2024 CLAM BAY WATER QUALITY ANALYSIS (WBID 3278Q4)

A Comprehensive Water Quality Assessment

SECTIONS 4/5/9/32/32, TOWNSHIPS 48/49 SOUTH, RANGE 25 EAST
COLLIER COUNTY, FLORIDA

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February 27, 2026

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2.0 EXECUTIVE SUMMARY

Earth Tech Environmental (ETE) conducted an analysis of water quality data in and adjacent to the Clam Bay Natural Resources Protection Area (NRPA) in coastal Naples, Florida. Clam Bay is comprised of approximately 560 acres of estuary, mangrove forest, and hand dug channels with connectivity to the Gulf of Mexico via Clam Pass. Water quality data was evaluated from 2024 and compared to long-term data from 2017 -2024.

While the bay remains a vital mangrove estuary, our findings confirm it continues to struggle with high levels of nutrients and remains on the state's list of impaired waters. Specifically, both total phosphorus (TP) and total nitrogen (TN) exceed the regulatory limits set by the Florida Department of Environmental Protection (FDEP). While nitrogen levels are only marginally above the limit, phosphorus remains as the primary concern, with 2024 showing a slight increase in exceedances compared to the previous year. The analysis identifies a clear link between high phosphorus levels and the overall decline in water quality, with phosphorus acting as the primary fuel for algal growth and subsequent dissolved oxygen depletion.

A distinct spatial gradient exists across the monitored zones, driven largely by proximity to tidal flushing. Water quality impairments are most severe in the northern, stagnant reaches of Upper Clam Bay, which exhibited the highest exceedance rates for TP and DO%. Moving south into Inner Clam Bay, conditions marginally improve as TP and DO% exceedances drop. Outer Clam Bay benefits most from tidal exchange, maintaining low DO% exceedances and zero Cu exceedances, though TP remains elevated. Conversely, the Seagate zone (CB9), located outside the Clam Bay NRPA, exhibits a distinctly different water quality regime; it recorded no exceedances for TP, DO%, or Cu, but experienced a high rate of TN exceedances.

While Clam Bay meets state standards for Cu and is not formally listed as impaired for this parameter (with long-term exceedances historically isolated to the Upper and Inner Bays), the persistent DO% and TP challenges highlight the system's vulnerability. Moving forward, the data suggests that reducing phosphorus inputs in the northern zones is the single most critical step to restoring the bay's ecological balance.

It is important to note that Pelican Bay Services Division (PBSD) is already actively implementing numerous Best Management Practices (BMPs) to address these pollutant loads. Current efforts include:

- Strict compliance with the local fertilizer ordinance.
- The use of phosphorus free and slow-release nitrogen fertilizers.
- Advanced IQ irrigation calculations to minimize runoff.
- The complete elimination of copper-based herbicides from PBSD managed areas.
- Public outreach efforts include informational displays, email blasts to residents, and social media campaigns.

Management recommendations based on this report and ongoing efforts include:

- Sample low DO% sites later in the day to remove the ambiguity caused by early morning sampling.
- Continuing and expanding source investigation for phosphorus and nitrogen from adjacent residential and golf course areas, including testing soil for phosphorus and utilizing the ongoing quarterly stormwater monitoring program.
- Better characterize and control adjacent sources of Cu from Clam Bay Inland (WBID 3287Q3) particularly near site CB1 and CB2 where Cu is typically higher.
- Continue public outreach and education efforts to inform residents and stakeholders about their role in nutrient and pollutant reduction.

3.0 LIMITATIONS AND EXCEPTIONS

This report is expressly for the sole and exclusive use of the party for whom this report was originally prepared for a particular purpose. Only the party for whom this report was originally prepared and/or other specifically named parties have the right to make use of and rely upon this report. Reuse of this report or any portion thereof other than for its intended purpose, or if modified, or if used by third parties, shall be at the user's sole risk. Past analyses were used for reference and not prepared by ETE for the purpose of this report.

4.0 INTRODUCTION

4.1 SITE DESCRIPTION

Clam Bay (WBID 3278Q4) is designated as Class II Waters – Shellfish Propagation and Harvesting. Three bays are present within the NRPA: Upper Clam Bay, Inner Clam Bay, and Outer Clam Bay (See Appendix A for Water Quality Sample Location Map). Clam Bay is bordered by the Pelican Bay residential community and Ritz Carlton Hotel to the north, the Pelican Bay residential community and golf course to the east, the Seagate residential community to the south, and Clam Pass Park/Pelican Bay beaches to the west. Clam Bay consists of brackish, tidally influenced water. Tidal flushing is greatest in waterways near Clam Pass and progressively decreases in areas farther from the pass. Eight sample locations are within the NRPA boundary, and one sample is located outside of the NRPA boundary in the Seagate community's canal system to the south, which is part of Clam Bay WBID 3278Q4. The specific locations of the nine water quality sample sites are detailed in the Water Quality Sampling Location Map (Appendix A).

4.2 BACKGROUND AND REGULATORY CONTEXT

In 2009, the U.S. Environmental Protection Agency (EPA) mandated nutrient concentration criteria for Florida under the Clean Water Act (CWA). The FDEP successfully adopted numeric nutrient criteria (NNC) for various Florida estuaries and coastal waters, including Clam Bay in 2012, which were approved by the EPA in fulfillment of the requirements of the CWA.

Clam Bay has been assigned NNCs for TP and TN that are termed Estuary-Specific Numeric Interpretations of the Narrative Nutrient Criterion (62-302.532(j) F.A.C.). These are based on the relationship between nutrient concentrations and the natural variability in salinity due to freshwater. The NNC for TP and TN are dynamic and based on specific conductance (which correlates to salinity). This approach accounts for natural fluctuations caused by variable freshwater inflow. The methodology recognizes that lower salinity (more freshwater) corresponds to a higher (less stringent) NNC for both TP (negative exponential curve) and TN (negative linear relationship)(Appendix B: Figures 1 and 2).

The FDEP's Statewide Comprehensive Verified List of Impaired Waters (Verified List) identifies waterbodies in Florida that do not meet water quality standards set forth in 62-302 F.A.C. Waterbodies on the Verified List are a priority for the development of total maximum daily loads (TMDLs) and Basin Management Action Plans (BMAPs). During the FDEP's biennial assessment, waterbodies are assessed for inclusion or delisting from the Verified List. Clam Bay (WBID 3278Q4) is listed as impaired for TN and TP, while Clam Bay Inland (WBID 3287Q3) is listed for Cu on the 2022-2024 FDEP Verified List. Clam Bay Inland is briefly discussed in the Berm Data section at the end of this report, because it is adjacent to Clam Bay and has influence on its water quality via stormwater outfalls located to the west of Clam Bay Inland.

The PBSD Municipal Services Taxing & Benefit Unit manages water, conservation areas, beach renourishment, and recreation facilities. PBSD advises Collier County on dredging and maintaining Clam Pass to ensure the health of the mangrove forest and estuary.

4.3 REPORT SCOPE

ETE prepared the current (2024) and previous (2022-2023) Clam Bay Water Quality Analysis reports. Data analyzed in this report is compared to findings from prior reports by other entities (e.g., Stantec) and has been re-evaluated by ETE in the long-term analysis. Previous reports are available on the Pelican Bay Property Owners Association website (https://pbpoa.org/pelican-bay-services-division-pbsd/).

According to the Estuary-Specific Numeric Interpretations of the Narrative Nutrient Criterion F.A.C. 62-302.532(j), Clam Bay is deemed impaired for TP or TN if the NNC is exceeded in over 10% of samples within the FDEP's evaluation period (the last 7.5 years of data). This report analyzes both 2024 data and the full publicly available dataset (November 2017 – December 2024, 7 years and 1 month) to evaluate impairment, determine water quality trends, and identify potential management responses based on the location, timing, and duration of exceedances.

4.4 KEY WATER QUALITY INDICATORS

The growth of primary producers (aquatic and marine plant life) is naturally limited by essential nutrients like nitrogen and phosphorus. However, inputs from sources like terrestrial runoff and fertilizers can lead to nutrient enrichment (Bricker et al., 2008). Signs of nutrient enrichment include increased biomass of plants and algae. This excessive growth disrupts the ecosystem's balance, leading to reduced water clarity, shifts in community composition, and potential harm to seagrass (e.g., reduced light). Furthermore, the decomposition of dead algae depletes oxygen, which can cause severe nighttime oxygen swings (Gobler and Baumann, 2016), encourage growth of anaerobic bacteria, and promote the production of toxic hydrogen sulfide (Perner et al., 2022).

Oxygen is critical for almost all marine life and the health of estuarine ecosystems. In seawater, the availability of oxygen to marine organisms is measured using DO%. This is one of the most vital indicators of water quality as low oxygen can cause stress, behavioral changes, and death in marine organisms, leading to an overall decrease in species abundance and diversity (Breitburg et al., 2018).

While Cu is an essential trace metal required for many biological processes, it can be toxic for marine life at increasing concentrations. Natural sources of Cu in aquatic systems include weathering and erosion of rocks and soils (Reichelt-Brushett and Batley, 2023). Anthropogenic sources of Cu include power plant cooling water discharges, stormwater, dredging, agricultural runoff, landfills, pesticides, and algaecides (Reichelt-Brushett and Batley 2023, Warne and Reichelt-Brushett, 2023). A major source of Cu in the marine environment is antifouling paints, used as coatings for ship hulls, buoys, and underwater surfaces (Warne and Reichelt-Brushett, 2023). Adverse effects of elevated Cu exposure on fishes include tumor formation, reduced growth and reproduction, altered metabolism, inhibited swimming, and death (Liao et al., 2023).

4.5 ENVIRONMENTAL INFLUENCES

In addition to the chemical and biological drivers, regional weather patterns and storm activity significantly influence estuarine water quality. In 2024, the Southwest Florida region received 53.50 inches of rain during the wet season (June 1–October 31), which was 130% of normal, and a total of 69.59 inches for the entire year (SFWMD, 2024). Furthermore, Hurricanes Helene (September 27, 2024) and Milton (October 10, 2024) generated significant storm surges of 4.02 ft and 5.08 ft, respectively (measured above Mean Higher High Water at the Naples Bay tide gauge). See Appendix B: Figure 3 for 2024 hydrographs from the three ETE water level loggers in Clam Bay.

The efficiency of tidal flushing and water residence time varies significantly across the sampling area. The entire system exhibits a general north-to-south flow which combined with the proximity to Clam Pass

dictates flushing rates (EPA, WATERS Geoviewer 2.0). The northern stations around Upper and Inner Clam Bay (CB1-CB4) receive the least amount of tidal flushing and possess the longest residence times. Conversely, the central and southern stations around Outer Clam Bay (CB5-CB9) benefit from greater tidal exchange. This varying tidal exchange directly impacts water quality, as areas with longer residence times are more susceptible to nutrient accumulation and subsequent dissolved oxygen depletion.

5.0 METHODOLOGY

Water quality samples were collected monthly at nine sample locations within the Clam Bay WBID (3278Q4) by Collier County Pollution Control. Water chemistry and physical properties were determined in the field. Samples were collected for nutrients, biological indicators, and metals and analyzed by Collier County Pollution Control Laboratory (Lab ID: E45464) or Pace Analytical (Lab ID: E83079), both of which are National Environmental Laboratory Accreditation Program (NELAP) accredited laboratories, ensuring they meet the rigorous quality and competence standards set by the National Environmental Laboratory Accreditation Council (NELAC). Some sites were not sampled in October and November of 2024 due to operational issues. In total, 17 properties were reported for each sample site, including:

- Nutrients: ammonia-N, nitrate-nitrite-N, nitrite-N, total Kjeldahl nitrogen (TKN), orthophosphate-P, and total phosphorus (TP).
- Biological Indicators: chlorophyll-a (Chl-a) and pheophytin-a.
- Water Chemistry: dissolved oxygen (DO mg/L), dissolved oxygen saturation (DO%), pH, salinity, specific conductance, and water temperature.
- Physical Properties: Secchi disk depth and turbidity.
- Metals: copper (Cu).

Water quality was evaluated using data from the FDEP's Watershed Information Network (WIN). This evaluation included two distinct analyses: a review of the 2024 calendar year and a long-term assessment of the full publicly available dataset (November 2017 – December 2024 or 7 years and 1 month). The one-year analysis focuses on recent conditions and serves as a point of comparison with previous reports, while the long-term analysis provides insight into the criteria FDEP uses to add waterbodies to its Verified List in their biennial assessment. The results specifically focus on TP, TN, DO%, and Cu. Data were analyzed for compliance with Estuary-Specific NNC and established criteria for Cu.

Appendix D shows a table of specific lab reported data qualifiers reported with individual water samples that create uncertainty in the data or result in data that may not be accurate. These data were excluded from the data analysis.

5.1 DATA ANALYSIS

All data analyses were conducted using R (R Core Team, 2025). The assumption of normality was assessed for all variables (TN, TP, DO, and Chl-a) using the Shapiro-Wilk test. This test indicated that TN was normally distributed, whereas TP, DO, and Chl-a were not. Consequently, Spearman's rank correlation coefficient was selected for the correlation analysis. The code used for all statistical models, criteria calculations, and data presentation is available upon request.

5.1.1 TOTAL PHOSPHORUS (TP) & TOTAL NITROGEN (TN)

The Estuary-Specific Numeric Interpretations of the NNC are calculated for each sample using the field-collected specific conductance, as outlined in 62-302.532(j) F.A.C and from "Correspondence Regarding Conductivity vs. Specific Conductivity" from Appendix C of the 2021 Clam Bay Water Quality Analysis (Stantec, 2022). TP was measured using EPA Method 365.3 or SM 4500-P E; both are colorimetric analyses

using ascorbic acid, performed after a persulfate digestion. Total Kjeldahl nitrogen was determined using EPA Method 351.2 which only measures ammonium and organic nitrogen. Nitrite-nitrite-N was determined using EPA method 353.2 (28 day hold time) which reduces nitrate to nitrite, forms into a colored azo dye, and is measured colorimetrically. TN was calculated as the sum of TKN + nitrate-nitrite-N (inorganic nitrogen).

The specific limits for each sampling location are calculated according to 62-302-532(j) F.A.C.:

$$TP\ Upper\ Limit(mg/L) = e^{(-1.06256-0.0000328465*Specific\ Conductance(\mu s/cm))} \quad (1)$$

$$TN\ Upper\ Limit\left(\frac{mg}{L}\right) = 2.3601 - 0.0000268325 * Specific\ Conductance(\mu S/cm) \quad (2)$$

In accordance with the Estuary-Specific Numeric Interpretations, the waterbody is considered impaired if more than 10% of the individual TP or TN measurements exceed the respective upper limit. The FDEP uses a binomial distribution with 90% confidence to determine if Clam Bay's water quality achieves the 10% standard set by the criteria for inclusion on the Verified List.

Since the sample size for the long-term data set exceeds the number of samples listed in Table 3 of Rule 62-303.420(1) F.A.C., the minimum number of samples not meeting the water quality criterion needed to determine if a waterbody should be placed on the Verified List was calculated using the binomial distribution formula described in Appendix E.

5.1.2 DISSOLVED OXYGEN SATURATION (DO%)

The amount of dissolved oxygen that water can hold is influenced by several factors, including water temperature, salinity, and atmospheric pressure. This report evaluates the instantaneous DO% values against the Class II water quality criteria (Rule 62-302.533(2)(a)(1) F.A.C.), which mandates that DO% saturation must not fall below 42% in more than 10% of samples.

DO% data underwent specific quality control and preparation protocols prior to analysis. As DO% is a field-collected parameter, the data were not subjected to laboratory assigned quality codes. To derive a single representative daily value, DO% readings collected at the same monitoring site on the same date were averaged. Furthermore, due to the physical limitation of dissolved oxygen saturation, any resulting value exceeding 100% was capped at 100%.

DO% is also compared against time of day the sample was taken using Spearman's rank correlation coefficient (ρ) to determine if there is any sampling bias, as DO% tends to be lower in the morning and higher in the afternoon as photosynthesis increases with greater light availability.

5.1.3 COPPER (CU)

Clam Bay is not currently listed as impaired for Cu. The FDEP water quality standard for Cu in Class II marine waters is set to never exceed 3.7 µg/L, as outlined in 62-302.530 (23) F.A.C. Cu was analyzed using EPA method 200.8 (180 day hold time) which uses inductively coupled plasma-mass spectrometry.

According to 62-303.320 (1), a waterbody is placed on the Planning List when 10% or more of its samples fail to meet the applicable criteria, with at least an 80% confidence level as determined by a binomial distribution. If the sample size exceeds the number of samples listed in Table 1 of Rule 62-303.320 (1) F.A.C., the minimum number of samples not meeting the water quality criterion needed to determine if a

waterbody should be placed on the Planning List was calculated using the binomial distribution with 80% confidence ($\alpha = 0.80$).

During data analysis, results reported with a "U" data qualifier code (indicating the result was not detected and below the Method Detection Limit (MDL)) are assessed as half the reported result or half the criterion, whichever is lower. Results with an "I" data qualifier code (indicating the value is between the MDL and the Practical Quantitation Limit (PQL)) are assessed as equal to the MDL. These methods are in accordance with 62.303.320 (12) F.A.C.

5.1.4 PAIRWISE COMPARISONS

The linear relationships among the 2024 water quality parameters TP, TN, Chl-a, and DO% were assessed using Spearman's rank correlation coefficient (ρ). To mitigate the disproportionate influence of extreme values, data were preprocessed to remove outliers. Outliers were identified using Tukey's fences method where any observation falling outside the range defined by $Q1-(1.5\times IQR)$ and $Q3+(1.5\times IQR)$ was removed from the analysis, where Q1 = quartile 1, Q3 = quartile 3 and IQR (interquartile range) = Q1 – Q3.

