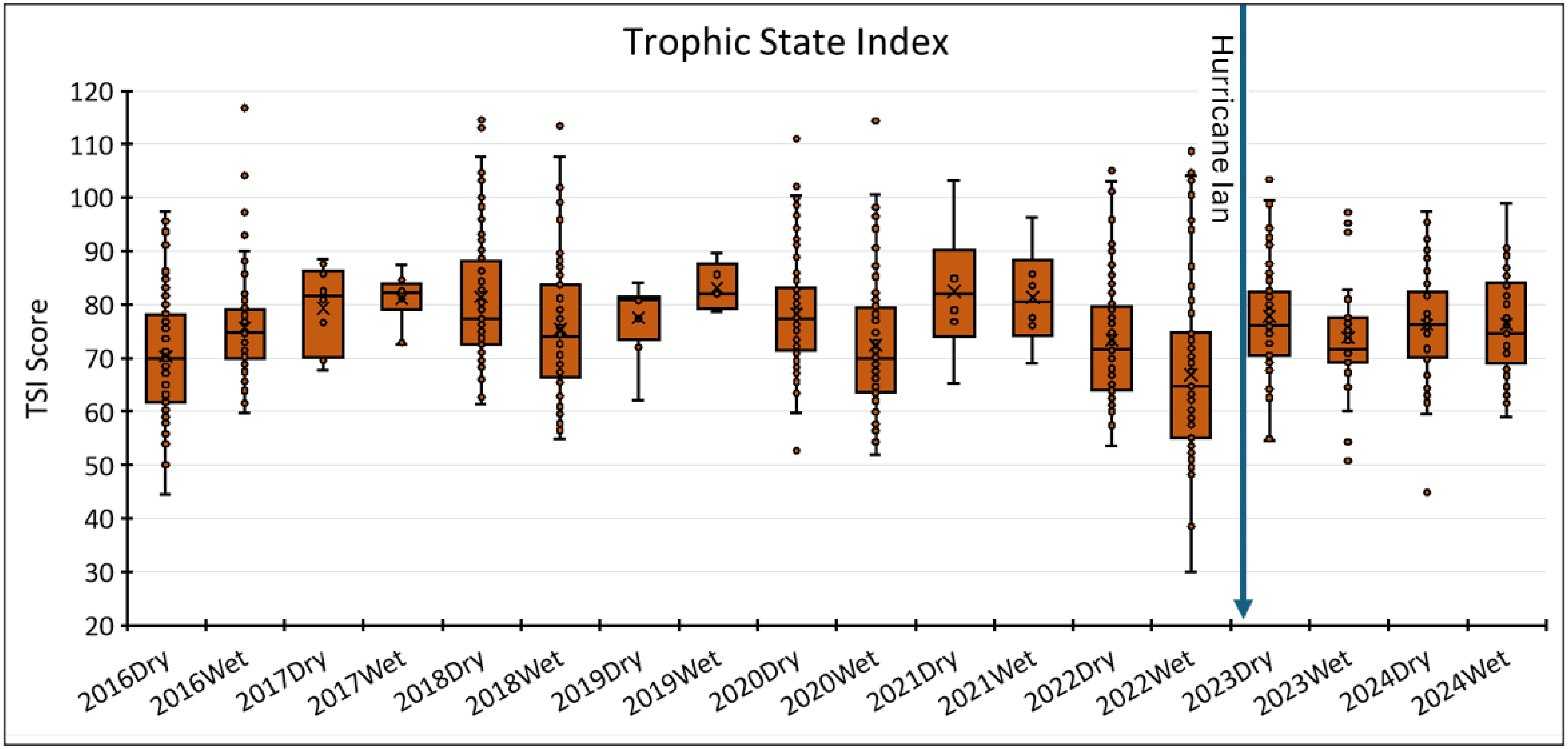


Figure 16. Boxplot of mean fluorometric dissolved organic matter (FDOM) per season for the lakes sampled during the Sanibel Communities for Clean Water project.

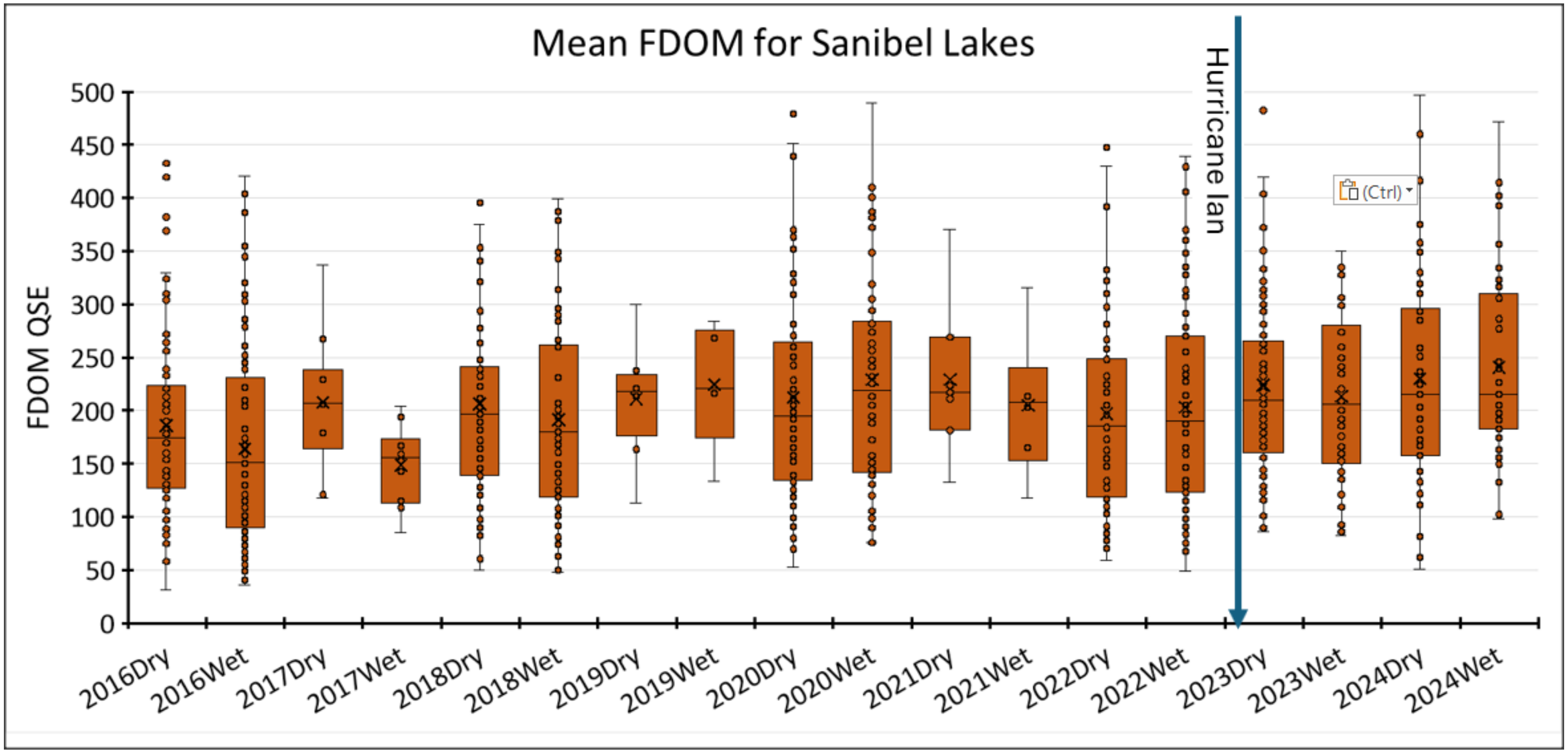


Figure 17. Time series boxplot of Turbidity for the lakes in this study for all periods sampled during the Sanibel Communities for Clean Water project

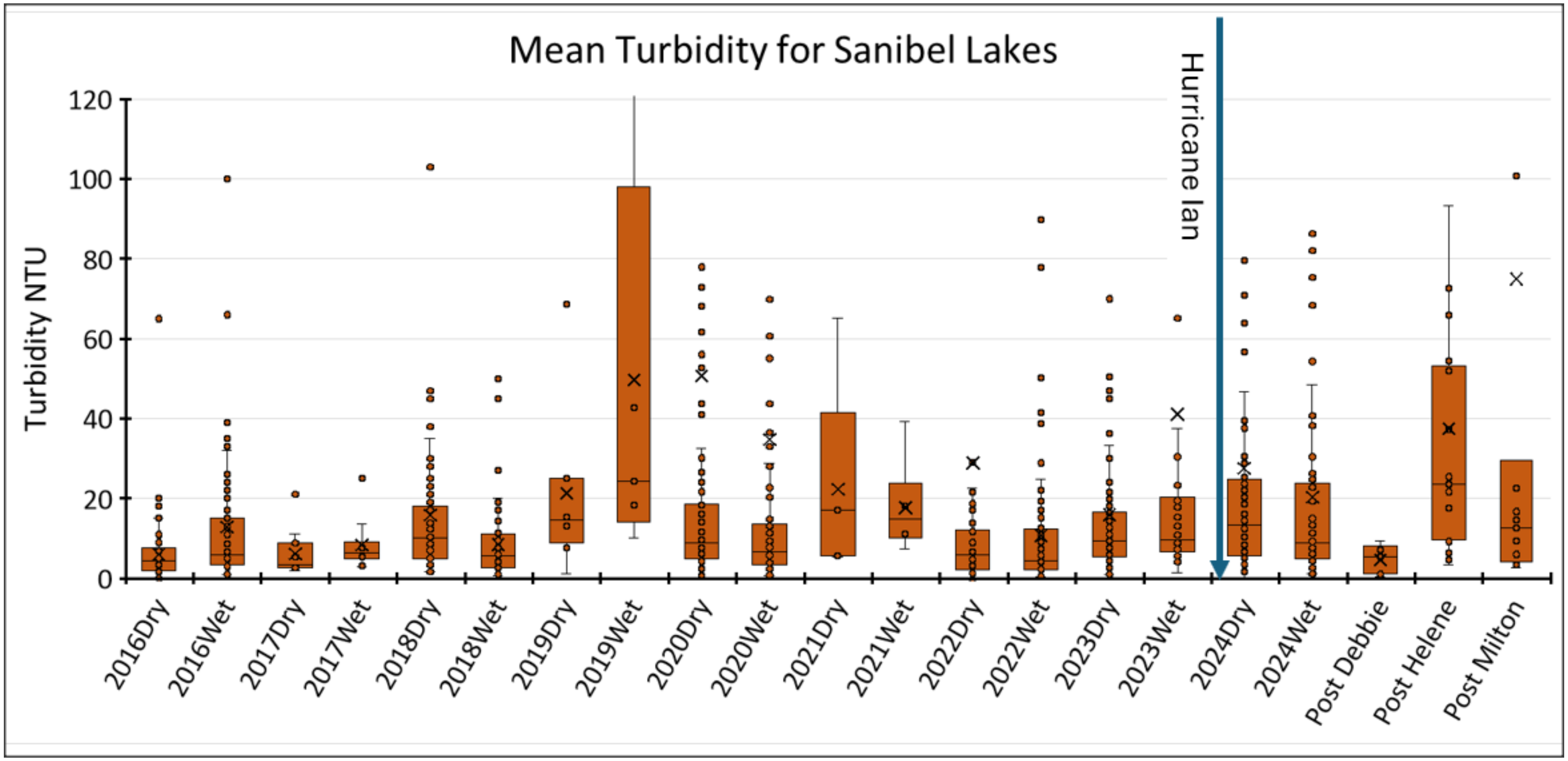


Figure 18. GIS interpolation of lake salinity across Sanibel before and after the 3 major surge events of 2024.

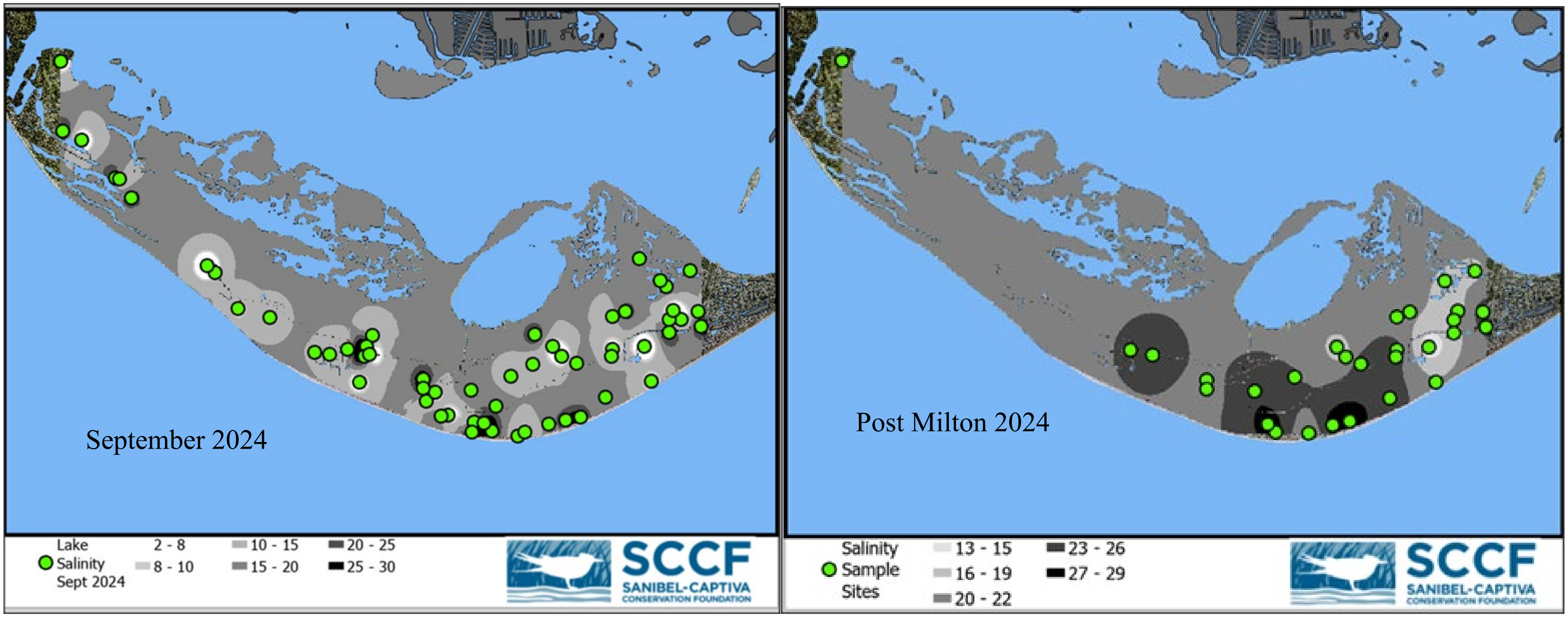


Figure 19. GIS interpolation of chlorophyll *a* across lakes and ponds on Sanibel Island for this study period before Hurricanes Helene and Milton.

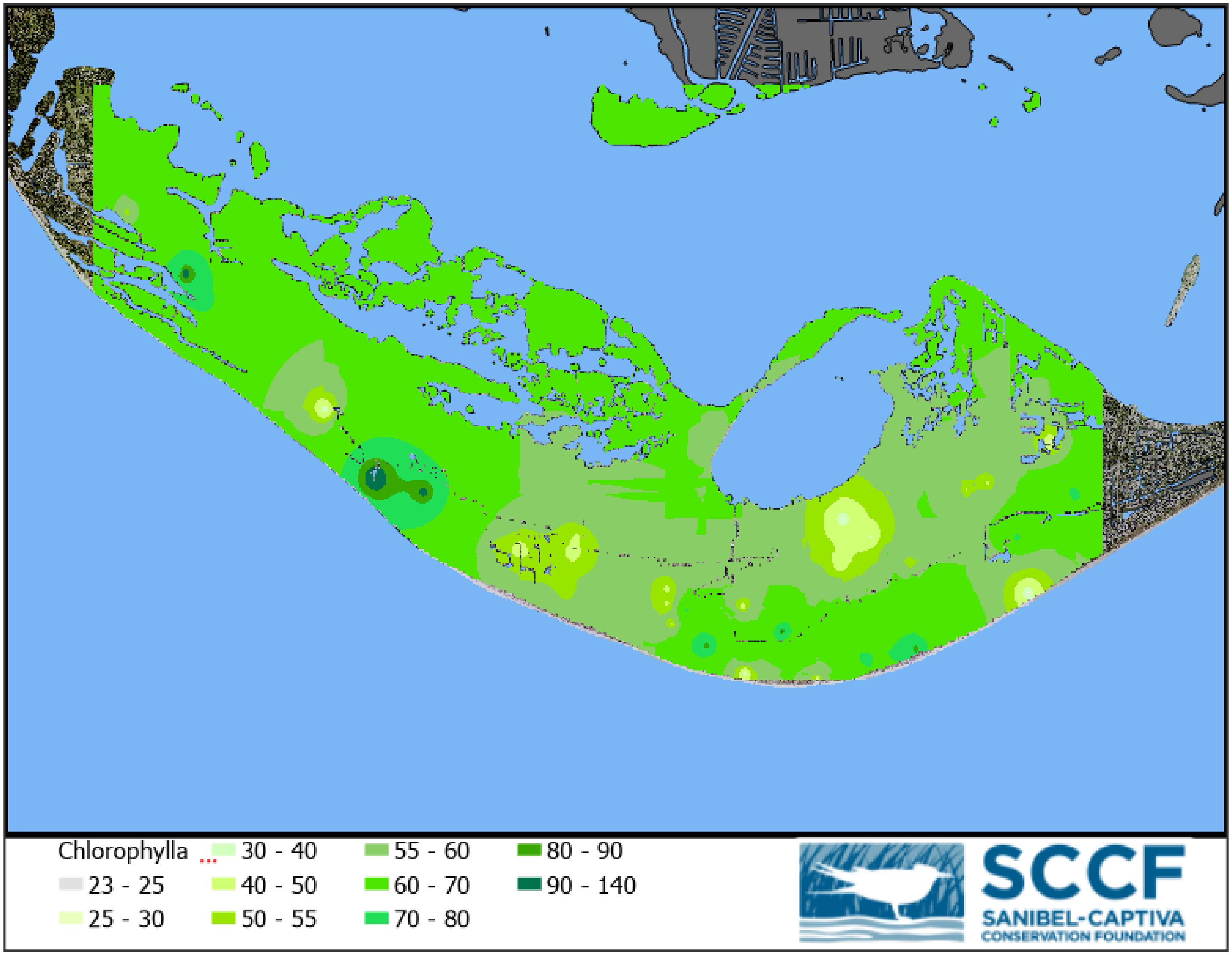


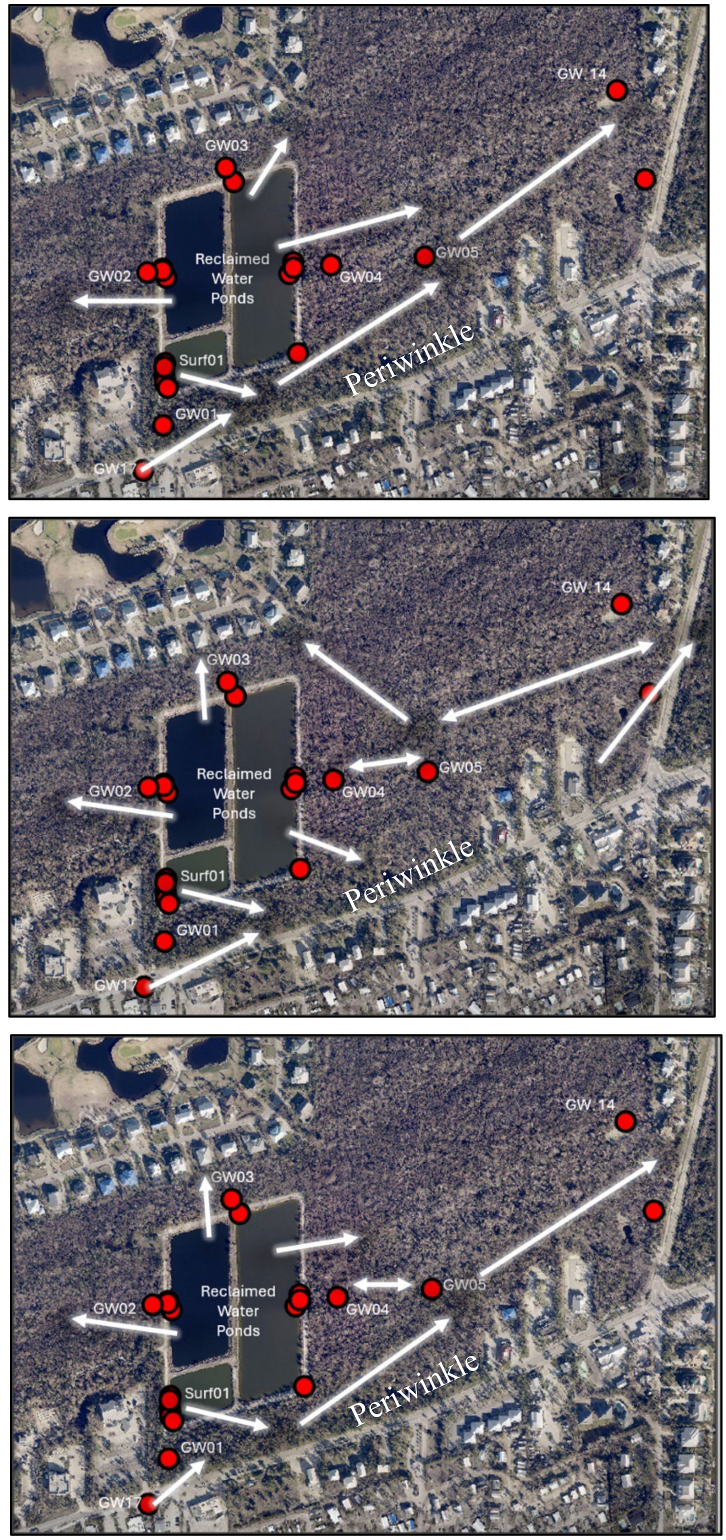
Figure 20. Flow direction in the vicinity of The Dunes Lake 5 for dry season, wet season and immediately after a rainfall event.

