Addendum I

Hurricane Milton Soil Salinity and pH Evaluation at the Wildflower Preserve

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Summary: This addendum builds upon an earlier study of soil salinity at the Preserve where soil samples were collected from five locations with sampling at 6-inch intervals from the surface to a depth of two feet. Elevated soil salinity levels resulting from the Hurricane Milton storm surge in October 2024 were found to be widespread and could negatively affect the native upland plant community. This soil sampling design was repeated in February 2026 to assess the impact of the 2025 rainy season on residual soil salinity levels. Although salinity levels had decreased significantly by February 2026, sufficient salinity remained in 3 of 4 sample locations to potentially reduce the survival and/or growth of some native plant species. Two additional test pits had been sampled in planting Zone M in December 2024 to validate the results of the single test pit that was sampled in November 2024. Salinity levels found in December 2024 were similar to those found in November 2024.

1) Introduction

A study of soil salinity at the Lemon Creek Wildflower Preserve (Preserve) was conducted in November 2024 to assess impacts of the Hurricane Milton storm surge (LBC and Houkal, 2025a). Soil samples were collected from five locations. Four locations were impacted by the storm surge and one location was above the surge, thus acting as a control or background location. At each location a test pit was dug and soil samples were collected at six-inch intervals from the soil surface to a depth of two feet. Results showed that all four sample locations that were covered by the storm surge had elevated salinity levels. Salinity was highest in the 0-to-6-inch soil strata and decreased with soil depth. The control sample location had a relatively low level of salinity in the 0-to-6-inch strata, probably caused by the salt spray associated with Hurricane Milton. The salinity in subsurface soil samples from the control location had very low salinity indicative of pre-Milton conditions.

It was assumed that the 2025 rainy season would leach most or all of the salt from the soil. The primary objective of this current study was to confirm that the salt was leached from the soil at the Preserve.

A secondary objective of this current study was to more fully characterize soil salinity in planting Zone M. There had been significant pine mortality in Zone M following Hurricane Milton. A study showed 57 percent mortality for pines growing in the lower elevation wet habitat at Zone M (LBC and Houkal, 2025b).

2) Methods and Material

The question of whether the salinity had been leached from the Preserve soil by the 2025 rainy season was addressed by resampling the soils in the four locations that were covered by the Hurricane Milton storm surge. Soil samples were collected on February 7, 2026, from Zones M, O, I, and L within 50 feet of the 2024 test pit locations (Figure 1). The methods and materials

used to collect these samples were the same as those used in 2024 (LBC and Houkal, 2025a). The only difference was that the soil samples were sent to the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) Analytical Laboratories Extension Soil Testing Laboratory in Gainesville, Florida instead of the UF/IFAS extension office in Sarasota, Florida. These laboratories used identical analytical procedures and expressed the salinity of a 1:2 soil to distilled water volumetric mixture as the electrical conductivity (EC) in decisiemens per meter (dS/m).

The original soil salinity sampling was conducted on November 14, 2024 and included one test pit from Zone M (test pit M-1). It was subsequently decided to collect two additional samples from Zone M to verify the results from November and help understand the causes of pine mortality (Figure 2). Sample M-2 was collected as a replicate sample on December 24, 2024, near the original test pit M-1 location in the low elevation wet habitat. Sample M-3 was collected on December 28, 2024, from an elevated location on the north end of Zone M to determine if the salinity in the drier habitat was comparable to that found in the wet habitat. The methods and materials used to collect these samples were the same as described above.

3) Results

a) Rainfall

Total monthly rainfall at the Preserve for 2024 and 2025 is shown in Figure 3. A total of 43.8 inches of rain fell between November 2024 and December 2025. LBC and Houkal (2025a) provides an analysis of the leaching fraction required to reduce the salinity in the upper 6 inches of soil to a safe level. The leaching requirements ranged from 8.8 inches of rain for Zones M and L to 21.2 inches for Zone I. These results suggest that there was sufficient rainfall during this period to reduce soil salinity to safe levels by 2026.

b) Resampling

Figures 4 through 7 show the test pits for planting Zones L, M, I, and O, respectively. No water pooled in the bottom of any pit following excavation indicating the surficial groundwater table was greater than two feet in depth. The soil in all test pits was moist. Large roots were encountered near the bottom of the Zone I test pit and there appeared to be a hard pan at a two-foot depth in Zone I.

Figure 8 shows the air-dry soil samples on March 2, 2026. The soil color is similar to what was found in these planting zones in November 2024 (LBC and Houkal, 2025a). The darker brown color typically indicates higher organic matter content.

