

Potential Wetlands in Nassau County, Florida - An Automated Approach for Planning

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Prepared for
Nassau County Property Appraiser Office
February 2022



Photo by: Leonard Pearlstine

Acknowledgment: This project is led by Jason Gregory (GIS director), Kevin Lilly (Chief Deputy), and Michael Hickox (Property Appraiser) from the Nassau County Property Appraiser’s Office, Kelly Gibson (Planning and Conservation Director) and Jacob Platt (Senior Planner) from the City of Fernandina Beach. Special thanks to Margaret Kirkland (Amelia Tree Conservancy), Kirk Waters (NOAA Digital Coast), Jason Harris (Chief Technology Officer from ROK Technologies, LLC)’s support.



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Abstract

The current Nassau County Geographic Information System (GIS) relies solely on the U.S. Fish and Wildlife Service (FWS) National Wetland Inventory (NWI) for its potential wetlands data. County and city government professional planning and engineering personnel, therefore, use NWI wetland maps for planning, flood control, land acquisition, development permitting, and regulatory decision making. Inaccuracies and missed wetlands are documented in NWI maps and observed in Nassau County. County-wide professional ground-survey wetland delineations would be unrealistic. Therefore, this wetland mapping effort was performed to improve the potential wetland map for Nassau County for the use of professional planning and engineering personnel.

To improve the identification of regional potential wetlands, GIS analysis is used to model the location and extent of potential wetlands continuously across the county by extracting elevation data from NWI mapping units and extrapolating to nearby areas. Those areas meeting the elevation criteria are identified as potential wetland.

The areas identified as potential wetland are then compared to the United States Department of Agriculture (USDA) Soils Map of Nassau County and the official list of hydric soils. Two classes of potential wetlands were then classified: Class 1 – Meets elevation criteria and overlies hydric soils; Class 2 – Meets elevation criteria outside of hydric soils.

As with all computer modelling, the results are only as accurate as the input data. The inherent errors in the NWI maps, therefore, contributed to inaccuracies in the potential wetland map, both errors of commission and errors of omission. The map product did, however, accurately expand existing NWI boundaries and capture a substantial amount of additional wetland areas missed by the NWI.

These potential wetlands maps are a planning level tool that can highlight areas that may require more in-depth wetland appraisal and that provides opportunities for identifying areas for conservation and restoration. They are not formal wetlands delineations and cannot be used for jurisdictional decisions. This product is primarily aimed at professionals with expertise and responsibilities in civil engineering, planning, natural sciences, wetland permitting, and natural resource management. It is not a wetlands map, but a map of the potential that a site is wetlands and, as such, requires local knowledge and understanding of wetlands mapping to be effectively used and to distinguish sources of mapping accuracy and error.

Keywords: wetland mapping, Nassau County, FL, automated mapping, potential wetland model.

Introduction

The National Wetland Inventory (NWI), using the Cowardin et al. (1979) wetlands classification system is the source of wetlands delineation for local government planning and decision making in Nassau County. Most of the imagery used for NWI classification in Nassau County is from the 1980s, predating large areas of existing development (Figure 1). Fernandina Beach and northeastern inland Nassau County are classified from the 2000s and southern Amelia Island uses imagery from the previous decade (2010s). Additionally, studies of NWI accuracy in Michigan (Kudray and Gale, 2000) and the northeast U.S. (Nichols, 1994; Morrissey and Sweeney, 2006) found most of the wetlands missed by the interpreters were forested wetlands. In the southeast U.S. (Florida through Virginia), Prisley et al. (2020) examined timberland field plot ground survey classifications against NWI aerial photo classifications and found that if NWI mapped a forested wetland, there was a 90% probability it would actually be present on the ground. However, NWI only accounted for 39% of those forested wetland features on the ground. Field observations identified wetland 2.3 times more often than NWI photo interpretation. Significantly for Nassau County, misclassifications were significantly higher than expected in younger flatwood stands, in pine forest types, and in planted stands (Prisley et al. (2020). Accuracies of non-forested wetlands such as marshes and ponds were not included in their study.

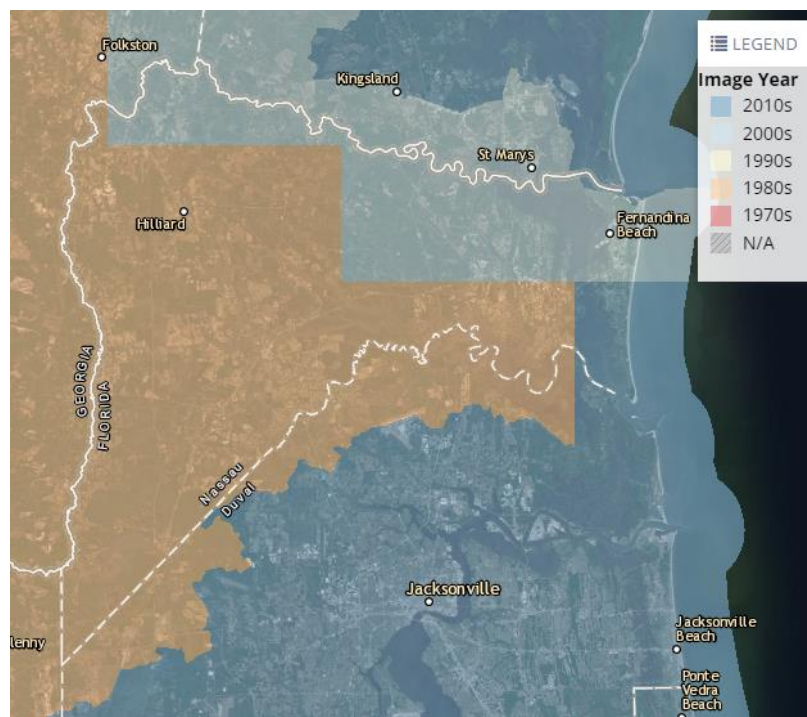


Figure 1. Dates of images used for NWI classification. Figure from <https://www.fws.gov/wetlands/data/mapper.html>.

Mis-mapped interior wetlands may be developed without review because their existence is not known. Wetland delineations with ground surveys across the entire county would be costly and impractical. Therefore, a semi-automated approach based on existing accessible information in the Nassau County Geographic Information Systems (GIS) was proposed by Warren Buchanan and Harrison Weisenborn (2019) to improve wetland mapping. There are three steps: 1) scrutinize those areas of muck or frequently

flooded hydric soils that were not captured as potential wetlands; 2) study the topography in which those soils and nearby designated NWI wetlands occur and select a topographic contour that best matches the apparent upper elevation of the wetland in that area; 3) apply that selected contour as the boundary of the missing wetland. The Buchanan and Weisenborn methods were never implemented county-wide because it is labor-intensive. Therefore, a fully automated procedure has been developed.

This report details the procedures and rules-based modeling that automates and extends the Buchanan and Weisenborn (2019) approach to spatially continuous mapping of potential wetlands in Nassau County. The computer-modeled unsupervised mapping of potential wetlands uses local elevation data, soils, and the NWI to extrapolate unidentified wetland areas continuously across the landscape.

This is not a certified professional site-visit wetlands delineation and should not be used for jurisdictional decisions. The accuracy of the mapping is dependent on the quality of the input data layers from previously mapped wetlands, soils, and elevations. It is a planning tool for quickly identifying the potential for wetlands at sites and across the broader landscape.

However, the proposed wetland layer may be used to identify permit requests that may have adjacent or on-site wetlands and should be targeted for a closer examination. It also benefits landscape and broad-scale planning. Planning offices have a critical responsibility for helping to shape the vision for future growth, conservation, and resilience. Potential wetland maps provide spatial representation of wetland patterns and distributions. Some issues of concern that, along with other models, these map products can help address include: 1) Evaluation of habitat connectivity, cumulative impacts, and area-wide influence on conservation, resilience, and development planning; 2) Resiliency and flood management and planning, enabling planners to identify and monitor patterns and change in wetlands for timelier and more effective planning to protect residents from potential flood hazards; and 3) planning adaptations and mitigations in preparation for sea level rise, storm surge, changing weather patterns, and extreme weather events.

The mapped potential wetlands may be accessed in a web viewer (powered by ESRI GIS Enterprise, see a detailed user instruction in Appendix B). It is important to note that the web applications are updated by developers constantly. This report records the most currently version of the viewer. However, with the updates, the screenshots and appearances could change. The Uniform Resource Locator (URL) of this viewer is:

<https://maps.nassaupla.com/portal/apps/webappviewer/index.html?id=bcad46586896401d855b0bec9a5ac159>

Methods

As reviewed below and detailed in Appendix A, the procedures and scripts were generated using ArcGIS Pro 2.8.2 & 2.9.0 (ESRI, 2021), R 4.1.0 (R Core Team, 2021) the R packages raster (Hijmans, 2021), rdgal (Bivand, Keitt, and Rowlingson, 2021), gdalUtils (Greenberg and Mattiuzzi, 2020) and igrph (Csardi and Nepusz, 2006), and Python ArcPy Version 2.8 (ESRI 2021).