Dry Season

Wet Season

After rainfall event

Figure 21. Flow direction in the vicinity of the Pond Apple Park reclaimed water ponds for dry season, wet season and immediately after a rainfall event.



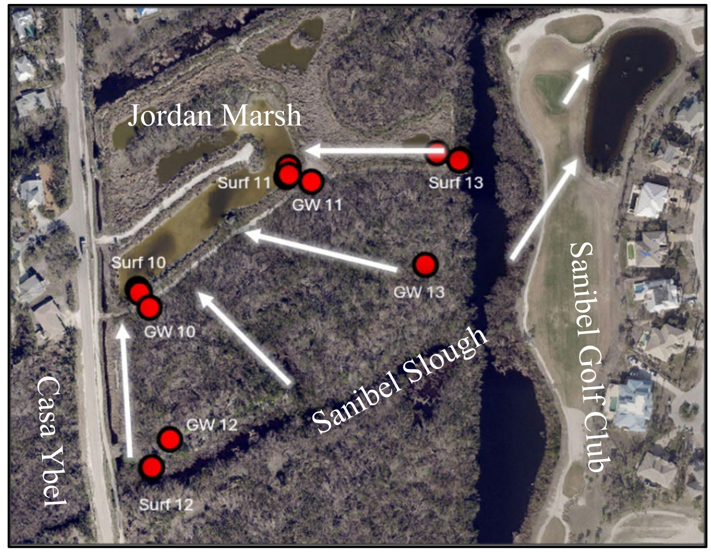
Dry Season

Wet Season

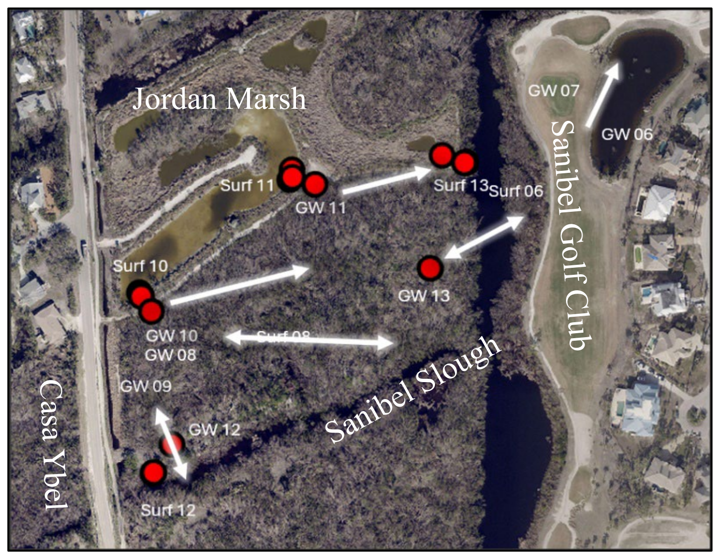
After rainfall event

Figure 22. Flow direction in the vicinity of the Jordan Marsh during dry season, wet season and immediately after a rainfall event.

Dry Season



Wet Season



After rainfall event

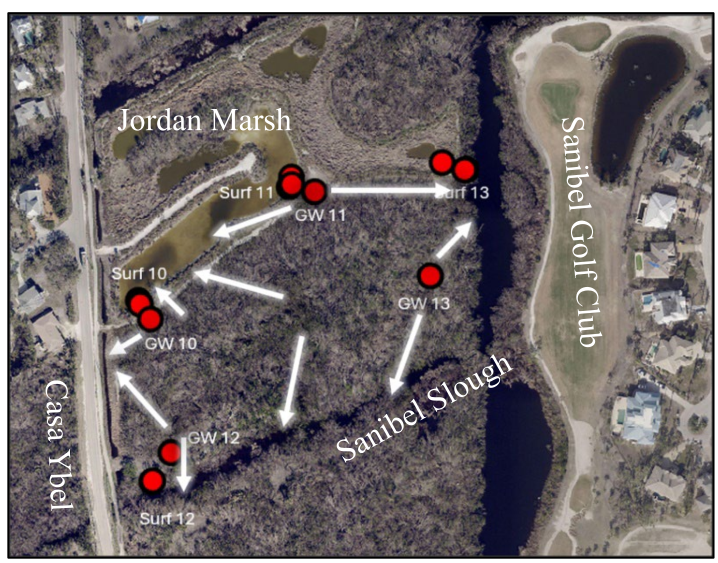
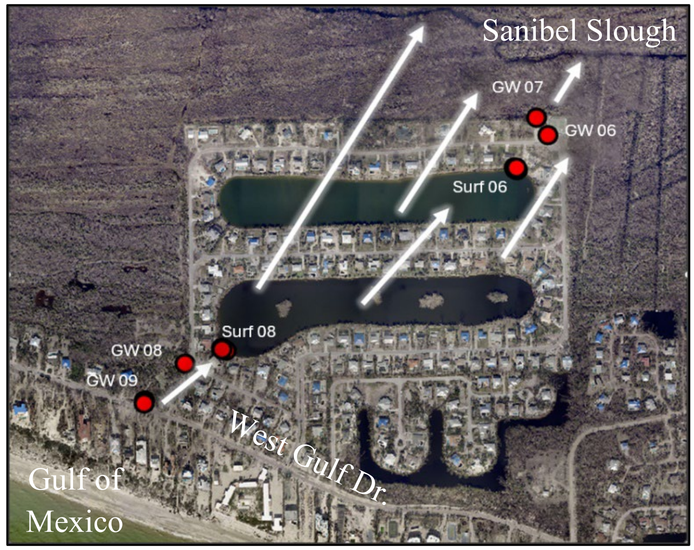


Figure 23. Flow direction in the vicinity of Murex Lakes for dry season, wet season and immediately after a rainfall event.

Dry Season



Wet Season

After rainfall event

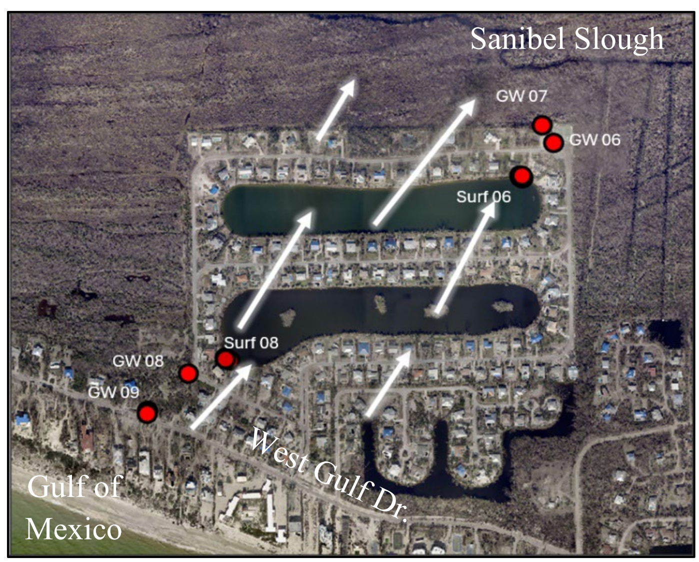


Figure 24. Flow direction in the vicinity of Sea Oats for dry season, wet season and immediately after a rainfall event.

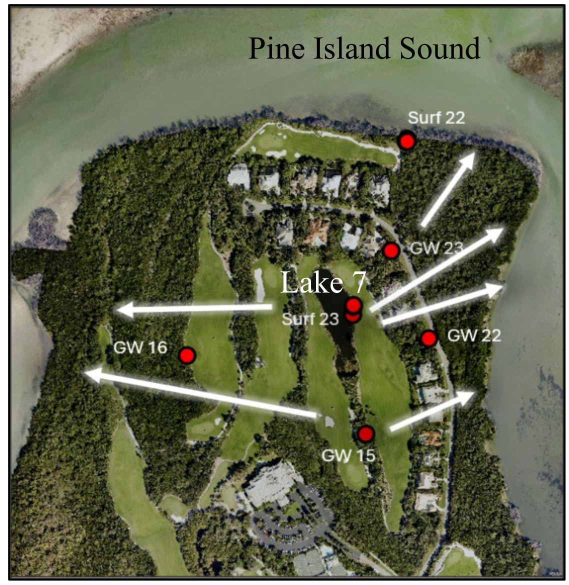
Dry Season

Wet Season

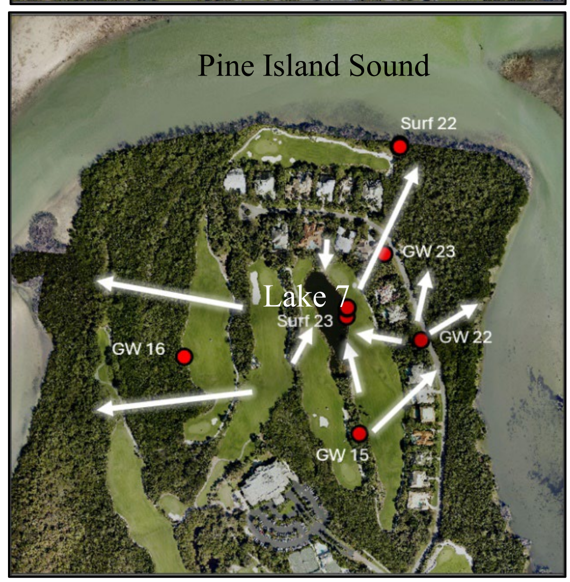
After rainfall event

Figure 25. Flow direction in the vicinity of The Sanctuary Lake 7 for dry season, wet season and immediately after a rainfall event.

Dry Season



Wet Season



After rainfall event

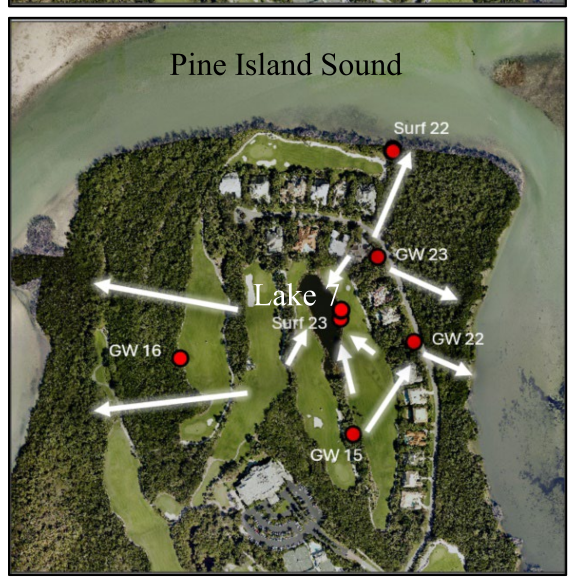


Figure 26. Comparison of groundwater nutrient concentrations to nearby surface water. Groundwater is significantly greater in IN and TP than surface water.

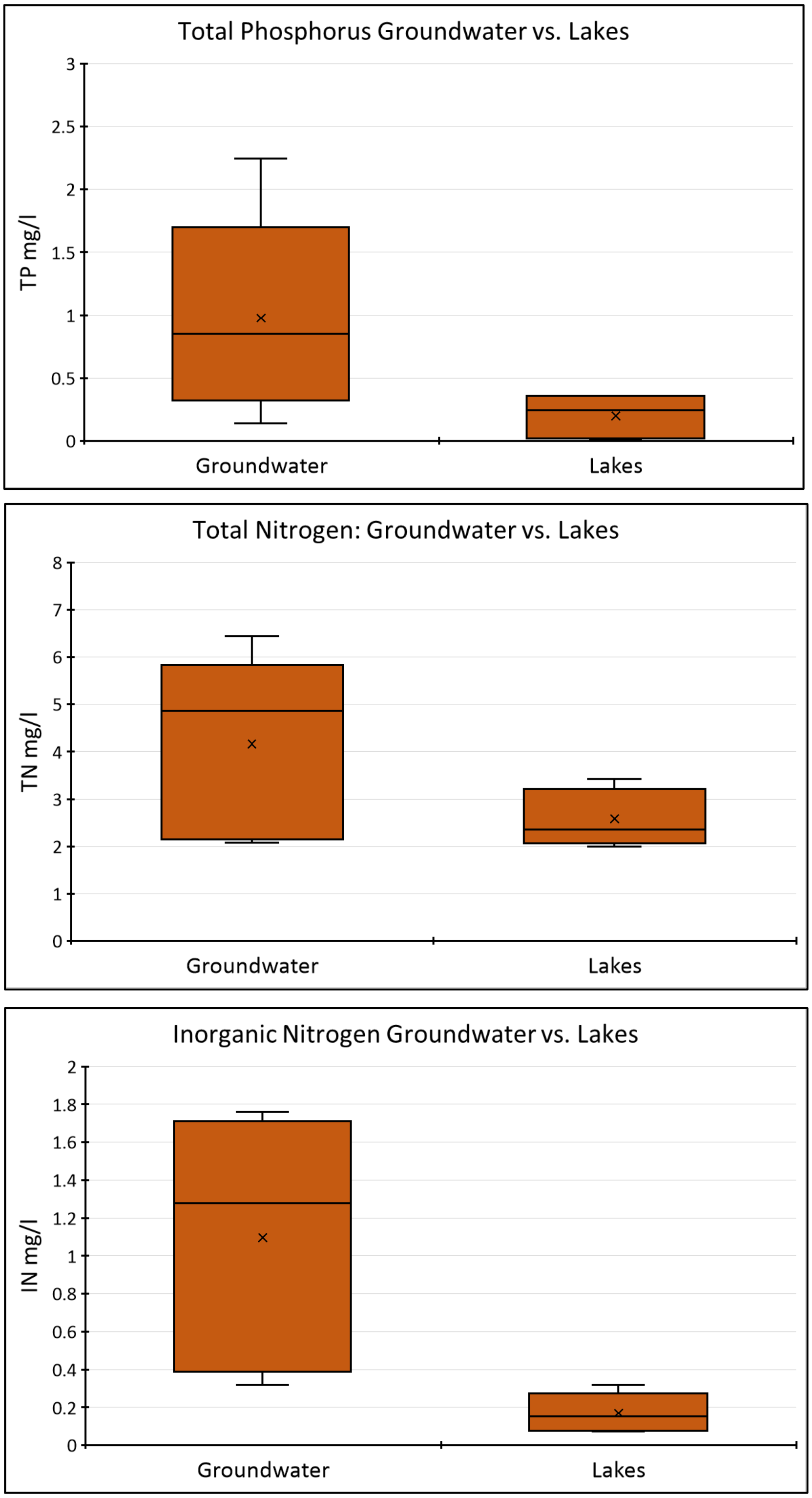


Figure 27. Mean salinity at surface water sites compared to adjacent groundwater after Hurricane Milton, October 2024.

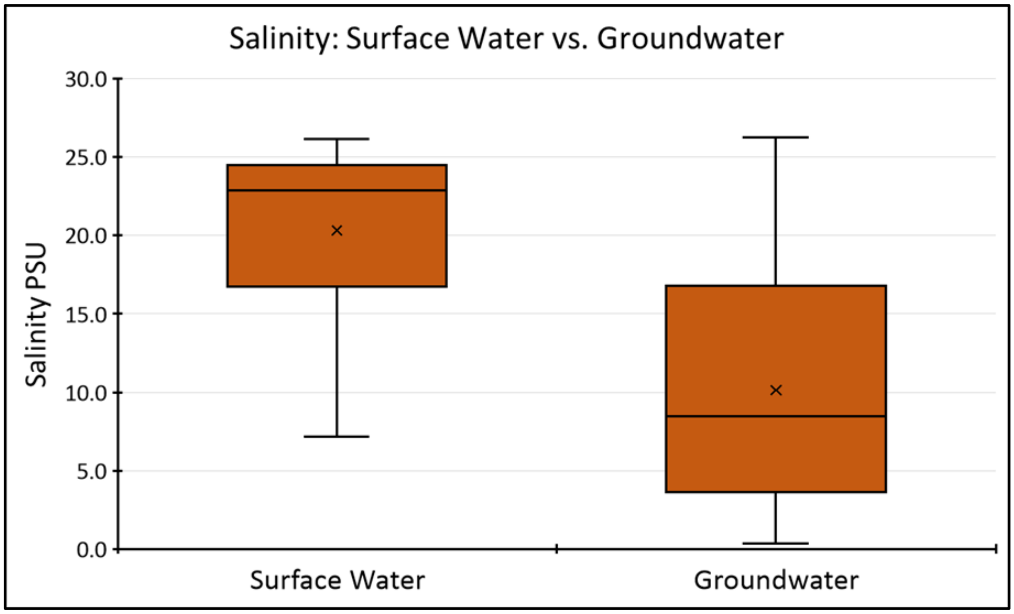


Figure 28. Salinity of groundwater verse the adjacent surface water monitoring site for sites which are at a ground elevation of more than 1 meter NAVD88.

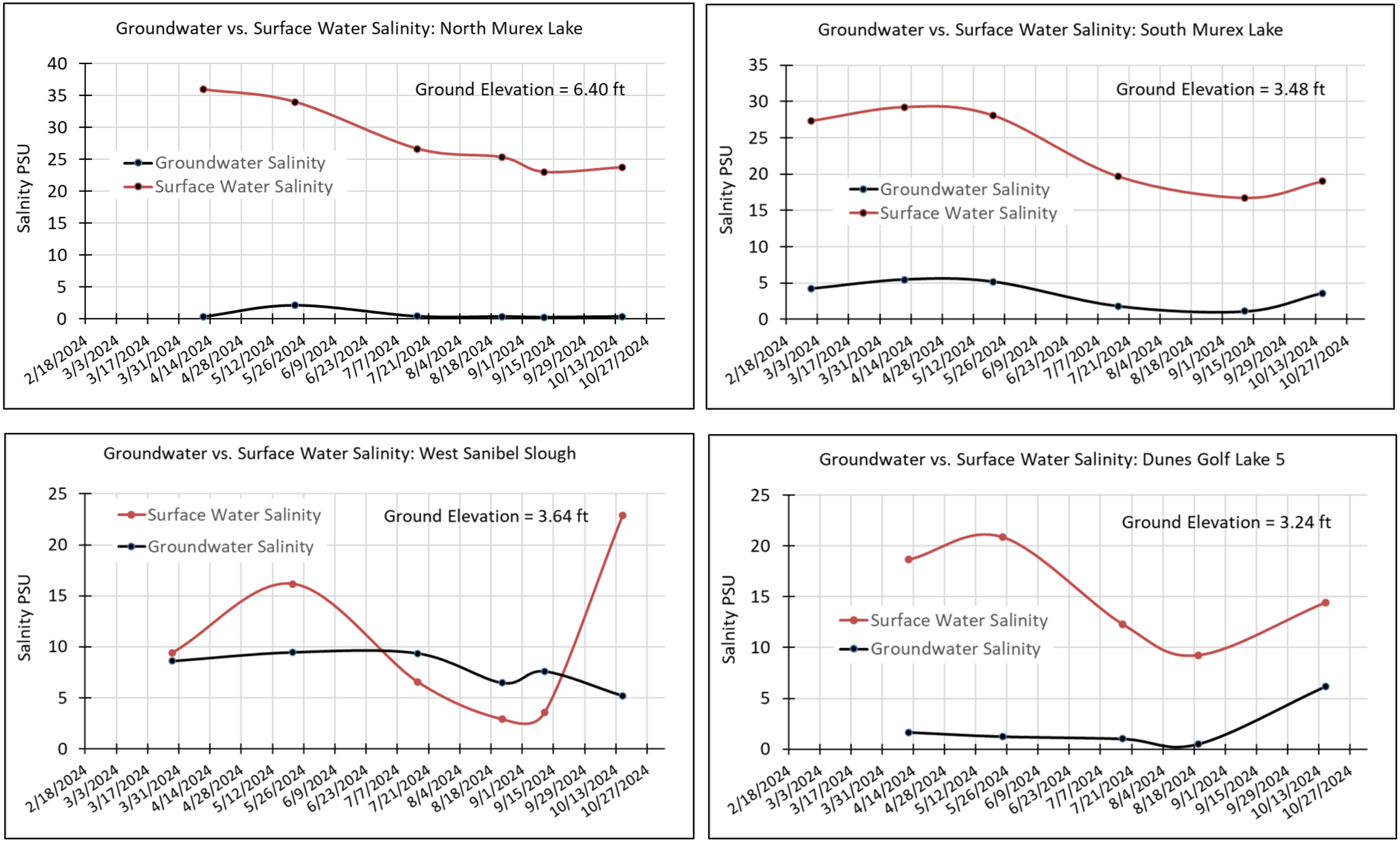


Figure 29. Salinity of groundwater verse the adjacent surface water monitoring site for sites which are at a ground elevation of less than 1 meter NAVD88.