5.1.5 EXCEEDANCES BY ZONE

To assess spatial variations and identify localized water quality regimes within the monitoring area, the nine sampling stations were aggregated into four distinct geographical zones. This classification was based on geographic proximity, hydrologic connectivity, and observed similarities in water quality. The zones were defined as follows:

- Upper Clam Bay (CB1, CB2): The northernmost section of the estuary, characterized by highly restricted tidal flushing and longer water residence times.
- Inner Clam Bay (CB3, CB4): A transitional area exhibiting moderate tidal influence and intermediate water quality characteristics.
- Outer Clam Bay (CB5, CB6, CB7, CB8): The southern region experiencing the highest degree of tidal exchange and flushing due to its direct proximity to Clam Pass.
- Seagate (CB9): Located outside the Clam Bay Natural Resources Protection Area (NRPA) boundary, this site was isolated into its own category as it represents a distinct and separate water quality regime.

Exceedance frequencies for total nitrogen (TN), total phosphorus (TP), dissolved oxygen saturation (DO%), and copper (Cu) were calculated for each zone by dividing the number of non-compliant samples by the total number of samples collected within that zone during the 2024 monitoring period.

6.0 RESULTS

6.1 2024 RESULTS

In previous reports, exceedances within 5% of the NNC were reported to provide context for interpretation, suggesting that a lack of compliance should be viewed cautiously due to the potential for analytical imprecision near the NNC threshold. However, the FDEP's official methodology is more rigorous: it includes all exceedances and employs a binomial distribution with 90% confidence to minimize Type I error (incorrectly listing a healthy waterbody as impaired). Therefore, in this and future reports, ETE will no longer report exceedances within the 5% threshold, as this exclusion method is not statistically relevant for FDEP's compliance assessment.

The visual compliance assessment presented in the heatmaps (Appendix B: Figures 11 and 13) reflects updated data scope and stringent quality control measures. Unlike previous reports, this analysis does not include data collected prior to November 2017, as these records are not available in the FDEP database (results for periods preceding November 2017 are in previous reports available on the Pelican Bay Property Owners Association website (https://pbpoa.org/pelican-bay-services-division-pbsd) Additionally, the heatmaps now incorporate the usage of data qualifiers to systematically exclude records deemed unreliable from the analysis, ensuring the visual representation of compliance accurately reflects high-quality, verified samples.

6.1.1 TOTAL PHOSPHORUS (TP) - 2024

In 2024, a total of 99 samples were initially collected for TP. After removing 5 data points due to qualifiers, 94 samples remained for analysis. Of these, 24 samples (25.5%) exceeded the NNC (Appendix B: Figure 4). The highest number of TP exceedances was observed at the northernmost sample locations, CB1 and CB2, which each had five exceedances out of 11 months sampled (Appendix B: Figure 11). April experienced the most exceedances overall, with five of nine sites exceeding the NNC.

TP exceedances also occurred at sites CB1, CB2, and CB3 following Hurricanes Helene and Milton, which generated storm surges of 4.02 feet and 5.08 feet, respectively, at the Naples Bay tide gauge. The storm surges also corresponded with a significant increase in salinity in Clam Bay. However, actual TP concentrations at most sites (excluding CB1 and CB2) did not increase directly after the hurricanes. The NNC for Clam Bay is defined by an exponential decay function based on salinity (Rule 62-302.532 F.A.C.), which sets lower TP thresholds at higher salinities (Appendix B: Figure 1).

6.1.2 TOTAL NITROGEN (TN) - 2024

In 2024, a total of 99 samples were initially collected for TN. After removing 26 data points due to qualifiers, 73 samples remained for analysis. A notable outlier was observed for site CB9 in February, which had an extremely high TN value compared to past data. This data point was not associated with a laboratory qualifier code and was retained for this analysis.

Of the 73 samples, eight (10.9%) exceeded the NNC for TN (Appendix B: Figures 5 and 13). The highest number of exceedances occurred in November, when four out of four sampling locations (CB4, CB5, CB8, and CB9) exceeded the NNC following Hurricane Milton (five sites were not sampled for logistical reasons). Conversely, samples collected after Hurricane Helene at sites CB1–CB5 in October did not exceed the NNC (four sites were not sampled for logistical reasons).

6.1.3 DISSOLVED OXYGEN SATURATION (DO%) - 2024

DO% was out of compliance in 18.3% (19/104) of samples collected throughout 2024 (Appendix B: Figure 6). DO% fell below the 42% threshold primarily in Upper and Inner Clam Bay (sites CB1, CB2, CB3, and CB4). However, time of day had a significant effect on DO%, with samples collected later in the day corresponding to samples with higher DO% ($\rho = 0.39$, $p < 0.0001$) (Appendix B: Figure 7). Samples in Upper and Inner Clam Bay were often sampled earlier in the day, when oxygen levels are naturally lower, which indicates a bias in the results.

6.1.4 COPPER (CU) - 2024

In 2024, a total of 99 samples were analyzed for Cu with no data points excluded. Cu concentrations exceeded the water quality criteria of 3.7 µg/L in 2% (2/99) of samples collected (Appendix B: Figure 8, Appendix C: Table 2). 49 samples had “U” qualified data, and 34 samples had “I” qualified data which were adjusted based on the methods described above. Site CB1 had one sample in May that had a Cu

concentration of 5.58 µg/L and CB4 had one sample with a Cu concentration of 7.7 µg/L in August. These elevated levels were not flagged with data qualifiers and are in exceedance of the 3.7 ug/L criteria.

6.1.5 COMPARISON SUMMARY - 2024

After removing qualified data, a total of 73 sampling events contained complete data for TN, TP, Chl-a, and DO%. 8 of these samples were removed from subsequent analysis due to the presence of statistical outliers in one or more of the variables, resulting in 65 samples for the final correlation analysis. Appendix B: Figure 9 and Appendix C: Table 3 show the results of the pairwise comparisons.

TN was positively correlated with Chl-a (ρ=0.40, p=0.0015) and TP (r=0.39, p=0.0021). TN has a slight negative correlation with DO%, but the relationship was not statistically significant (ρ =−0.16, p=0.213). TP showed a strong positive correlation with Chl-a (ρ =0.68, p=<0.001) and a strong negative correlation with DO% (ρ =−0.67, p=<0.001). DO% was negatively correlated with Chl-a (ρ =−0.28, p=0.0277).

6.1.6 EXCEEDANCE BY ZONE – 2024

Water quality compliance for the 2024 monitoring period varied across the four designated geographic zones. A north-to-south gradient was documented for total phosphorus (TP) exceedances, with Upper Clam Bay exhibiting the highest rate of non-compliance at 45.5%. These exceedance frequencies decreased moving south through the system to 26.1% in Inner Clam Bay and 20.5% in Outer Clam Bay, while the Seagate zone recorded no TP exceedances (0.0%) (Appendix C: Table 4).

Dissolved oxygen saturation (DO%) compliance followed a similar spatial pattern. Upper Clam Bay recorded the highest frequency of samples falling below the state minimum criteria with an exceedance rate of 50.0%, compared to 24.0% in Inner Clam Bay, 2.3% in Outer Clam Bay, and 0.0% in Seagate (Appendix C: Table 4).

Unlike TP and DO%, total nitrogen (TN) exceedances did not follow a north-to-south gradient. The highest rate of TN non-compliance was observed in the Seagate zone (22.2%), followed by Upper Clam Bay at 18.8%. Inner and Outer Clam Bay recorded TN exceedance rates of 5.9% and 6.5%, respectively (Appendix C: Table 4).

Total copper (Cu) exceedances were observed exclusively at the northernmost monitoring stations, with Upper Clam Bay (4.5%) and Inner Clam Bay (4.3%) recording samples that exceeded established criteria (Appendix C: Table 4). Outer Clam Bay and Seagate recorded no Cu exceedances (0.0%) during the 2024 monitoring period (Appendix C: Table 4).

6.2 LONG-TERM DATA RESULTS – NOVEMBER 2017 – DECEMBER 2024

The data used for this analysis spans a time period from November 2017 through December 2024 or 7 years and 1 month which includes all of the data available in WIN.

6.2.1 TOTAL PHOSPHORUS (TP) – NOVEMBER 2017 – DECEMBER 2024

A total of 736 samples were initially collected for TP. After removing 79 data points due to qualifiers and an additional seven samples lacking corresponding specific conductance data, 650 samples remained for analysis. Based on the binomial distribution with 90% confidence for this dataset, the maximum allowable number of exceedances before impairment is concluded is 76 samples. 248 samples (38.2%) exceeded the NNC (Appendix B: Figures 10 and 11). The highest number of TP exceedances were observed at the northernmost sample locations, CB1 and CB2, where 54% and 52% of all samples exceeded the NNC, respectively (Appendix C: Table 5). The site with the lowest exceedances was CB5, with 24% of all samples exceeding the NNC (Appendix C: Table 5).

6.2.2 TOTAL NITROGEN (TN) – NOVEMBER 2017 – DECEMBER 2024

A total of 761 samples were initially collected for TN. After removing 55 data points due to qualifiers and an additional 6 samples lacking corresponding specific conductance data, 700 samples remained for analysis. Based on the binomial distribution with 90% confidence for this dataset, the maximum allowable number of exceedances before impairment is concluded is 81 samples. 105 samples (15%) exceeded the NNC (Appendix B: Figures 12 and 13). The highest number of TN exceedances was observed at CB1 and CB8, where 23% of all samples exceeded the NNC each (Appendix C: Table 6). The site with the lowest number of exceedances was CB5, with 7.5% of all samples exceeding the NNC (Appendix C: Table 6).

6.2.3 DISSOLVED OXYGEN SATURATION – NOVEMBER 2017 – DECEMBER 2024

DO% was out of compliance in 13.4% (99/741) of samples collected, falling below the 42% threshold primarily in Upper and Inner Clam Bay (sites CB1, CB2, CB3, and CB4) (Appendix B: Figure 14).The highest number of exceedances was observed at CB1 and CB2, where 34% and 52% of all samples exceeded the criterion, respectively (Appendix C: Table 7). In contrast, sites CB4–CB9 all had <10% exceedances, and sites CB5, CB6, and CB8 had no exceedances over the entire study period (Appendix C: Table 7).

A separate analysis found that time of day had a significant effect on DO% (ρ= 0.42, $p < 0.0001$), with samples collected later in the day corresponding to higher DO% (Appendix B: Figure 15). It was also observed that samples in the northernmost sites were often collected earlier in the day.

6.2.4 COPPER (CU) – NOVEMBER 2017 – DECEMBER 2024

A total of 764 samples were initially collected for Cu. 588 samples remained for long-term analysis after 176 data points were excluded due to data quality qualifiers. 316 samples had “U” qualified data, and 205 samples had “I” qualified data which were adjusted based on the methods described above. Based on the binomial distribution with 80% confidence for this dataset, the maximum allowable number of exceedances before impairment is concluded is 66 samples. 16 samples (2.7%) exceeded the Class III criterion for Cu (3.7 ug/L) (Appendix B: Figure 16). The highest number of Cu exceedances was observed at CB1 and CB2, where 11% and 9% of all samples exceeded the criterion, respectively, while sites CB5 – CB9 had no exceedances over the entire study period (Appendix C: Table 8).

7.0 DISCUSSION & RECOMMENDATIONS

7.1 NUTRIENT IMPAIRMENTS

Clam Bay remains impaired for TP (38.2% long-term exceedance) and TN (15.0% long-term exceedance), as determined by the Estuary-Specific Numeric Interpretations (62-302.532(j) F.A.C.) against the 10% threshold. While both nutrients are excessive, the strong correlation between TP and algal growth indicators (Chl-a) and water quality degradation (DO%) suggests that TP is the primary driver of these impairments in Clam Bay.

In 2024, the TP exceedance rate was 25.5%, a slight increase from 22% in 2023 but still a significant reduction from the 40% rate in 2022.The slight increase from 2023 likely reflects the extreme hydrologic conditions of the 2024 wet season, which recorded 130% of average rainfall and included two hurricane impacts. High freshwater inflow delivers greater nutrient loads (consistent with the NNC model) via runoff from surrounding land uses (e.g., Pelican Bay residential and golf course areas).

When evaluated by geographic zone, a distinct spatial gradient emerges. In 2024, Upper Clam Bay (CB1, CB2) and Inner Clam Bay (CB3, CB4) experienced the highest TP exceedance rates (45.5% and 26.1%,

respectively), highlighting the impact of limited tidal flushing in these northern reaches compared to the well-flushed Outer Clam Bay (20.5%) and Seagate (0.0%) zones

However, the 2024 data suggests that the post-hurricane exceedances at CB1, CB2, and CB3 were not driven by an increase in nutrient loading. In fact, TP concentrations at most sites did not increase. Instead, the exceedances appear to be an artifact of the NNC's salinity-based function. The storm surge from Hurricanes Helene and Milton significantly increased salinity in the bay, which in turn lowered the NNC threshold for TP. This regulatory mechanism, rather than an actual increase in TP, is what caused the samples to fall into non-compliance. The differences in the number of exceedances between the two storm events may be attributed to the higher storm surge from Hurricane Milton. However, due to missing data for some sites in both October and November, it is difficult to establish a definitive cause and effect pattern. The FDEP may exclude samples collected immediately after hurricanes from the biennial assessment, as they may not represent the waterbody's general condition.

The 2024 TN data (10.9% exceedance) was also heavily influenced by the hurricanes, but in a different manner than TP. Exceedances were recorded at all sampled sites following Hurricane Milton, but at none of the sites sampled after Hurricane Helene. This difference may be attributed to the higher storm surge from Hurricane Milton, which likely transported more nitrogen-rich organic material or sediment. However, as noted in the results, significant missing data in both October and November make a definitive cause and effect conclusion difficult.

In 2024, TN non-compliance also demonstrated a localized concentration in the northern reaches of the estuary. Upper Clam Bay recorded an 18.8% TN exceedance rate, which is notably higher than the better-flushed Inner Clam Bay (5.9%) and Outer Clam Bay (6.5%) zones. Similar to the spatial trends observed for TP, this indicates that the highly restricted tidal flushing in Upper Clam Bay causes nitrogen from watershed runoff and internal organic decomposition to accumulate rather than efficiently cycle though the system and out to the Gulf of Mexico.

Additionally, the 2024 TN dataset included a significant outlier at CB9 in February, driving an anomalous 22.2% exceedance rate for the Seagate zone. While this value was not removed from the analysis, it is far outside the expected range for this site and should be interpreted with caution, as it may not accurately reflect the typical conditions of the waterbody.

7.2 OXYGEN IMPAIRMENTS

The negative correlation of DO% with TP and Chl−a suggest that high nutrient loading drives excessive algal biomass which consumes oxygen during algal respiration and decomposition and creating low oxygen conditions. In 2024, the overall 42% DO saturation criterion was exceeded (i.e., values were below 42%) in 18.3% of all samples.

In 2024, Upper and Inner Clam Bay were the most susceptible to low DO% (50.0% and 24.0% exceedance rates, respectively) because they receive the least tidal flushing from Clam Pass, allowing nutrients and organic matter to accumulate and exacerbate oxygen depletion. In contrast, the Outer Clam Bay (2.3%) and Seagate (0.0%) zones maintained excellent compliance.

The long-term analysis of DO% confirms that exceedances of the 42% threshold are predominantly concentrated in the Upper and Inner Clam Bay (CB1, CB2, and CB3). Sites CB4 through CB9 consistently exhibit high compliance, with less than 10% of samples falling below the threshold (see Appendix C: Table 7). The most severely affected site was CB2, which had the highest number of exceedances, with 51.8% of samples falling below the criterion.

A proper assessment of the long-term DO% data requires a deeper analysis of the sampling time bias, as outlined in FDEP's guidance (FDEP, 2013). FDEP uses the 10% binomial test for this assessment but acknowledges that time of day can bias the results. However, FDEP also recognizes that grab samples taken during a typical 8:00am to 5:00pm workday are expected to be within 20% of the daily mean (FDEP, 2013). Before a final impairment decision, FDEP performs a deeper review to evaluate this potential bias.

This bias is the key to interpreting the Clam Bay DO% data. FDEP considers non-compliance to be ambiguous if the sample was collected early in the morning when DO% levels are naturally lowest (FDEP, 2013). This scenario directly applies to sites CB1-CB3, which had the highest number of exceedances (34%, 52%, and 19%, respectively) but were also consistently sampled before noon (Appendix B: Figures 14 and 15).

Conversely, FDEP's guidance states that if a site is sampled early in the morning and still passes, it can be confidently concluded that the site achieves the criteria (FDEP, 2013). This scenario applies to site CB5 which had zero exceedances over the entire study period, even though it was typically sampled early in the day. This provides strong evidence that this specific site within Clam Bay is not impaired for DO%.

7.3 COPPER IMPAIRMENTS

Clam Bay is not currently impaired for Cu, with only 2.7% (16) of 588 samples exceeding the criteria (3.7µg/L), a rate well below the FDEP threshold.

Although the overall system meets compliance, the Upper Clam Bay zone (sites CB1 and CB2) exhibits the highest localized rates of noncompliance in the long-term data and shows consistently higher overall Cu concentrations compared to other zones. Future monitoring efforts should target Upper Clam Bay to identify if localized sources are contributing to Cu loading.