Soil sample salinity levels for February 7, 2026, are shown in Table 1. Comparative results for November 14, 2024, are shown in Table 2. There was a marked decrease in salinity between November 2024 and February 2026 in the 0-to-6-inch soil strata in all Zones. However, the salinity in some zones at greater depths either stayed constant or showed a slight increase. The increases in salinity may be caused by leaching of the relatively high salt concentrations from the 0-to-6-inch strata.

Figures 9 through 12 provide a graphic comparison of the 2024 versus 2026 soil salinity levels for each sample zone. The decrease is soil salinity from 2024 to 2026 was the most significant in Zone M (Figure 9), where the soil EC at all sample depths dropped to the background level of approximately 0.05 dS/m. The salinity in the 0-to-6-inch strata in Zones I, L, and O was significantly above the background level. All of the subsurface samples for Zones I, L, and O also had soil salinity levels above the background level. These results show that the total rainfall from November 2024 through December 2025 did not leach sufficient salt from the soil to reach background salinity levels across much of the Preserve.

c) Zone M

Figures 13, 14, and 15 show the test pits for sample M-1, M-2, and M-3, respectively. Test pits M-1 and M-2 were both located in the low elevation wet habitat. Test pit M-1 was sampled on November 14 and water collected in the bottom of the pit. Test pit M-2 was sampled on December 24 and no water pooled at the bottom of the pit. The shallow groundwater table had dropped between those two dates. Test pit M-3 was located on higher ground and no water accumulated in the bottom of that pit. Figure 16 shows the air-dried soil samples collected from the three test pits. The colors of samples from M-1 and M-2 are similar, but there is a distinct change in color in sample 18-24 from M-3.

Results of the intensive soil salinity testing at Zone M in 2024 are shown in Table 3. These results are graphically displayed in Figure 17. This information shows test pits M-1 and M-2 have a similar vertical pattern of soil salinity with salinity decreasing with depth of the sample. This is expected since the pits were located close to one another in the low elevation wet habitat of Zone M. Test pit M-3 shows a relatively high salinity in the 0-to-6-inch strata, but the salinity in the deeper strata is essentially at background levels. This pattern suggests that storm surge water likely flowed across this area from the southern tip of Long Pond. Since this area is elevated, so the surge water likely receded relatively quickly such that the salt water did not infiltrate very deeply into the soil.

4) Conclusions and Recommendations

Results of this study show that residual salt levels remained elevated in 3 of 4 sample locations in February 2026. It is concluded that the 2025 rainy season did not provide enough rainfall to adequately leach salt from the soil to reach background levels.

Results of the more intensive soil salinity testing in Zone M support our understanding of the dynamics of the Hurricane Milton storm surge. These results also support the findings of the pine mortality study in Zone M (LBC and Houkal, 2025b) that the synergistic effects of salt stress and waterlogging were responsible for the high pine mortality in the low elevation wet habitat of Zone M.

Since residual salinity persists in 3 of 4 sample locations on the Preserve in February 2026, it is recommended that salinity testing be repeated in all four sample locations after the 2026 rainy season to document the successful return to pre-Hurricane Milton soil salinity conditions.

5) Discussion

a) Factors Affecting Leaching of Salt from the Soil

A previous analysis of the leaching fraction required to reduce the salinity in the upper 6 inches of soil to safe levels estimated that between 8.8 and 21.2 inches of rainfall were required to fully leach the salt from the upper 6-inches of soil at the Preserve (LBC and Houkal, 2025a). Since the total rainfall at the Preserve between November 2024 and December 2025 was of 43.8 inches (Figure 3), it would be expected that the salt should have all leached from the upper six inches of soil. The data in Table 1 shows there were significant levels of salt remaining in three of four soil sample locations. Why wasn't the salt leached from the upper soil profile?

The theoretical leaching fraction estimation provided in LBC and Houkal (2025a) assumed that the leaching water would be applied in a continuous manner. However, the actual rainfall pattern was very different and that pattern could increase the leaching water requirement. For example, small amounts of rainfall (e.g., 0.5 inch) distributed over many months would allow much of the soil moisture to be lost to evapotranspiration. In this case, only small amounts of water might leach down through the subsoil.

Most of the native soil covering the Preserve was the Smyrna series. This soil is characterized as a poorly to very poorly drained soil. This poor drainage will impede the rain fed leaching of salt from the soil.