All data layers were resampled as rasters (composed of a continuous grid rather than vector lines and polygons) at a working resolution of 6 x 6 ft. A raster data model was used rather than discrete contour or boundary lines to improve accuracy with a continuous, floating-point surface. Figure 2a illustrates the Digital Elevation Model (DEM) generated using 2018-2020 Lidar (NOAA, 2020) for Nassau County. Figure 2a also shows NWI wetland boundaries obtained from the U.S. Fish and Wildlife Service (FWS, 2021) for Nassau County.

The purpose of the next steps is to find the elevations in the nearest wetland from each cell (site) in the continuous grid (Figure 2b). It is used to determine in later steps if the elevation at the site is higher or lower than the elevation of nearby wetlands using one of the criteria used to determine if the site is potentially wetland. Two elevation files were generated using the DEM and NWI layers. The first was elevations just along the edges of the NWI wetlands. The second was elevations within the NWI wetlands. Circular filters moving to each grid cell in the elevation files were used to analyze the NWI elevations. This step in the data preparation is to find the 75th quantile elevation within the search radii at each site from the NWI upper boundaries nearest to the site. The 75th quantile was selected after statistical exploration of the elevations along NWI edges along with trial model runs (Appendix A). If the wetlands are relatively small, then a smaller search radius can dramatically change the found boundary for the better. On one hand, a local substantial change in elevation with a larger search is likely to create an unrealistic median at a site. On the other hand, a small search radius will not find wetlands a further distance from the NWI boundaries, so a larger radius is needed. Although it is possible to quantitatively determine distances beyond which the elevations at a wetland no longer influence the likelihood of wetlands (e.g., Palaseanu and Pearlstine, 2008), this project selected 1/4 mile as a reasonable working distance based on the authors' experience with the region and because only small areas of county are further than 1/4 mile from a NWI mapped wetland (Figure 2b). A continuously variable radius finding the nearest wetland would be ideal, but unnecessarily complex, so this approach used elevations found at wetlands edges in a moving window at 3 search radii: 1/4, 1/8, and 1/16 mile (1320, 660, and 330 ft) to create the new 75th quantile data layer.

This approach is effective for depression wetlands where the wetland boundaries are the highest elevation points in the wetland. Nassau County also has wide wetlands where interior sediment builds up to a higher elevation than at the wetland's edge. The marsh adjacent to Egans Creek on Amelia Island is an example. To identify these wetlands, a small footprint, 96 ft radius, moving window found maximum elevations within the interior of NWI wetlands rather than just at their boundary (Figure 3).

The final layer of elevations at the nearest wetland is a merge of the elevation data layers created at different search radii. If the 96 ft search results find wetland elevation values, then those values are used. When no wetlands are within 96 ft of a site, the 1/16-mile results are used if they have a value. The elevation layer accepts the 1/8-mile results when the 1/16-mile search doesn't have a value, but the 1/8 does. Finally, it uses the 1/4-mile results when the 1/8-mile search doesn't have a value. In this version, wetlands further than 1/4 mile from the edge of known (i.e., NWI) wetlands will be missed because NWI edges beyond 1/4 mile from a grid cell are not expected to have a relationship to wetland edges at that grid cell (Figure 2b).

Prior to finding wetland elevations, excavated freshwater ponds were excluded from the analysis (Appendix A). These retention ponds and farm ponds are often at a higher elevation than the surrounding landscape which would cause nearby sites to overestimate the elevation of potential wetlands.

Wetland soils (Figure 4) were identified and extracted from the USDA soils data layers for Nassau County (Watts 1991, Natural Resources Conservation Service, 2014) creating a new data layer with values of 0=non-wetland soils, and 1=wetland soils. The decision was made to include all soil mapping units on the official USDA list of hydric soils for Nassau County (Appendix A). Many of these hydric soil mapping units contain considerable amounts of upland soils, even in some cases more than 90% upland soils. But they are listed as hydric because they have inclusions of hydric soils where they might have depressions that are saturated much of the year. Since the model is driven by the identification of lower elevations in the landscape, it was logical to include all hydric soils and assume the model is biased toward the hydric inclusions.

The potential wetlands map is created using a simple, rules-based model. The map finds two classes of potential wetlands based on these rules:

Class 1 – Meets elevation criteria and overlies hydric soils and elevation criteria: The elevation at a site is less than or equal to the elevation of the nearest known wetland and the soils are hydric.

Class 2 – Meets elevation criteria outside of hydric soils: The elevation at a site is less than or equal to the elevation of the nearest known wetland, but the soils are not hydric.

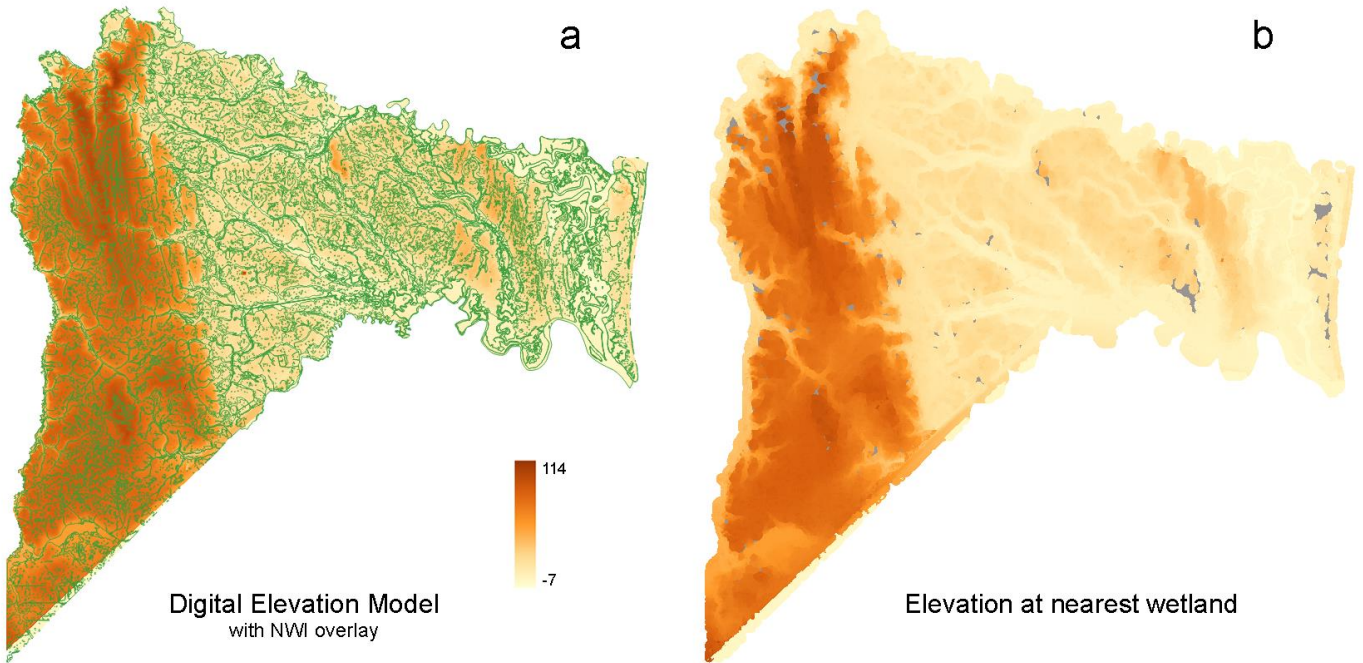


Figure 2. a) Digital elevation model from 2018-2020 lidar. NWI wetland boundaries are overlain. b) Elevation from the nearest known wetland. In Figure 2b, gaps in the coverage (grey cavities) can be seen where the sites are beyond the modeled 1/4 mile search radius.



Figure 3. a) Wetlands occur at elevations equal to or lower than their outermost boundaries. b) Wide alluvial wetlands may have sediment deposits that raise the interior wetland elevations above the elevations at their outermost edges.