7.4 BERM DATA

Previous reports included a full analysis of data from six outfall berm sites along the eastern side of Clam Bay (Appendix A: Water Quality Sample Location Map). Since 2021, this full data analysis has not been performed, and therefore, it was not included in this assessment. Nevertheless, a preliminary review of the 2024 trends across the six sites highlighted several noteworthy observations:

- The southernmost berm sites (Glenview and PB-11) recorded the highest TP and showed significant spikes following Hurricanes Helene and Milton.
- The highest spike of Total Nitrogen TN occurred at the N_berm site in June.
- The N_boardwalk site had the highest levels of Cu, particularly during the dry season, peaking in May.
- DO% was variable overall at each site, but it was consistently low (<25%) at the Glenview site.

8.0 REFERENCES

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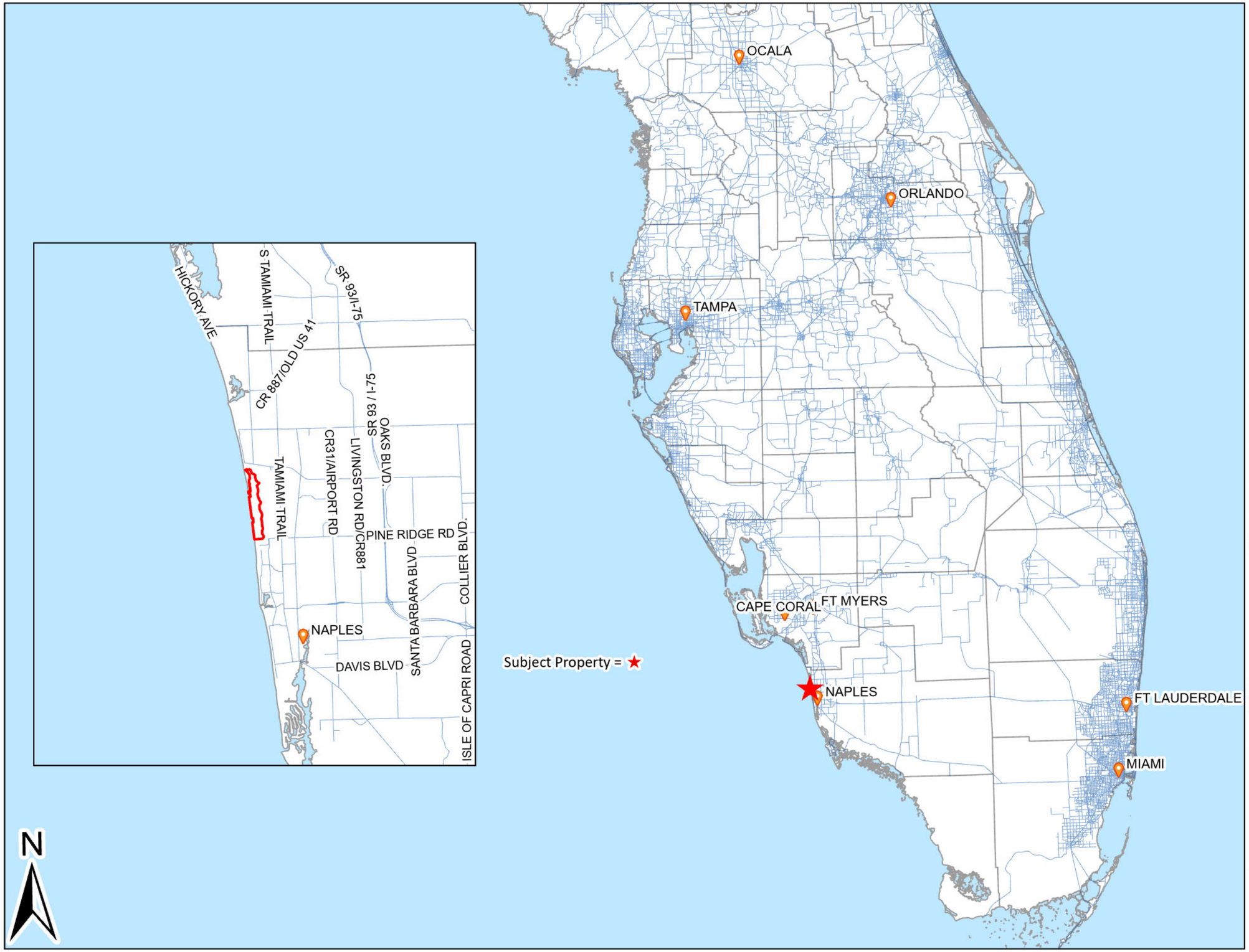
APPENDIX A

EXHIBITS



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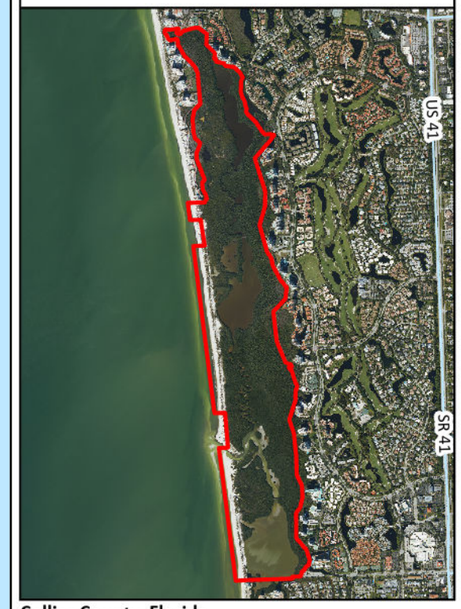
Location Map

PROJECT:

Clam Bay



Collier County, Florida

Legend

Clam Bay NRPA (±560 Ac)

Note:

1. 2025 Aerials obtained from Collier County Property Appraiser.

2. All acreages are approximate.

PROJECT MANAGER: Leah Reidenbach
DRAWN BY: Jessica Mee
DATE: 10/9/2025

Earth Tech Environmental, LLC
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www.eteflorida.com

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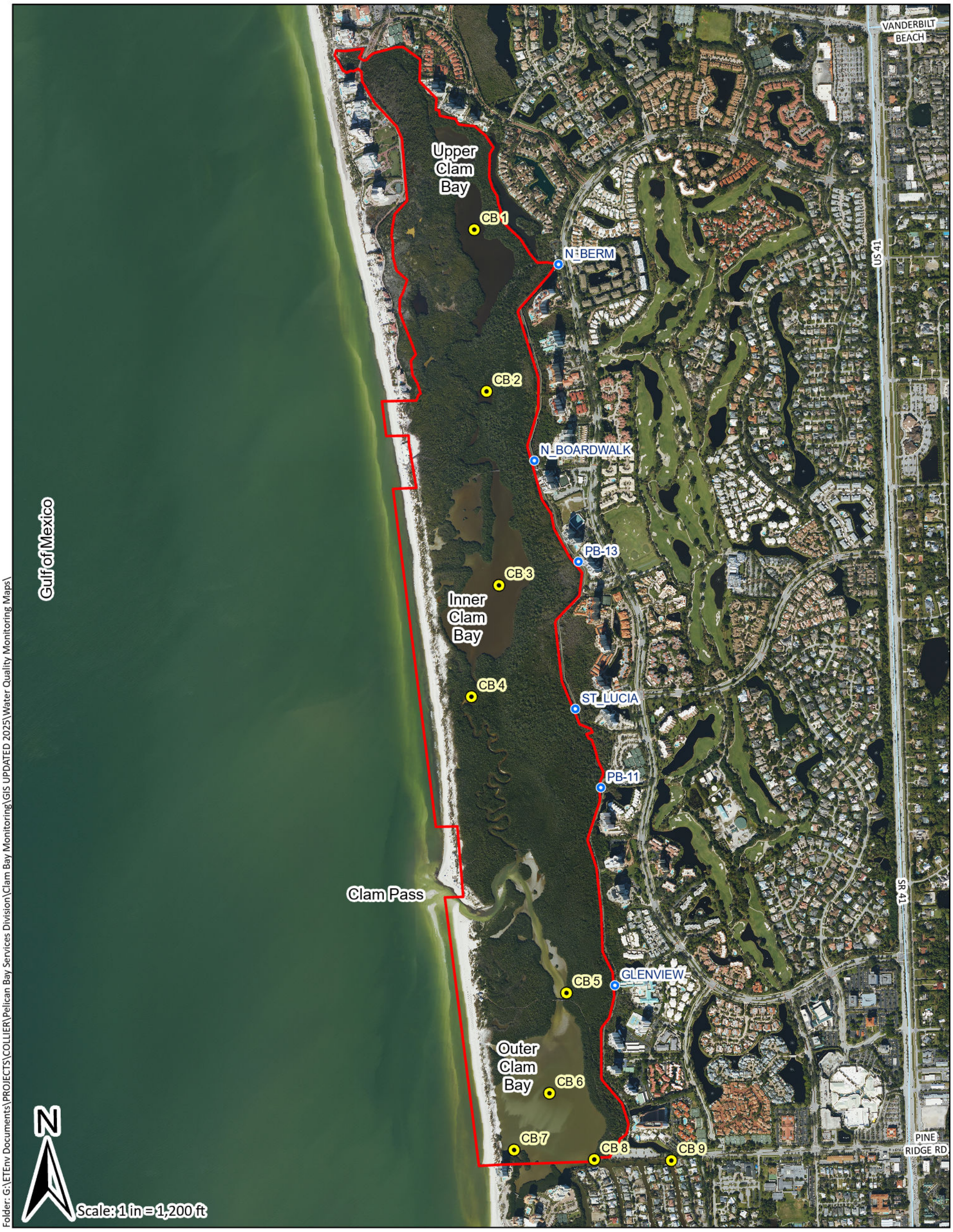

TITLE:

Water Quality Sample Location Map

PROJECT:

Clam Bay

Note:

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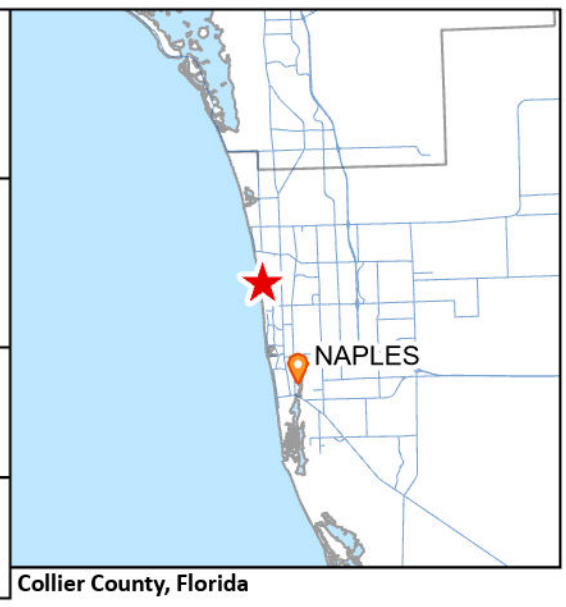
2. All acreages are approximate.

PROJECT MANAGER: Jeremy Sterk
DRAWN BY: JessicaMiller
DATE: 11/11/2025



Collier County, Florida

Legend

- Clam Bay NRPA (±560 Ac)
- Water Quality Sample Locations (9)
- Berm Sites

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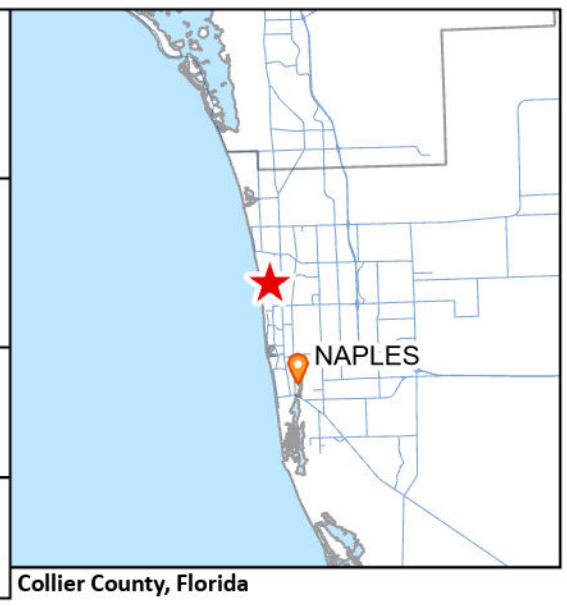
TITLE:
Waterbody ID (WBID) Map

PROJECT:
Clam Bay

Note:
1. 2025 Aerials obtained from Collier County Property Appraiser.
2. All acreages are approximate.

PROJECT MANAGER: Jeremy Sterk
DRAWN BY: JessicaMiller
DATE: 1/23/2026



Collier County, Florida

Legend

Waterbody ID

- CLAM BAY
- CLAM BAY INLAND

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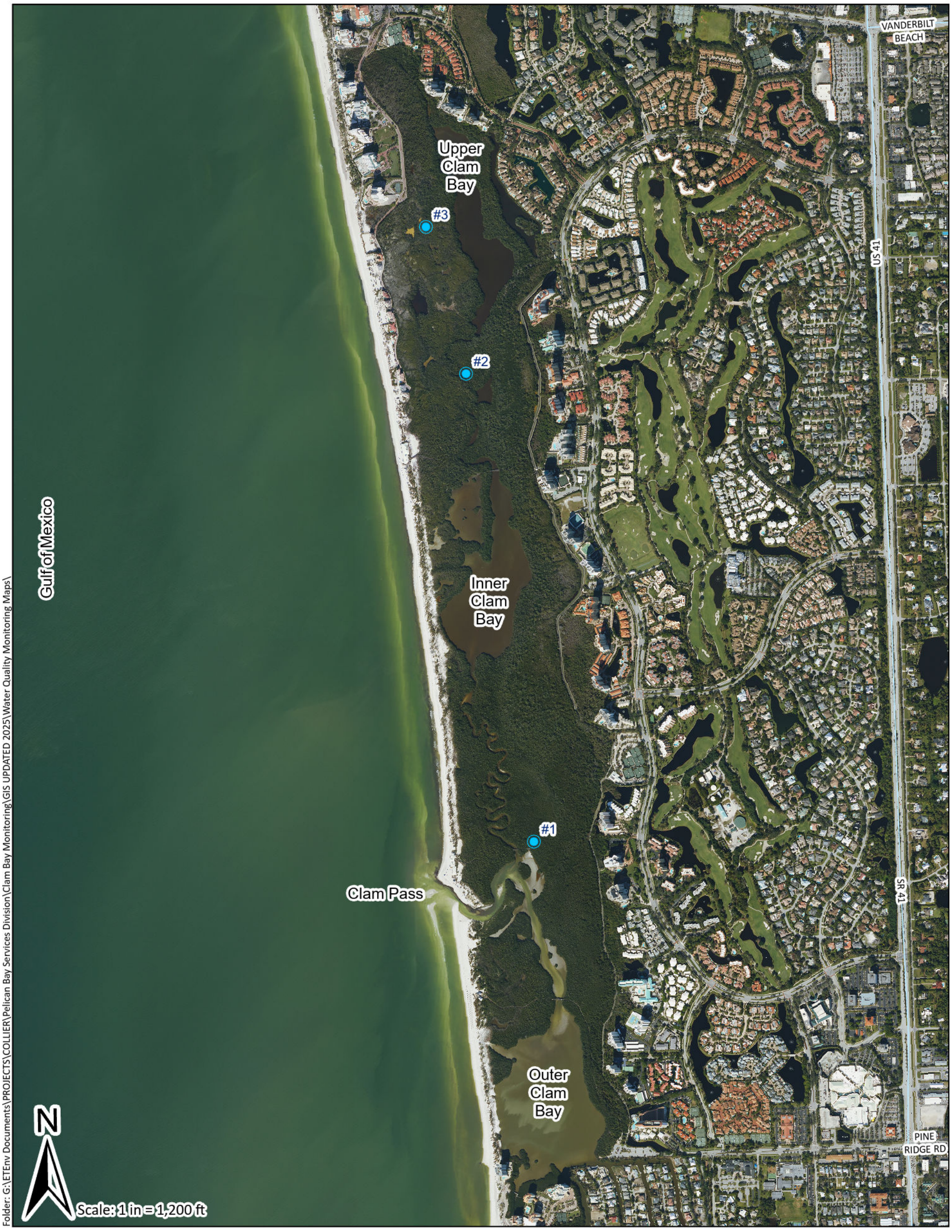

TITLE:
Water Level Logger Location Map

PROJECT:
Clam Bay

Note:
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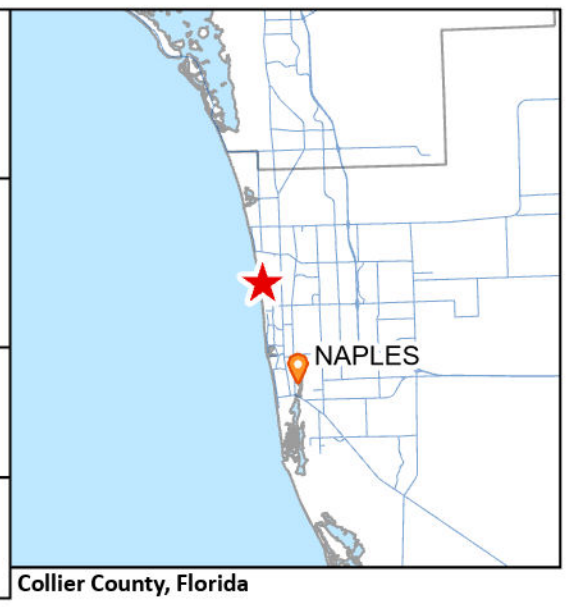
2. All acreages are approximate.