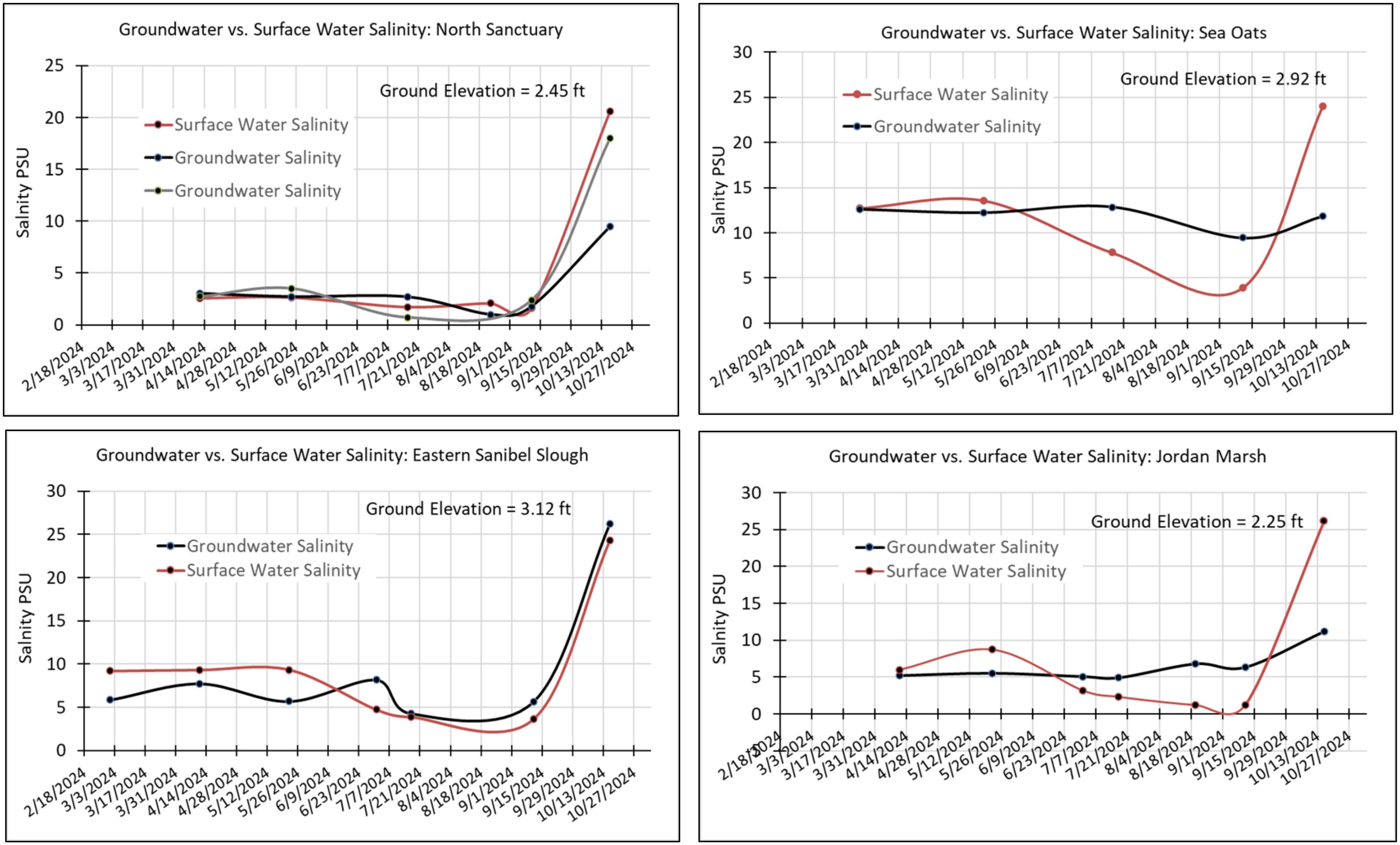


Figure 30. Change in surficial aquifer water table elevations after rainfall events at our 6 study sites.

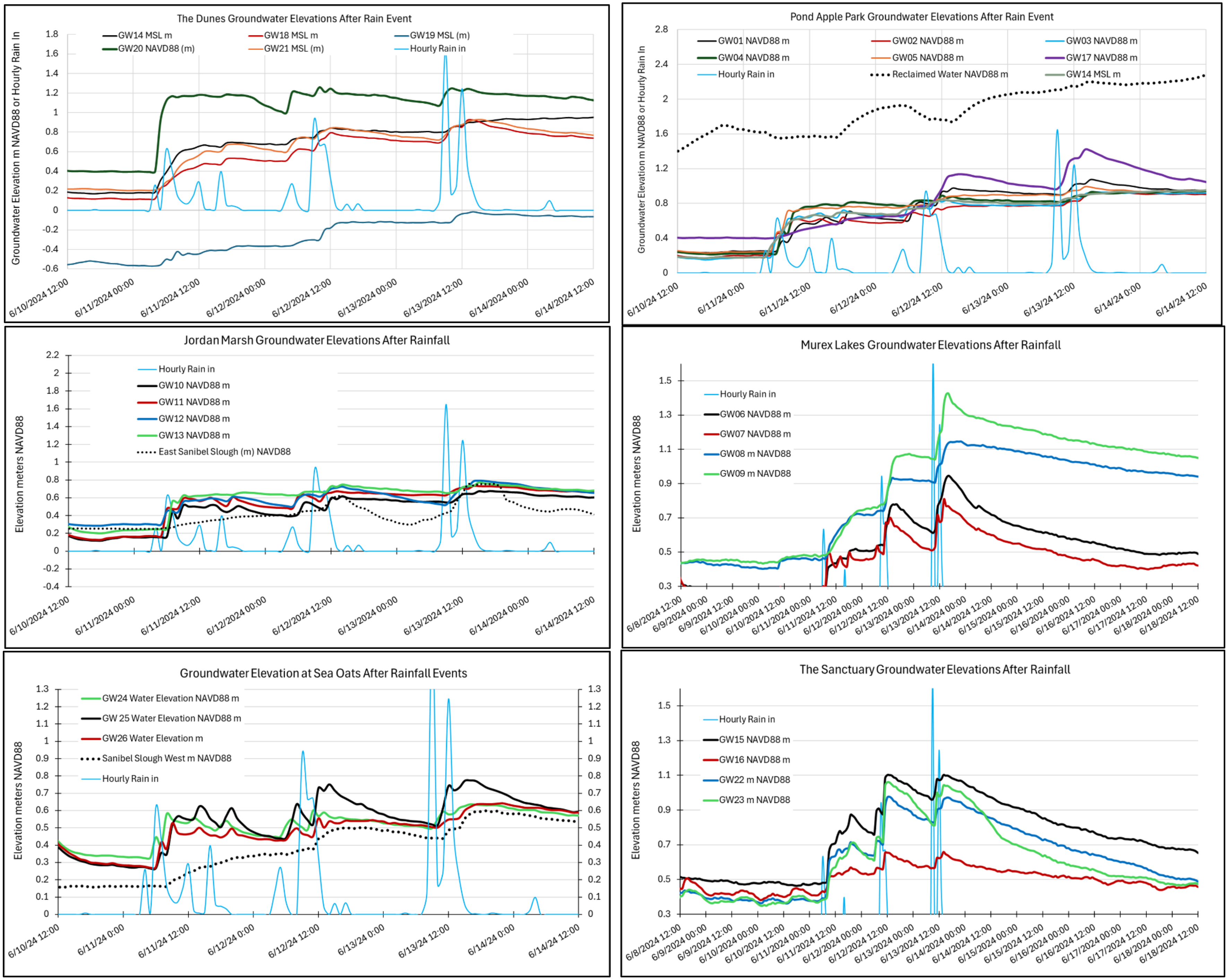
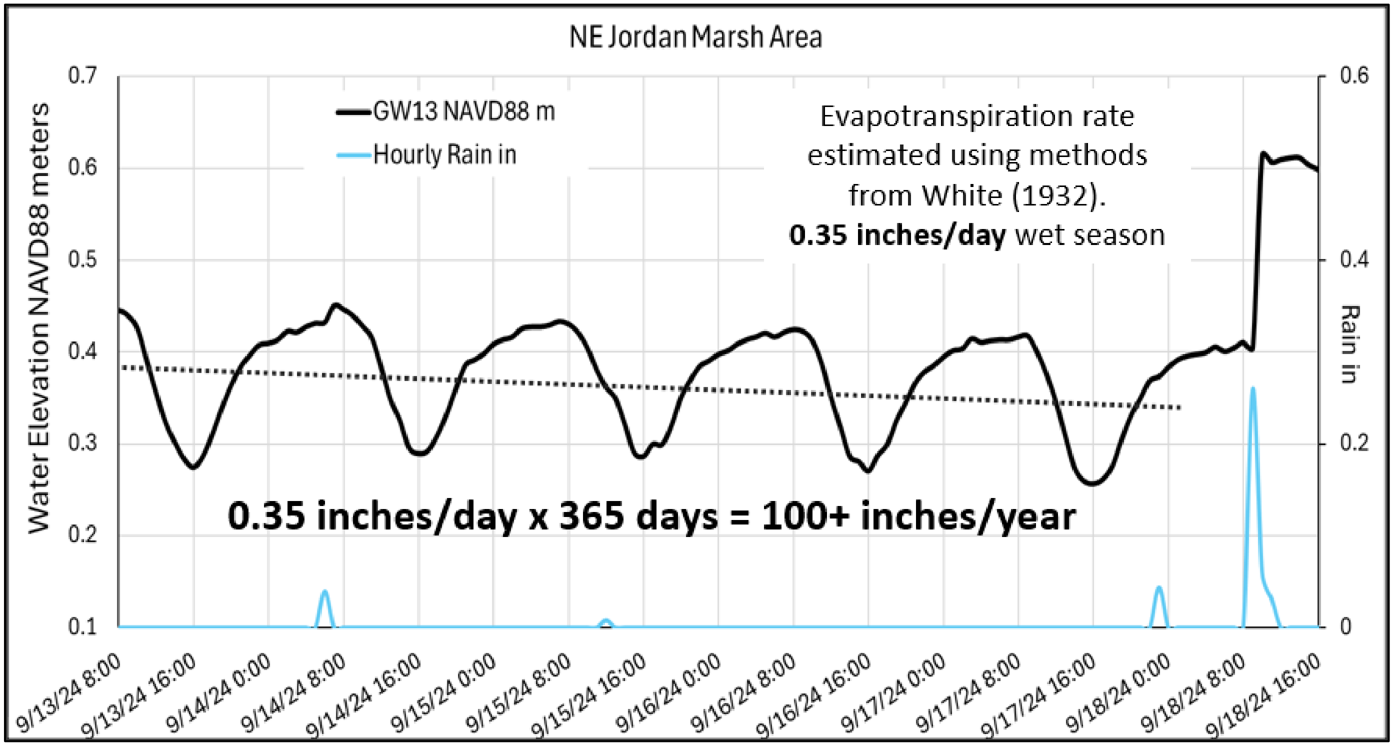
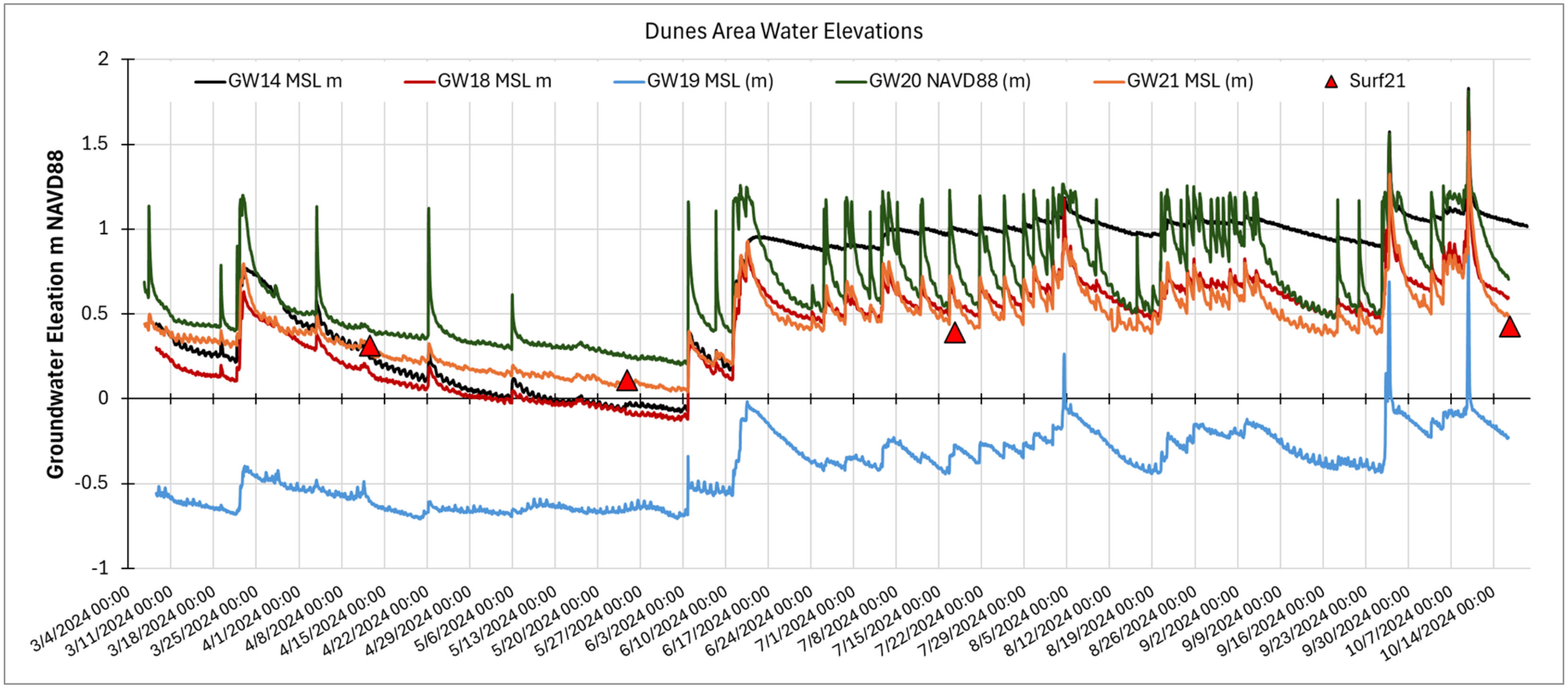


Figure 31. The diurnal pumping of groundwater by vegetation is apparent in continuously recorded groundwater elevation data. Beginning at daybreak, vegetation pumps groundwater through its biomass, evapotranspiration most of it through the day. As the sun sets, pumping is much reduced and groundwater flows into the area where it was pumped from.

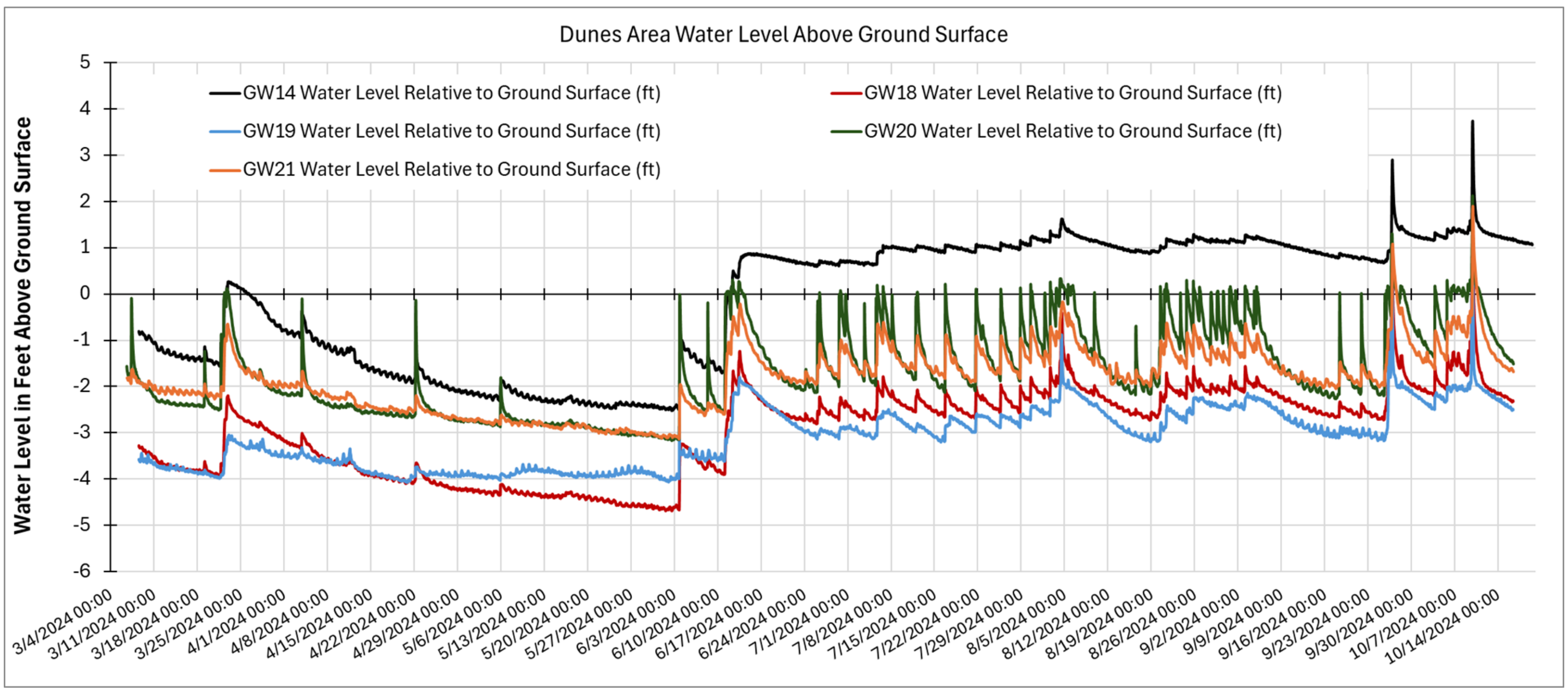


APPENDIX I

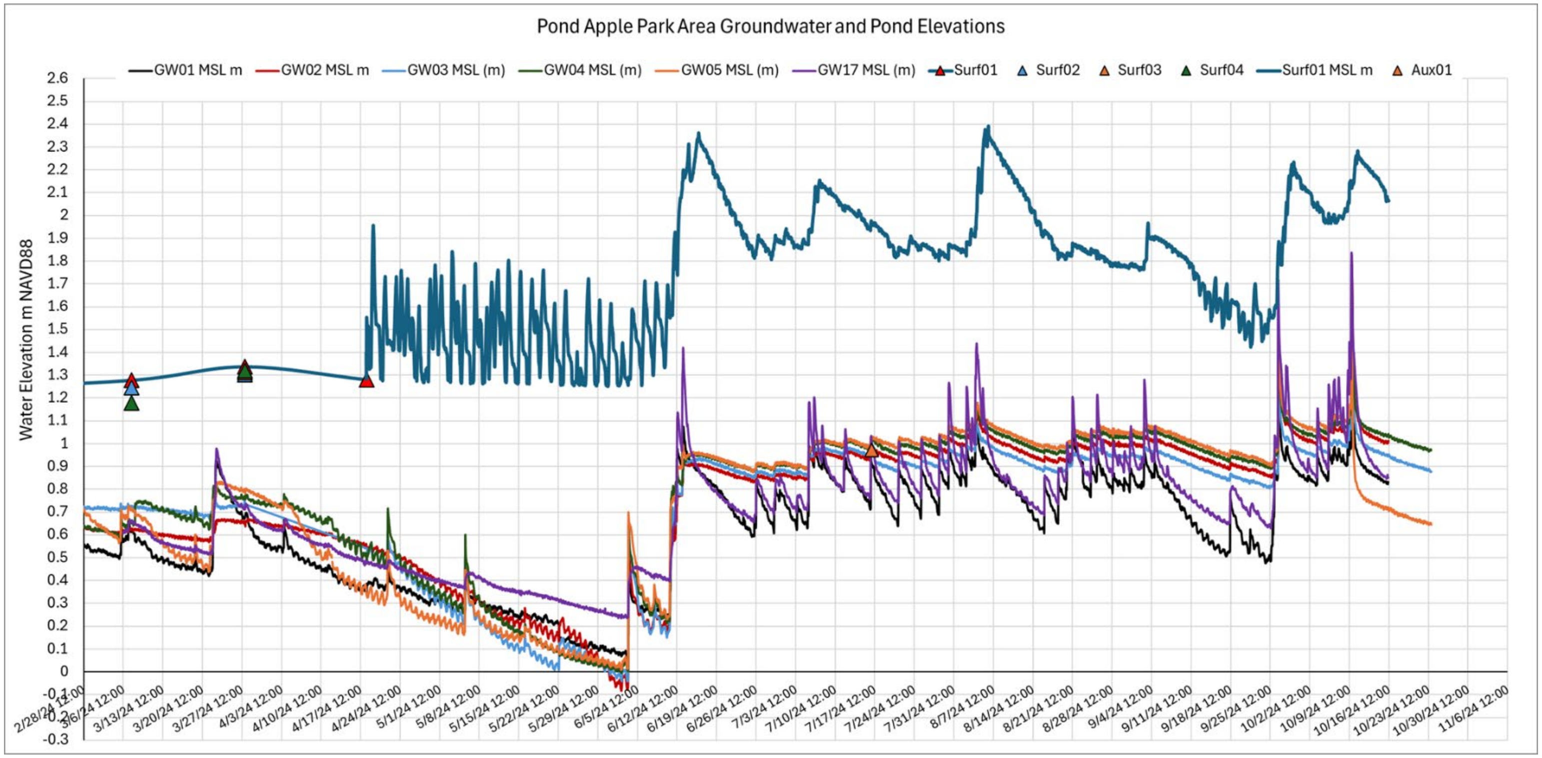
Well depth logger plots for 6 sites monitored during this study.