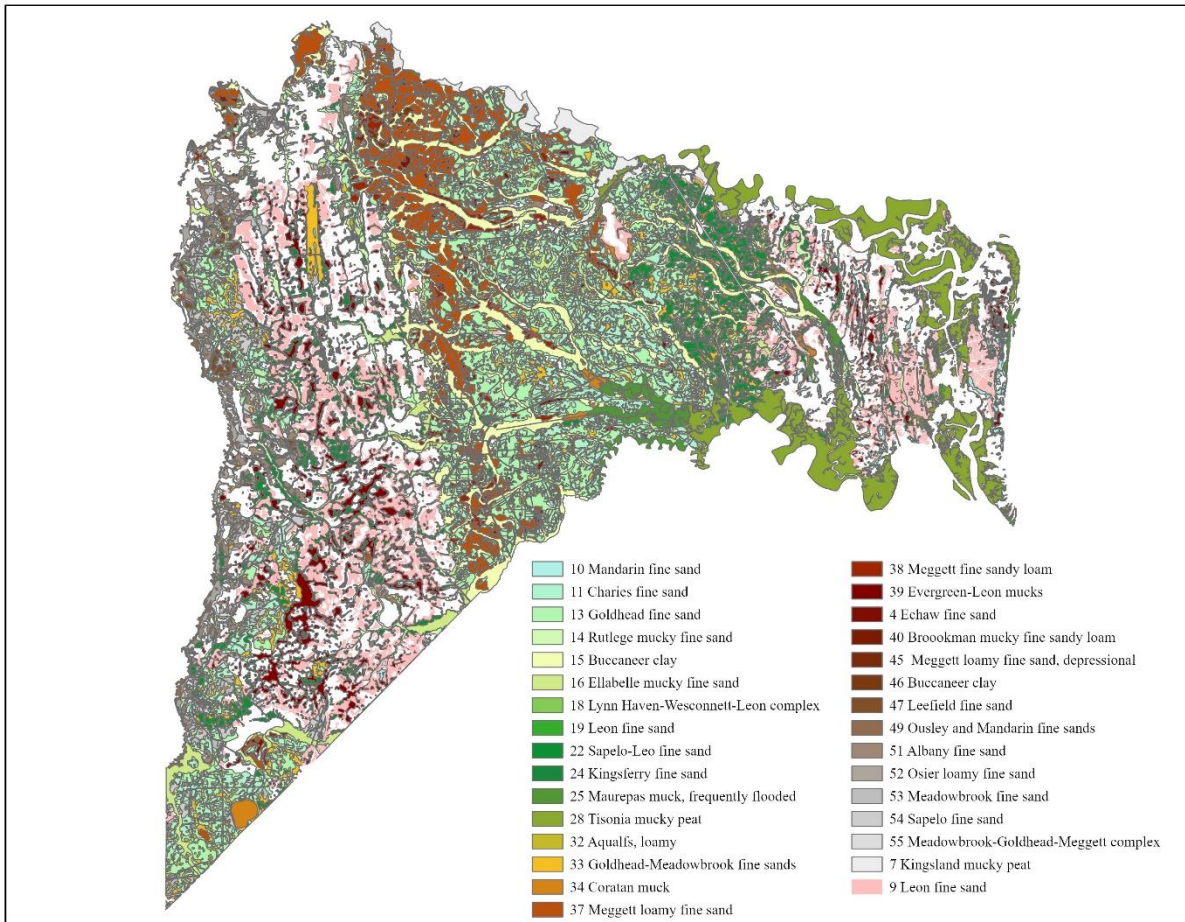


Figure 4. Nassau hydric soils used for modeling potential wetlands.

Results and Discussion

Overview

This work captures the potential of a location to be wetlands from Nassau County NWI, lidar elevations, and soils maps (Figure 5). The NWI maps of potential wetlands were used to extract elevation data from those raster cells that comprised their mapping unit. As illustrated below, the model effectively captures wetlands in close agreement with the NWI maps and finds wetlands that were not identified in the NWI. The potential wetlands maps are created from a rules-based model that can only be as good as its input data layers. Both NWI mapping from photo interpretation and the potential wetlands model used here will have errors of omission and commission; wetlands that are still missed and misidentification of wetlands where there are none. Examples of the potential wetlands model successes and its limitations are both presented (Figures 6 - 13).

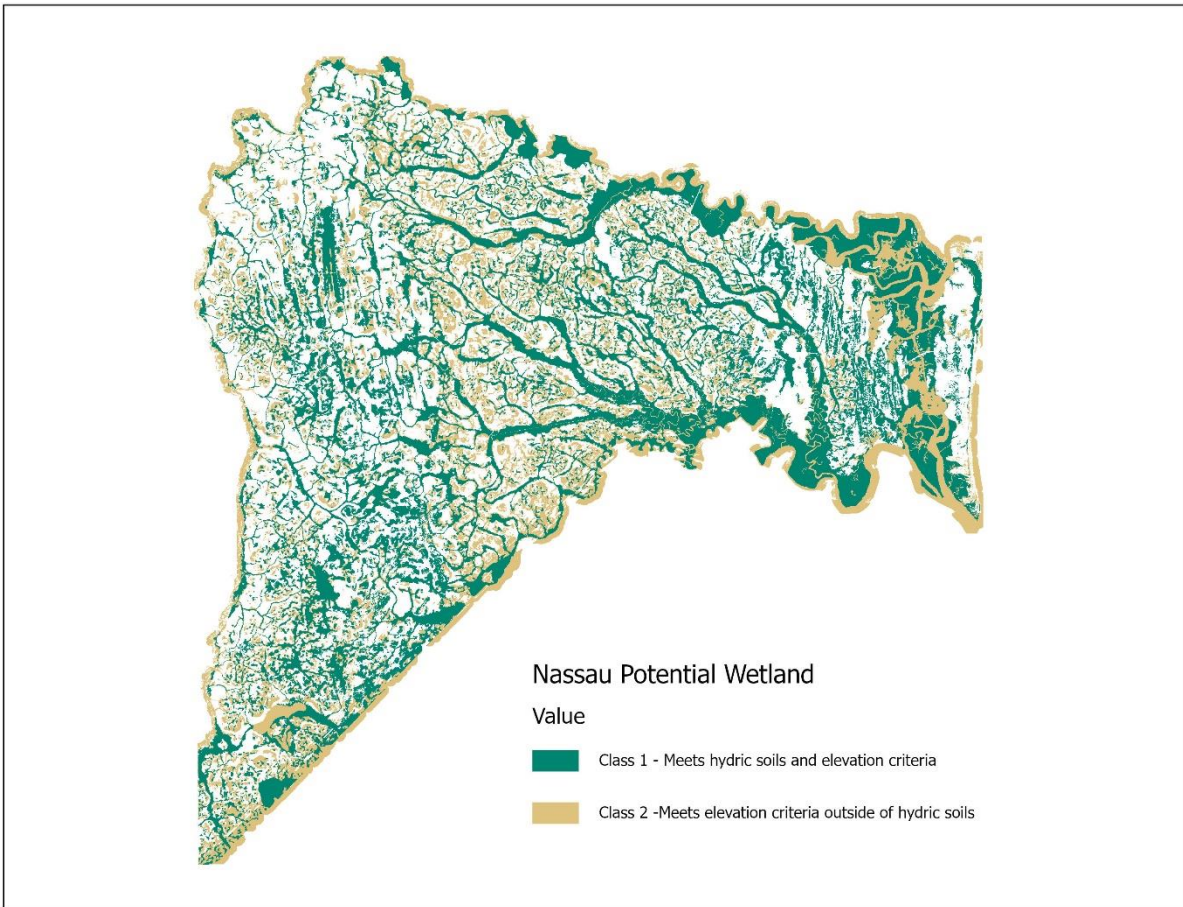


Figure 5. Nassau potential wetlands Class 1 and Class 2.

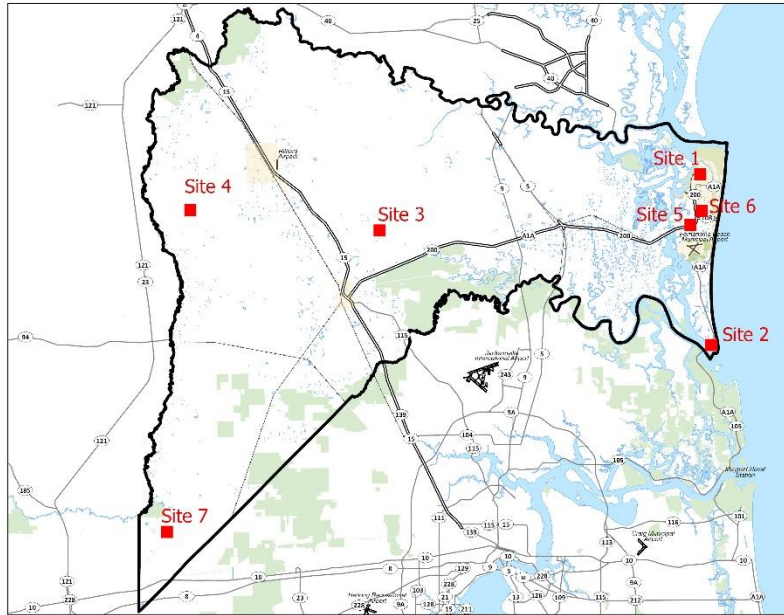


Figure 6. Location map for the sites used as examples in Figures 6 – 13.

Class 1 and Class 2

The potential of a location to be wetlands is derived from the elevations ranges of the nearest mapped wetlands. These areas that meet the elevation criteria are then overlain on the Nassau County soils map to identify those that reside on designated hydric soils (Class 1) and those that reside on non-hydric soils (Class 2). Figures below of features of the potential wetlands mapping illustrate several general outcomes of the mapping and of Class 1 and Class 2 distinctions that are seen across the landscape. There is a general agreement of Class 1 with NWI, but with expansion of potential wetland along NWI edges and identification of potential missing wetland in both classes. Class 2 can frequently be important in the identification of wetlands missed by Class 1 because of errors in the soils mapping. More often than Class 1, however, Class 2 overestimates potential wetland because it is unconstrained by soils, illustrating the importance of ground knowledge in application of the potential wetlands mapping. Both classes may provide important spatial insight, but without the soils map constraints, Class 2 generally should be treated with lower confidence than Class 1 (but see the section on input data layer errors). These potential wetlands maps are best used with concert with review of aerial imagery and ground visits to the extent that resources allow.