PROJECT MANAGER: Jeremy Sterk
DRAWN BY: JessicaMiller
DATE: 10/10/2025



Collier County, Florida

Legend
- Clam Bay NRPA (±560 Ac)
- Water Level Loggers (3)

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APPENDIX B

GRAPHS

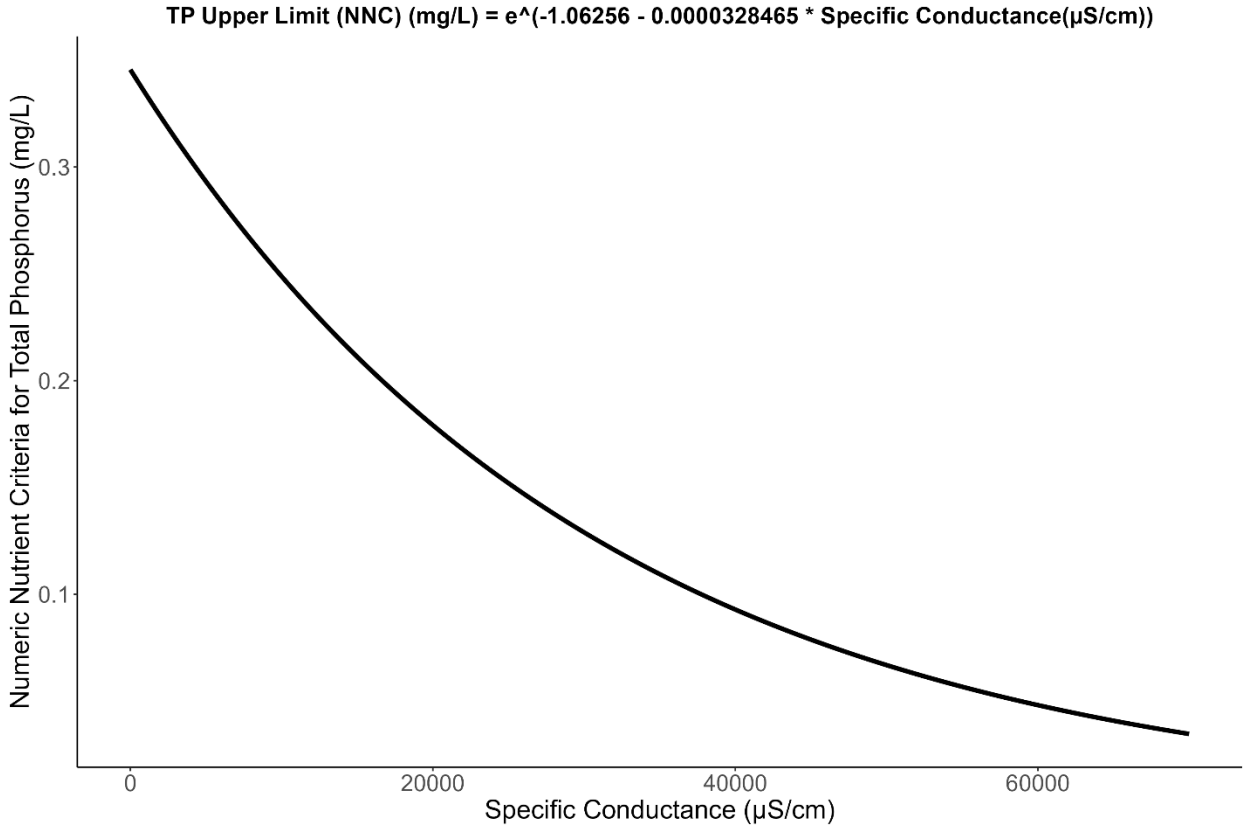

Figure 1: Relationship between Numeric Nutrient Criteria (NNC) for Total Phosphorus (TP) and Specific Conductance (µS/cm). The line represents the estuary-specific TP upper limit as determined by the equation: TP Upper Limit (NNC) (mg/L) = $e^{(-1.06256-0.0000328465* \text{ Specific Conductance } (\mu S/cm))}$. Nutrient concentrations above this line are considered non-compliant with the established criteria. The negative exponential relationship means that the NNC is lower at higher salinities and higher (or less stringent) at lower salinities.

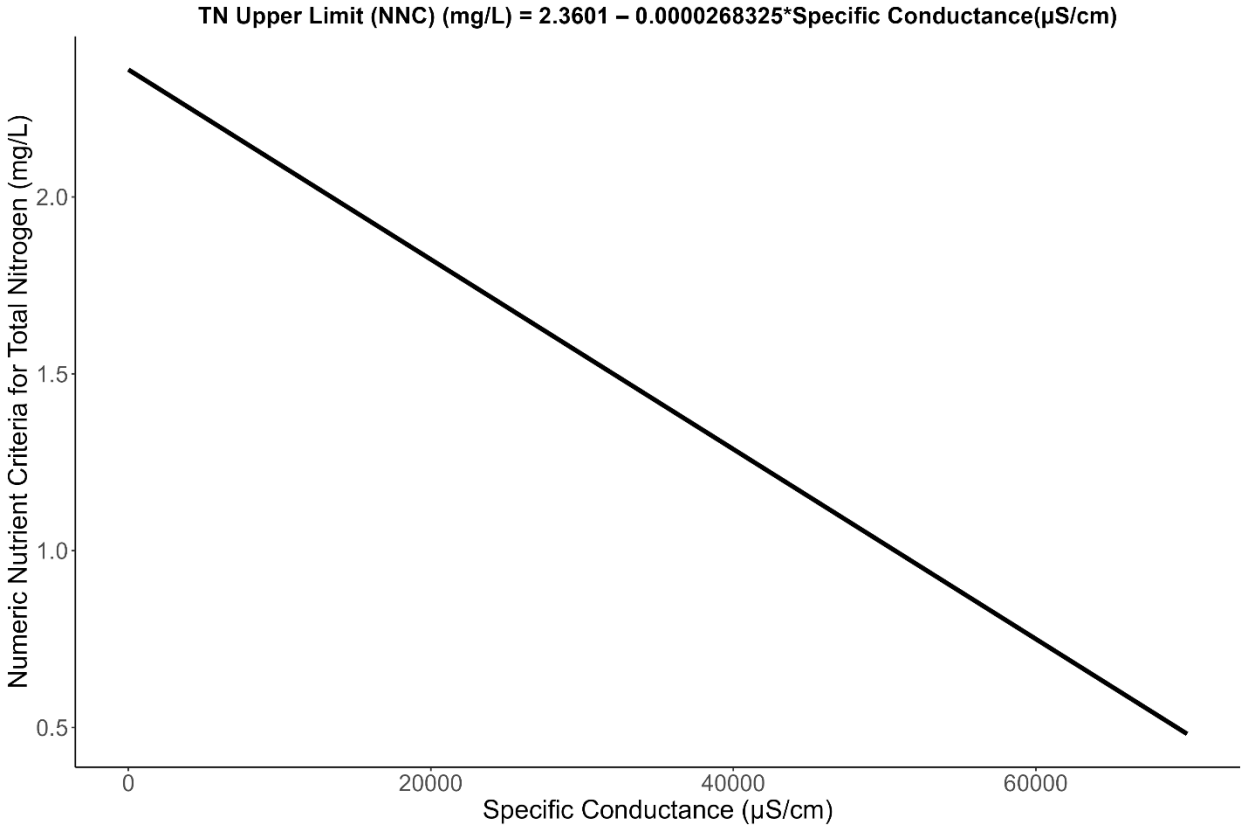

Figure 2: Relationship between Numeric Nutrient Criteria (NNC) for Total Nitrogen (TN) and Specific Conductance (µS/cm). The line represents the estuary-specific TN upper limit as determined by the equation: TN Upper Limit(mg/L) = 2.3601 – 0.0000268325*Specific Conductance(µS/cm). Nutrient concentrations above this line are considered non-compliant with the established criteria. Nutrient concentrations above this line are considered non-compliant with the established criteria. The negative linear relationship means that the NNC is lower at higher salinities and higher (or less stringent) at lower salinities.

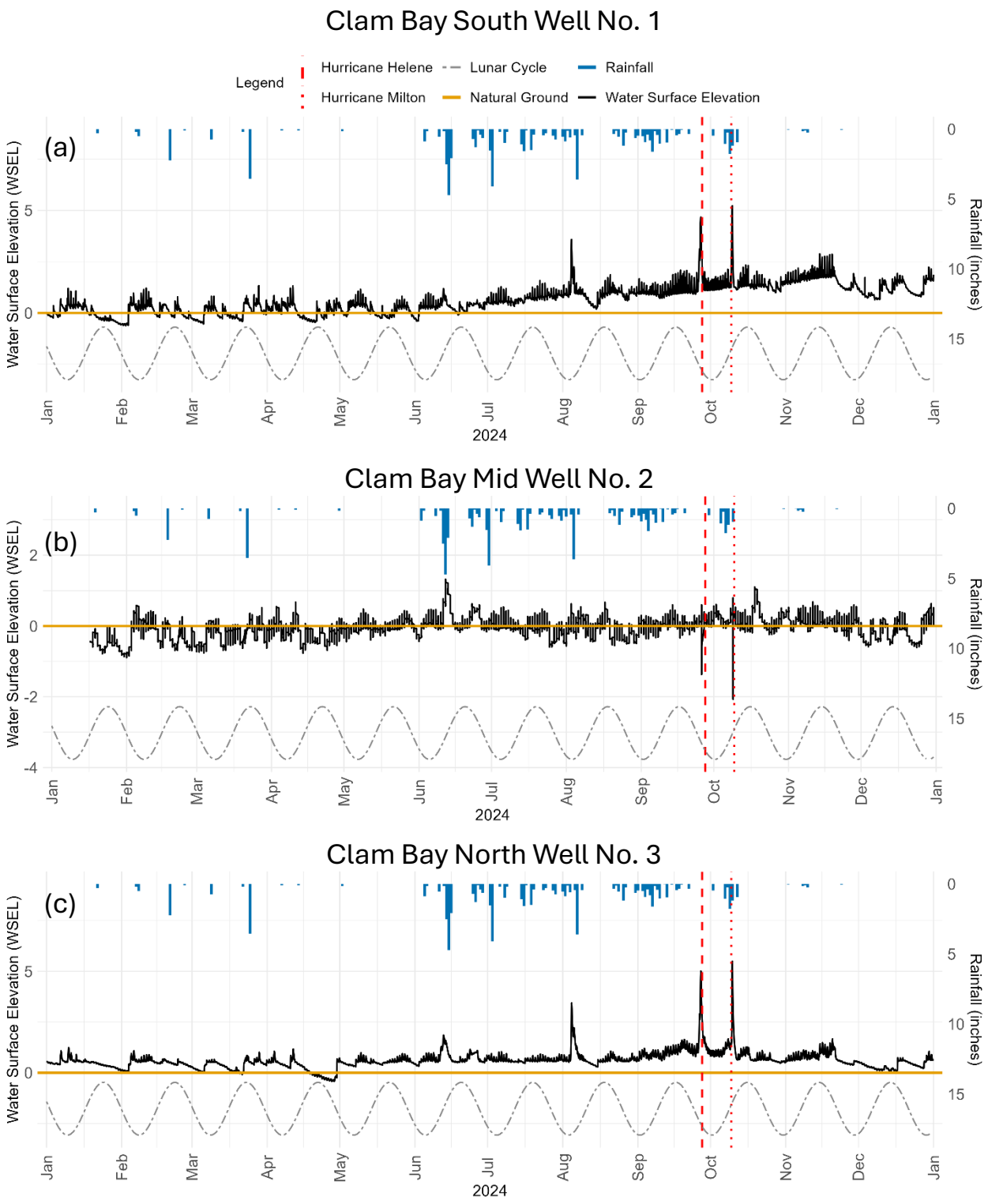

Figure 3: Hydrographs for Clam Bay North monitoring wells during 2024, showing (a) Clam Bay South Well No. 1, (b) Clam Bay Mid Well No. 2, and (c) Clam Bay North Well No. 3. Each hydrograph displays water surface elevation (WSEL, solid black line) relative to the Natural Ground elevation (solid orange line). Daily rainfall (blue bars), the daily lunar cycle (dashed grey line), and the approximate timing of Hurricanes Helene and Milton (vertical red lines) are also shown.

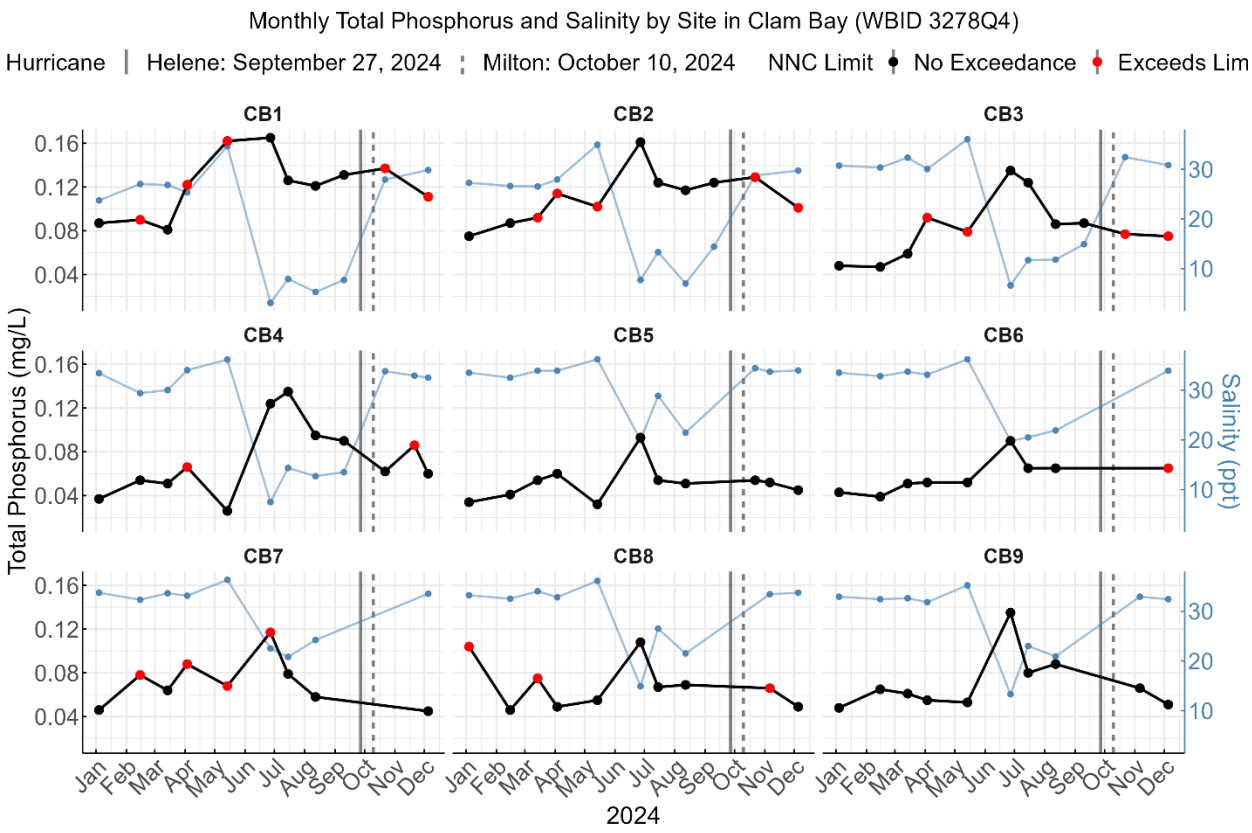

Figure 4: Monthly Total Phosphorus (TP) Concentrations at Nine Monitoring Sites in Clam Bay In 2024 With Respect to Numeric Nutrient Criteria and Major Hurricane Events. Monthly TP concentrations and corresponding salinity (blue line) are displayed for nine monitoring sites (represented by each panel). TP samples exceeding the numeric nutrient criteria (out of compliance) are highlighted with red dots, while those below the criteria are marked with black dots. Salinity values are plotted on the right y-axis. The timing of two significant hurricane events are indicated by vertical lines: Hurricane Helene, September 29, 2024 (solid line) and Hurricane Milton, October 10, 2024 (dashed line).