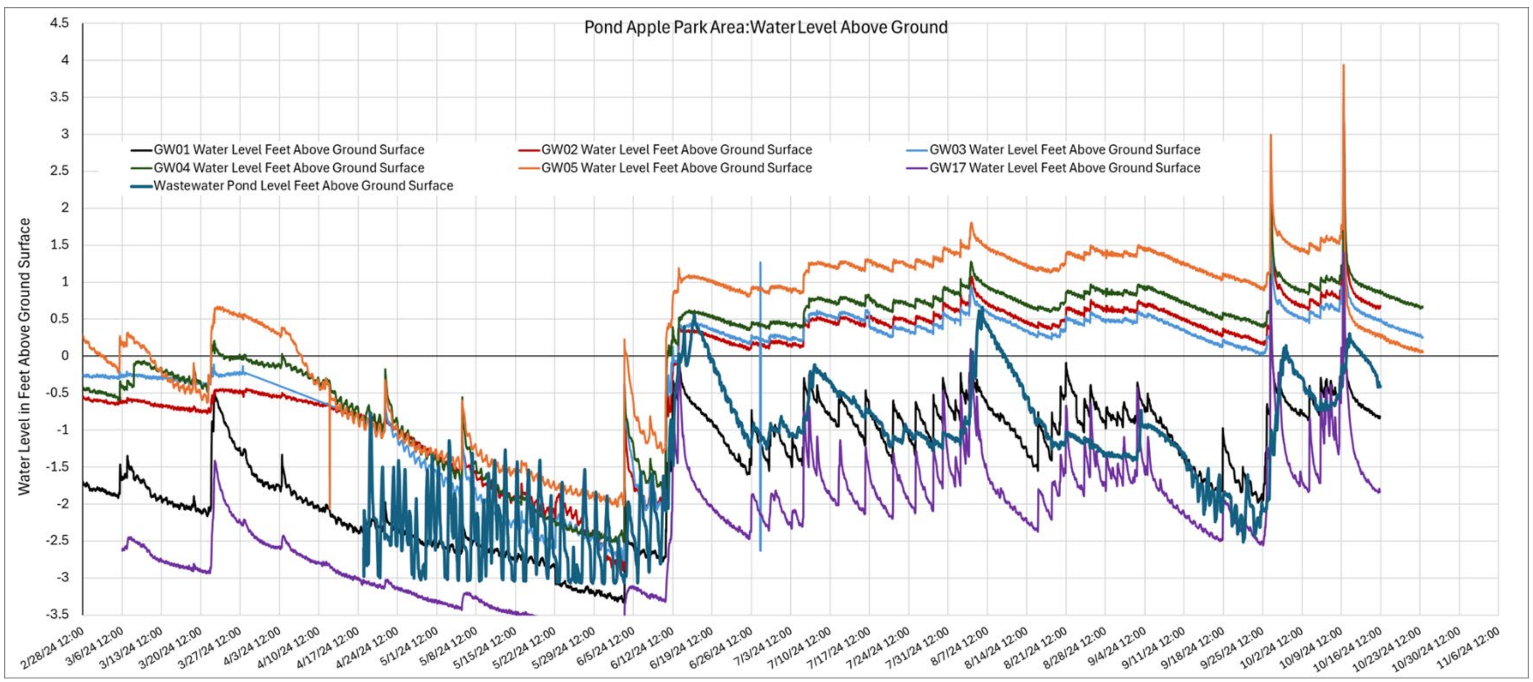
Dunes Area Water Elevations
GW14 MSL m
GW18 MSL m
GW19 MSL (m)
GW20 NAVD88 (m)
GW21 MSL (m)
Surf21
Groundwater Eleation m NAVD88
2
1.5
1
0.5
0
-0.5
-1
3/4/2024 00:00
3/11/2024 00:00
3/18/2024 00:00
3/25/2024 00:00
4/1/2024 00:00
4/8/2024 00:00
4/15/2024 00:00
4/22/2024 00:00
4/29/2024 00:00
5/6/2024 00:00
5/13/2024 00:00
5/20/2024 00:00
5/27/2024 00:00
6/3/2024 00:00
6/10/2024 00:00
6/17/2024 00:00
6/24/2024 00:00
7/1/2024 00:00
7/8/2024 00:00
7/15/2024 00:00
7/22/2024 00:00
7/29/2024 00:00
8/5/2024 00:00
8/12/2024 00:00
8/19/2024 00:00
8/26/2024 00:00
9/2/2024 00:00
9/9/2024 00:00
9/16/2024 00:00
9/23/2024 00:00
9/30/2024 00:00
10/7/2024 00:00
10/14/2024 00:00



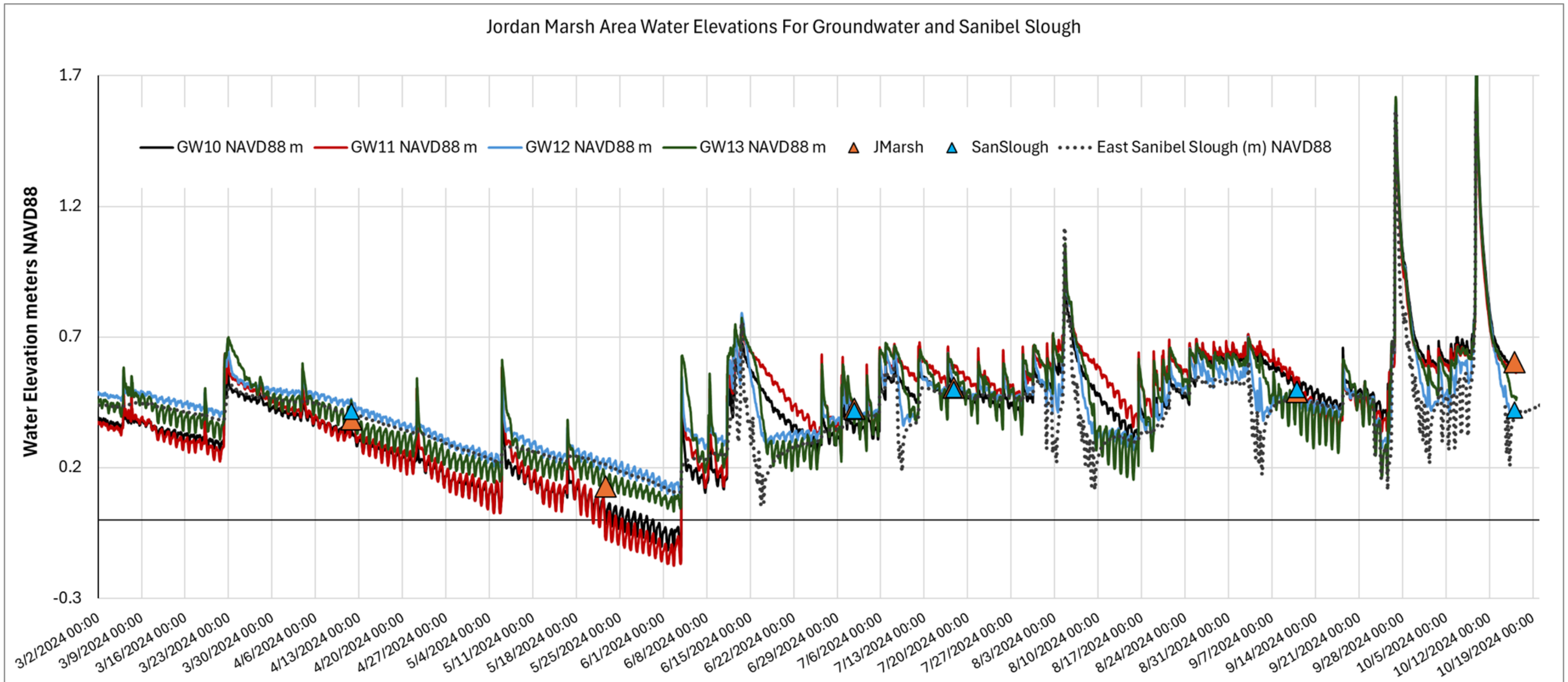
Dunes Area Water Level Above Ground Surface
GW14 Water Level Relative to Ground Surface (ft)
GW18 Water Level Relative to Ground Surface (ft)
GW19 Water Level Relative to Ground Surface (ft)
GW20 Water Level Relative to Ground Surface (ft)
GW21 Water Level Relative to Ground Surface (ft)
Water Level in Feet Above Ground Surface
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
3/4/2024 00:00
3/11/2024 00:00
3/18/2024 00:00
3/25/2024 00:00
4/1/2024 00:00
4/8/2024 00:00
4/15/2024 00:00
4/22/2024 00:00
4/29/2024 00:00
5/6/2024 00:00
5/13/2024 00:00
5/20/2024 00:00
5/27/2024 00:00
6/3/2024 00:00
6/10/2024 00:00
6/17/2024 00:00
6/24/2024 00:00
7/1/2024 00:00
7/8/2024 00:00
7/15/2024 00:00
7/22/2024 00:00
7/29/2024 00:00
8/5/2024 00:00
8/12/2024 00:00
8/19/2024 00:00
8/26/2024 00:00
9/2/2024 00:00
9/9/2024 00:00
9/16/2024 00:00
9/23/2024 00:00
9/30/2024 00:00
10/7/2024 00:00
10/14/2024 00:00



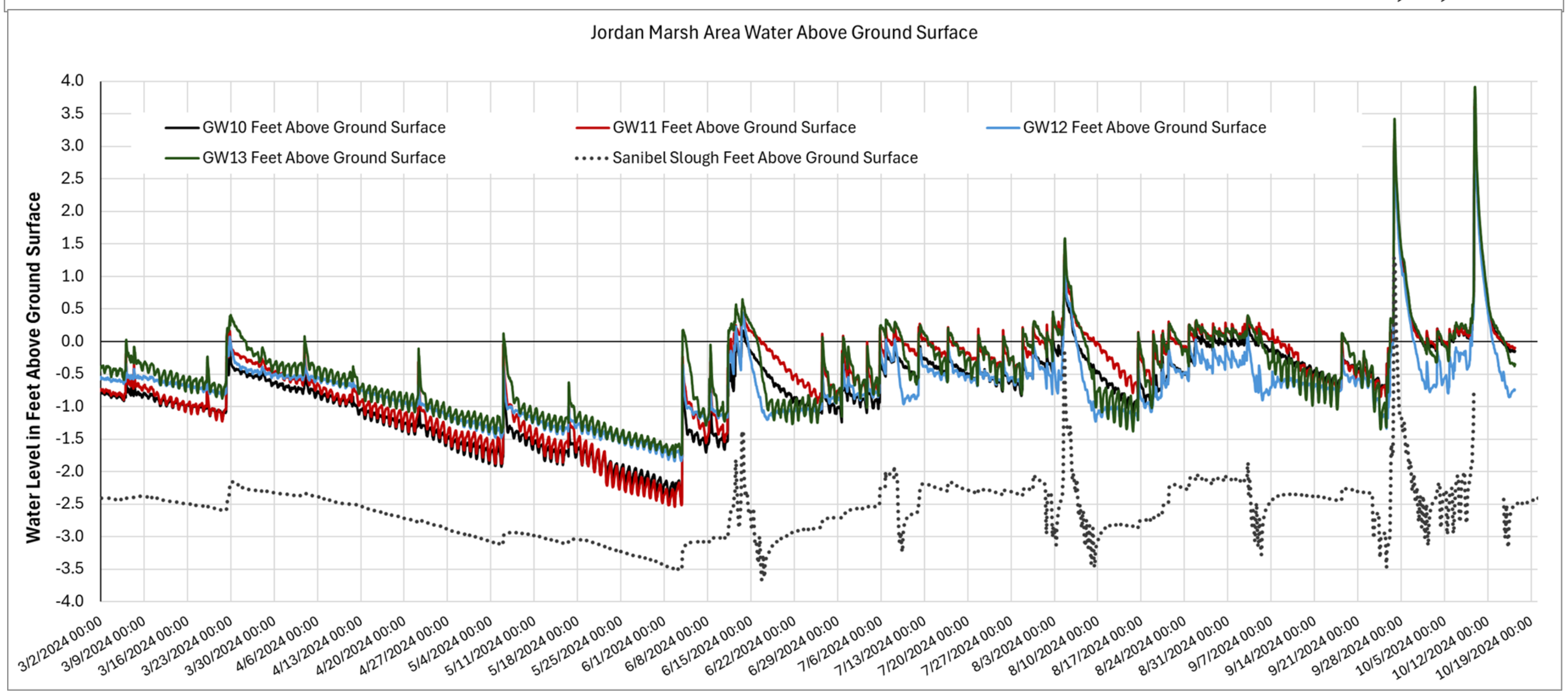
Pond Apple Park Area Groundwater and Pond Elevations
GW01 MSL m
GW02 MSL m
GW03 MSL (m)
GW04 MSL (m)
GW05 MSL (m)
GW17 MSL (m)
Surf01
Surf02
Surf03
Surf04
Surf01 MSL m
Aux01
Water Elevation m NAVD88



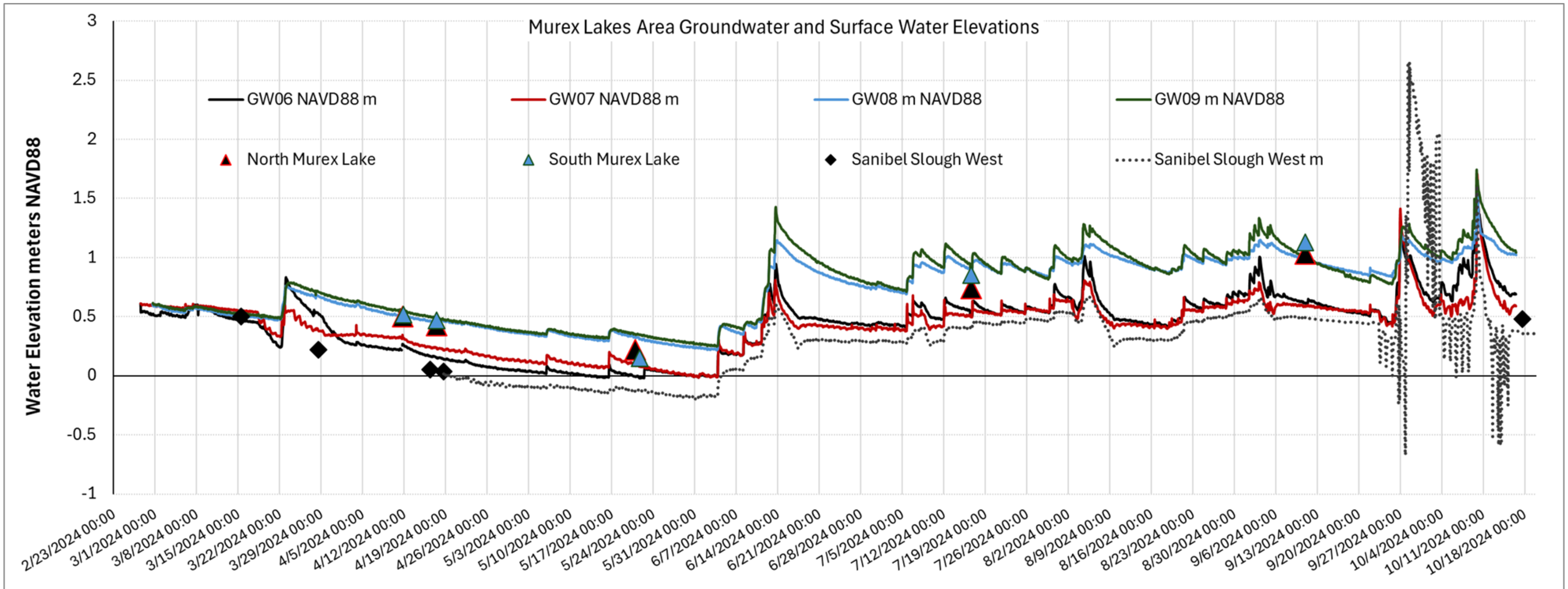
Pond Apple Park Area:Water Level Above Ground
GW01 Water Level Feet Above Ground Surface
GW02 Water Level Feet Above Ground Surface
GW03 Water Level Feet Above Ground Surface
GW04 Water Level Feet Above Ground Surface
GW05 Water Level Feet Above Ground Surface
GW17 Water Level Feet Above Ground Surface
Wastewater Pond Level Feet Above Ground Surface
Water Level in Feet Above Ground Surface

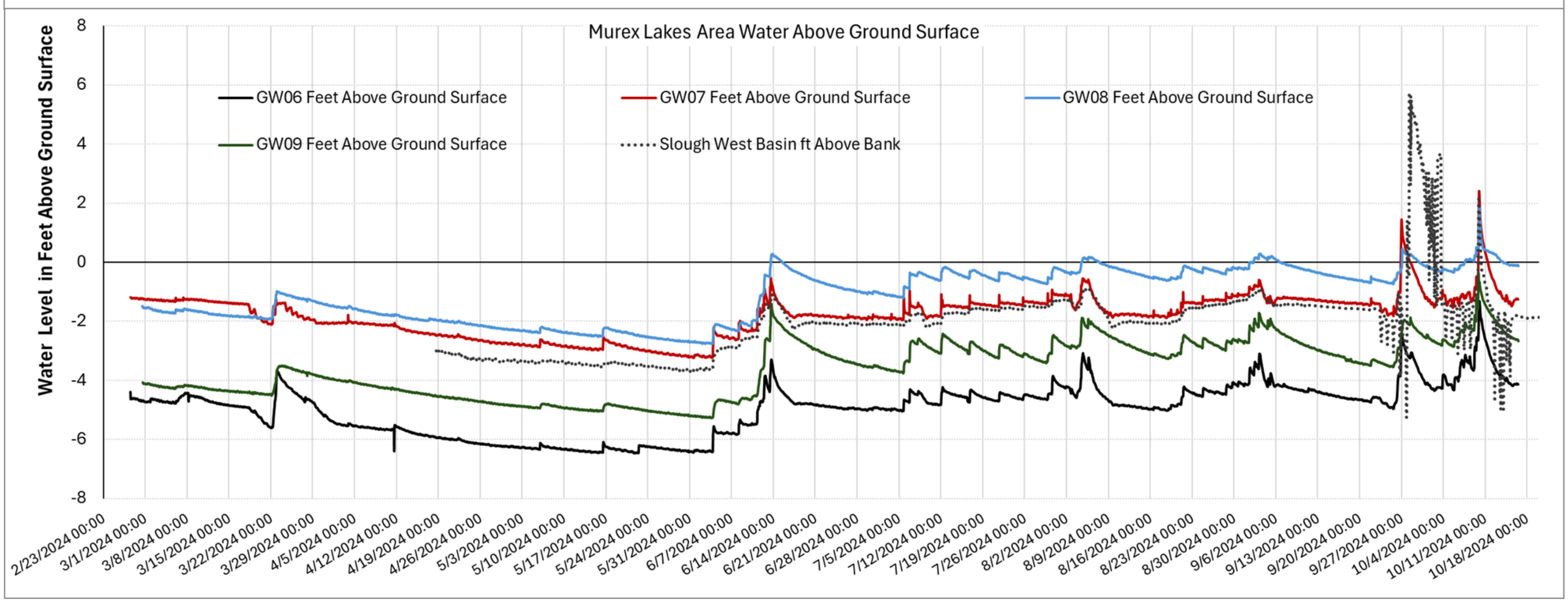


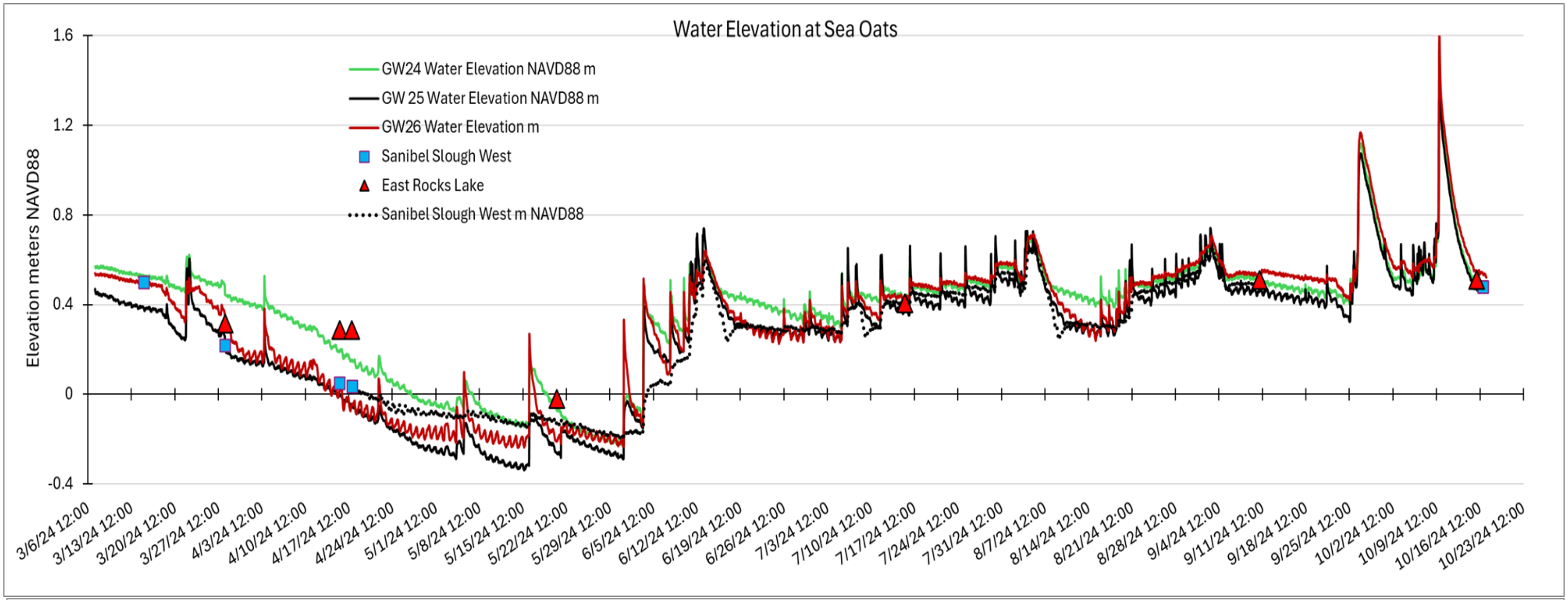
Jordan Marsh Area Water Elevations For Groundwater and Sanibel Slough
GW10 NAVD88 m
GW11 NAVD88 m
GW12 NAVD88 m
GW13 NAVD88 m
JMarsh
SanSlough
East Sanibel Slough (m) NAVD88
Water Elevation meters NAVD88
1.7
1.2
0.7
0.2
-0.3
3/2/2024 00:00
3/9/2024 00:00
3/16/2024 00:00
3/23/2024 00:00
3/30/2024 00:00
4/6/2024 00:00
4/13/2024 00:00
4/20/2024 00:00
4/27/2024 00:00
5/4/2024 00:00
5/11/2024 00:00
5/18/2024 00:00
5/25/2024 00:00
6/1/2024 00:00
6/8/2024 00:00
6/15/2024 00:00
6/22/2024 00:00
6/29/2024 00:00
7/6/2024 00:00
7/13/2024 00:00
7/20/2024 00:00
7/27/2024 00:00
8/3/2024 00:00
8/10/2024 00:00
8/17/2024 00:00
8/24/2024 00:00
8/31/2024 00:00
9/7/2024 00:00
9/14/2024 00:00
9/21/2024 00:00
9/28/2024 00:00
10/5/2024 00:00
10/12/2024 00:00
10/19/2024 00:00