Another factor that could affect soil salinity is the interaction between the soil and surficial groundwater aquifer. The water table occurs at depths of less than 18 inches for 1 to 4 months in most years. During the rainy season, the water table may rise above the soil surface for short

periods. The salinity levels in the surficial groundwater aquifer are unknown, but could be affected by both on- and off-site factors and could affect soil salinity levels.

b) Potential Salinity Effects on Plants

The question arises whether or not the residual soil salinity levels found at the Preserve in February 2026 have a negative impact on the native plant community. Williams et al. (1988) evaluated the effect of soil salinity on seven Florida native tree species in a greenhouse pot trial where seedlings were drip irrigated with water at six levels of salinity (0, 2, 4, 8, 15, and 22 g/L NaCl (ppt)). After 6 months, seedling survival at 2 ppt was below 50 percent for three of seven species. Williams et al. (1988) also found that seedling survival was below 10 percent for 3 of seven species at the 4 ppt salinity level and survival dropped below 20 percent for all seven species at the 22 ppt salinity level. The EC in the 0-to-6-inch soil strata was 1.09 dS/m for Zone I, 0.54 dS/m for Zone L and 0.33 dS/m for Zone O. These EC levels were converted to a salt concentration in ppt[1] yielding the following approximations: Zone I = 4.0 ppt, Zone L = 1.9 ppt and Zone O = 1.1 ppt. These results indicate that the residual salinity levels found in 3 of 4 sample locations at the Preserve may cause plant mortality of the more salt sensitive species.

Of course, salt stress can also impact other plant characteristics such as growth, seed germination, and flower/seed production. Grieve et al. (2012) evaluated the salt tolerance of a large number of woody crops. Plants that showed salt stress symptoms and had a > 50 percent reduction in growth at an electrical conductivity of a saturated soil paste (EC_e) of less than 1.5 dS/m were classified as salt sensitive, while plants that showed salt stress symptoms and had a > 50 percent reduction in growth at a soil EC_e greater than 5 dS/m were classified as salt tolerant. The methods used by Grieve et al. (2012) to calculate soil salinity differed from the methods used by UF/IFAS as they measured the electrical conductivity of a saturated soil paste (EC_e), while the UF/IFAS measured the electrical conductivity (EC) of a 1:2 soil/distilled water volumetric mixture. So, the electrical conductivity data needed to be converted to be comparable[2]. The EC reported by UF/IFAS in the 0-to-6-inch soil strata was 1.09 dS/m for Zone I, 0.54 dS/m for Zone L and 0.33 dS/m for Zone O. The converted EC_e approximations were: Zone I = 7.3 dS/m, Zone L = 3.6 dS/m and Zone O = 2.2 dS/m. It appears that the residual soil salinity levels in sample locations at Zones I, L, and O are high enough to cause a 50 percent reduction

[1] Used an online salinity conversion calculator available at: https://www.hamzasreef.com/Contents/Calculators/SalinityConversion.php.

[2] The UF/IFAS laboratory mixed a 20 ml soil sample with 40 ml of distilled water to prepare a soil suspension to measure EC. Assuming the porosity of a fine sand soil is 30 percent, a 20 ml fine sand soil sample would contain 6 ml of water at saturation. So, the 1:2 soil:water suspension would contain 6.7 times more water than the fine sand at saturation. Therefore, multiplying the EC of 1:2 soil/water suspension by 6.7 would approximate the soil EC_e.

in the growth of salt sensitive species. The higher salinity level in Zone I could cause a 50 percent reduction in growth of salt tolerant species.

6) References

Grieve, C.M., S.R. Grattan, and E.V. Maas. 2012. Plant salt tolerance. In: W.W. Wallender and K.K. Tanj (eds.) ASCE Manual and Reports on Engineering Practice No. 71 Agricultural Salinity Assessment and Management (2nd Edition). ASCE, Reston, VA. Chapter 13 pp: 405-459.

LBC and D. Houkal. 2025a. Hurricane Milton Soil Salinity and pH Evaluation at the Wildflower Preserve. 22 p. On file at the LBC Office, 460 W. Dearborn St, Englewood, FL. 34223.

LBC and D. Houkal. 2025b. Study of Pine Mortality Following Hurricane Milton in Planting Zone M at the Lemon Creek Wildflower Preserve. 20 p. On file at the LBC Office, 460 W. Dearborn St, Englewood, FL. 34223.

Williams, K. M.V. Meads, and D.A. Saurbrey. 1998. The roles of seedling salt tolerance and resprouting in forest zonation on the west coast of Florida, USA. American Journal of Botany 85(12): 1745-1752.

Table 1. Soil Sample Electrical Conductivity (EC) Results (dS/m) for February 7, 2026.

Sample Depth (inches)	Sample Location			
	Zone M	Zone I	Zone L	Zone O
0-6	0.06	1.09	0.54	0.33
6-12	0.03	0.81	0.15	0.13
12-18	0.02	0.42	0.13	0.12
18-24	0.02	0.3	0.15	0.18

Table 2. Soil Sample Electrical Conductivity (EC) Data (dS/m) for November 14, 2024.