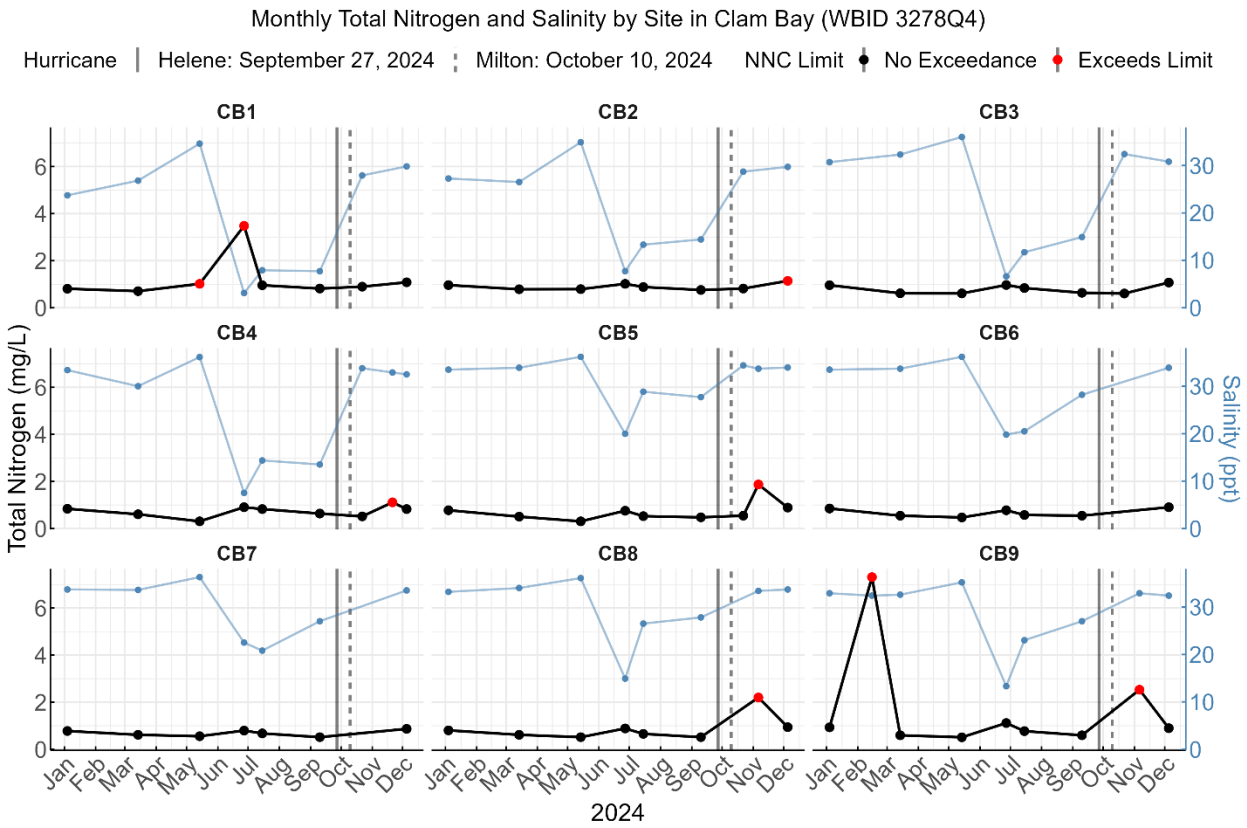

Figure 5: Monthly Total Nitrogen (TN) Concentrations and Salinity at Nine Monitoring Sites in Clam Bay In 2024 With Respect to Numeric Nutrient Criteria and Major Hurricane Events. Monthly TN concentrations and corresponding salinity (blue line) are displayed for nine monitoring sites (represented by each panel). TN samples exceeding the numeric nutrient criteria (out of compliance) are highlighted with red dots, while those below the criteria are marked with black dots. Salinity values are plotted on the right y-axis. The timing of two significant hurricane events are indicated by vertical lines: Hurricane Helene, September 29, 2024 (solid line) and Hurricane Milton, October 10, 2024 (dashed line).

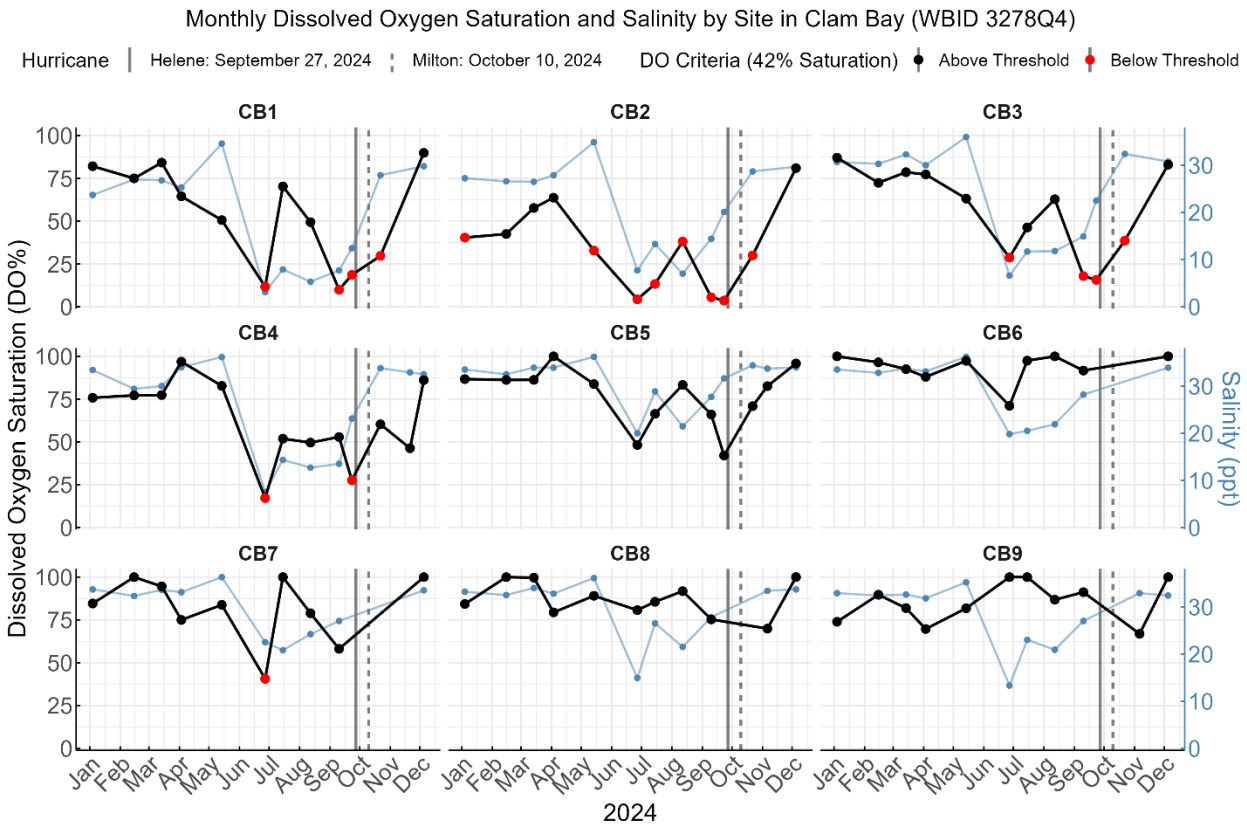

Figure 6: Monthly Dissolved Oxygen Saturation (DO%) And Salinity at Nine Monitoring Sites in Clam Bay In 2024 With Respect to the DO% Criteria and Major Hurricane Events. Monthly DO% concentrations and corresponding salinity (blue line) are displayed for nine monitoring sites (represented by each panel). DO% samples below the criteria (out of compliance) are highlighted with red dots, while those above the criteria are marked with black dots. Salinity values are plotted on the right y-axis. The timing of two significant hurricane events are indicated by vertical lines: Hurricane Helene, September 29, 2024 (solid line) and Hurricane Milton, October 10, 2024 (dashed line).

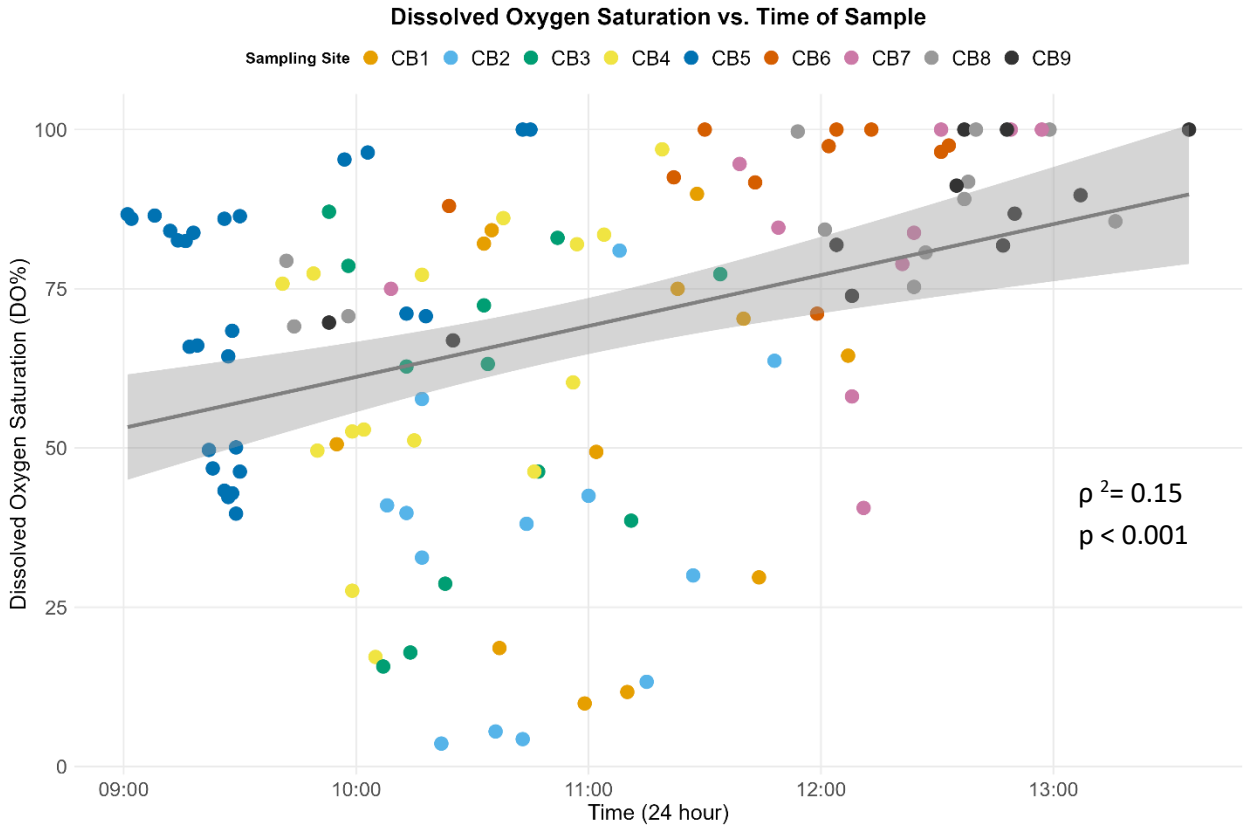

Figure 7: Dissolved Oxygen Saturation (DO%) Vs. Time of Sample in Nine Monitoring Sites in Clam Bay in 2024. Dissolved oxygen saturation (DO%) is plotted against the time of sample collection for nine monitoring sites in Clam Bay, with each site represented by a different color. A linear model shows the relationship between DO and the time of day. The Spearman's rank correlation coefficient (ρ = 0.39) is statistically significant (p = <0.0001). The ρ^2 value (ρ^2=0.15) means that 15% of the variance in the DO% is explained by the time of day sampled illustrating a sampling bias, where samples collected earlier in the day generally exhibit lower dissolved oxygen levels. The grey shaded area represents the 95% confidence interval (or standard error) for the regression line, indicating the range within which the true relationship is expected to lie.

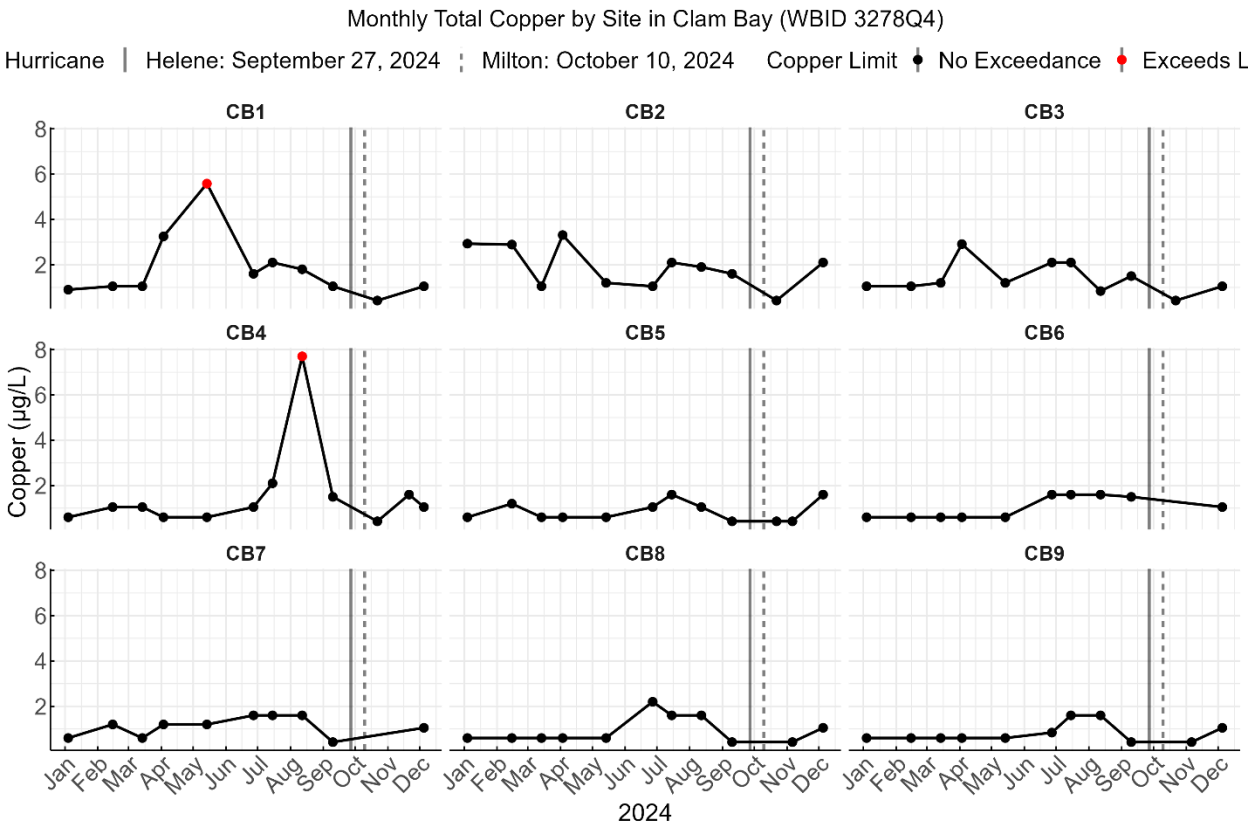

Figure 8: Monthly Copper (Cu) Concentrations at Nine Monitoring Sites in Clam Bay In 2024 With Respect to the Cu Criteria and Major Hurricane Events. Monthly Cu concentrations are displayed for nine monitoring sites (represented by each panel). Cu samples above the criteria (out of compliance) are highlighted with red dots, while those below the criteria are marked with black dots. The timing of two significant hurricane events are indicated by vertical lines: Hurricane Helene, September 29, 2024 (solid line) and Hurricane Milton, October 10, 2024 (dashed line).

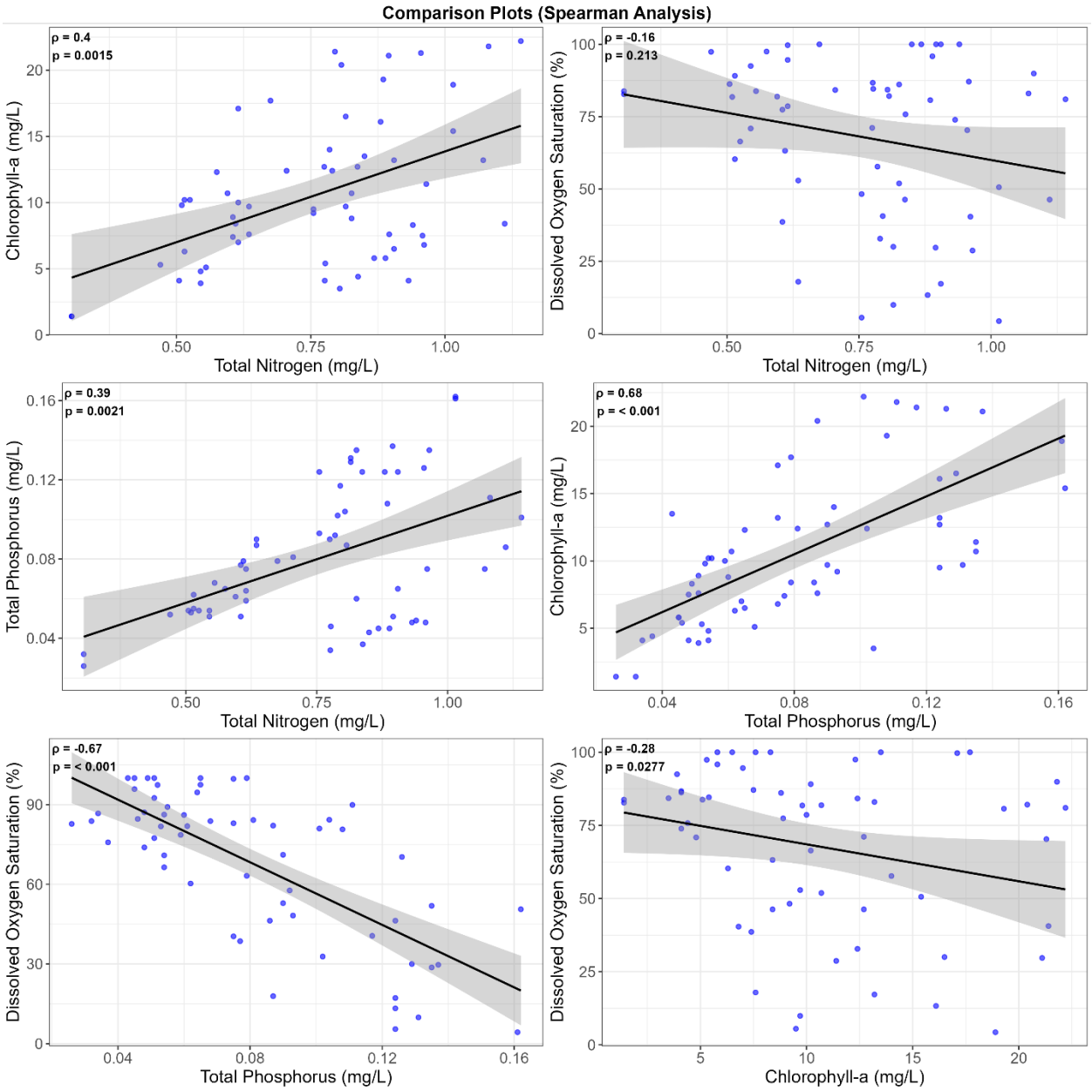

Figure 9. Pairwise Comparisons of the Four Main Water Quality Parameters: Total Nitrogen (TN), Total Phosphorus (TP), Chlorophyll-A (Chl), And Dissolved Oxygen Saturation (DO%). The data represent consolidated water quality measurements across all sites and dates, after the removal of non-detect/qualified results and statistical outliers (1.5 * Interquartile Range). Each panel displays a scatterplot with a linear regression line (black) and its 95% confidence interval (shaded gray). Annotations within each plot show the Spearman's correlation coefficient (ρ) and the associated p-value (p) from Spearman's rank correlation test.