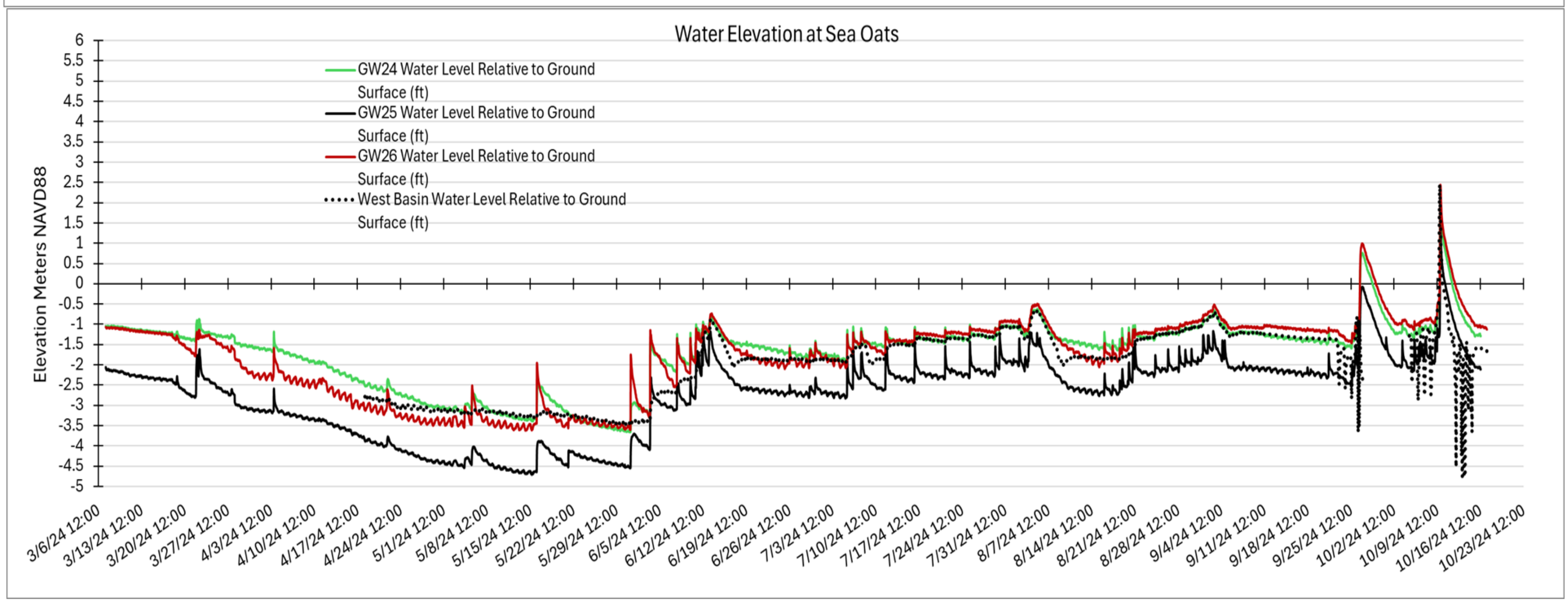
Jordan Marsh Area Water Above Ground Surface
GW10 Feet Above Ground Surface
GW11 Feet Above Ground Surface
GW12 Feet Above Ground Surface
GW13 Feet Above Ground Surface
Sanibel Slough Feet Above Ground Surface
Water Level in Feet Above Ground Surface
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
3/2/2024 00:00
3/9/2024 00:00
3/16/2024 00:00
3/23/2024 00:00
3/30/2024 00:00
4/6/2024 00:00
4/13/2024 00:00
4/20/2024 00:00
4/27/2024 00:00
5/4/2024 00:00
5/11/2024 00:00
5/18/2024 00:00
5/25/2024 00:00
6/1/2024 00:00
6/8/2024 00:00
6/15/2024 00:00
6/22/2024 00:00
6/29/2024 00:00
7/6/2024 00:00
7/13/2024 00:00
7/20/2024 00:00
7/27/2024 00:00
8/3/2024 00:00
8/10/2024 00:00
8/17/2024 00:00
8/24/2024 00:00
8/31/2024 00:00
9/7/2024 00:00
9/14/2024 00:00
9/21/2024 00:00
9/28/2024 00:00
10/5/2024 00:00
10/12/2024 00:00
10/19/2024 00:00


Murex Lakes Area Groundwater and Surface Water Elevations
Water Elevation meters NAVD88
GW06 NAVD88 m
GW07 NAVD88 m
GW08 m NAVD88
GW09 m NAVD88
North Murex Lake
South Murex Lake
Sanibel Slough West
Sanibel Slough West m
3
2.5
2
1.5
1
0.5
0
-0.5
-1
2/23/2024 00:00
3/1/2024 00:00
3/8/2024 00:00
3/15/2024 00:00
3/22/2024 00:00
3/29/2024 00:00
4/5/2024 00:00
4/12/2024 00:00
4/19/2024 00:00
4/26/2024 00:00
5/3/2024 00:00
5/10/2024 00:00
5/17/2024 00:00
5/24/2024 00:00
5/31/2024 00:00
6/7/2024 00:00
6/14/2024 00:00
6/21/2024 00:00
6/28/2024 00:00
7/5/2024 00:00
7/12/2024 00:00
7/19/2024 00:00
7/26/2024 00:00
8/2/2024 00:00
8/9/2024 00:00
8/16/2024 00:00
8/23/2024 00:00
8/30/2024 00:00
9/6/2024 00:00
9/13/2024 00:00
9/20/2024 00:00
9/27/2024 00:00
10/4/2024 00:00
10/11/2024 00:00
10/18/2024 00:00

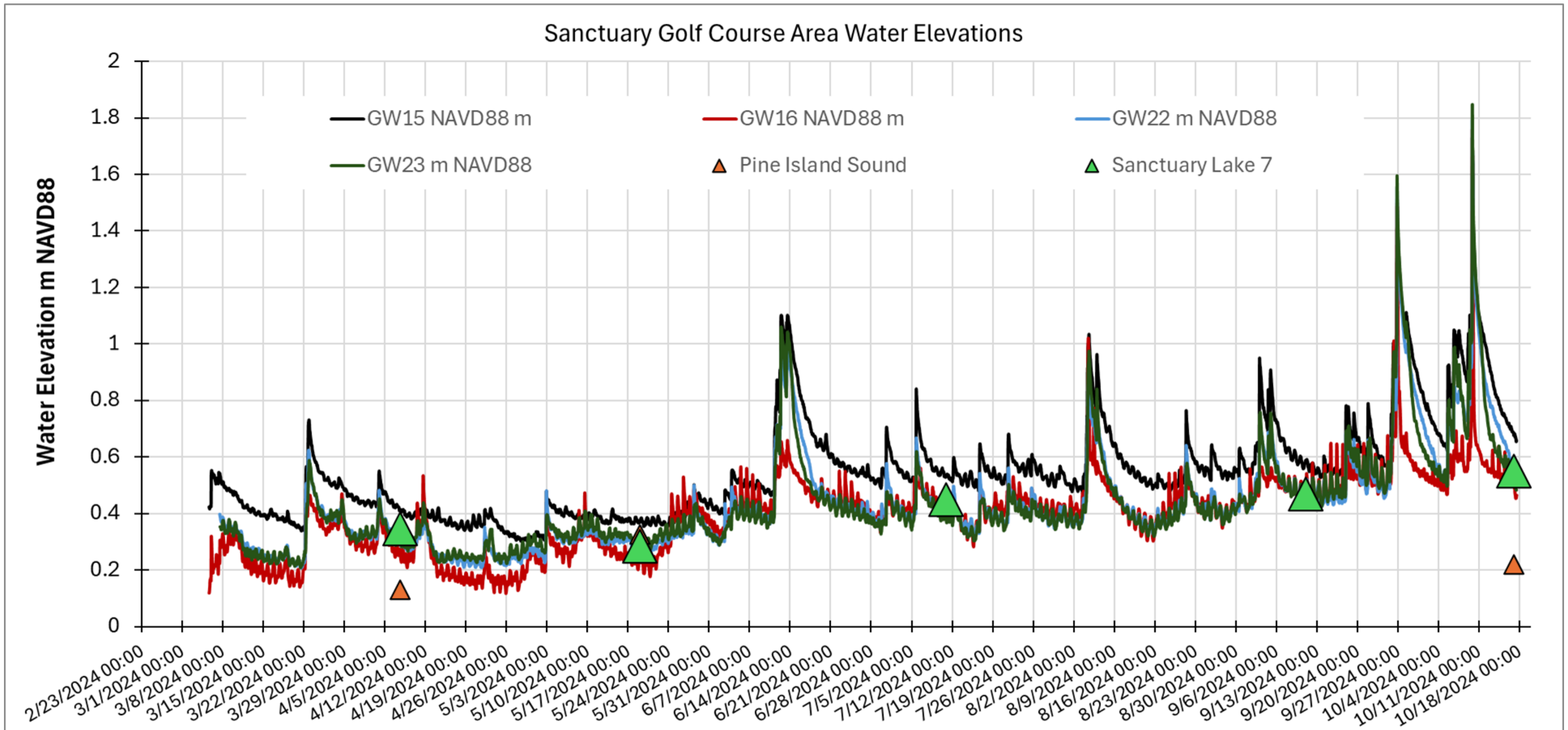

Murex Lakes Area Water Above Ground Surface
Water Level in Feet Above Ground Surface
GW06 Feet Above Ground Surface
GW07 Feet Above Ground Surface
GW08 Feet Above Ground Surface
GW09 Feet Above Ground Surface
Slough West Basin ft Above Bank
8
6
4
2
0
-2
-4
-6
-8
2/23/2024 00:00
3/1/2024 00:00
3/8/2024 00:00
3/15/2024 00:00
3/22/2024 00:00
3/29/2024 00:00
4/5/2024 00:00
4/12/2024 00:00
4/19/2024 00:00
4/26/2024 00:00
5/3/2024 00:00
5/10/2024 00:00
5/17/2024 00:00
5/24/2024 00:00
5/31/2024 00:00
6/7/2024 00:00
6/14/2024 00:00
6/21/2024 00:00
6/28/2024 00:00
7/5/2024 00:00
7/12/2024 00:00
7/19/2024 00:00
7/26/2024 00:00
8/2/2024 00:00
8/9/2024 00:00
8/16/2024 00:00
8/23/2024 00:00
8/30/2024 00:00
9/6/2024 00:00
9/13/2024 00:00
9/20/2024 00:00
9/27/2024 00:00
10/4/2024 00:00
10/11/2024 00:00
10/18/2024 00:00

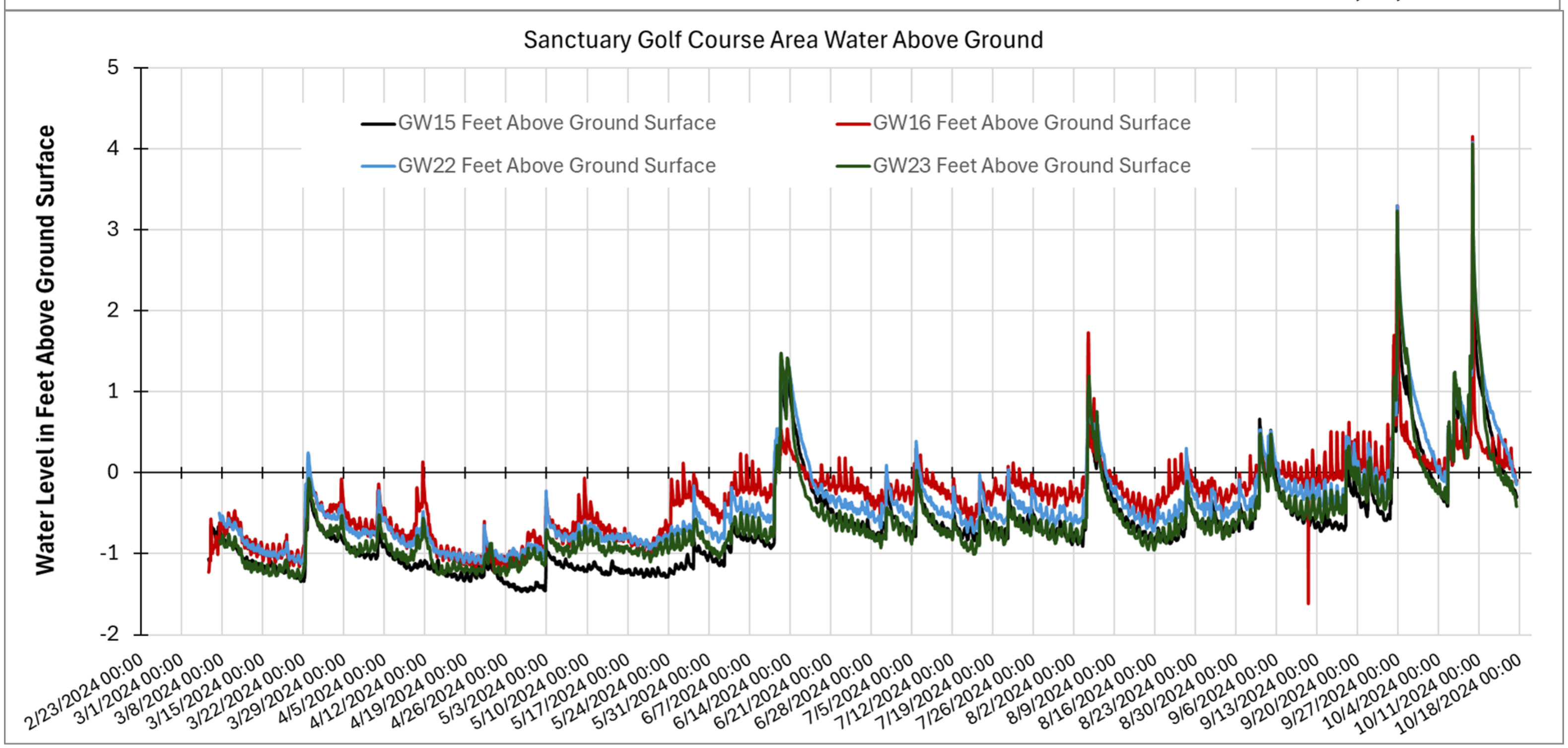


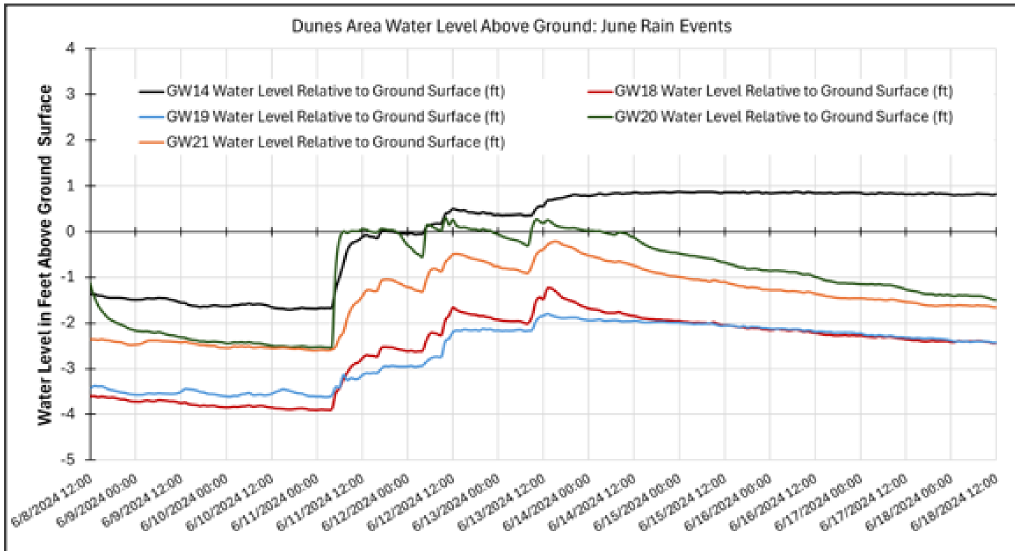
Water Elevation at Sea Oats
GW24 Water Elevation NAVD88 m
GW 25 Water Elevation NAVD88 m
GW26 Water Elevation m
Sanibel Slough West
East Rocks Lake
Sanibel Slough West m NAVD88
Elevation meters NAVD88
1.6
1.2
0.8
0.4
0
-0.4
3/6/24 12:00
3/13/24 12:00
3/20/24 12:00
3/27/24 12:00
4/3/24 12:00
4/10/24 12:00
4/17/24 12:00
4/24/24 12:00
5/1/24 12:00
5/8/24 12:00
5/15/24 12:00
5/22/24 12:00
5/29/24 12:00
6/5/24 12:00
6/12/24 12:00
6/19/24 12:00
6/26/24 12:00
7/3/24 12:00
7/10/24 12:00
7/17/24 12:00
7/24/24 12:00
7/31/24 12:00
8/7/24 12:00
8/14/24 12:00
8/21/24 12:00
8/28/24 12:00
9/4/24 12:00
9/11/24 12:00
9/18/24 12:00
9/25/24 12:00
10/2/24 12:00
10/9/24 12:00
10/16/24 12:00
10/23/24 12:00

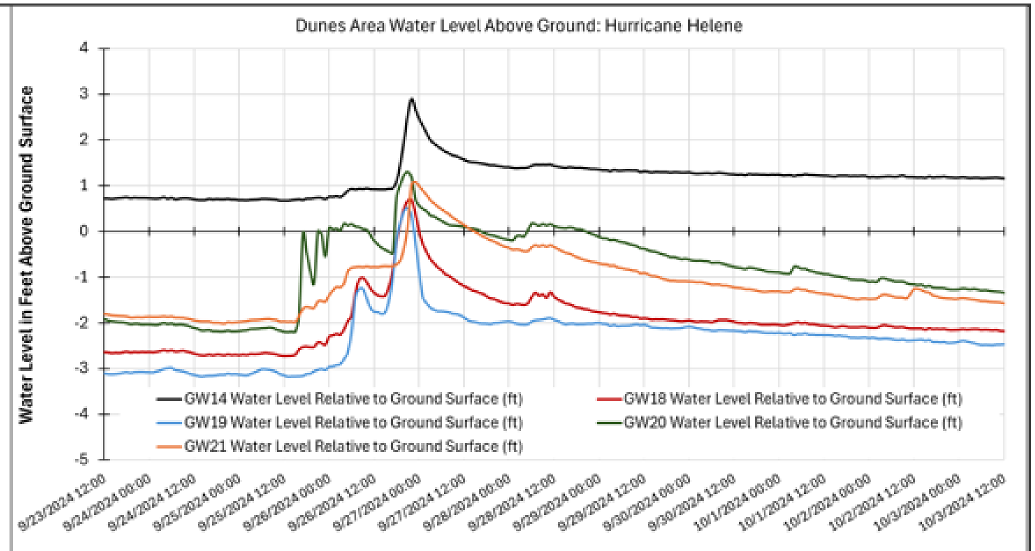


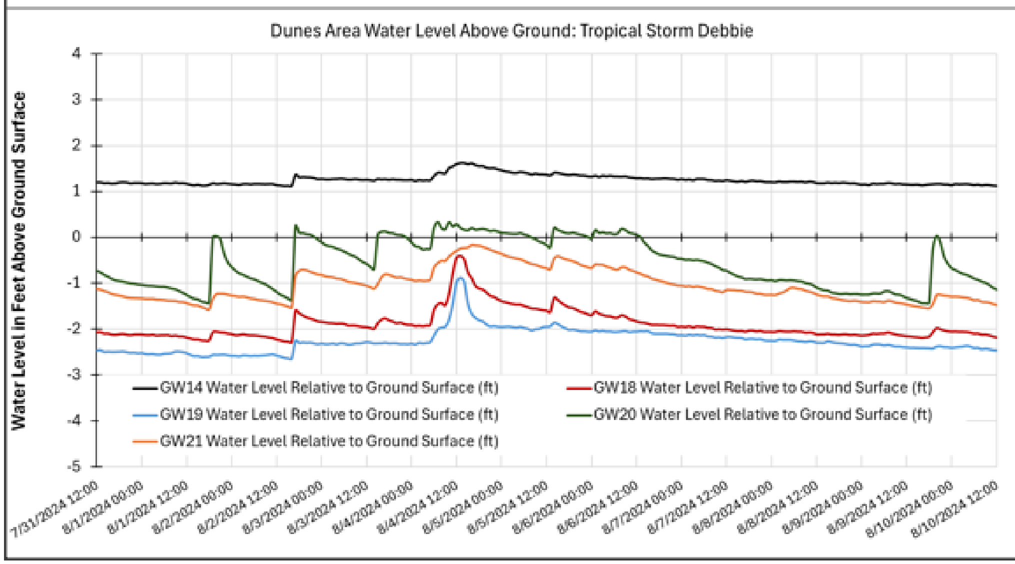
Water Elevation at Sea Oats
GW24 Water Level Relative to Ground Surface (ft)
GW25 Water Level Relative to Ground Surface (ft)
GW26 Water Level Relative to Ground Surface (ft)
West Basin Water Level Relative to Ground Surface (ft)
Elevation Meters NAVD88
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
3/6/24 12:00
3/13/24 12:00
3/20/24 12:00
3/27/24 12:00
4/3/24 12:00
4/10/24 12:00
4/17/24 12:00
4/24/24 12:00
5/1/24 12:00
5/8/24 12:00
5/15/24 12:00
5/22/24 12:00
5/29/24 12:00
6/5/24 12:00
6/12/24 12:00
6/19/24 12:00
6/26/24 12:00
7/3/24 12:00
7/10/24 12:00
7/17/24 12:00
7/24/24 12:00
7/31/24 12:00
8/7/24 12:00
8/14/24 12:00
8/21/24 12:00
8/28/24 12:00
9/4/24 12:00
9/11/24 12:00
9/18/24 12:00
9/25/24 12:00
10/2/24 12:00
10/9/24 12:00
10/16/24 12:00
10/23/24 12:00