Sample Depth (inches)	Sample Location				
	Zone M	Zone I	Big Mound	Zone L	Zone O
0-6	1.16	4.2	0.29	1.73	1.79
6-12	0.75	0.58	0.05	1.31	0.21
12-18	0.15	0.19	0.05	0.73	0.1
18-24	0.14	0.17	0.05	0.11	0.12

Table 3. Soil Sample Electrical Conductivity (EC) Data (dS/m) for Zone M.

Sample Depth (inches)	Sample Location		
	Zone M-1	Zone M-2	Zone M-3
0-6	1.16	0.58	0.92
6-12	0.75	0.55	0.09
12-18	0.15	0.45	0.05
18-24	0.14	0.06	0.05
Notes:			
Samples were collected on 11/14/24 for M-1, 12/24/24 for M-2, and 12/28/24 for M-3.			

Figure 1. Soil Sample Locations for Salinity Testing.

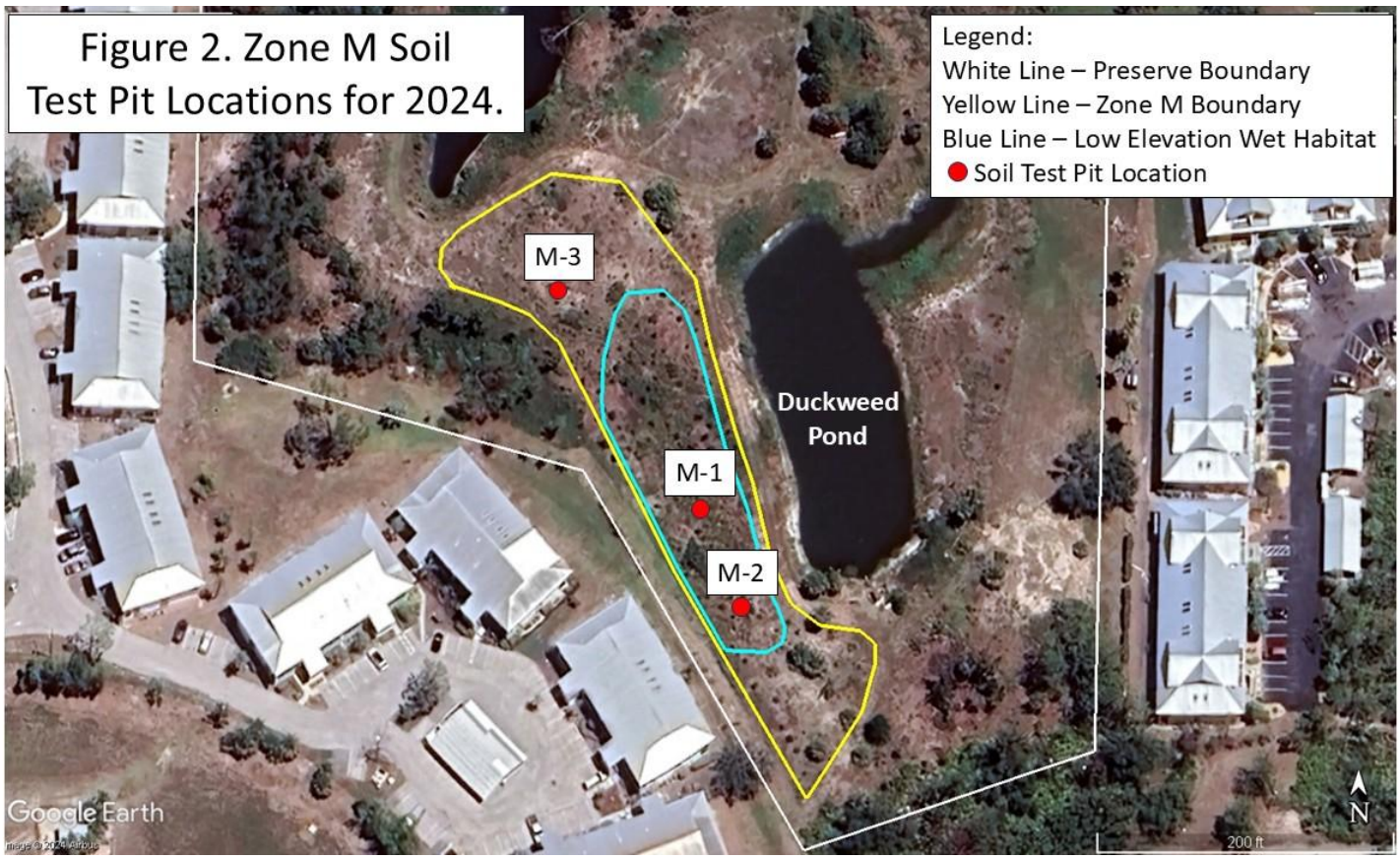

Figure 2. Zone M Soil Test Pit Locations for 2024.