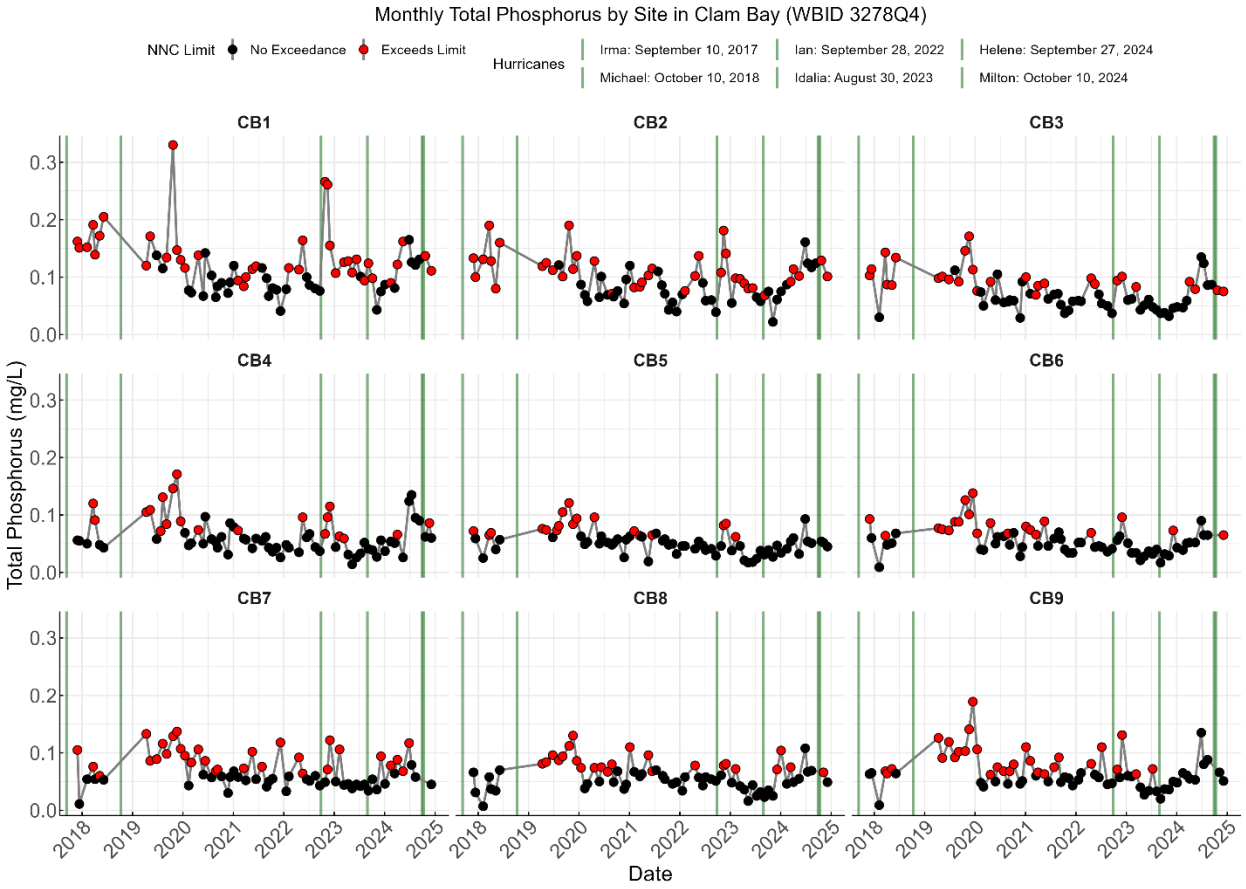

Figure 10: Monthly Total Phosphorus (TP) Concentrations at Nine Monitoring Sites in Clam Bay from November 2017 – December 2024 with Respect to Numeric Nutrient Criteria and Major Hurricane Events. Monthly TP concentrations are displayed for nine monitoring sites (represented by each panel). TP samples exceeding the numeric nutrient criteria (out of compliance) are highlighted with red dots, while those below the criteria are marked with black dots. The timing of significant hurricane events are indicated by green vertical lines.

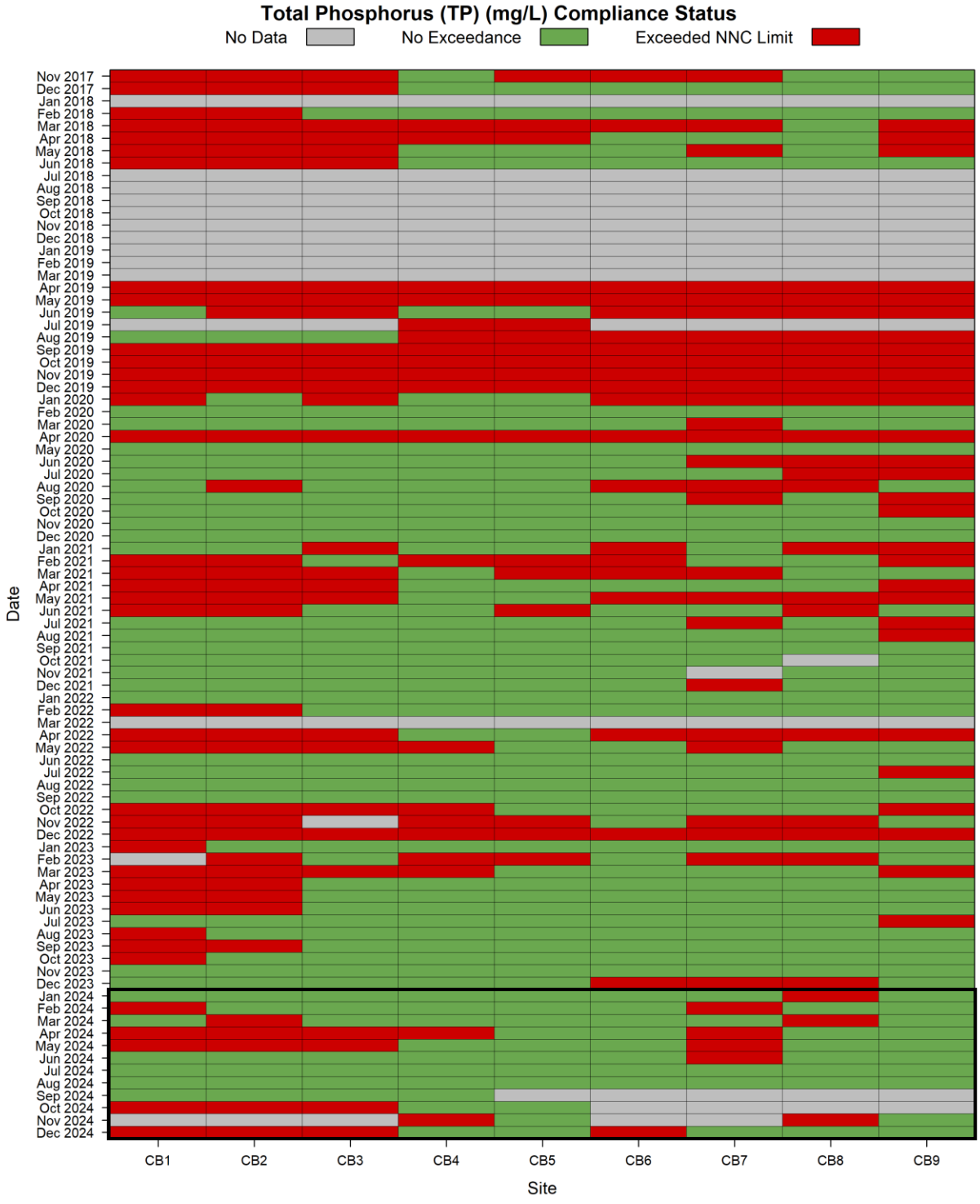

Figure 11: Heat Map of Long-Term Assessment of Total Phosphorus (TP) Compliance Across Clam Bay Monitoring Sites (CB1–CB9). Each cell represents a single monitoring event, with colors indicating whether the TN concentration exceeded the established NNC limit (red) or was in compliance (green). Sites are ordered CB1 (left) to CB9 (right), and dates are ordered chronologically from bottom (oldest) to top (newest). A black rectangle around samples from 2024 is used for visual clarity.

Figure 12: Monthly Total Nitrogen (TN) Concentrations at Nine Monitoring Sites in Clam Bay from November 2017 – December 2024 with Respect to Numeric Nutrient Criteria and Major Hurricane Events. Monthly TN concentrations are displayed for nine monitoring sites (represented by each panel). TN samples exceeding the numeric nutrient criteria (out of compliance) are highlighted with red dots, while those below the criteria are marked with black dots. The timing of significant hurricane events are indicated by green vertical lines.

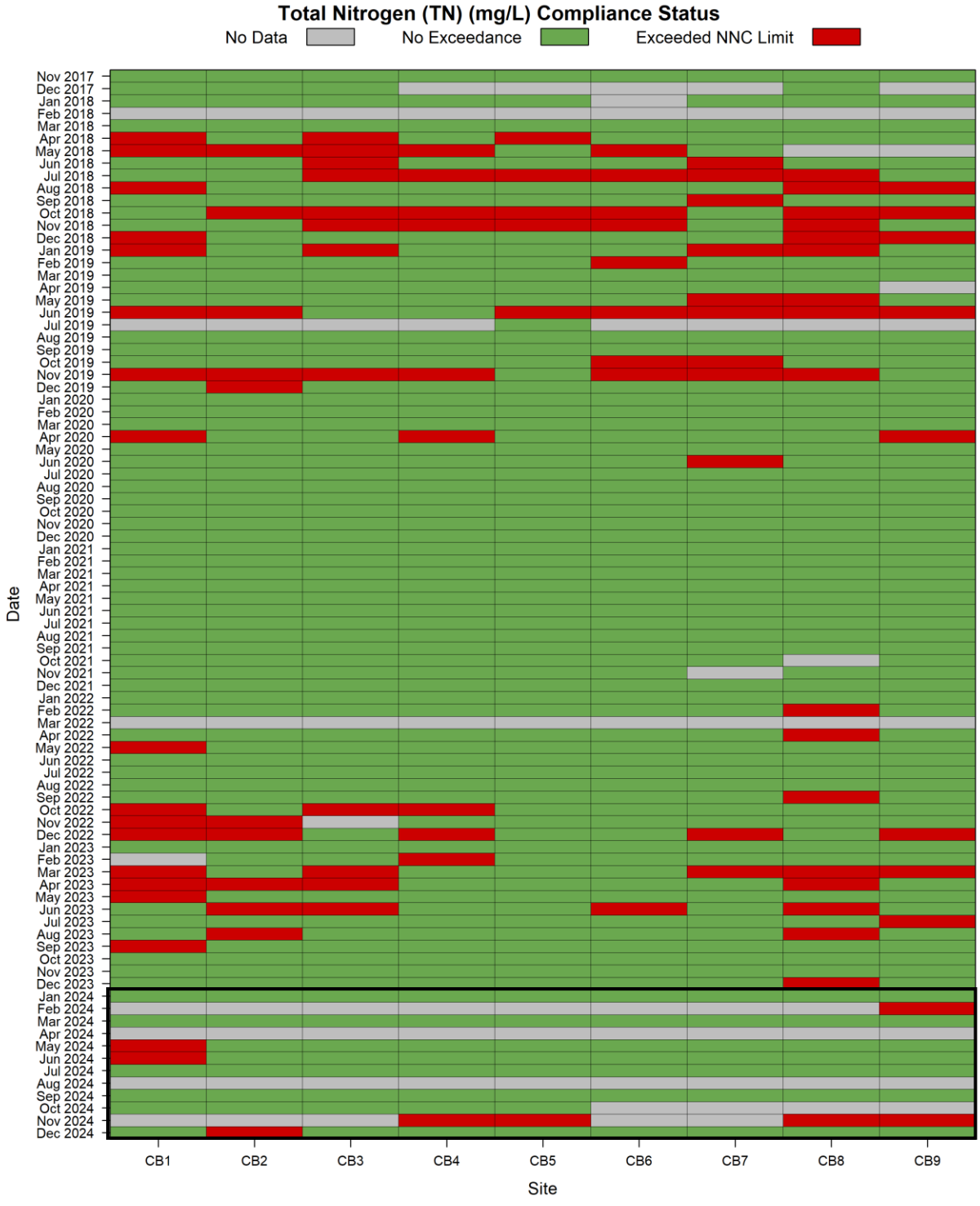

Figure 13: Heat Map of Long-Term Assessment of Total Nitrogen (TN) Compliance Across Clam Bay Monitoring Sites (CB1–CB9). Each cell represents a single monitoring event, with colors indicating whether the TN concentration exceeded the established NNC limit (red) or was in compliance (green). Sites are ordered CB1 (left) to CB9 (right), and dates are ordered chronologically from bottom (oldest) to top (newest).

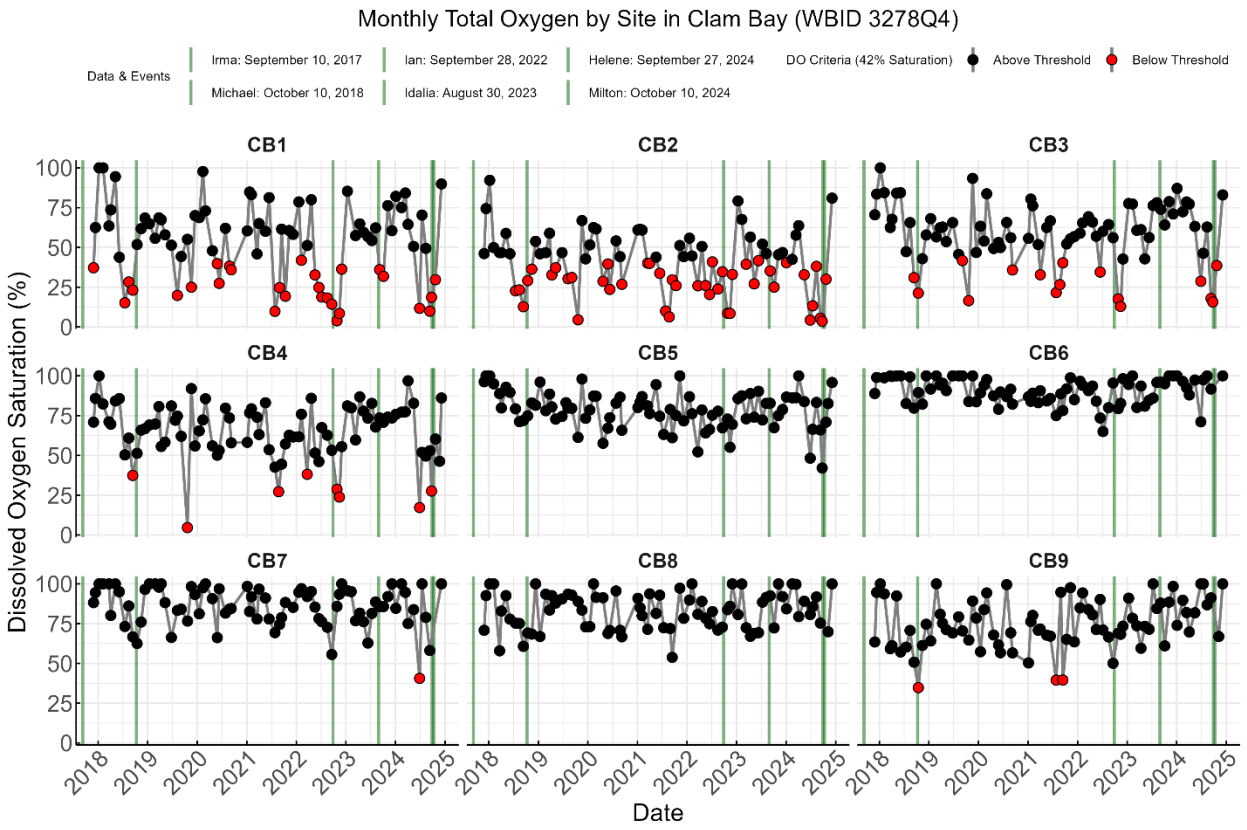

Figure 14: Monthly Dissolved Oxygen Saturation (DO%) at Nine Monitoring Sites in Clam Bay from November 2017 – December 2024 with Respect to the DO% Criteria and Major Hurricane Events. Monthly DO% concentrations are displayed for nine monitoring sites (represented by each panel). DO% samples below the DO% criteria (<42%) are highlighted with red dots, while those above the criteria are marked with black dots. The timing of significant hurricane events are indicated by green vertical lines.