Expansion of NWI beyond mapped boundaries

Figure 7 illustrates excellent agreement of Class 1 potential wetlands mapping with observed wetland position on the ground. The wet forested and mixed vegetated open water communities between 8th and 15th St in Fernandina Beach demonstrate the applications ability to follow an elevation gradient and capture wetland that is missed in the NWI coverage. This is particularly the case for wetlands between 14th and 15th St and for the bottomland forests that grade uphill behind the school administration building between 11th and 13th St. Marsh and wet forest west of 8th and to the south of Dade St are another example in this figure of wetlands missed by NWI.

The area north of Amelia Island State Park known as 50 acres is characterized by forested dune and swale. Here substantial area of potential wetland missing from the NWI coverage is mapped (Figure 8).

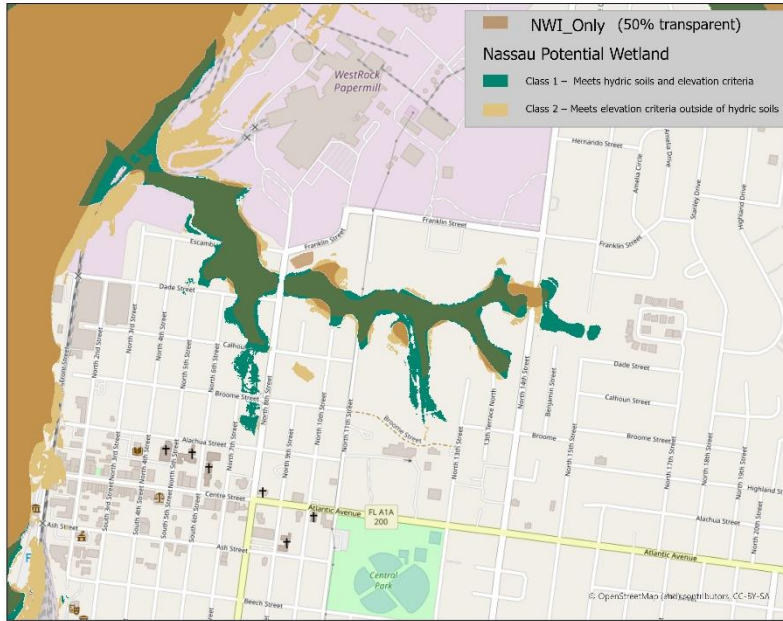


Figure 7. Potential wetlands with NWI overlay.
Site 1, 8th Dade to Alachua and 8th to 15th Streets in Fernandina Beach.

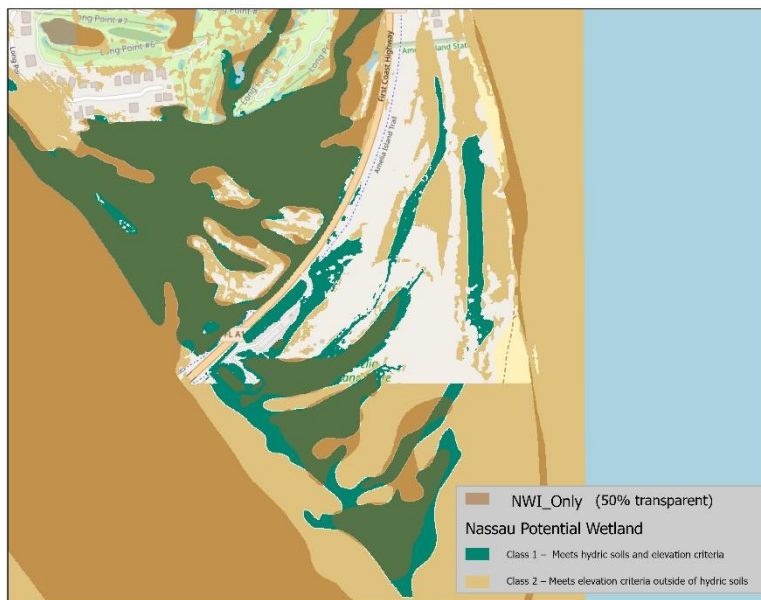


Figure 8. Potential wetlands with NWI overlay.
Site 2, Amelia State Park and 50 acres.

Detection of missed wetlands, wetland connections and channels

Most frequently, the type of potential wetlands identified as missed are spatial connections among the NWI mapped wetlands. This is illustrated in western Nassau County as seen in Figure 9 both with the spatial connections found among the NWI's otherwise disjunct wetlands and in the potential wetland drainages along the western edge of the county. Figure 9 also shows again the close match up of NWI with Class 1, but with extended margins, locations where Class 2 picks up wetland connections missing in NWI and Class 1, and the likely commission errors of Class 2 that add to its uncertainty. Figure 10, on Amelia Island, is another example of a substantial channelized wetland feature that has been underestimated by NWI.

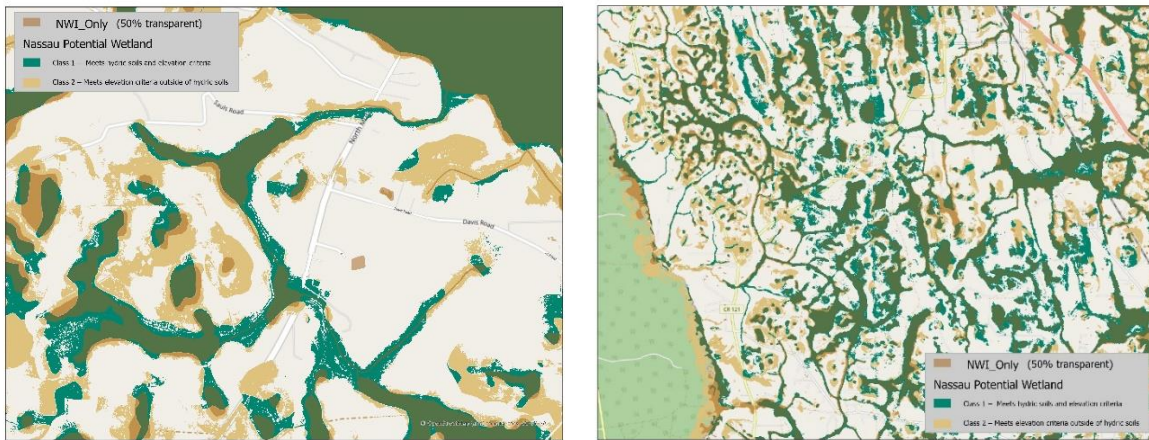


Figure 9. Potential wetlands with NWI overlay.
Site 3, Musslewhite at Sauls and Site 4, CR121 & CR108 in western Nassau County

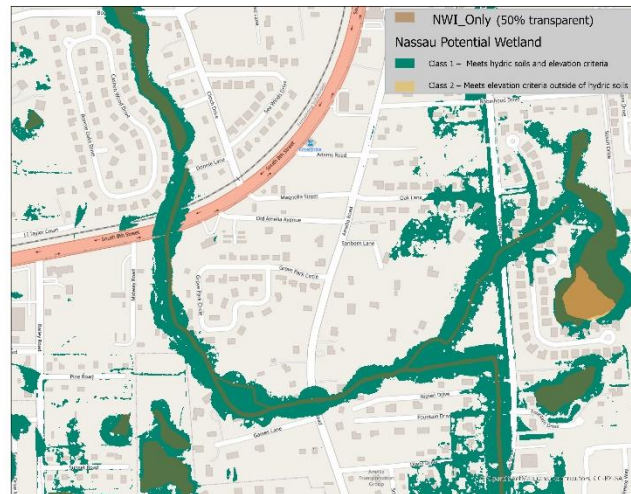


Figure 10. Potential wetlands with NWI overlay.
Site 5, east of Midway Street.

Commission errors in potential wetlands

Scrutiny of errors in the mapping results shows that errors of commission are the most common. There are several underlying reasons for these errors, all relating to inaccuracies in the NWI maps from which the elevation criteria are derived. The largest blocks of commission error occur in areas of commercial development or new residential subdivisions. The NWI has wetlands that no longer exist because they have been altered by filling or draining. The program still identifies them as wetland, then extracts current elevation data from within them. Filled wetlands are being represented by elevation data that are possibly much higher than what accurately represented the wetland before it was filled or altered. Areas nearby, including vacant, unaltered lots, may also be mis-classified because of the over-estimated elevations of the nearby NWI wetlands that are no longer present in these modified sites. Figure 11 highlights a commercial area of Fernandina Beach, but the Yulee commercial and residential development along A200 and new residential subdivision southwest of Amelia Concourse are additional examples.