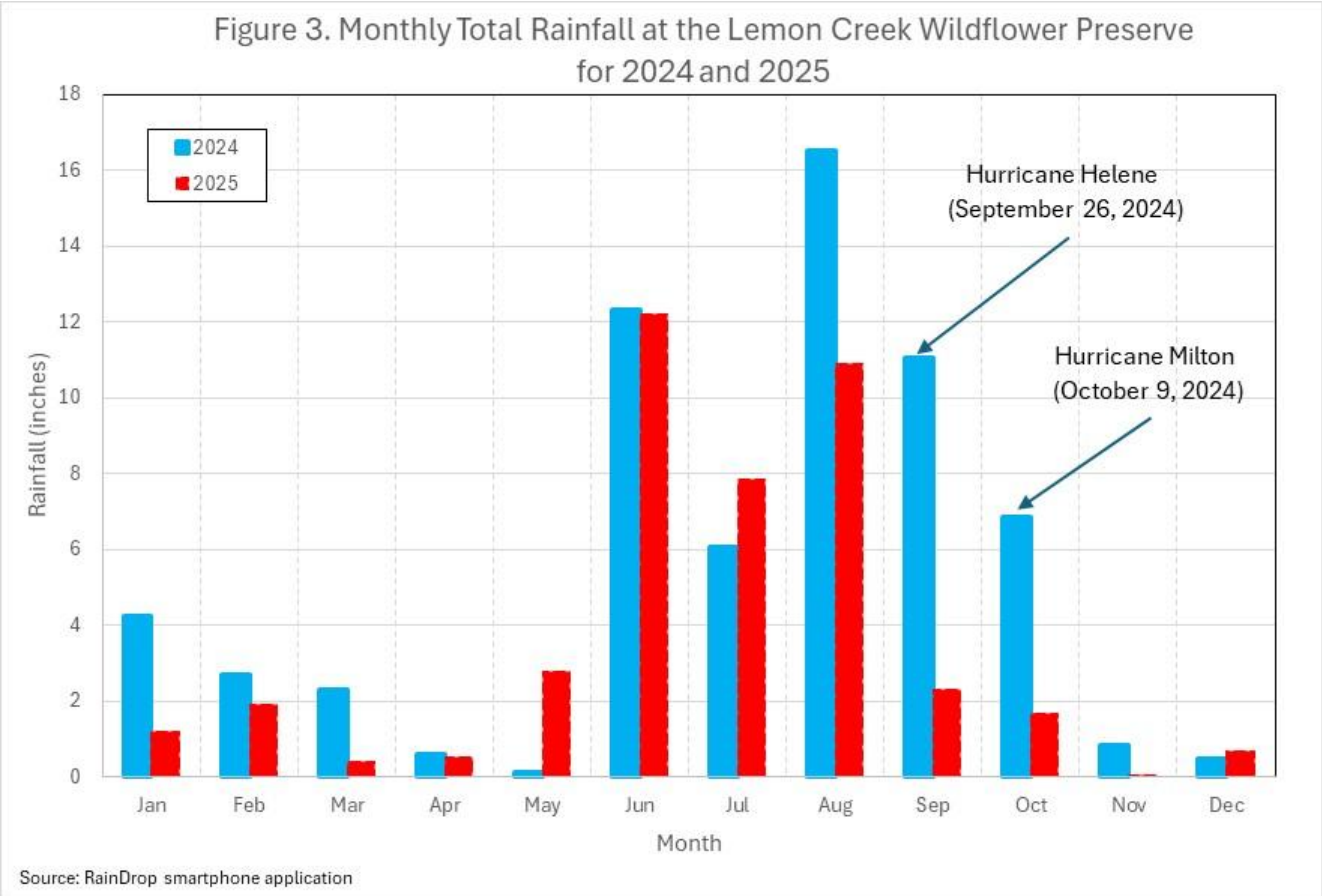
Figure 3. Monthly Total Rainfall at the Lemon Creek Wildflower Preserve for 2024 and 2025
2024
2025
Hurricane Helene (September 26, 2024)
Hurricane Milton (October 9, 2024)
Rainfall (inches)
0
2
4
6
8
10
12
14
16
18
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Source: RainDrop smartphone application

Figure 4. Test pit Zone L. (02/07/26)

Figure 5. Test pit Zone M. (02/07/26)

Figure 6. Test pit Zone I. (02/07/26)

Figure 7. Test pit Zone O. (02/07/26)

Figure 8. Air-dried soil samples. Columns from left to right are Zone L, Zone M, Zone I, and Zone O. Rows from bottom to top are 0-6”, 6-12”, 12-18”, and 18-24”. (03/02/26)

Figure 9. Comparison of Soil Salinity Levels in Zone M for 2024 and 2026.