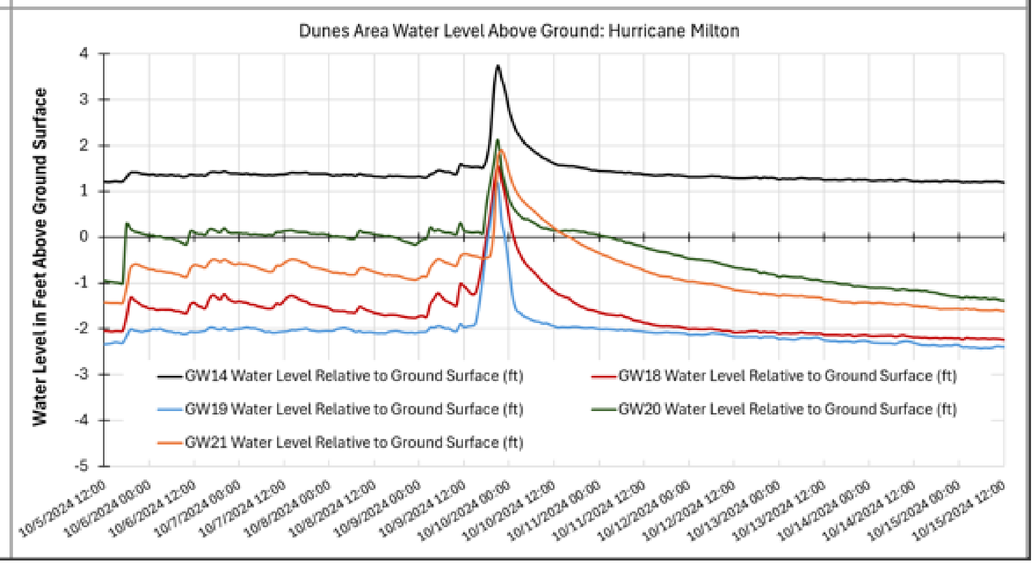

Sanctuary Golf Course Area Water Elevations
Water Elevation m NAVD88
GW15 NAVD88 m
GW16 NAVD88 m
GW22 m NAVD88
GW23 m NAVD88
Pine Island Sound
Sanctuary Lake 7

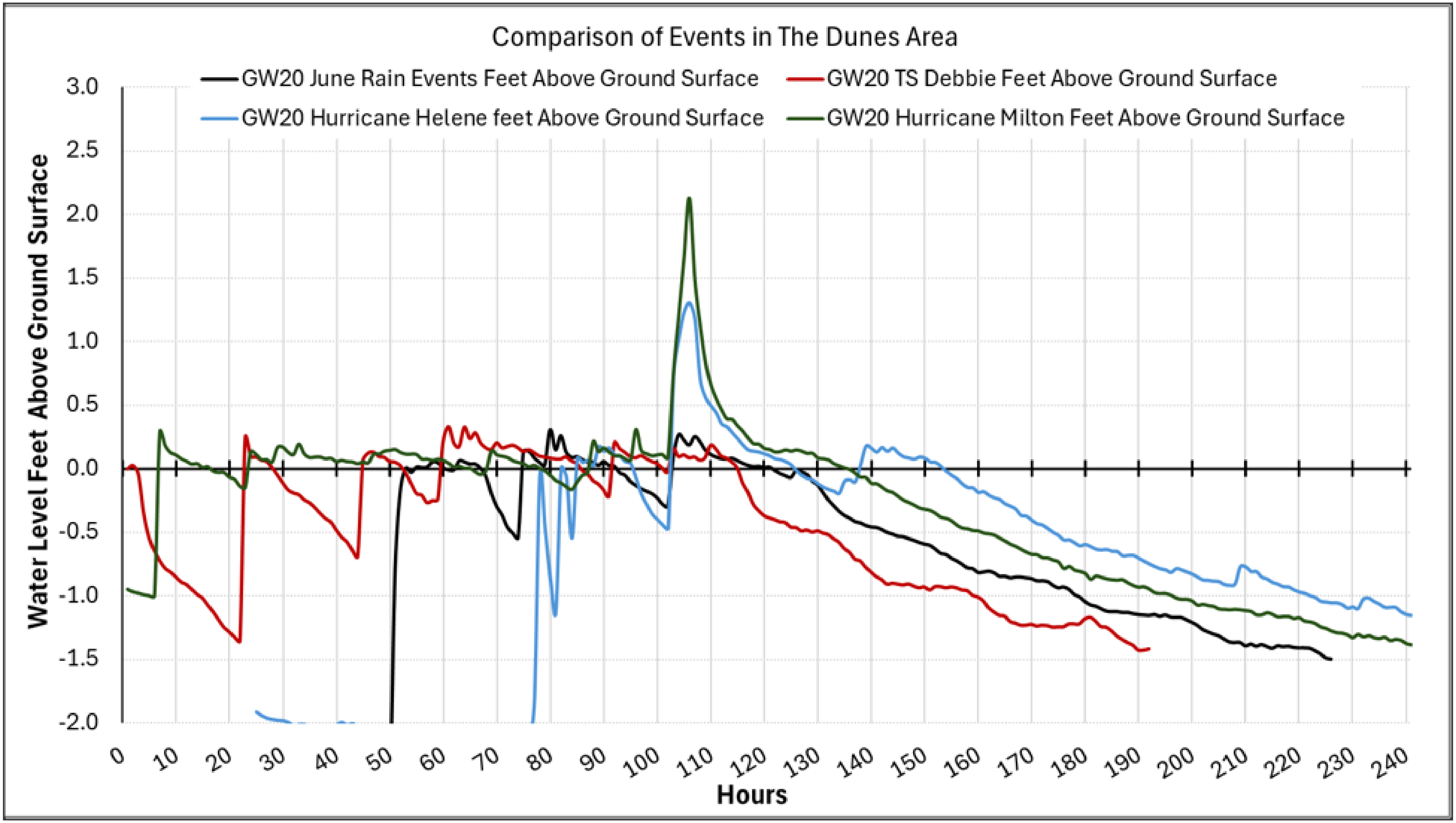

Sanctuary Golf Course Area Water Above Ground
Water Level in Feet Above Ground Surface
GW15 Feet Above Ground Surface
GW16 Feet Above Ground Surface
GW22 Feet Above Ground Surface
GW23 Feet Above Ground Surface


Dunes Area Water Level Above Ground: June Rain Events
Water Level in Feet Above Ground Surface
GW14 Water Level Relative to Ground Surface (ft)
GW18 Water Level Relative to Ground Surface (ft)
GW19 Water Level Relative to Ground Surface (ft)
GW20 Water Level Relative to Ground Surface (ft)
GW21 Water Level Relative to Ground Surface (ft)
4
3
2
1
0
-1
-2
-3
-4
-5
6/8/2024 12:00
6/9/2024 00:00
6/9/2024 12:00
6/10/2024 00:00
6/10/2024 12:00
6/11/2024 00:00
6/11/2024 12:00
6/12/2024 00:00
6/12/2024 12:00
6/13/2024 00:00
6/13/2024 12:00
6/14/2024 00:00
6/14/2024 12:00
6/15/2024 00:00
6/15/2024 12:00
6/16/2024 00:00
6/16/2024 12:00
6/17/2024 00:00
6/17/2024 12:00
6/18/2024 00:00
6/18/2024 12:00

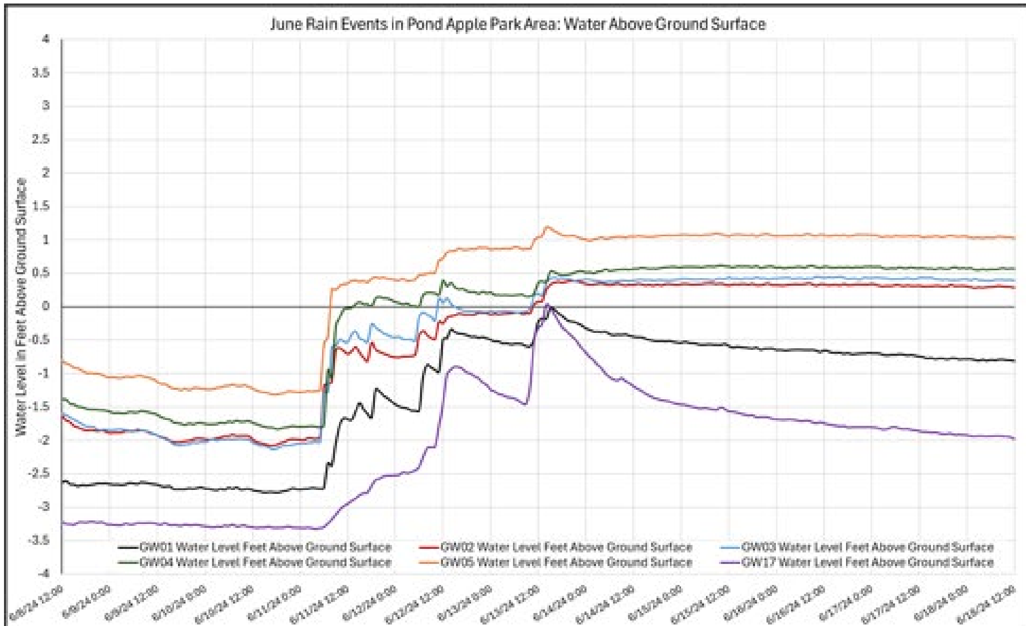

Dunes Area Water Level Above Ground: Hurricane Helene
Water Level in Feet Above Ground Surface
GW14 Water Level Relative to Ground Surface (ft)
GW18 Water Level Relative to Ground Surface (ft)
GW19 Water Level Relative to Ground Surface (ft)
GW20 Water Level Relative to Ground Surface (ft)
GW21 Water Level Relative to Ground Surface (ft)
4
3
2
1
0
-1
-2
-3
-4
-5
9/23/2024 12:00
9/24/2024 00:00
9/24/2024 12:00
9/25/2024 00:00
9/25/2024 12:00
9/26/2024 00:00
9/26/2024 12:00
9/27/2024 00:00
9/27/2024 12:00
9/28/2024 00:00
9/28/2024 12:00
9/29/2024 00:00
9/29/2024 12:00
9/30/2024 00:00
9/30/2024 12:00
10/1/2024 00:00
10/1/2024 12:00
10/2/2024 00:00
10/2/2024 12:00
10/3/2024 00:00
10/3/2024 12:00

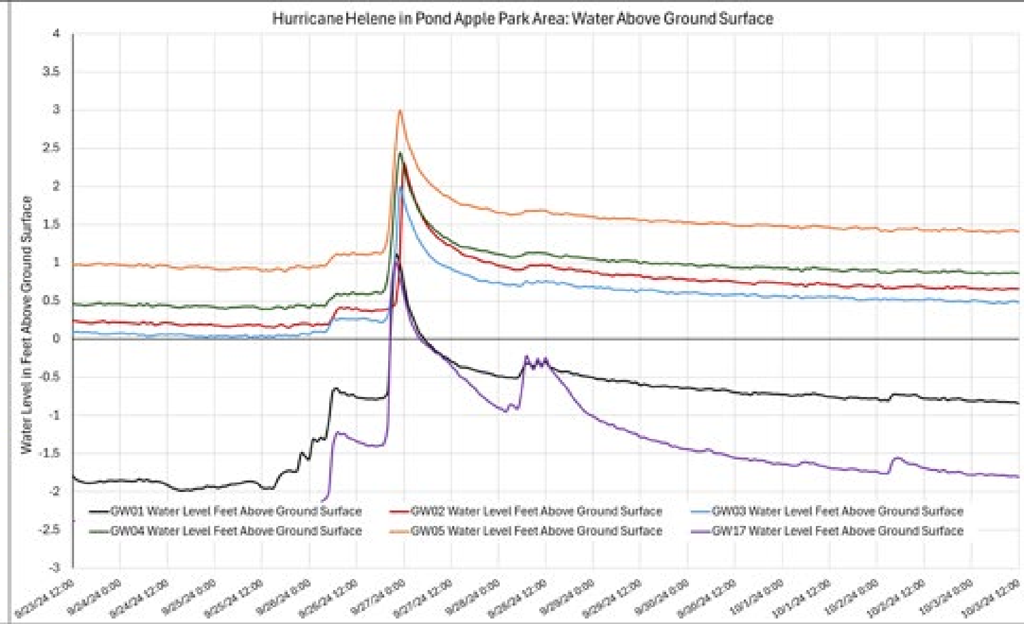

Dunes Area Water Level Above Ground: Tropical Storm Debbie
Water Level in Feet Above Ground Surface
GW14 Water Level Relative to Ground Surface (ft)
GW18 Water Level Relative to Ground Surface (ft)
GW19 Water Level Relative to Ground Surface (ft)
GW20 Water Level Relative to Ground Surface (ft)
GW21 Water Level Relative to Ground Surface (ft)
4
3
2
1
0
-1
-2
-3
-4
-5
7/31/2024 12:00
8/1/2024 00:00
8/1/2024 12:00
8/2/2024 00:00
8/2/2024 12:00
8/3/2024 00:00
8/3/2024 12:00
8/4/2024 00:00
8/4/2024 12:00
8/5/2024 00:00
8/5/2024 12:00
8/6/2024 00:00
8/6/2024 12:00
8/7/2024 00:00
8/7/2024 12:00
8/8/2024 00:00
8/8/2024 12:00
8/9/2024 00:00
8/9/2024 12:00
8/10/2024 00:00
8/10/2024 12:00

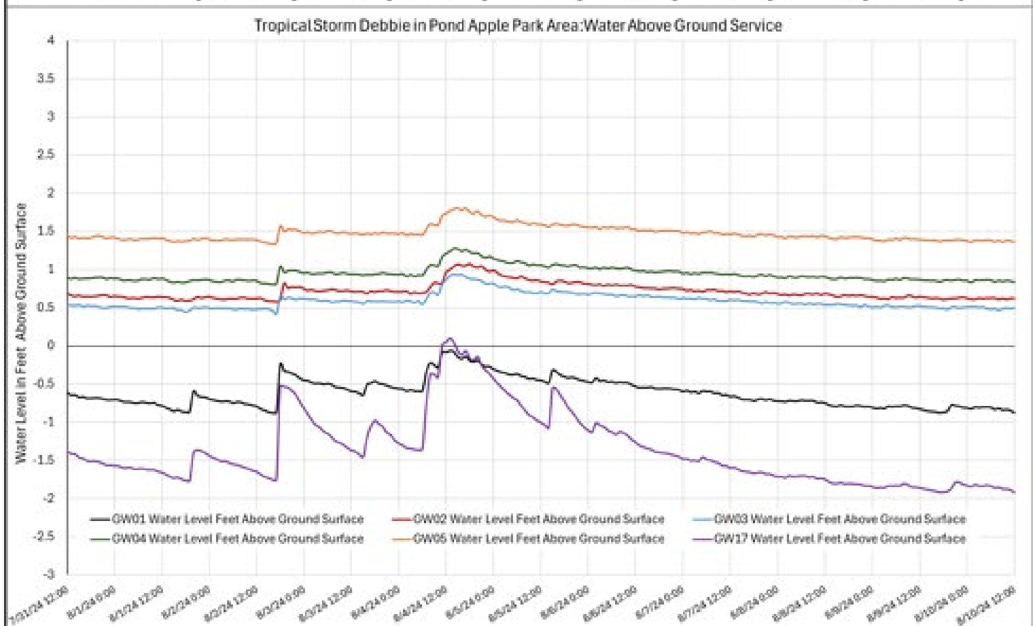

Dunes Area Water Level Above Ground: Hurricane Milton
Water Level in Feet Above Ground Surface
GW14 Water Level Relative to Ground Surface (ft)
GW18 Water Level Relative to Ground Surface (ft)
GW19 Water Level Relative to Ground Surface (ft)
GW20 Water Level Relative to Ground Surface (ft)
GW21 Water Level Relative to Ground Surface (ft)
4
3
2
1
0
-1
-2
-3
-4
-5
10/5/2024 12:00
10/6/2024 00:00
10/6/2024 12:00
10/7/2024 00:00
10/7/2024 12:00
10/8/2024 00:00
10/8/2024 12:00
10/9/2024 00:00
10/9/2024 12:00
10/10/2024 00:00
10/10/2024 12:00
10/11/2024 00:00
10/11/2024 12:00
10/12/2024 00:00
10/12/2024 12:00
10/13/2024 00:00
10/13/2024 12:00
10/14/2024 00:00
10/14/2024 12:00
10/15/2024 00:00
10/15/2024 12:00

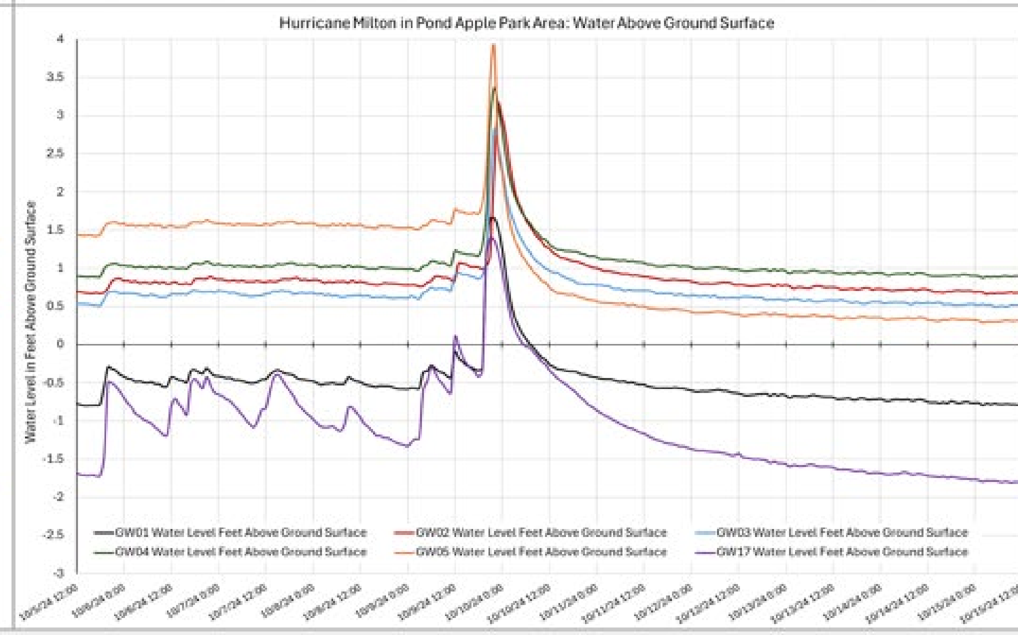


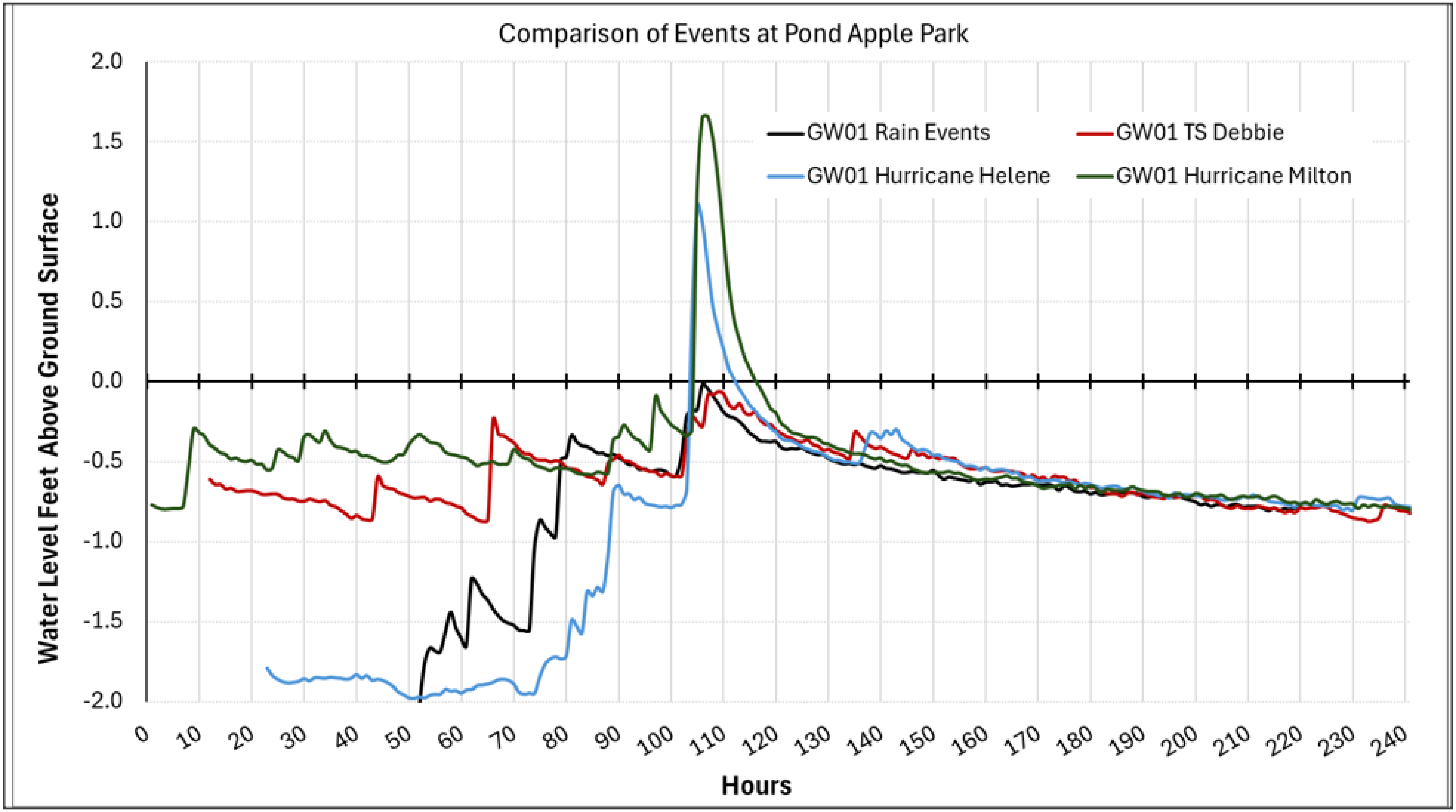
Comparison of Events in The Dunes Area
GW20 June Rain Events Feet Above Ground Surface
GW20 TS Debbie Feet Above Ground Surface
GW20 Hurricane Helene feet Above Ground Surface
GW20 Hurricane Milton Feet Above Ground Surface
Water Level Feet Above Ground Surface
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Hours