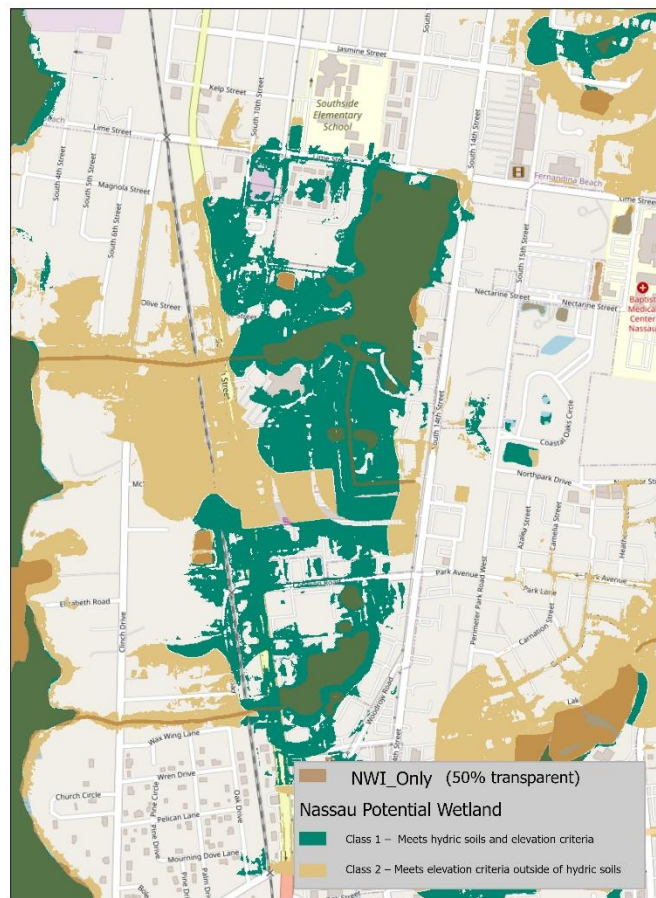


Figure 11. Potential wetlands with NWI overlay.
Site 6, Commercial development between 8th and 14th Streets on Fernandina Beach.

Another source of error is when elevation data are extracted from an elevated depressional wetland, then the computer classifies wetland on nearby land that is at lower elevations, even though they are well drained uplands. Most of this type of error is in Class 2 potential wetland units. This error was especially

prevalent in earlier versions of the model where the NWI includes man-made ponds and impoundments, so this situation was improved by screening out NWI wetlands classified as man-made. However, this type of error still occurs because there are naturally occurring upland wet depressions identified by NWI and there are man-made ponds or impoundments that NWI incorrectly classifies as naturally-occurring.

Omission errors in potential wetlands

Errors of omission occur due to wetlands occurring on an elevation gradient that is difficult for the model to capture (Figure 12). When the nearest NWI is in a creek bottom or floodplain and the wetland drainage runs up a long gradient there may come a point when it is not captured by the elevation criteria that the model extracts from that nearest lower NWI. Similarly, the same gap in potential wetland identification can occur if there is also a up-gradient NWI wetland, but it still not the nearest wetland along the elevation gradient. It is often obvious where this is occurring, particularly when viewed in concert with imagery of the area, and the potential wetlands mapping in these areas still represent spatial connections and drainage better than the NWI.

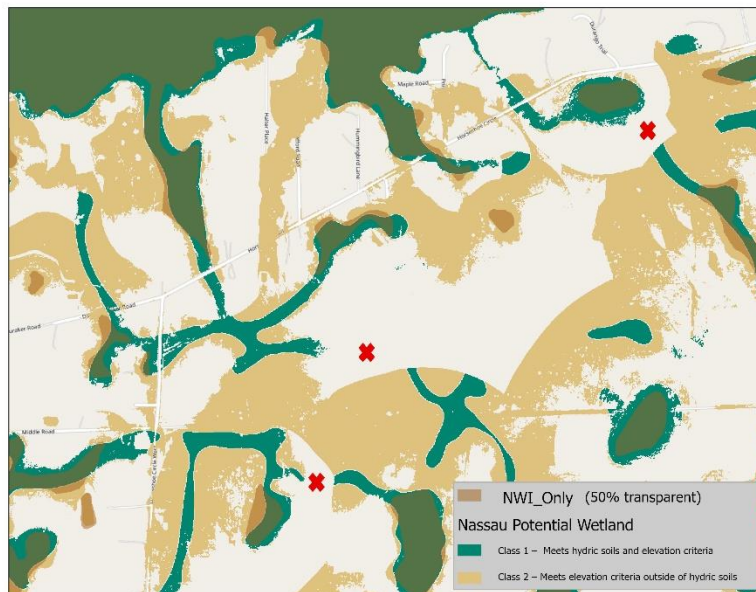


Figure 12. Potential wetlands with NWI overlay.

Site 7. Horseshoe & Durango Trail. Red crosses indicate where wetland connections are missed because the nearest NWI wetland's elevation doesn't represent the wetland's elevation along an elevation gradient.

Errors in the input data layers

Two other input data errors may contribute to these results.

NWI registration errors. NWI wetland map units may sometimes run up onto adjacent slopes or fall to one side or another of the real wetland boundary either because of the limits of NWI horizontal mapping accuracy or geo-registration errors. In that circumstance the elevation data extracted to represent the perimeter of the NWI wetland is influenced by included upland elevations or missed lower wetland

elevations. The soils data layer may aid here in keeping Class 1 restricted to actual wetlands, but broad commission errors may be present in Class 2 because of the NWI misregistration.

Soil map generalizations. Soils mapping units are approximations of soil type boundaries based on sparse ground sampling and image interpretation of the landscape. Many of the ground-based soils surveys are now decades old. Soils listed as hydric might be mostly hydric or might have only a few hydric inclusions in what is otherwise an upland soil. Soils mapping units may not accurately adhere to elevation contours and end users who observe the borders of Class 1 or Class 2 potential wetland map units produced by this model should take this into consideration.

Future Directions

Overview

Models are never final. There are always ways to improve on the next iteration. Listed in this section are several tasks that would reduce omission and commission errors in the potential wetlands mapping. In addition, most of the suggestions would result in other new or improved products advantageous far beyond this application for planning, engineering, and conservation spatial decision-making.

Boundary refinements

It is valuable to refine the potential wetlands mapping using ground observations where necessary. Aerial and drone manual image interpretation could be used to improve the potential wetlands elevation boundaries.

Existing certified site wetland delineations should be compiled, rectified, and digitized into the GIS system. Once entered, this information can supplement NWI mapping to redo the potential wetlands model run with much improved data inputs.

Updates and corrections to input data layers

One of the values of the potential wetlands modeling exercise is that it further elicited the need for updating and improving the NWI and soils data layers. As has been discussed above, errors of commission and omission are often the result of errors in the input data layers. NWI and soil mapping are both subject to multiple sources of delineation uncertainty. Image registration, discrepancy among photo interpreters, judgements on placement of hard polygons boundaries on possibly, and variously, diffuse class boundaries on the ground, the complexity and size of the features, image resolution, and image date or season (Tiner, 1997; Prisley et al., 2020). Recognizing those difficulties, aerial photo interpretation to update the NWI and Soils layers is important spatial information in rapidly growing Nassau County.

Incorporation of impervious surfaces data layer

A GIS data layer of impervious surfaces could be a valuable addition to the modeling effort in areas that have been modified by development and filling. Mapped NWI wetlands in these areas that are now buildings, parking and other hard surfaces can readily be extracted before they influence the mapping of potential wetlands on and adjacent to the site. Fortunately, Nassau County GIS staff are exploring options for the creation of this layer. As a demonstration, Figure 13 presents the changes in potential wetlands

found for a commercial area in Fernandina Beach when an aerial image Normalized Different Vegetation Index (NDVI) was used as a surrogate for the impervious surfaces data layer. In short, NDVI is a ratio of imagery Infrared band and red bands of information to create a chlorophyll index. Higher values are canopy and locations with a lot of photosynthesis going on. Low values vegetatively barren areas (see Mulcahy et al., 2021 for details). In the figure, showing Class 1 only, dark green is the current potential wetlands mapping and light green is the reduced area of potential wetlands when the model incorporated the NDVI information (using a 0.2 threshold). The procedure substantial reduces misclassification, but it doesn't eliminate all the commission errors. The corner of Lime St and 14th St is filled wetland for apartments, but it remains mapped as Class 1 potential wetland because it mostly lawn rather than hard surfaces.