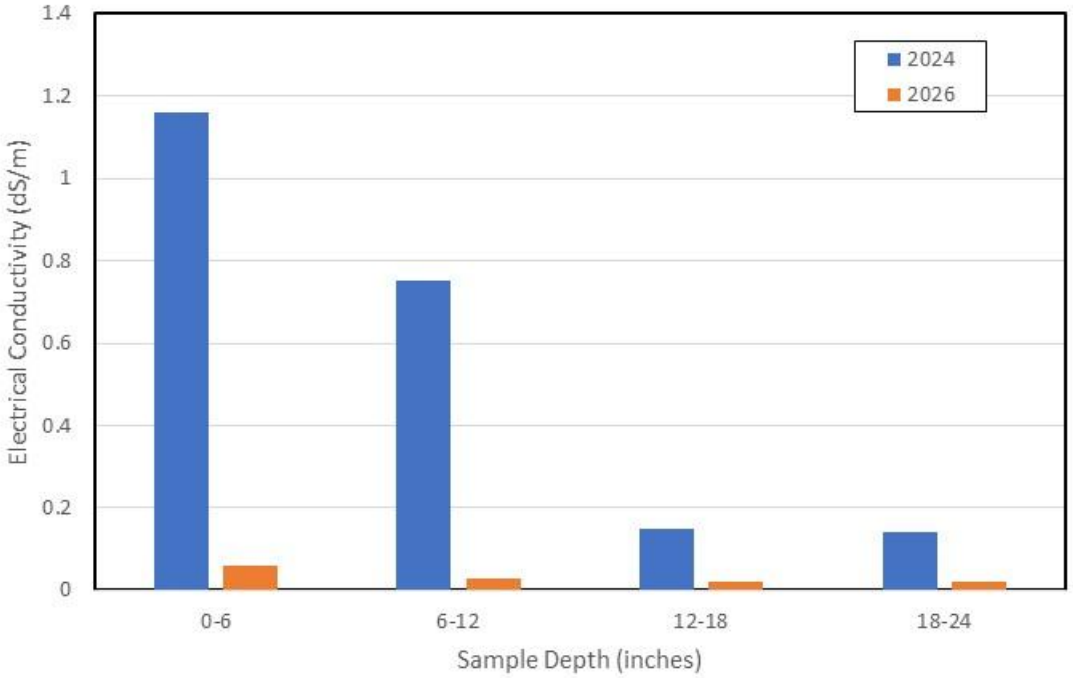

Figure 10. Comparison of Soil Salinity Levels in Zone L for 2024 and 2026.