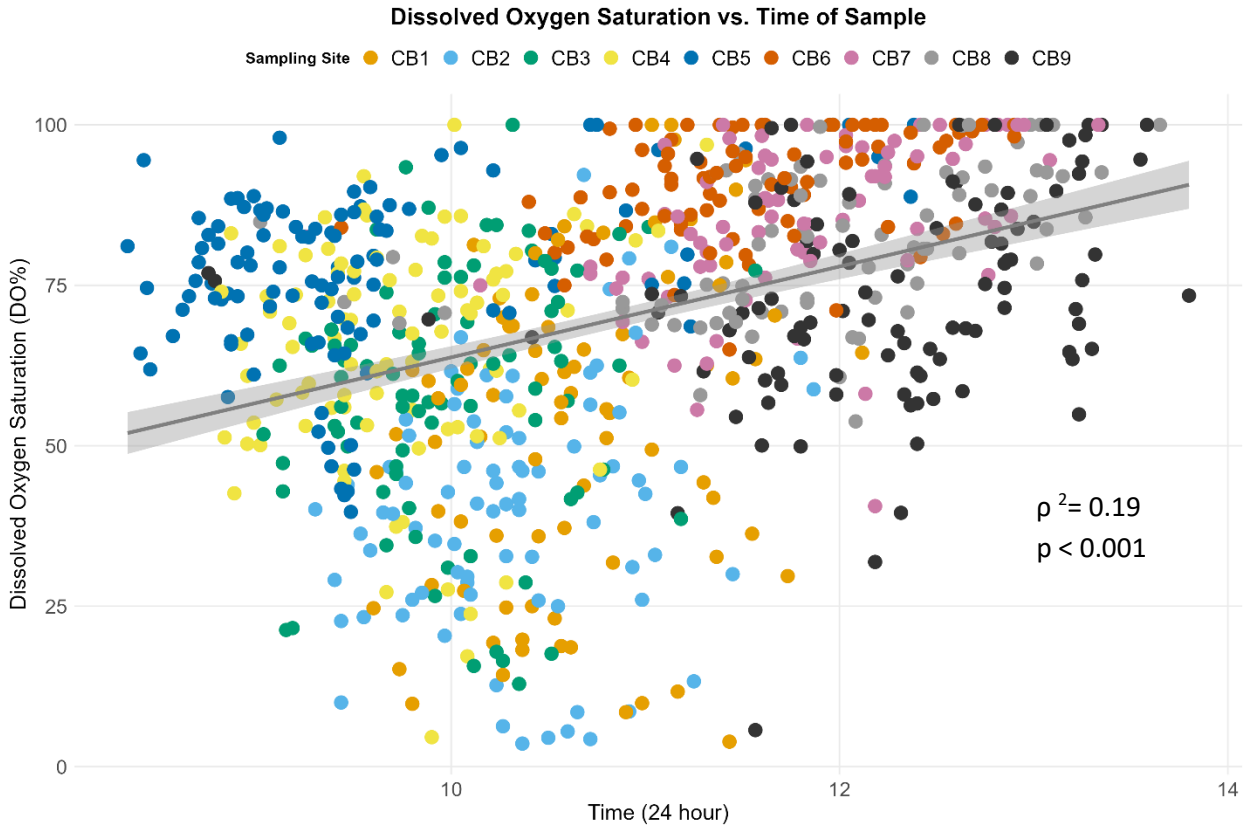

Figure 15: Dissolved Oxygen Saturation (DO%) vs. Time of Sample in Nine Monitoring Sites in Clam Bay from November 2017 – December 2024. Dissolved oxygen saturation (DO%) is plotted against the time of sample collection for nine monitoring sites in Clam Bay, with each site represented by a different color. A linear model shows the relationship between DO and the time of day. The Spearman's rank correlation coefficient (ρ = 0.43) is statistically significant (p = <0.0001). The ρ^2 value (ρ^2=0.19) means that 19% of the variance in the DO% is explained by the time of day sampled illustrating a sampling bias, where samples collected earlier in the day generally exhibit lower dissolved oxygen levels. The grey shaded area represents the 95% confidence interval (or standard error) for the regression line, indicating the range within which the true relationship is expected to lie.

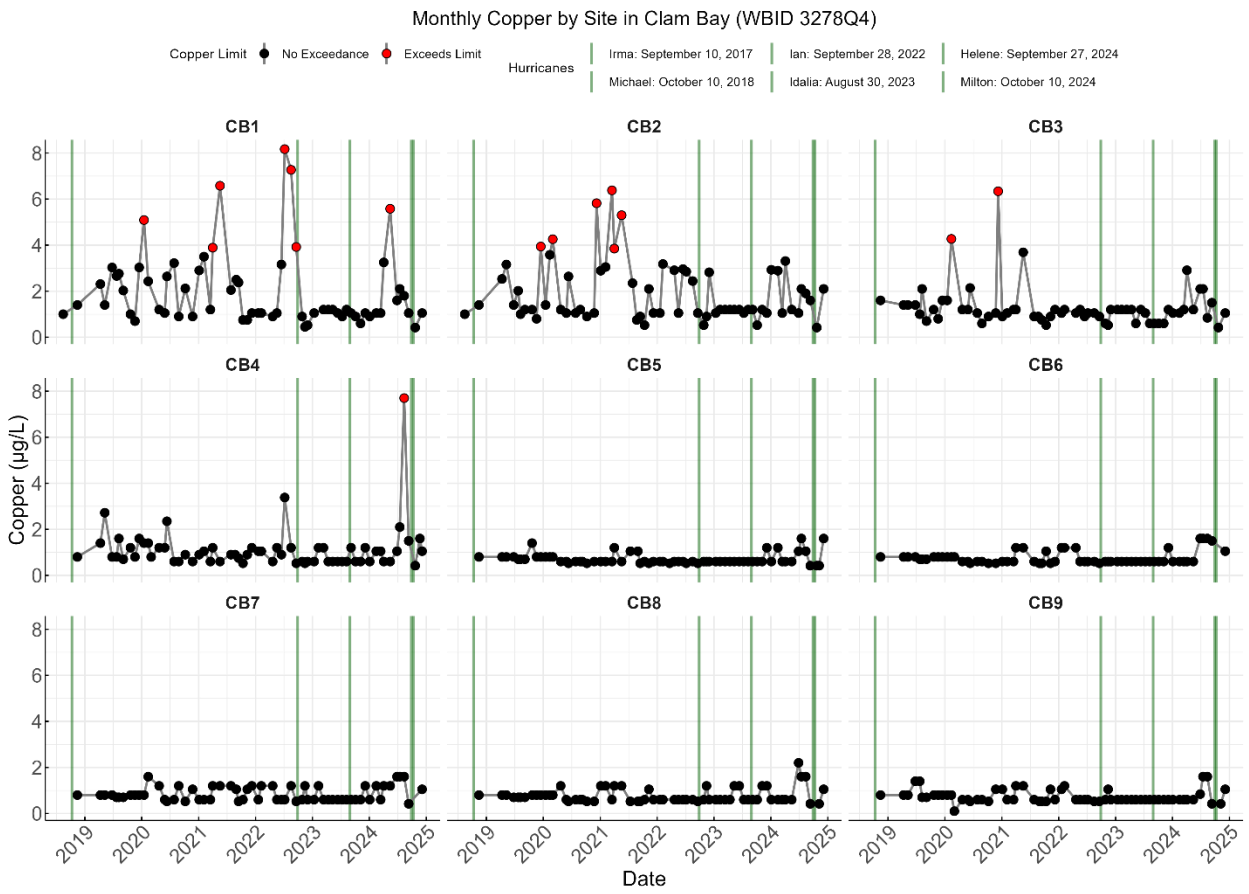

Figure 16: Monthly Copper (Cu) Concentrations at Nine Monitoring Sites in Clam Bay from November 2017 – December 2024 with Respect to the Cu Criteria and Major Hurricane Events. Monthly Cu concentrations are displayed for nine monitoring sites (represented by each panel). Cu samples exceeding the Cu criteria (>3.7 µg/L) are highlighted with red dots, while those below the criteria are marked with black dots. The timing of significant hurricane events are indicated by green vertical lines.

APPENDIX C

TABLES

Table 1. Dissolved Oxygen Saturation (DO%) Compliance in Clam Bay (January–December 2024). DO% at monitoring sites CB1 through CB9 within Clam Bay over the period of January 2024 to December 2024. The data is evaluated against the established minimum standard criterion of 42% saturation for Class II waters. Samples that did not meet this criterion are highlighted in yellow, indicating non-compliance with the water quality standard.

TABLE 1. Dissolved Oxygen Saturation (%)									
Date (month/year)	Station Location								
	CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8	CB9
4-Jan-2024	82.1	40.4	87.1	75.8	86.7	100	84.6	84.3	73.9
15-Feb-2024	75	42.5	72.4	77.2	86.2	96.5	100	100	89.7
14-Mar-2024	84.2	57.7	78.6	77.4	86.25	92.5	94.6	99.7	81.9
3-Apr-2024	64.5	63.7	77.3	96.9	100	88	75	79.4	69.7
14-May-2024	50.6	32.8	63.2	82.75	83.8	97.4	83.8	89.1	81.8
27-Jun-2024	11.7	4.3	28.7	17.2	48.23	71.1	40.6	80.7	100
15-Jul-2024	70.3	13.3	46.3	51.9	66.4	97.5	100	85.6	100
12-Aug-2024	49.4	38.1	62.8	49.6	83.3	101	78.9	91.8	86.8
10-Sep-2024	9.9	5.5	17.9	52.9	66	91.7	58.1	75.3	91.2
23-Sep-2024	18.6	3.6	15.7	27.6	42.05				
22-Oct-2024	29.7	30	38.6	60.3	70.9				
6-Nov-2024				46.3	82.6			69.9	66.9
21-Nov-2024	89.9	81	83	86.1	95.85	100	100	100	100

Table 2. Copper (Cu) Concentration Compliance in Clam Bay (January–December 2024). Cu concentrations (µg/L) at monitoring sites CB1 through CB9 in Clam Bay from January 2024 through December 2024. The data is compared to the established standard criterion of 3.7 µg/L for Class II waters. Cells highlighted in yellow indicate a non-compliant exceedance of this standard.

TABLE 2. Copper (µg/L)									
Date (month/year)	**Sample Location**								
	CB1	**CB2**	**CB3**	**CB4**	**CB5**	**CB6**	**CB7**	**CB8**	**CB9**
Jan-24	0.90 I	2.93	1.05 I	0.60 U	0.60 U	0.60 U	0.60 U	0.60 U	0.60 U
Feb-24	1.05 I	2.89	1.05 I	1.05 I	1.20 I	0.60 U	1.20 I	0.60 U	0.60 U
Mar-24	1.05 I	1.05 I	1.20 I	1.05 I	0.60 U	0.60 U	0.60 U	0.60 U	0.60 U
Apr-24	3.25	3.31	2.91	0.60 U	0.60 U	0.60 U	1.20 I	0.60 U	0.60 U
May-24	5.58	1.20 I	1.20 I	0.60 U	0.60 U	0.60 U	1.20 I	0.60 U	0.60 U
Jun-24	1.60	1.05 U	2.10 I	1.05 U	1.05 U	1.60 U	1.60 U	2.20	0.84 I
Jul-24	2.10	2.10 I	2.10 I	2.10 I	1.60 U	1.60 U	1.60 U	1.60 U	1.60 U
Aug-24	1.80	1.90	0.84 I	7.70	1.05 U	1.60 U	1.60 U	1.60 U	1.60 U
Sep-24	1.05 U	1.60	1.50	1.50	0.42 I	1.50	0.42 I	0.42 I	0.42 I
Oct-24	0.42 I	0.42 I	0.42 I	0.42 I	0.42 I				
Nov-24				1.60 U	0.42 I			0.42 I	0.42 I
Dec-24	1.05 U	2.1 I	1.05 U	1.05 U	1.60 U	1.05 U	1.05 U	1.05 U	1.05 U

I = The reported value is greater than or equal to the laboratory method detection limit but less than the laboratory practical quantitation limit.
U = Indicates that the compound was analyzed for but not detected. This symbol shall be used to indicate that the specified component was not detected. The value associated with the qualifier shall be the laboratory method detection limit.

Table 3. Pairwise Correlation Results for Key Water Quality Parameters. Key water quality parameters include total nitrogen (TN), total phosphorus (TP), chlorophyll-a (chl-a), and dissolved oxygen saturation (DO%). The results include the Spearman's correlation coefficient (ρ) and p-value for each comparison, indicating the strength and statistical significance of the linear relationships**.** Significant p-values (<0.05) are printed in bold font.

TABLE 3. PAIRWISE COMPARISON RESULTS		
Comparison	ρ	**p-value**
TN vs Chl-a	0.4	**0.001**
TN vs DO%	-0.16	0.213
TN vs TP	0.39	**0.0021**
TP vs Chl-a	0.68	**<0.001**
TP vs DO%	-0.62	**<0.001**
Chl-a vs. DO%	-0.28	**0.0277**

Table 4. Exceedances by Zone. This table summarizes the compliance of water quality samples with the established criteria for TN, TP, DO% and Cu over the period of January 2024 to December 2024. Data is grouped by geographical zone to reflect the unique water quality regimes of Upper Clam Bay (CB1, CB2), Inner Clam Bay (CB3, CB4), Outer Clam Bay (CB5–CB8), and Seagate (CB9). Cells highlighted in yellow indicate that the number of exceedances is above the 10% criteria used by the FDEP.

TABLE 4. EXCEEDANCES BY ZONE				
Parameter	**Upper Clam Bay**	**Inner Clam Bay**	**Outer Clam Bay**	**Seagate**
TP	45.5%	26.1%	20.5%	0.0%
TN	18.8%	5.9%	6.5%	22.2%
DO%	50.0%	24.0%	2.3%	0.0%
Cu	4.5%	4.3%	0.0%	0.0%

Table 5. Total Phosphorus (TP) Numeric Nutrient Criteria (NNC) Exceedances by Site. This table summarizes the compliance of water quality samples with the established NNC for TP at various monitoring sites (CB1 through CB9). The table presents the number of exceedances (measurements above the NNC threshold), the total number of samples collected, and the resulting percent exceedance for each site.

TABLE 5. TP NNC EXCEEDANCES BY SITE			
Site	**Exceedances**	**Samples**	**Percent Exceedance**
CB1	39	72	54.17%
CB2	38	73	52.05%
CB3	28	72	38.89%
CB4	20	75	26.67%
CB5	18	74	24.32%
CB6	21	71	29.58%
CB7	31	70	44.29%
CB8	24	71	33.80%
CB9	29	72	40.28%
Total:	**248**	**650**	**38.15%**

Table 6. Total Nitrogen (TN) Numeric Nutrient Criteria (NNC) Exceedances by Site. This table summarizes the compliance of water quality samples with the established NNC for TN at various monitoring sites (CB1 through CB9) in Clam Bay from November 2017 – December 2024. The table presents the number of exceedances (measurements above the NNC threshold), the total number of samples collected, and the resulting percent exceedance for each site.

TABLE 6. TN NNC EXCEEDANCES BY SITE			
Site	**Exceedances**	**Samples**	**Percent Exceedance**
CB1	18	78	23.08%
CB2	11	79	13.92%
CB3	12	78	15.38%
CB4	10	79	12.66%
CB5	6	80	7.50%
CB6	9	76	11.84%
CB7	11	76	14.47%
CB8	18	77	23.38%
CB9	10	77	12.99%
Total:	**105**	**700**	**15.00%**

Table 7. Dissolved Oxygen Saturation (DO%) Exceedances by Site. This table summarizes the compliance of water quality samples with the established dissolved oxygen saturation criteria (42%) at various monitoring sites (CB1 through CB9) in Clam Bay from November 2017 – December 2024. The table presents the number of exceedances (measurements below the criteria), the total number of samples collected, and the resulting percent exceedance for each site.

TABLE 7. DO% EXCEEDANCES BY SITE			
Site	**Exceedances**	**Samples**	**Percent Exceedance**
CB1	28	82	34.15%
CB2	43	83	51.81%
CB3	16	83	19.28%
CB4	8	85	9.41%
CB5	0	85	0.00%
CB6	0	80	0.00%
CB7	1	80	1.25%
CB8	0	81	0.00%
CB9	3	82	3.66%
Total:	**99**	**741**	**13.36%**

Table 8. Copper (Cu) Exceedances by Site. This table summarizes the compliance of water quality samples with the established Cu Criteria (3.7 µg/L) at various monitoring sites (CB1 through CB9) in Clam Bay from November 2017 – December 2024. The table presents the number of exceedances (measurements above the NNC threshold), the total number of samples collected, and the resulting percent exceedance for each site.