June Rain Events in Pond Apple Park Area: Water Above Ground Surface
Water Level in Feet Above Ground Surface
GW01 Water Level Feet Above Ground Surface
GW02 Water Level Feet Above Ground Surface
GW03 Water Level Feet Above Ground Surface
GW04 Water Level Feet Above Ground Surface
GW05 Water Level Feet Above Ground Surface
GW17 Water Level Feet Above Ground Surface

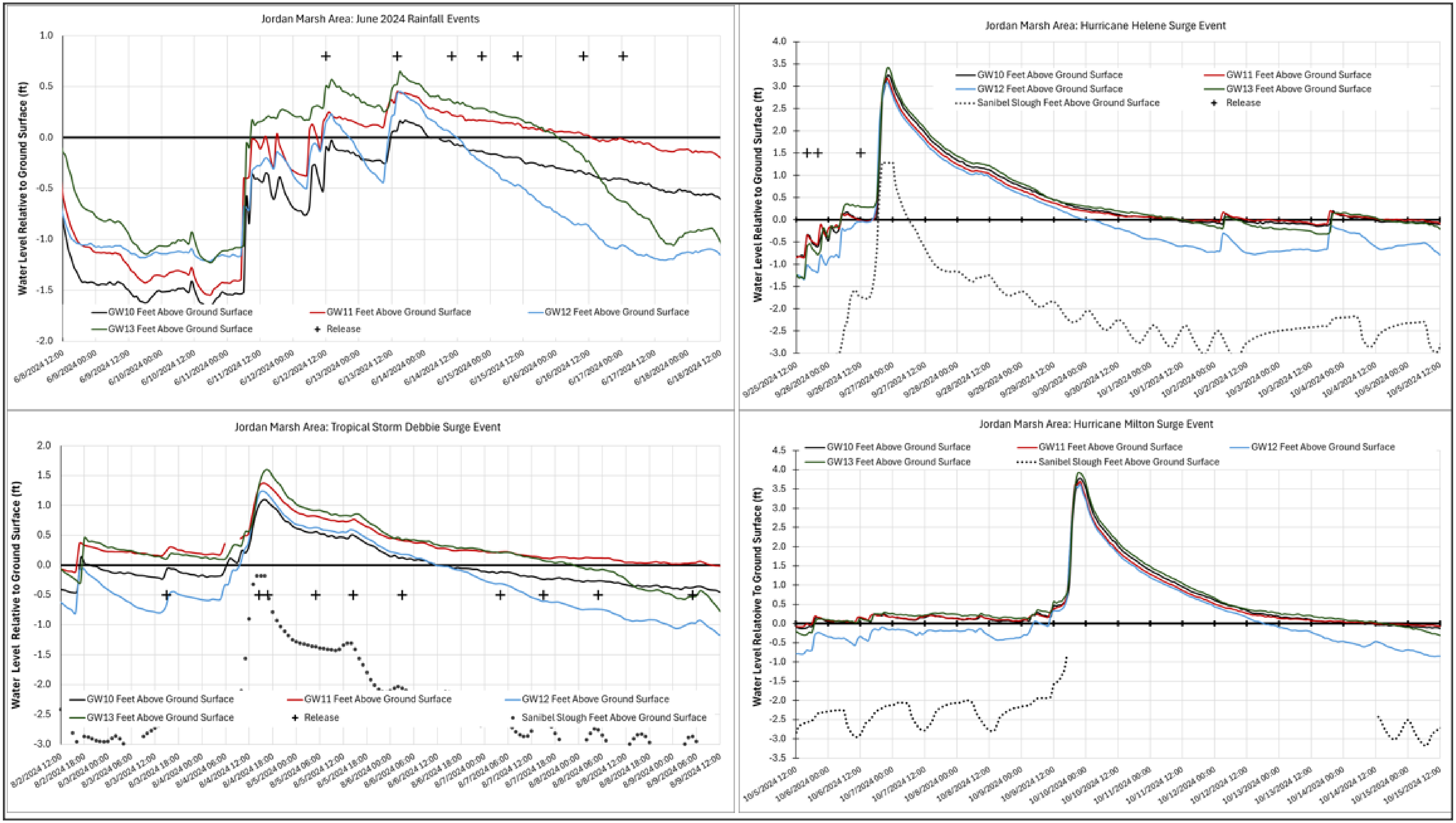

Hurricane Helene in Pond Apple Park Area: Water Above Ground Surface
Water Level in Feet Above Ground Surface
GW01 Water Level Feet Above Ground Surface
GW02 Water Level Feet Above Ground Surface
GW03 Water Level Feet Above Ground Surface
GW04 Water Level Feet Above Ground Surface
GW05 Water Level Feet Above Ground Surface
GW17 Water Level Feet Above Ground Surface

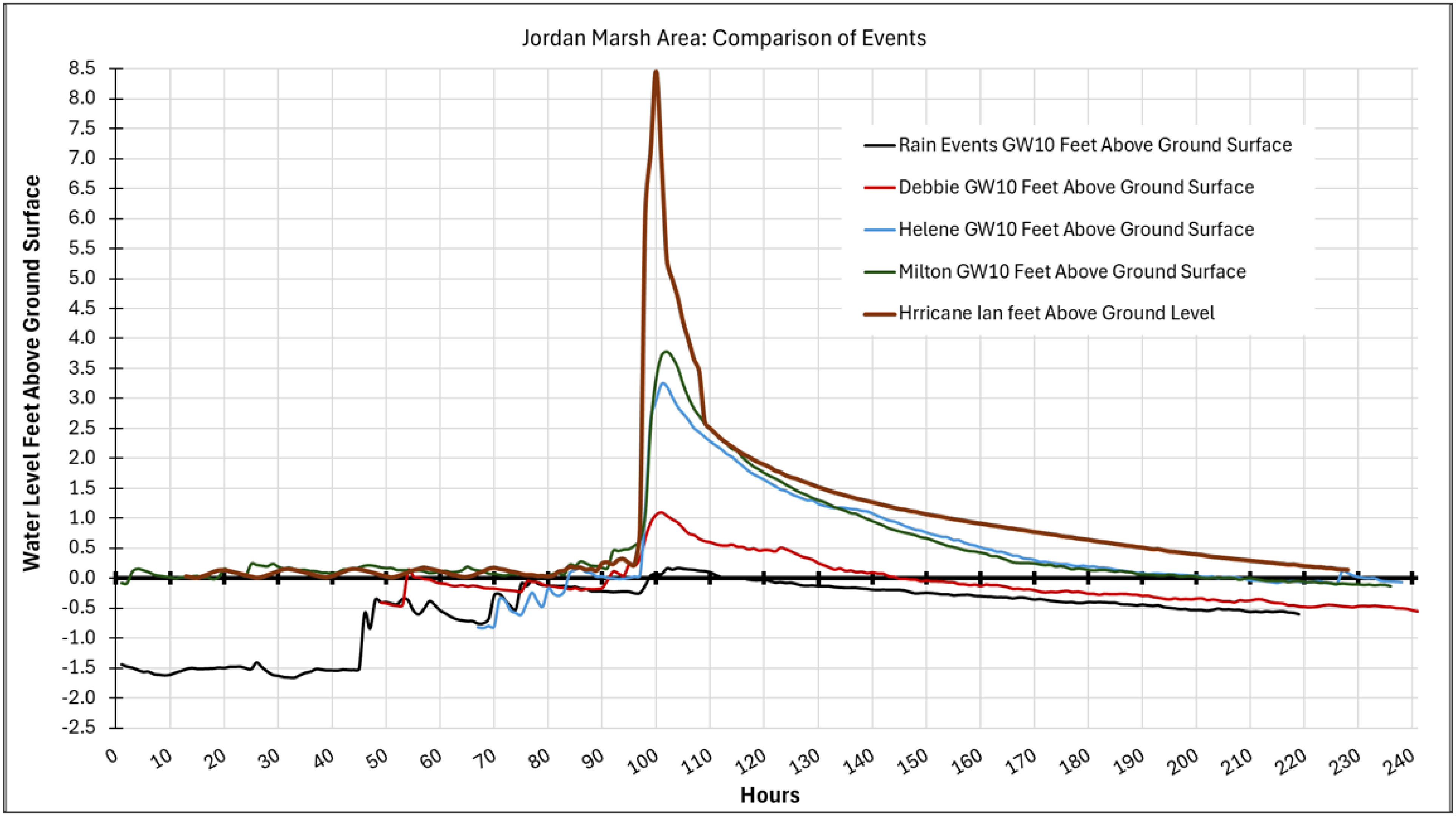

Tropical Storm Debbie in Pond Apple Park Area:Water Above Ground Service
Water Level in Feet Above Ground Surface
GW01 Water Level Feet Above Ground Surface
GW02 Water Level Feet Above Ground Surface
GW03 Water Level Feet Above Ground Surface
GW04 Water Level Feet Above Ground Surface
GW05 Water Level Feet Above Ground Surface
GW17 Water Level Feet Above Ground Surface


Hurricane Milton in Pond Apple Park Area: Water Above Ground Surface
Water Level in Feet Above Ground Surface
GW01 Water Level Feet Above Ground Surface
GW02 Water Level Feet Above Ground Surface
GW03 Water Level Feet Above Ground Surface
GW04 Water Level Feet Above Ground Surface
GW05 Water Level Feet Above Ground Surface
GW17 Water Level Feet Above Ground Surface

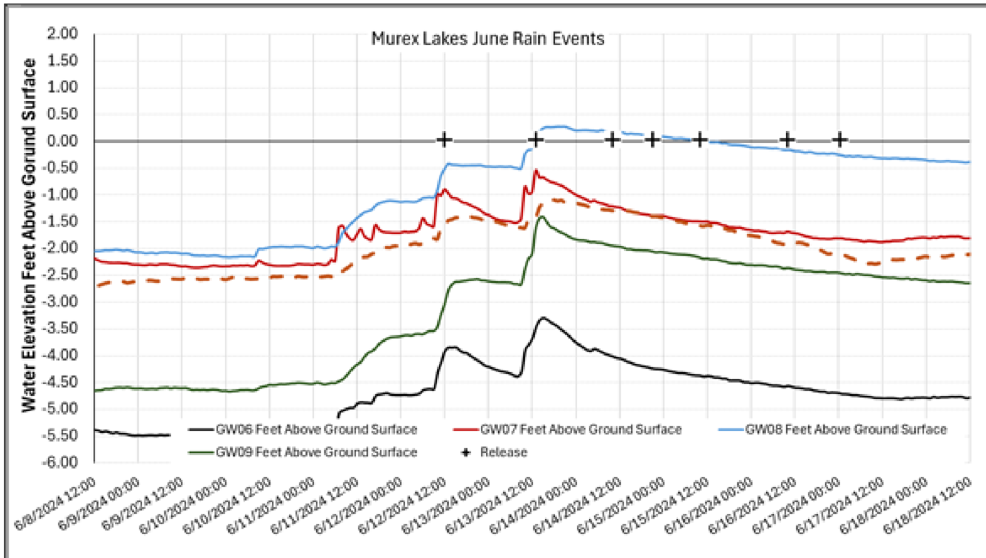


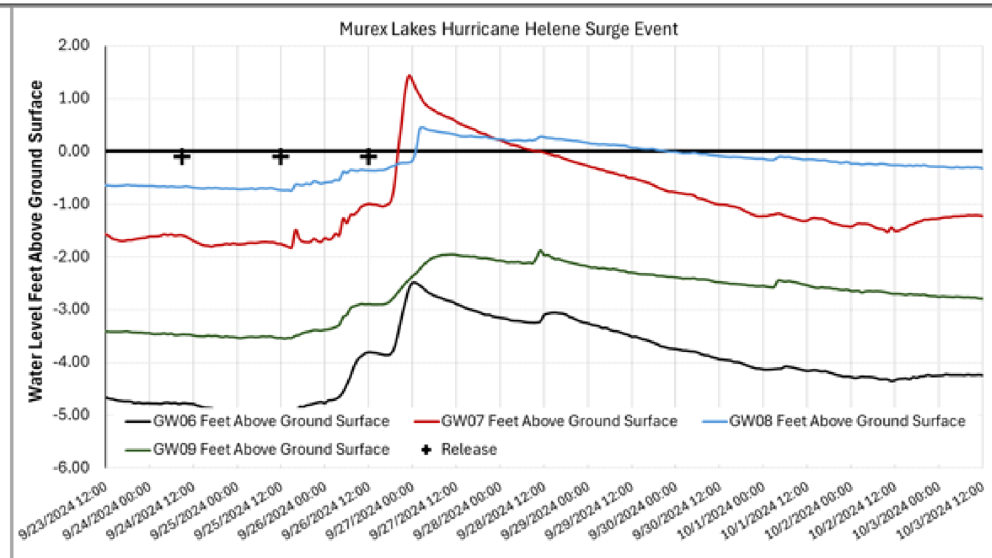
Comparison of Events at Pond Apple Park
GW01 Rain Events
GW01 TS Debbie
GW01 Hurricane Helene
GW01 Hurricane Milton
Water Level Feet Above Ground Surface
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Hours

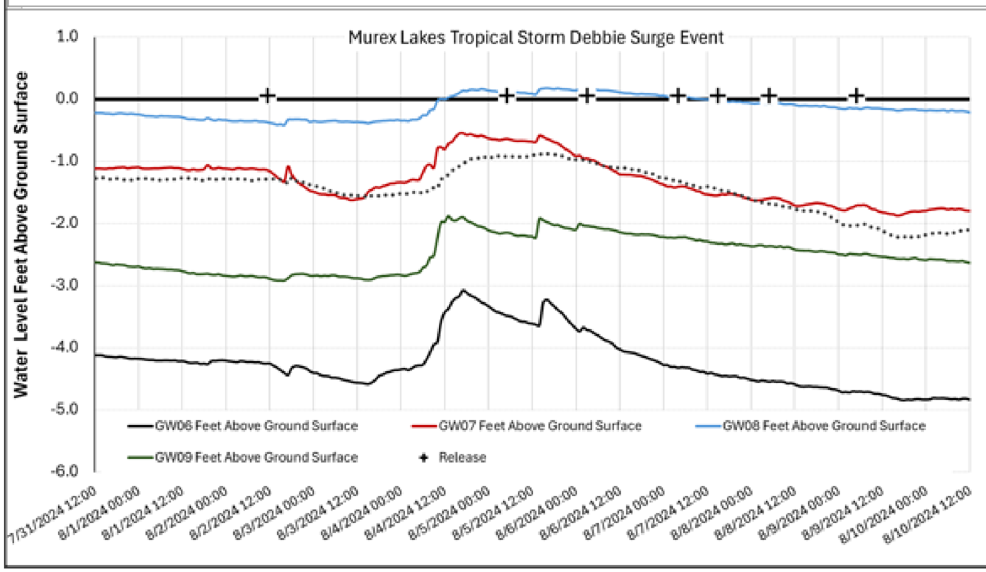

Jordan Marsh Area: June 2024 Rainfall Events
Water Level Relative to Ground Surface (ft)
GW10 Feet Above Ground Surface
GW11 Feet Above Ground Surface
GW12 Feet Above Ground Surface
GW13 Feet Above Ground Surface
Release
Jordan Marsh Area: Hurricane Helene Surge Event
Water Level Relative to Ground Surface (ft)
GW10 Feet Above Ground Surface
GW11 Feet Above Ground Surface
GW12 Feet Above Ground Surface
GW13 Feet Above Ground Surface
Sanibel Slough Feet Above Ground Surface
Release
Jordan Marsh Area: Tropical Storm Debbie Surge Event
Water Level Relative to Ground Surface (ft)
GW10 Feet Above Ground Surface
GW11 Feet Above Ground Surface
GW12 Feet Above Ground Surface
GW13 Feet Above Ground Surface
Release
Sanibel Slough Feet Above Ground Surface
Jordan Marsh Area: Hurricane Milton Surge Event
Water Level Relatoive To Ground Surface (ft)
GW10 Feet Above Ground Surface
GW11 Feet Above Ground Surface
GW12 Feet Above Ground Surface
GW13 Feet Above Ground Surface
Sanibel Slough Feet Above Ground Surface

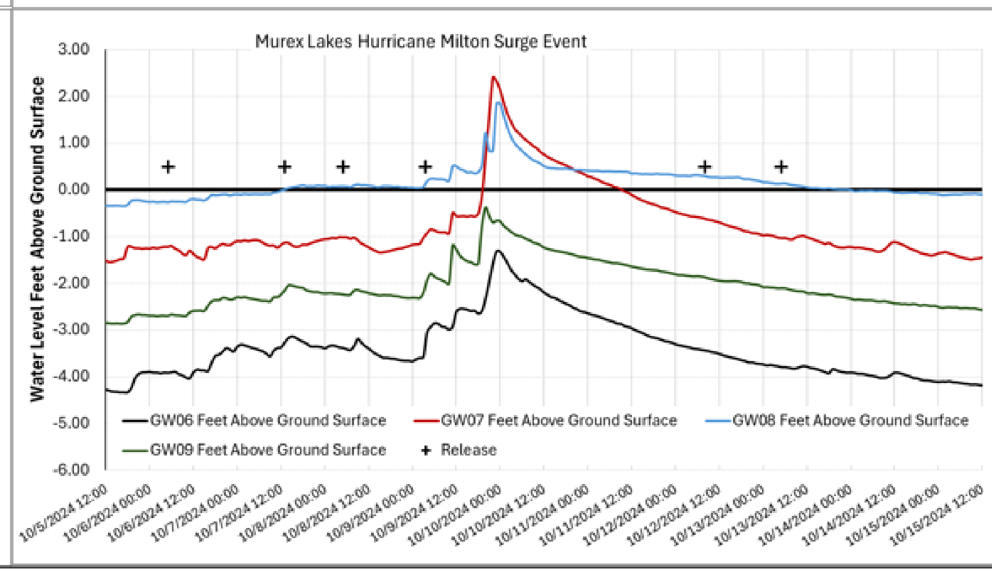


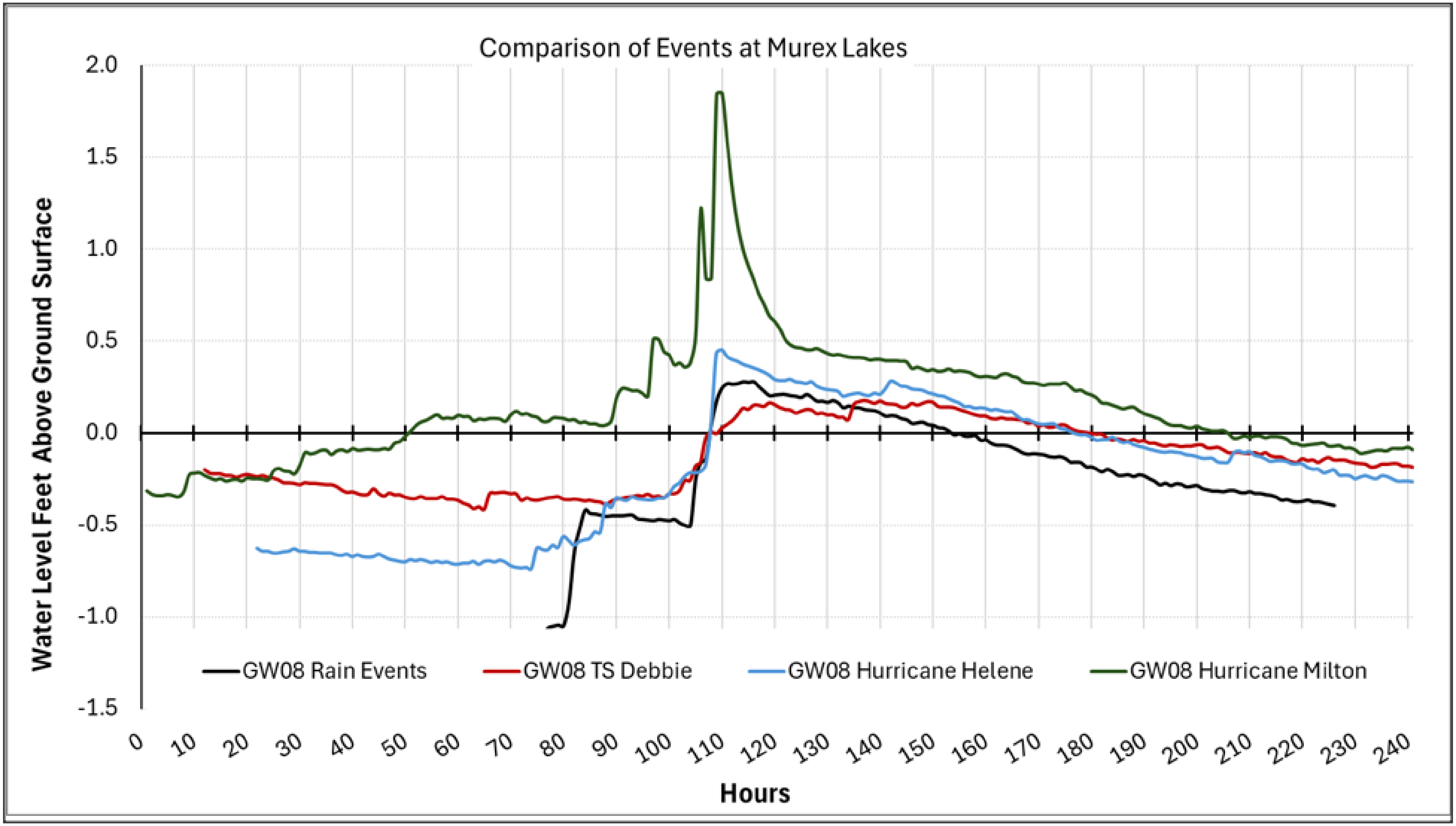
Jordan Marsh Area: Comparison of Events
Water Level Feet Above Ground Surface
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Hours
Rain Events GW10 Feet Above Ground Surface
Debbie GW10 Feet Above Ground Surface
Helene GW10 Feet Above Ground Surface
Milton GW10 Feet Above Ground Surface
Hrricane Ian feet Above Ground Level