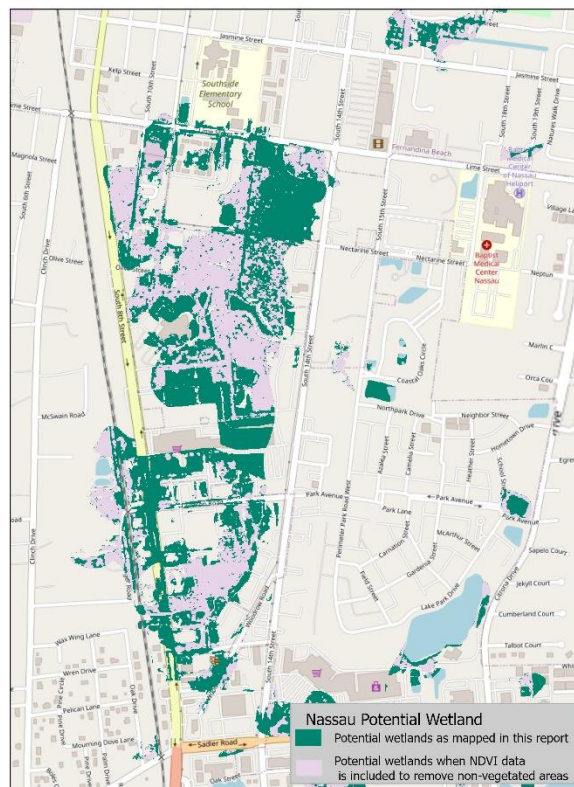


Figure 13. Site 6, Class 1 potential wetlands as mapped in this report and as mapped when NDVI data is applied to the rules.

Hierarchical mapping

One of the roles in which the potential wetlands map could be valuable is as a filter to focus on areas of uncertainty that need additional attention. The manual mapping of potential wetlands (Buchanan and Weisenborn, 2019) that was the foundation for this automated procedure was never implemented county-wide because it is labor-intensive. The opportunity with this product is to establish standard protocols for iterative feedback between the two methods such that the automated potential wetlands mapping highlights a reduced set of sites for further investigation by finer scale manual mapping and the manual mapping updates the wetland boundaries for refinement of inputs to the automated procedure.

GIS wetland assessments

Wetland mapping is a valuable tool for identifying existing wetland locations and size, however it provides no information on the wetland's ecological condition or function. Several states have developed specific GIS tools to support more detailed wetland assessments. Dooley and Stelk (2021, Chapter 2) provide examples of the diversity of some of the state-wide and local tools being used.

Disclaimer: These potential wetlands maps and associated documents are for planning purposes only. They are not formal wetlands' delineations and cannot be used for jurisdictional decisions.

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Appendix A: Details of Methods and Procedures

Input Data Layers

1. **Soils**, Nassua_Soils shapefile: <https://maps.nassauflpa.com/portal/apps/sites/#/data/items?tags=Environmental>
2. **Elevation**, 2018-2020 FDEM Lidar: Lidar https://chs.coast.noaa.gov/htdata/lidar4_z/geoid18/data/9275/nassau/
3. **NWI**, Nassau County, Florida shapefiles: <https://www.fws.gov/wetlands/data/data-download.html>

Data Preparation

R scripts and a Python script used in these procedures are parenthetically listed in this section and code is provided in the Supplemental Materials.

1. **Create Mask Raster:** Use the R script (**1CreateMaskRaster.r**) to create a rectangular blank mask for Nassau County. All data layers will be clipped to this area and transformed to same projection and cell size.

6 x 6 ft cell size

Florida East State Plane, CRS: "+proj=tmerc +lat_0=24.3333333333333 +lon_0=-81 +k=0.999941177 +x_0=200000.0001016 +y_0=0 +ellps=GRS80 +units=us-ft +vunits=us-ft +no_defs"

extent: UL: 501710, 2316920 LR: 522170, 2246210

Result: mask.tif

2. **Generate Wet_Soils Layer:** ArcGIS Pro 2.8.2 was used to select wet soils through Definition Query function (Table1) from the NassauSoil.shp file and the resulting selections were aggregated into two classes:

Class = 1. Target wetland soils

Class = 0. Non-target soils.

Table 1. Hydric Soil classes selected for Nassau County, Florida.

From: Natural Resources Conservation Service (2014),

https://efotg.sc.egov.usda.gov/references/Delete/2014-12-6/FL089_Hydric_Soils--Nassau_County_Florida.pdf

Soils Mapping Unit	Name
4	Echaw fine sand
7	Kingsland mucky peat, frequently flooded
9	Leon fine sand
10	Mandarin fine sand
11	Charies find sand
13	Goldhead fine sand
14	Rutlege mucky fine sand, frequently flooded
15	Buccaneer clay, frequently flooded
16	Ellabelle mucky fine sand, frequently flooded

18	Lyn Haven-Wesconnett-Leon complex depressional
19	Leon fine sand, tidal
22	Sapelo-Leo fine sand
24	Kings Ferry fine sand
25	Maurepas muck, frequently flooded
28	Tisonia mucky peat, tidal
32	Aqualfs, loamy
33	Goldhead-Meadowbrook fine sands, depressional
34	Croatan muck, frequently flooded
37	Meggett loamy fine sand
38	Meggett fine sandy loam
39	Evergreen-Leon muck, depressional
40	Brookhaven mucky fine sandy loam, depressional
45	Meggett loamy fine sand, depressional
46	Buccaneer clay
47	Leefield fine sand
49	Ousley and Mandarin fine sands
51	Albany fine sand
52	Osier loamy fine sand, frequently flooded
53	Meadowbrook fine sand
54	Sapelo fine sand
55	Meadowbrook-Goldhead-Meggett complex

(ArcGIS Definition Query (SQL command):

MUSYMIN ('4','7','9','10','11','13','14','15','16','18','19','22','24','25','28','32','33','34','37','38','39','40','45','46','47','49','51','52','53','54','55')

The resulting shapefile was then converted to a raster matching the Nassau County mask in R (**2HydricSoils.r, 3shp2raster.r**).

Result: Nassau_HydricSoils3.tif

- 3. Generate Digital Elevation Model (DEM) from LIDAR data:** A total of 763 LIDAR point cloud files (.laz) for the 2018- 2020 FDEM Lidar, Florida Peninsular subdirectory Nassau were downloaded from the NOAA Digital Coast (URL: https://chs.coast.noaa.gov/htdata/lidar4_z/geoid18/data/9275/nassau/ files: Point cloud files for 2018 – 2020 FDEM Lidar: Florida Peninsular subdirectory Nassau, Total size of directory contents = 270G). ArcGIS Pro 2.8.2 were used to generate a DEM from these Lidar point clouds. The first step was to use the “Convert LAS” tool to convert LAZ files to LAS files (Figure 1).

Geoprocessing Tool Name: Convert LAS		
Parameters Name	Parameters Used to Execute	Explanation
Input LAS	Named: NassauLAS2018-2020	The LAS data that will be converted. A folder can be specified to process all of the .las files contained therein. A folder path that contains 763 LIDAR point cloud files (*.laz)
Target Folder	Outlas	The existing folder to which the output .las files will be written. A target folder that yields the files that were converted from (*.laz) to (.las)
Compression	No Compression	No Compression—The output will be in the standard LAS format (*.las). This is the default.
File Version	Same As Input	The output file version will be the same as the input. This is the default.
LAS Options	Rearrange Points	Specifies modifications that will be made to reduce the size of the output .las files and improve their usability and performance in display and analysis operations. Rearrange Points—Points will be rearranged to improve display and analysis performance. Statistics will be automatically computed during this process.
Define Input Coordinate System	No LAS Files	Specifies how the coordinate system of input .las files will be defined.

Table 1. The detail parameters set in the “Convert LAS” geoprocessing tools in ArcGIS Pro.
Reference: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/convert-las.htm>

The second step created a LAS Dataset. All the points were filtered from “All points” to “Grounds” (Table 2).

Geoprocessing Tool Name: Create a LAS Dataset		
Parameters Name	Parameters Used to Execute	Explanation
Input Files	Drive Path + Outlas folder + *.las (763)	A folder path that contains 763 LIDAR point cloud files (*.las). The LAS files and folders containing LAS files that will be

		referenced by the LAS dataset.
Output LAS Dataset	Path + file name.lasd: NassauCounty.lasd	The LAS dataset that will be created.
Surface Constraints	None	This is Optional, left "Input Features", "Height Field", and "Type" all blank.
Coordinate System	NAD_1983_2011_StatePlane_Florida_East_FIPS_0901_Ft_US	The spatial reference of the LAS dataset.
Create PRJ for LAS Files	No LAS Files	Specifies whether .prj files will be created for the LAS files referenced by the LAS dataset. No LAS Files— No files will have a PRJ file created.
Compute Statistics	Checked	Specifies whether statistics for the LAS files will be computed and a spatial index generated for the LAS dataset. The presence of statistics allows the LAS dataset layer's filtering and symbology options to only show LAS attribute values that exist in the LAS files. A .lasx auxiliary file is created for each LAS file. Checked— Statistics will be computed.
Store Relative Paths	Checked	Checked— Relative paths will be used for the data referenced by the LAS dataset.

Table 2. The detail parameters set in the “Create LAS Dataset” geoprocessing tools in ArcGIS Pro. Reference: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/create-las-dataset.htm>

The third step was to run the “LAS Dataset to Raster” conversion tool to get the Nassau DEM files (Table 3).