TABLE 8. CU EXCEEDANCES BY SITE			
Site	**Exceedances**	**Samples**	**Percent Exceedance**
CB1	7	64	10.94%
CB2	6	67	8.96%
CB3	2	65	3.08%
CB4	1	66	1.52%
CB5	0	68	0.00%
CB6	0	64	0.00%
CB7	0	63	0.00%
CB8	0	66	0.00%
CB9	0	65	0.00%
Total:	**16**	**588**	**2.72%**

APPENDIX D

DATA EXCLUDED FROM ASSESSMENTS

DATA EXCLUDED FROM THE ASSESSMENTS	
Data Excluded	**Comments**
Results reported with a “G” qualifier code	Indicates that the analyte was detected at or above the method detection limit in both the sample and the associated field blank, equipment blank, or trip blank, and the blank value was greater than 10% of the associated sample value The data may not be accurate.
Results reported with a “V” qualifier code	Indicate that the analyte was detected at or above the method detection limit in both the sample and the associated method blank and the blank value was greater than 10% of the associated sample value. The data may not be accurate
Results reported with a “Y” qualifier code	Indicate that the laboratory analysis was from an improperly preserved sample. The data may not be accurate.
Results reported with a “?” qualifier code	Indicate that the data were rejected. Some or all of the quality control data for the analyte are outside criteria and the presence or absence of the analyte cannot be determined from the data
Results reported with a “Q” qualifier code	Indicate that the holding time was exceeded.
Results reported with an “R” qualifier code	Significant rain in the past 48 hours. (Significant rain typically involves rain in excess of 1/2 inch within the past 48 hours.) This code shall be used when the rainfall might contribute to a lower than normal value.
Results reported as “Not Representative”	Data with this qualifier do not represent typical conditions and are therefore excluded from the analysis.

APPENDIX E

BINOMIAL EQUATION

Binomial Equation

$$\sum_{i=x}^{n}\binom{n}{i}(p_0)^i(1-p_0)^{n-i} \geq 1-\alpha$$

Where:

- *n* = Total number of samples.
- *i* = The number of samples exceeding the criterion.
- p_0 = The exceedance rate threshold, which is 10% (or 0.10) for placing a waterbody on the Verified List.
- $(\frac{n}{i})$ = The binomial coefficient, calculated as $\frac{n!.}{i!(n-i)!}$
- 1-α = the confidence level, or the probability of not committing a type I error (concluding that a water body is impaired when it actually is not)
- α = 0.90

APPENDIX F

LIST OF ACRONYMS

List of Acronyms

BMAPs	Basin Management Action Plans
BMPs	Best Management Practices
Cu	Copper
CWA	Clean Water Act
DO%	Dissolved Oxygen Saturation
EPA	Environmental Protection Agency
ETE	Earth Tech Environmental
FDEP	Florida Department of Environmental Protection
IQR	Interquartile Range
MDL	Minimum Detection Limit
NNC	Numeric Nutrient Criteria
NRPA	Natural Resources Protection Area
PBSD	Pelican Bay Services Division
PQL	Practical Quantitation Limit
TN	Total Nitrogen
TP	Total Phosphorus
WBID	Waterbody ID
WIN	Watershed Information Network

APPENDIX G

PUBLIC COMMENTS AND RESPONSE

Why were WQ data from 2015, 2016 and Jan-Oct. 2017 not included in the report?

Those data are not available on FDEP's database WIN (Watershed Information Network), but that information is available in the previous reports which can be found on the Pelican Bay Property Owners Association website (https://pbpoa.org/pelican-bay-services-division-pbsd/).

Why were some WQ data from Jan 2018-Feb. 2023 excluded when they had been used in previous reports, including those completed by Dr. David Tomasko and Dr. Jennifer Brunty?

Data with certain qualifying codes indicates that the sample result is not accurate and fundamentally unreliable. Therefore, they were excluded from this analysis in the red and green heat maps. I can't speak to why these data were not excluded in previous reports, but it is not correct to include them in the analysis, and it is standard practice to exclude qualified data. The FDEP do not use data with these qualifying codes in their analysis of water quality, so I wanted to make sure that we were replicating the analysis in a similar manner to the FDEP and that we are only using high-quality data. Including inaccurate data introduces a lot of uncertainty to the results.

Without consultation with Dr. Tomasko, who helped FDEP develop the site-specific criteria for estuaries and Dr. Brunty, I don't think the WQ data they reported should be modified. I am not suggesting that the changes you made in the data in the 2024 report be changed, but in future reports I think data in previous reports should not be modified without consultation with those reporting it. I am not recommending that PBSD invest resources in such consultations, but that previous data be accepted as presented in real time.

While I understand the concern regarding consistency with previous reports, it's important to note that excluding data with qualifying codes does not change the historical record or the actual sampling results. Instead, it is a quality control filter applied during analysis to ensure we are basing our conclusions on valid scientific data and standard practice, as FDEP protocols dictate that we should exclude samples flagged as unreliable when assessing compliance.

Moving forward, we will continue to archive and reference the older reports exactly as they were written. However, for all current and future analysis, we will adhere to the strictest data quality standards to ensure our findings are defensible to regulators.

What accounts for the large number of data exclusions in 2024 e.g. 26% of TN samples being excluded?

26 of the samples had qualifying codes (G or V). G means the field blank, equipment blank, or trip blank were greater than 10% of the associated sample value. V means the method blank was greater than 10% of the associated sample value. These blanks are different types of quality control samples that are run with each batch of sampling trips or laboratory runs. Appendix D of the report includes a table indicating which qualifying codes were to be excluded and this was discussed with Collier County Pollution Control prior to the completion of the analysis.

What caused this large number of disqualifications in the 2024 data, i.e. issues with field conditions and/or reporting of them; issues with lab analysis, etc.? How can the number of data that were discarded be reduced in 2026?

2024 did have an unusually high number of samples with fatal V and G data qualifiers. The samples with G qualifiers are caused by issues with field blanks which indicate an issue that occurred during sampling. Field contamination of blanks can be reduced by following FDEP's Standard Operating Procedures for collecting surface water samples and reviewing quality assurance protocols with staff who are handling collection of field samples.

The samples with V qualifiers are caused by issues with method blanks which indicate an issue with the lab analysis. Many of the samples that had fatal qualifiers (G and V) were from Pace Analytical rather than Collier County Pollution Control. If Collier County Pollution Control can analyze the samples again, the rate of qualified samples may be reduced as in previous years.

Why were data and information about FDEP's biennial assessment included in the report?

FDEP started doing biennial (every two years) assessments in 2020 rather than rotating through each of the 5 basins in 6 districts every year (essentially doing the assessment every 5 years for each basin). I updated the report to reflect these changes. I added the long-term analysis to provide insight into how the FDEP assesses a waterbody for impairment. While the year-to-year analysis is beneficial for evaluating water quality in the short term, the long-term assessment is more reflective of the FDEP's method for evaluating impairment.

PBSD's annual Clam Bay WQ report is a stand-alone report of the WQ at nine sampling sites in the Clam Bay NRPA that uses FDEP criteria to assess TP, TN, Cu, and DO. Working with PBSD's consultants the Clam Bay Committee has made several modifications in the report since the initial report in 2015, including adding the 5% threshold notation to TN and TP data to differentiate data that are very close to the benchmark and those that are not. FDEP's periodic assessments of FL WBIDs are also stand-alone reports. I don't believe we know what WQ data FDEP used in its recent biennial assessment and why FDEP included Seagate's man-made canals in what it considers Clam Bay WBID 3278Q4. Until we are able to obtain this information, I don't think references to FDEP's recent biennial assessment should be included in PBSD's 2024 WQ report. If we get this information, PBSD may want to share FDEP's recent assessment data with the PB community.

While this report is designed to serve the needs of the Pelican Bay community, determining if Clam Bay is considered impaired by FDEP and EPA standards has always been a large component of this report. We do know what data the FDEP uses to determine impairment and how they do it is outlined in the Background and Regulatory Context and Methodology sections of this report.

Including the FDEP assessment is about ensuring PBSD is fully informed of its official regulatory standing. Providing this insight allows us to compare our analysis against the state's findings, which is a powerful tool for the community.

Remove references to WBID 3278Q4, including in the report's title, the exhibit showing the WBID, and the body of the report and to FDEP's biennial assessments because the scope of the PBSD's report is the nine sampling sites in Clam Bay and whether they meet FDEP criteria for TN, TP, Cu, and DO. The WBID 3278Q4 includes an area outside Clam Bay, and to date we don't know why FDEP included it in the Clam Bay WBID. FDEP's assessments warrant additional background information and context. After PBSD begins to address the development of TMDLs, it may want to share information about FDEPs assessments and PBSD's response to these assessments with PB members.

I understand the concern regarding the boundary discrepancies between the Clam Bay NRPA and the FDEP's designated WBID. While it is true that one site (CB9) sits outside the NRPA boundary, it is inside the FDEP's designated WBID along with the other eight sites. This means the water quality at every single site we analyzed is also analyzed by the FDEP to determine impairment. To ensure the report remains technically accurate and defensible, we must identify the correct state-designated basin that dictates the specific criteria for these sites.

Move figures 11 and 12, and tables 1, 2, 4, 5, 6 and 7 (also labeled 6) to the body of the report because they clearly show WQ results. Move the table re: qualifiers to an Appendix.

I have moved the Data Qualifiers table to the Appendix and corrected the numbering error on Table 7 as requested.

Large data visualizations were removed from the body of the report to maintain the readability of the report's narrative. Instead, I have embedded internal hyperlinks directly in the body text. This allows the reader to click and view the relevant Figure or Table when it is discussed. If you decide to print the report, you can have the figures and tables separate from the main body of the report for quick reference.

Remove WQ reports for 2021, 2022, and 2023 from the 2024 report so the report is a reader friendly and/or a printer friendly report of about 40 pages.

Older reports will not be included in the appendix since they make the report cumbersome to read and print. A reference to where the older reports are kept online will be included in the body of the report.

Add to the recommendations how to significantly reduce the number of qualifiers in the data in future reports.

Collier County Pollution Control is aware of the issue with the large number of qualifiers for the 2024 calendar year and know more than I do about how to reduce those. Therefore, I will not be including those recommendations in the body of the report.

1. **Clearly identify organizational roles and responsibilities**
    a. **Consider rephrasing "ETE analyzed water quality samples" to clearly identify interpretation/assessment vs. collection/analysis**

        The report has been edited to state "Earth Tech Environmental (ETE) conducted an analysis of water quality data…"

    b. **Not all samples were analyzed by Collier County Pollution Control Laboratory**
        i. **Utilized subcontracted laboratory (identified in WIN under LAB ID; E83079)**

        The laboratories that analyzed the water samples and their accreditations have been added to the methodology section.

2. **Align with FDEP's biennial assessment methodology outlined in the Impaired Surface Water Rule (IWR) F.A.C. Chapter 62-303**
    a. **Data exclusions**
        i. **Consider adding "G" and "R" to the table in *5.0 Methodology of the report***

        These have been added the methodology and analysis.

ii. **There is also a column in WIN *titled Activity Representative Ind* data marked "Not Representative" are typically excluded**

These have been added the methodology and analysis.

b. Copper

i. **The "U" qualified 4.2 µg/L Copper data was analyzed by a subcontracted laboratory**

1. **Pollution Control requested in February of 2025 the contractor reanalyze samples that had not exceeded holding time**
2. **Resolution of the ongoing corrective action will require some data in WIN will be updated**

We acknowledge that some data may be subject to change if corrective action is taken in the future. If changes are made, we would like to be informed of these changes, and we can reanalyze the data if needed.

ii. **"U" qualified data is assessed as half the reported result or half the criterion, whichever is lower; Apply to all data except nutrients. (F.A.C. 62-303.320 (12)**

Thank you for your direction in how to handle these types of qualified data, we updated the methods and have reanalyzed the data using this method.

iii. **"I" qualified data (data with values between the MDL and PQL) will be treated as equal to the MDL; Apply to all data except nutrients. (F.A.C. 62-303.320 (##)**

Thank you for your direction in how to handle these types of qualified data, we updated the methods and have reanalyzed the data using this method.

iv. **The report concludes that "*Cu is not an impairment issue for Clam Bay*" however IWR Cycle 7 has it meeting requirements for the Verified List using data from 2024**

1. **Language should clarify; data reviewed vs. data used in FDEP biennial assessment reporting period**

After contacting David Tyler from the Watershed Assessment Section of the FDEP, I clarified that copper will not be listed as impaired for Clam Bay during the next assessment.

c. Dissolved Oxygen

i. **Diel (24-hour) DO monitoring is not required for assessment**

While 62-302.533 F.A.C. states that for Class II waters:

"(a) Minimum DO saturation levels shall be as follows:

1. The daily average percent DO saturation shall not be below 42 percent saturation in more than 10 percent of the values,

2. The seven-day average DO percent saturation shall not be below 51 percent more than once in any twelve week period; and,

3. The 30-day average DO percent saturation shall not be below 56 percent more than once per year.

(b) To calculate a seven-day average DO percent saturation, there shall be a minimum of three full days of diel data collected within the seven-day period, or a minimum of ten grab samples collected over at least three days within that seven-day period, with each sample measured at least four hours apart.

(c) To calculate a 30-day average DO percent saturation, there shall be a minimum of three full days of diel data with at least one day of data collected in three different weeks of the 30-day period, or grab samples collected from a minimum of ten different days of the 30-day period.

(d) A full day of diel data shall consist of 24 hours of measurements collected at a regular time interval of no longer than one hour."

We acknowledge that, with regard to dissolved oxygen, the FDEP may use additional data to inform their decision, such as instantaneous dissolved oxygen saturation measurements and co-impairments with nutrients. Emphasis on diel measurements has been removed from the report.

ii. Diel data is not needed for Planning List as IWR Cycle 7 shows DO meeting requirements for Planning List and the Study List.

You are correct. Since the initial draft of this report, FDEP published the 2024-2026 Draft Verified List, which identifies Clam Bay as impaired for DO%. This confirms that FDEP utilizes alternative assessment guidance (FDEP, 2013) to determine impairment even when the specific diel data outlined in Rule 62-302.533 F.A.C. is unavailable. Accordingly, the text stating that diel data is required for assessment has been removed from the report.

iii. FDEP has and continues to assess dissolved oxygen using daily average values from grab samples

Please see previous response to comment 2(c)(iii).

iv. Time of day translations are not utilized in estuaries, but are in freshwater lakes and streams.

It is well established that DO% correlates with time of day due to biological activity, specifically photosynthesis and respiration. An analysis of the Clam Bay data confirms a moderate, but significant, relationship between time of day and DO%. This relationship should be acknowledged when translating the data. A

discussion of these findings has been added to the discussion section of the report.

v. **DO measurements above 100% are assigned a value of 100% for calculating daily, weekly and monthly averages**

The methods for DO% analysis have been updated and the data were reanalyzed with DO capped at 100%.

3. **General Discussion**
   a. **Pollution Control conducted a broad review and but did not evaluate statistical methodology, modeling, criteria calculations, WIN data pulls, or references from ETE.**

      We acknowledge this comment and understand that you did not reevaluate the data.

   b. **The report references December 2025 data, which appears to be an error**

      We have corrected December 2025 to December 2024.

   c. **Some dates in table titles don't match the dates in the table. (Table 3 Oxygen)**

      Table dates have been corrected.

   d. **BERM data were combined in previous reports; define clear benefits to separating them.**

      A brief discussion of the berm data has been added to the report. A discussion of whether or not a more in-depth analysis of the berm data for this report for next year is needed.

   e. **Title suggests report is limited to NNC but is much more comprehensive**

      The subtitle of the report has been changed from "Water Quality Analysis for Evaluation of Limit with Numeric Nutrient Criteria" to "A Comprehensive Water Quality Assessment".

   f. **Mentioning Sampling/Measurement and Laboratory Accreditations establishes credibility and defensibility**

      Laboratory accreditations have been added to the methodology section of the report as well as brief descriptions of the laboratory methods used.

   g. **Ensure consistent use of Specific Conductance (µS/cm) rather than Conductivity in all text and graphics**

      To ensure coherence throughout the report and to reduce confusion, all mentions of conductivity were changed to Specific Conductance (uS/cm).

   h. **Why were turbidity, TSS and chlorophyll not discussed as they directly relate to water clarity and sea grass health?**

This report does not focus on water clarity or seagrass health, which is only discussed briefly to provide context and background information. In the past, this report has specifically focused on TN, TP, DO%, and Cu. Chlorophyll-a is analyzed in this report as it is related to the aforementioned parameters. TSS is not a parameter evaluated by the FDEP and was not within the scope of the 2024 Clam Bay water quality assessment but may be included in future reports upon request from the Pelican Bay Service Division members.

i. **Public Perception and Optics**
    i. **Hand-dug sediments from channel maintenance are offered as a possible nutrient source, while other sources are not discussed**
        1. **Why is it being stockpiled and not removed? Potential violation**

    The 2023 water quality report mentions that hand-dug channels, which are critical for mangrove health, may be a source of nutrients to Upper Clam Bay. However, there is no data available to suggest that this is the driver of nutrient enrichment in this area. This discussion has been removed from the report, as it is speculative, and the hand dug channels are necessary to prevent large swaths of mangrove die-offs which have been seen in the past.

    ii. **New terms include eutrophic, eutrophication, and hypoxic**

    These terms have been removed per your request.

    iii. **Conclusions and Management Recommendations**
        1. **PBSD <u>continues</u> source investigation for pollutants of concern during quarterly stormwater monitoring.**
        2. **Highlight PBSD BMPs already in place including but not limited to; compliance with fertilizer ordinance, slow-release fertilizer percentage, phosphorus free, IQ irrigation calculations, PBSD <u>elimination of copper-based herbicides</u>**
        3. **Initiate public outreach and continue education efforts**

    We have included these recommendations in the report.