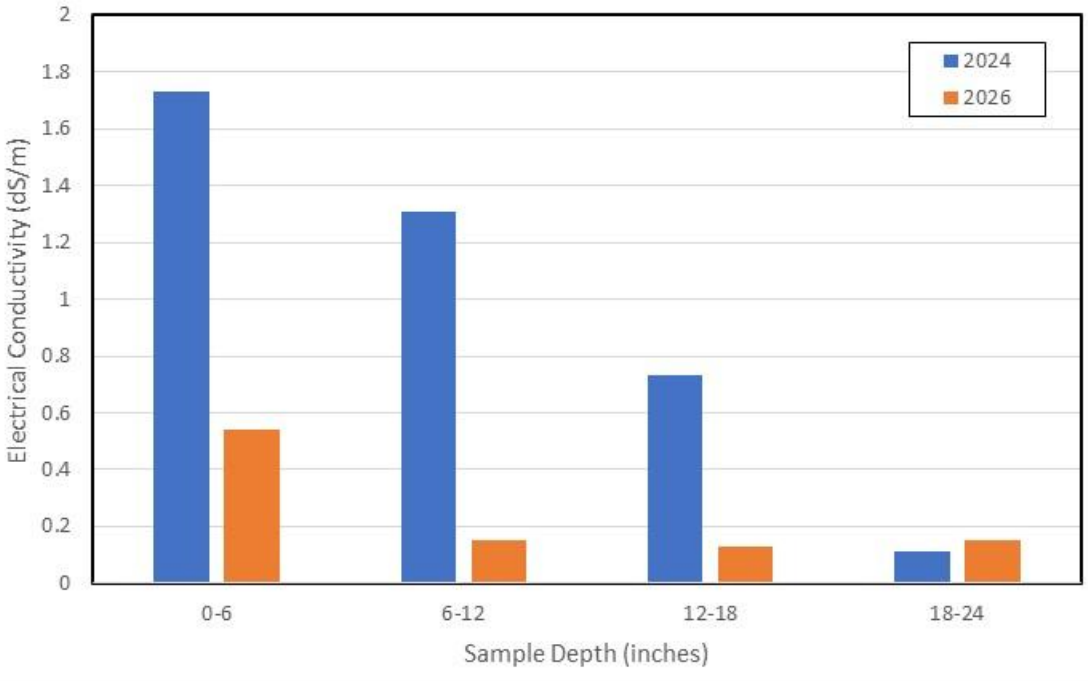

Figure 11. Comparison of Soil Salinity Levels in Zone I for 2024 and 2026.

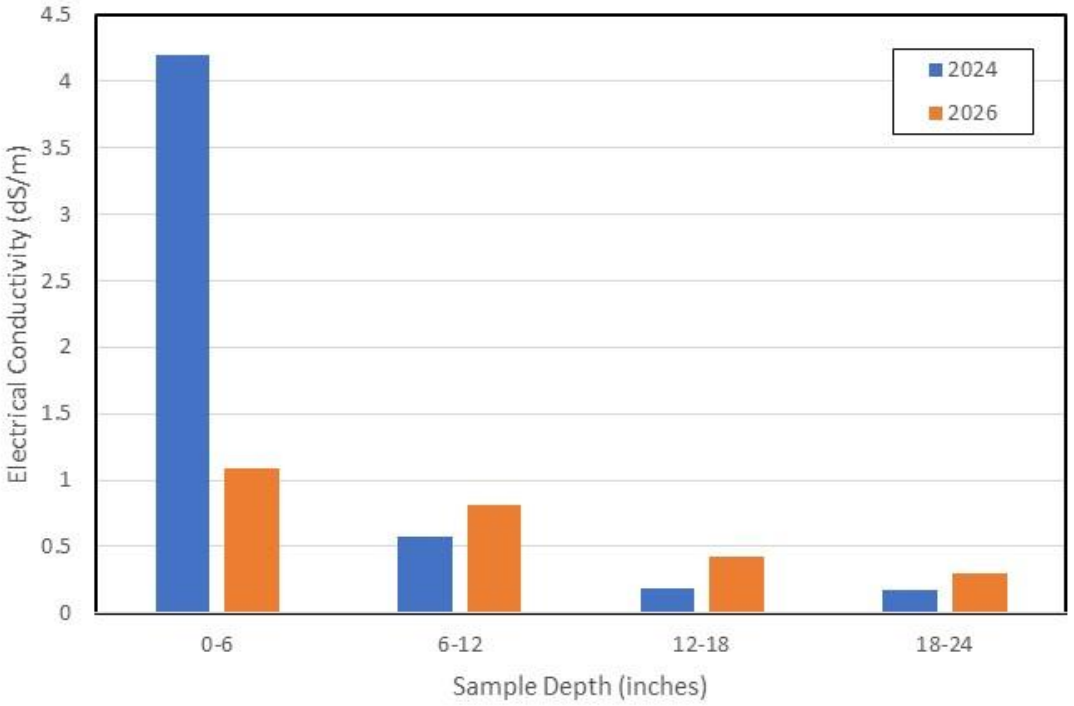

Figure 12. Comparison of Soil Salinity Levels in Zone O for 2024 and 2026.