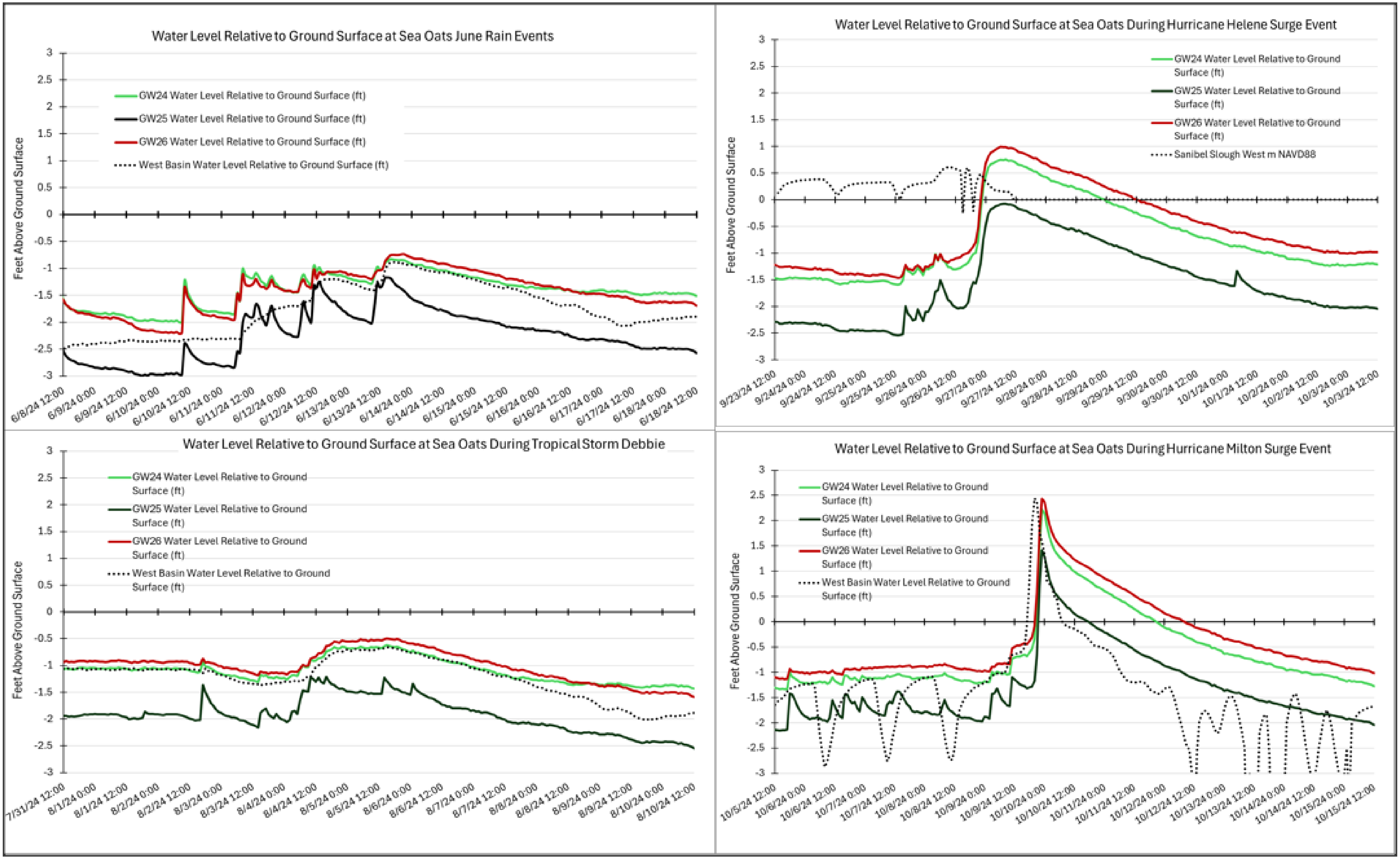

Murex Lakes June Rain Events
Water Elevation Feet Above Gorund Surface
GW06 Feet Above Ground Surface
GW07 Feet Above Ground Surface
GW08 Feet Above Ground Surface
GW09 Feet Above Ground Surface
Release


Murex Lakes Hurricane Helene Surge Event
Water Level Feet Above Ground Surface
GW06 Feet Above Ground Surface
GW07 Feet Above Ground Surface
GW08 Feet Above Ground Surface
GW09 Feet Above Ground Surface
Release

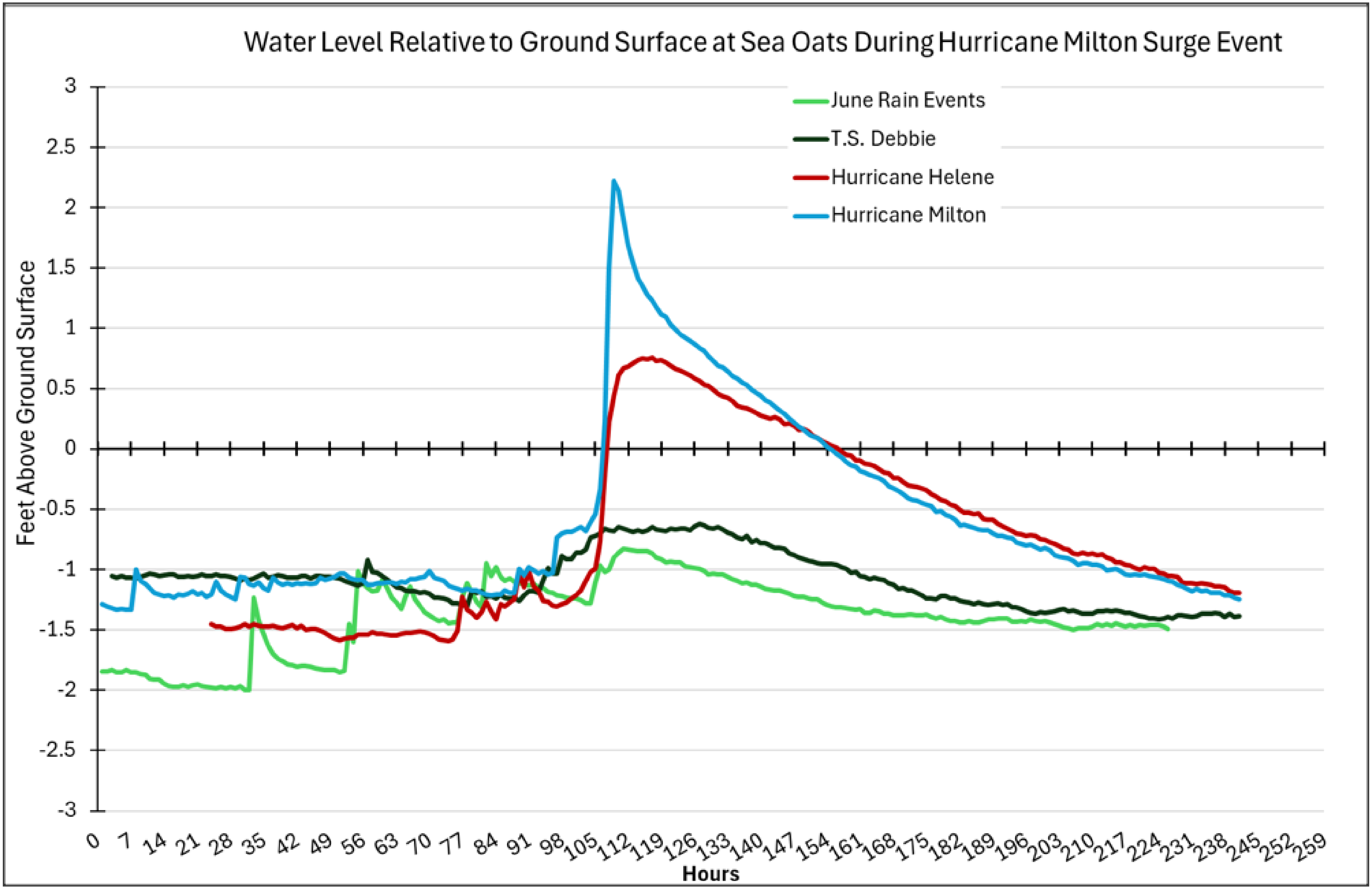

Murex Lakes Tropical Storm Debbie Surge Event
Water Level Feet Above Ground Surface
GW06 Feet Above Ground Surface
GW07 Feet Above Ground Surface
GW08 Feet Above Ground Surface
GW09 Feet Above Ground Surface
Release


Murex Lakes Hurricane Milton Surge Event
Water Level Feet Above Ground Surface
GW06 Feet Above Ground Surface
GW07 Feet Above Ground Surface
GW08 Feet Above Ground Surface
GW09 Feet Above Ground Surface
Release

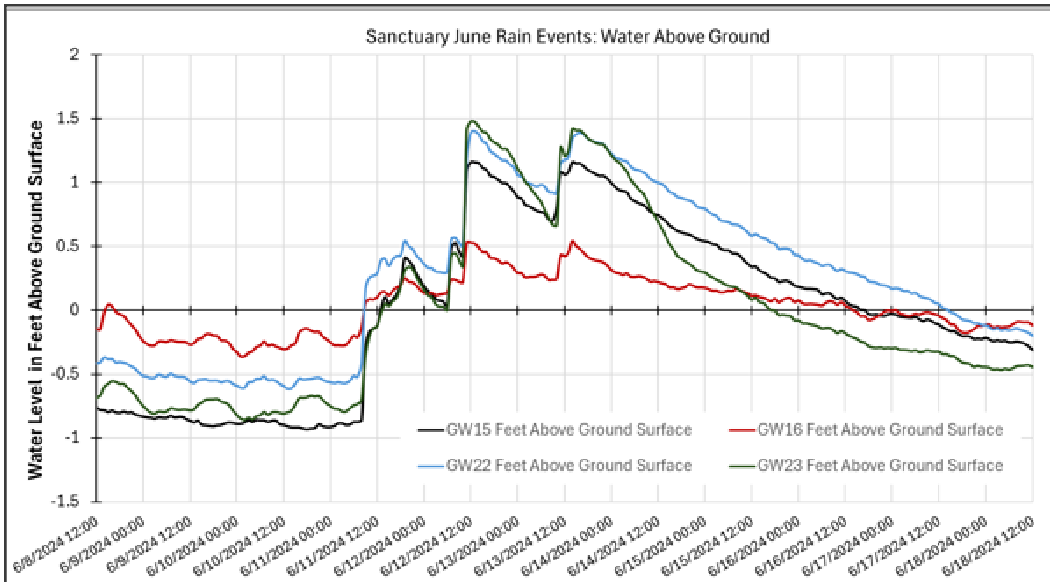

Comparison of Events at Murex Lakes
Water Level Feet Above Ground Surface
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
GW08 Rain Events
GW08 TS Debbie
GW08 Hurricane Helene
GW08 Hurricane Milton
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Hours

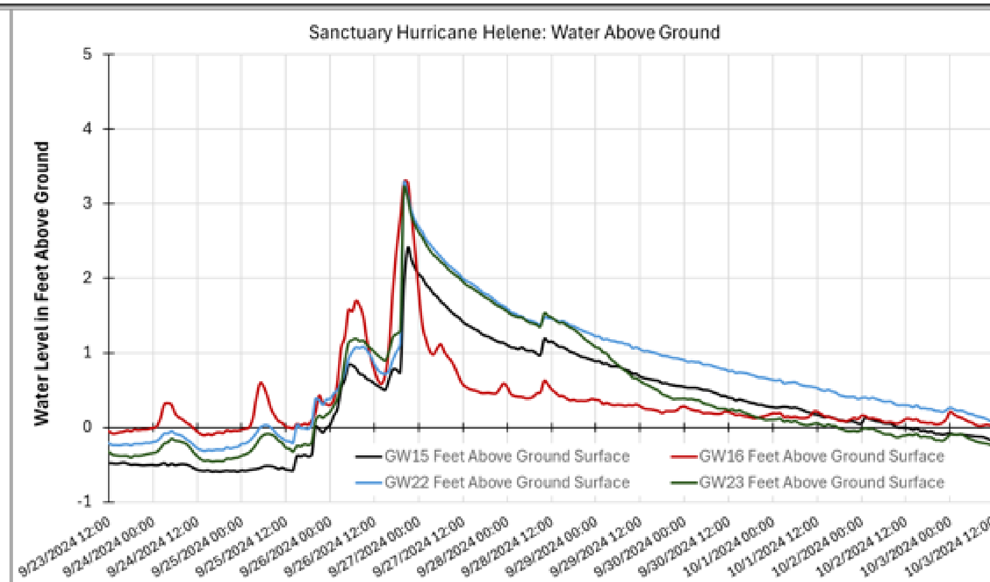


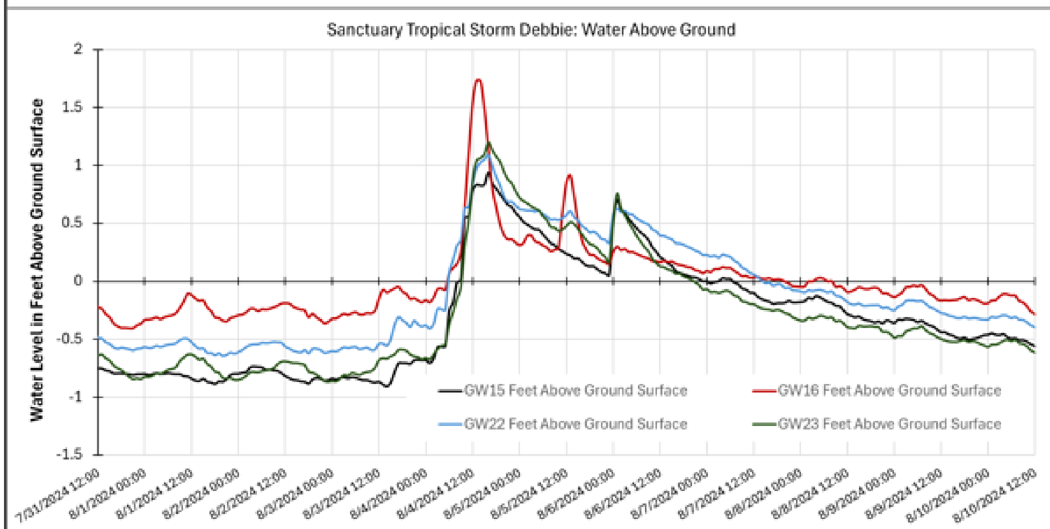
Water Level Relative to Ground Surface at Sea Oats June Rain Events
GW24 Water Level Relative to Ground Surface (ft)
GW25 Water Level Relative to Ground Surface (ft)
GW26 Water Level Relative to Ground Surface (ft)
West Basin Water Level Relative to Ground Surface (ft)
Feet Above Ground Surface
Water Level Relative to Ground Surface at Sea Oats During Hurricane Helene Surge Event
GW24 Water Level Relative to Ground Surface (ft)
GW25 Water Level Relative to Ground Surface (ft)
GW26 Water Level Relative to Ground Surface (ft)
Sanibel Slough West m NAVD88
Feet Above Ground Surface
Water Level Relative to Ground Surface at Sea Oats During Tropical Storm Debbie
GW24 Water Level Relative to Ground Surface (ft)
GW25 Water Level Relative to Ground Surface (ft)
GW26 Water Level Relative to Ground Surface (ft)
West Basin Water Level Relative to Ground Surface (ft)
Feet Above Ground Surface
Water Level Relative to Ground Surface at Sea Oats During Hurricane Milton Surge Event
GW24 Water Level Relative to Ground Surface (ft)
GW25 Water Level Relative to Ground Surface (ft)
GW26 Water Level Relative to Ground Surface (ft)
West Basin Water Level Relative to Ground Surface (ft)
Feet Above Ground Surface

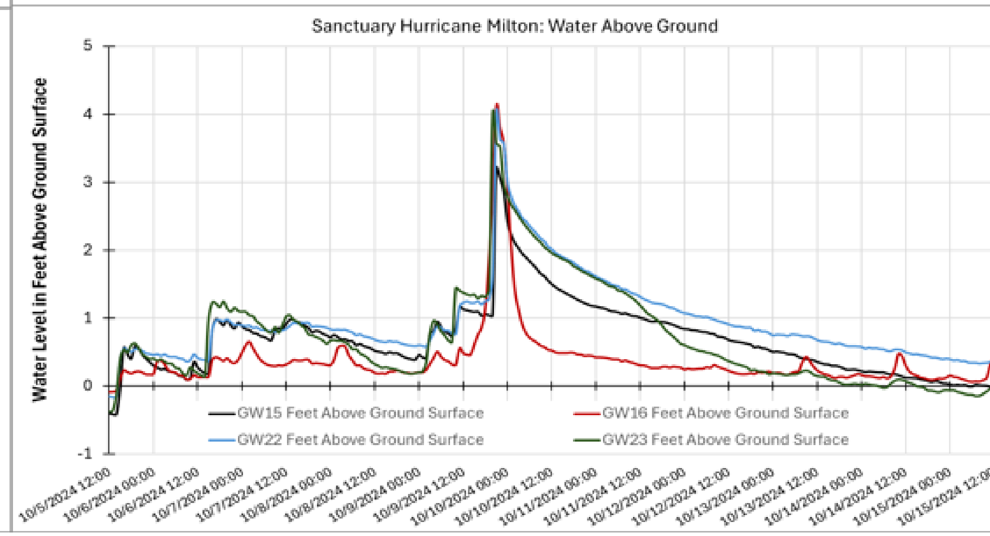


Water Level Relative to Ground Surface at Sea Oats During Hurricane Milton Surge Event
June Rain Events
T.S. Debbie
Hurricane Helene
Hurricane Milton
Feet Above Ground Surface
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
0 7 14 21 28 35 42 49 56 63 70 77 84 91 98 105 112 119 126 133 140 147 154 161 168 175 182 189 196 203 210 217 224 231 238 245 252 259
Hours


Sanctuary June Rain Events: Water Above Ground
Water Level in Feet Above Ground Surface
2
1.5
1
0.5
0
-0.5
-1
-1.5
GW15 Feet Above Ground Surface
GW16 Feet Above Ground Surface
GW22 Feet Above Ground Surface
GW23 Feet Above Ground Surface
6/8/2024 12:00
6/9/2024 00:00
6/9/2024 12:00
6/10/2024 00:00
6/10/2024 12:00
6/11/2024 00:00
6/11/2024 12:00
6/12/2024 00:00
6/12/2024 12:00
6/13/2024 00:00
6/13/2024 12:00
6/14/2024 00:00
6/14/2024 12:00
6/15/2024 00:00
6/15/2024 12:00
6/16/2024 00:00
6/16/2024 12:00
6/17/2024 00:00
6/17/2024 12:00
6/18/2024 00:00
6/18/2024 12:00


Sanctuary Hurricane Helene: Water Above Ground
Water Level in Feet Above Ground
5
4
3
2
1
0
-1
GW15 Feet Above Ground Surface
GW16 Feet Above Ground Surface
GW22 Feet Above Ground Surface
GW23 Feet Above Ground Surface
9/23/2024 12:00
9/24/2024 00:00
9/24/2024 12:00
9/25/2024 00:00
9/25/2024 12:00
9/26/2024 00:00
9/26/2024 12:00
9/27/2024 00:00
9/27/2024 12:00
9/28/2024 00:00
9/28/2024 12:00
9/29/2024 00:00
9/29/2024 12:00
9/30/2024 00:00
9/30/2024 12:00
10/1/2024 00:00
10/1/2024 12:00
10/2/2024 00:00
10/2/2024 12:00
10/3/2024 00:00
10/3/2024 12:00


Sanctuary Tropical Storm Debbie: Water Above Ground
Water Level in Feet Above Ground Surface
2
1.5
1
0.5
0
-0.5
-1
-1.5
GW15 Feet Above Ground Surface
GW16 Feet Above Ground Surface
GW22 Feet Above Ground Surface
GW23 Feet Above Ground Surface
7/31/2024 12:00
8/1/2024 00:00
8/1/2024 12:00
8/2/2024 00:00
8/2/2024 12:00
8/3/2024 00:00
8/3/2024 12:00
8/4/2024 00:00
8/4/2024 12:00
8/5/2024 00:00
8/5/2024 12:00
8/6/2024 00:00
8/6/2024 12:00
8/7/2024 00:00
8/7/2024 12:00
8/8/2024 00:00
8/8/2024 12:00
8/9/2024 00:00
8/9/2024 12:00
8/10/2024 00:00
8/10/2024 12:00


Sanctuary Hurricane Milton: Water Above Ground
Water Level in Feet Above Ground Surface
5
4
3
2
1
0
-1
GW15 Feet Above Ground Surface
GW16 Feet Above Ground Surface
GW22 Feet Above Ground Surface
GW23 Feet Above Ground Surface
10/5/2024 12:00
10/6/2024 00:00
10/6/2024 12:00
10/7/2024 00:00
10/7/2024 12:00
10/8/2024 00:00
10/8/2024 12:00
10/9/2024 00:00
10/9/2024 12:00
10/10/2024 00:00
10/10/2024 12:00
10/11/2024 00:00
10/11/2024 12:00
10/12/2024 00:00
10/12/2024 12:00
10/13/2024 00:00
10/13/2024 12:00
10/14/2024 00:00
10/14/2024 12:00
10/15/2024 00:00
10/15/2024 12:00