Geoprocessing Tool Name: LAS Dataset To Raster		
Parameters Name	Parameters Used to Execute	Explanation
Input LAS Dataset	Input Data Source Path + file name.lasd: NassauCounty.lasd	The LAS dataset to process.
Output Raster	Output Data Path + file name.tif: Nassau_DEM.tif	If the raster is stored as a TIFF file or in a geodatabase, its raster compression type and quality can be specified using geoprocessing environment settings (Raster Storage Compression Type: LZ77).
Value Field	Elevation	The lidar data that will be used to generate the raster output. Elevation from the lidar files will be used to create the raster.
Interpolation Type	Binning	The binning approach provides a Cell Assignment Method for determining each output cell using the points that fall within its extent, along with a Void Fill Method to determine the value of cells that do not contain any LAS points.
Cell Assignment	Maximum	MAXIMUM—Assigns the maximum value found in the points within the cell.
Void Fill Method	Natural Neighbor	NATURAL_NEIGHBOR—Uses natural neighbor interpolation to determine the cell value.
Output Data Type	Floating Point	Specifies the type of numeric values stored in the output raster. Floating Point—The output raster will use 32-bit floating point, which supports values ranging from -3.402823466e+38 to 3.402823466e+38.
Sampling Type	Cell Size	Cell Size—The cell size of the output raster will be used
Sampling Value	6	The value used in conjunction with the Sampling Type parameter to define the resolution of the output raster. The resolution is set for 6 feet for the purpose of computation.

Z Factor	1	The factor by which z-values will be multiplied. This is typically used to convert z linear units to match x,y linear units. The default is 1, which leaves elevation values unchanged.
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Table 3. The detail parameters set in the “LAS Dataset to Raster” geoprocessing tools in ArcGIS Pro. Reference: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/las-dataset-to-raster.htm>

Result: Nassau_DEM.tif

The DEM generated from LIDAR cloud points was resampled to the mask using **R(4LidarDEMResample.r)**.

Result: Nassau_LidarDEM.tif

4. Create NWI raster: To create a data layer for elevations within NWI polygons and at the NWI upper elevation boundaries, Nassau_NWI (Nassau_NWI.shp) was reprojected in ArcGIS pro to Florida State Plane East 0901 and transformed to a raster TIFF file (Nassau_NWI.tif) using the ArcGIS Pro Polygon to Raster tool. R (5NWIResample.r) resampled the GeoTiff file to match the Nassau County mask. (**5NWIResample.r**)

Result: Nassau_NWI_resample.tif

5. Freshwater excavated ponds were identified and removed prior to using the NWI raster in the next step. The NWI freshwater excavated ponds were selected in Arc Pro from the attribute table using "ATTRIBUTE" IN ('PUBFx', 'PUBGx', 'PUBHx', 'PUBx') N = 1030 ponds. The excavated ponds were removed from the NWI raster in Arc Pro Raster Calculator using *Con(Nassau_NWI_FreshwaterPondExcavated, 0, Nassau_NWI_resample)*

Result: Nassau_NWI_resample_excludeP_resample.tif

6. Elevations were then found at all the NWI edges and within all the NWI patches (**6potentialWetlands_DataPrep.r**).

*Result: NWI_EdgeElev.tif
NWI_ElevInNWI.tif*

7. **Sectioning Nassau County:** Prior to finding elevations in the next step at each grid cell of the nearest NWI boundary, Nassau County was sectioned into 12 overlapping areas. This was done because the next step is time consuming and data I/O (Input/Output) intensive. Running the County in sections allowed us to avoid memory issues, extend processing times, track progress better, and avoid potential memory/software crashes. Sections were selected by lining up

boundaries with the Department of Transportation Aerial Collection tiles. Collections tiles are in a 5000 ft x 500ft grid (0.947 miles). Section boundaries have a one tile overlap ensure there were sufficient data in the next step to avoid boundary issues when the sections were merged back together. The selection of the 12 areas started from the right-hand side of the county vertically, and cross horizontally across. The sections ranged from 54 to 110 square miles each. A python script (**AddFieldFieldCalculator.py**) was used to automate adding a field for each of the grid area and set a value for a common field to dissolve each.

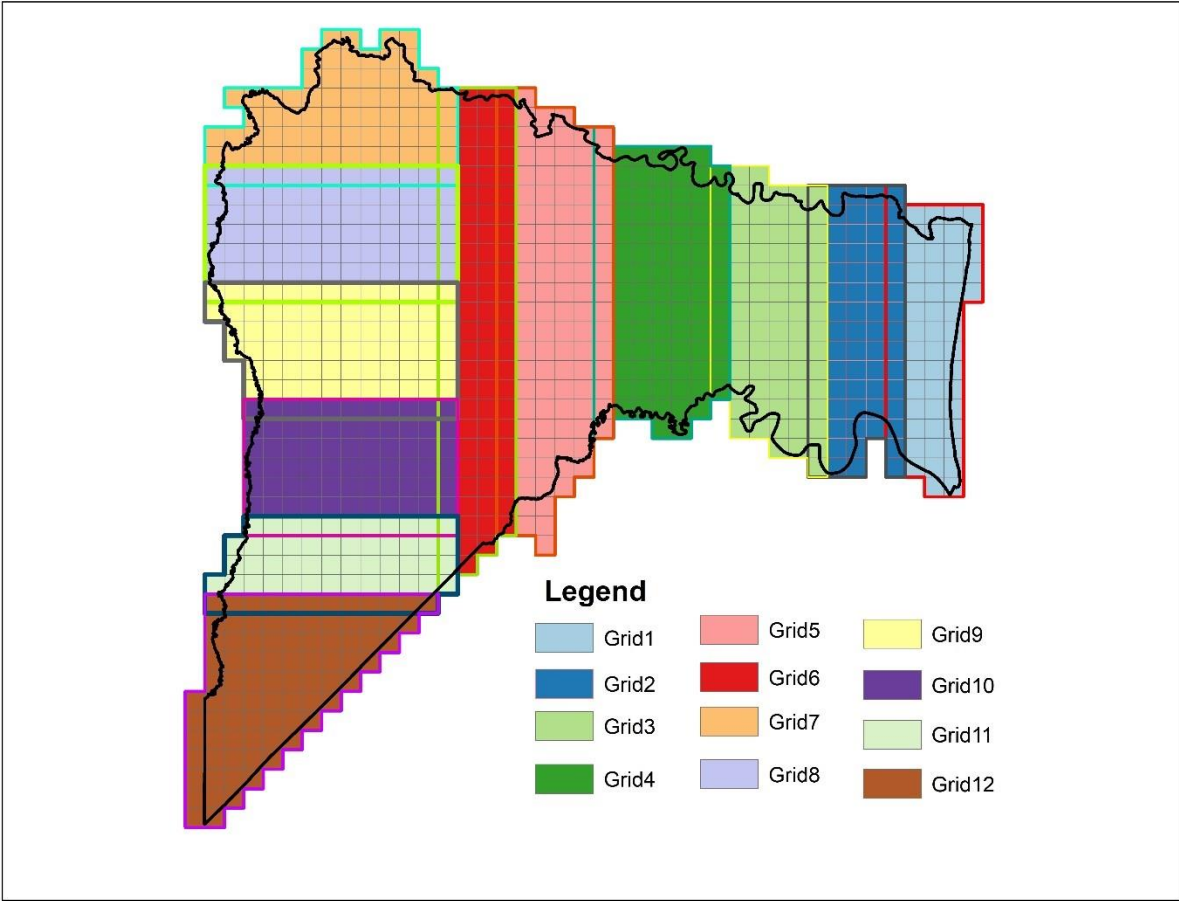


Figure 3. Analysis section grids using Florida Department of Transportation aerial collection tiles.

8. Find elevation at Distance: This step in the data preparation is to find the threshold elevation of the nearest known wetland at each grid cell. An R script A series of moving circular windows was used to find the 75th quantile elevation at each grid cell from the elevations at NWI edges layer (*NWI_EdgeElev*) created in Step 6 and the maximum elevation at each grid cell from the NWI elevations layer (*NWI_ElevInNWI*) also created in Step 6. The circular window results were merged to create a final layer of elevation thresholds from the nearest wetland (**7potentialWetlands_DataPrep_ElevAtDist.r**). The analysis was repeated for each of the

sections in step 6. The sections were then clipped a little over 1/4 miles (1380 ft) at overlapping boundaries to remove edge effects and the sections were merged (**8ElevAtDist_Crop&Merge_Grids1-12.r**).

Result: ElevAtDist_merge_Grids1-12.tif

9. Potential Wetlands Model (PotentialWetlands_rasterstack-NassuaCty.r): The input layer names in the rules below represent the layers created during data preparation:

- (1) DEM is *Nassau_LidarDEM.tif*.
- (2) ElevAtDist is *ElevAtDist_merge_Grids1-12.tif*.
- (3) Wet_Soils is *Nassau_HydricSoils.tif*.

The output layer of model results is the potential wetland layer.

Pot_Wet: It created a new potential soils layer or attribute field to receive output. Set all cells or table values to zero. Start at the grid cell (site) in upper left corner of study area (Nassau County).