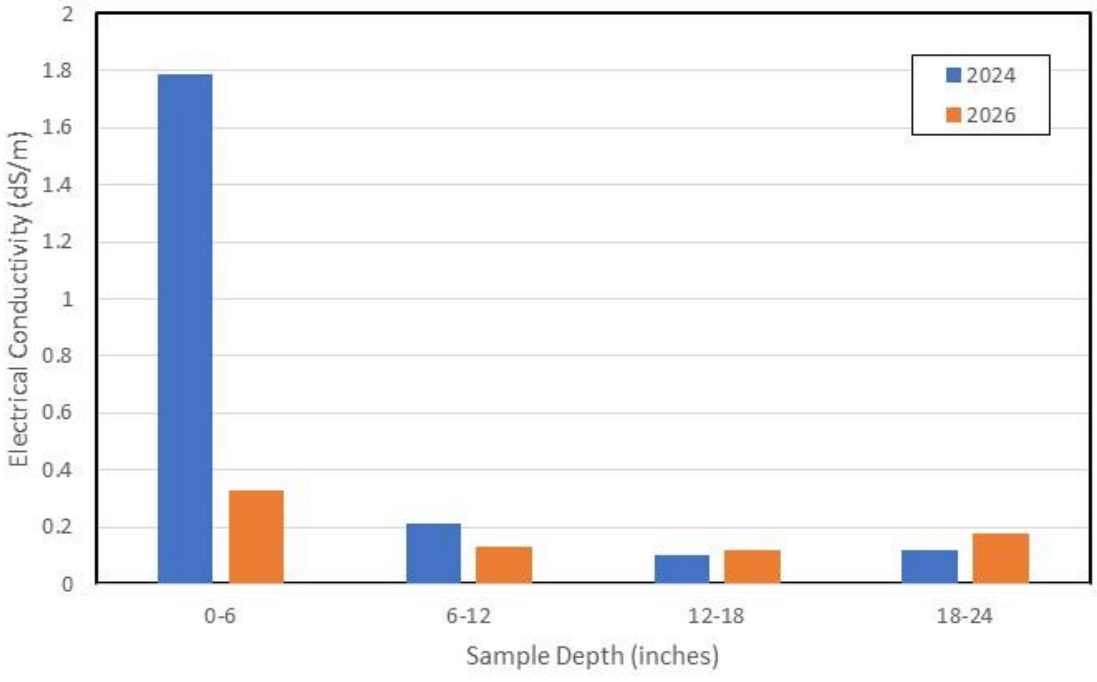

Figure 13. Test pit Zone M-1. (10/14/24)

Figure 14. Test pit Zone M-2. (12/24/24)

Figure 15. Test pit Zone M-3. (12/28/24)

Figure 16. Air-dried soil samples. Columns from left to right are test pits M-1, M-2, and M-3. Rows from bottom to top are 0-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches.
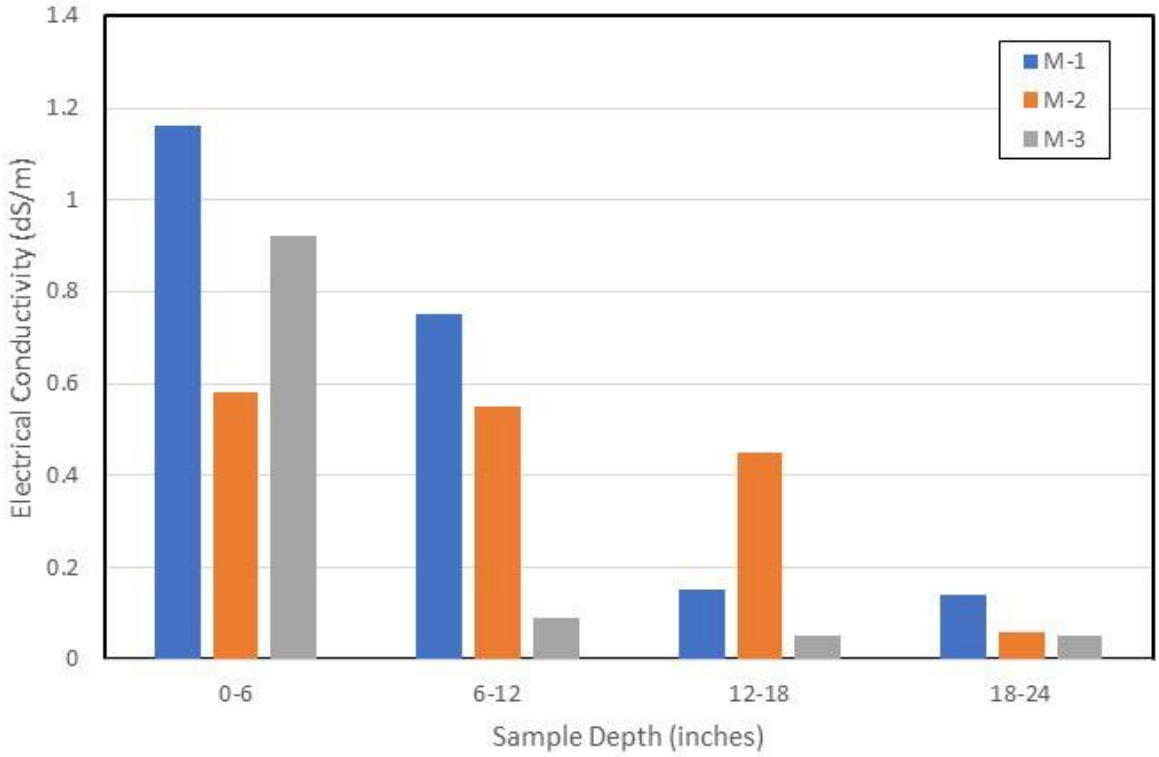
Figure 17. Comparison of Soil Salinity Levels in Three Test Pit Locations in Zone M in 2024.