For all Sites:

If **DEM** equal or less than **ElevAtDist AND Wet_Soils** is mapped,
then **Pot_Wet** = 1

If **DEM** equal or less than **ElevAtDist AND Wet_Soils** is not mapped,
then **Pot_Wet** = 2

REPEAT for each site

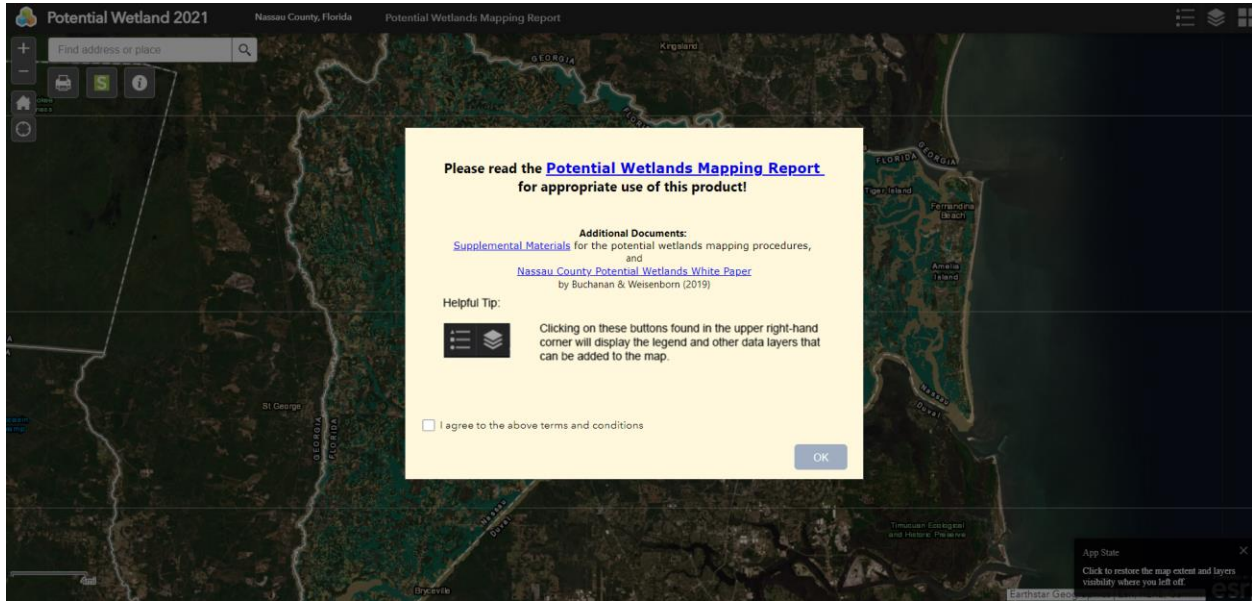
Result: Nassau_potential_wetland_merge.tif

Appendix B: User’s guide to the Potential Wetlands Online Viewer

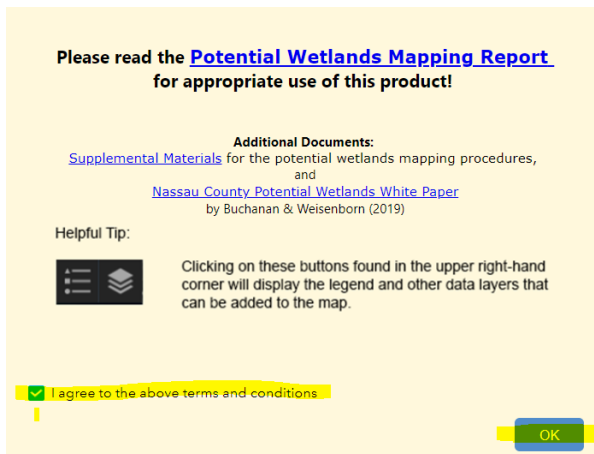
Potential Wetland 2021 Viewer URL:

<https://maps.nassauflpa.com/portal/apps/webappviewer/index.html?id=bcad46586896401d855b0bec9a5ac159>

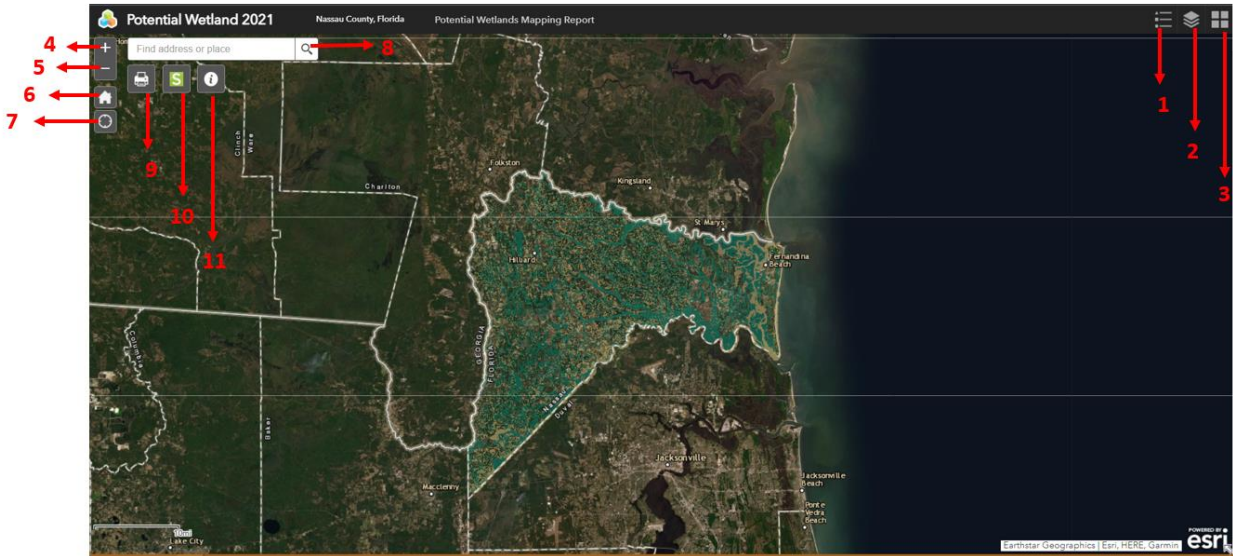
A screenshot of the landing page when first clicked the URL:



Click the check box in front of the “I agree to the above terms and conditions” and click the OK button to start to use the web viewer.



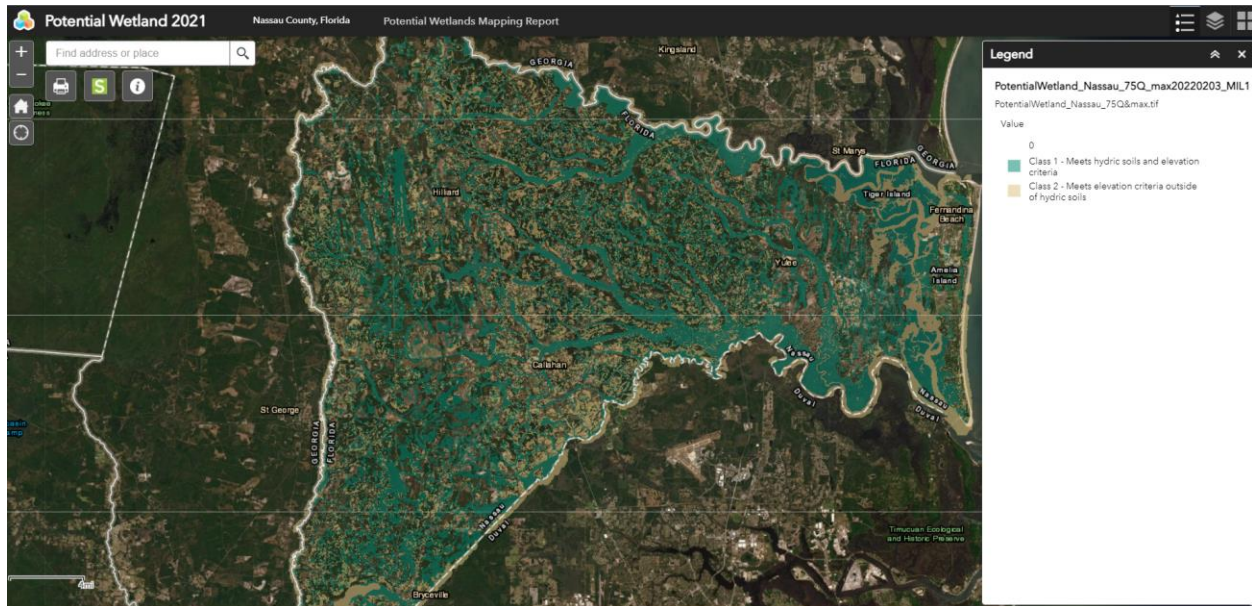
There are ten icons to support the viewer (see the screenshot below). The following section will start to illustrate from the right-hand side corner to the left-hand side corner. The right-hand side corner has three icons: #1 Legend, #2 Layer display control, and #3 Basemap option. The left-hand side corner has the function to control and the search bar.



1 Legend

To understand the layer information, the legend displays and explains the symbology and color code for each layer.

Click this icon  to view as the legend:



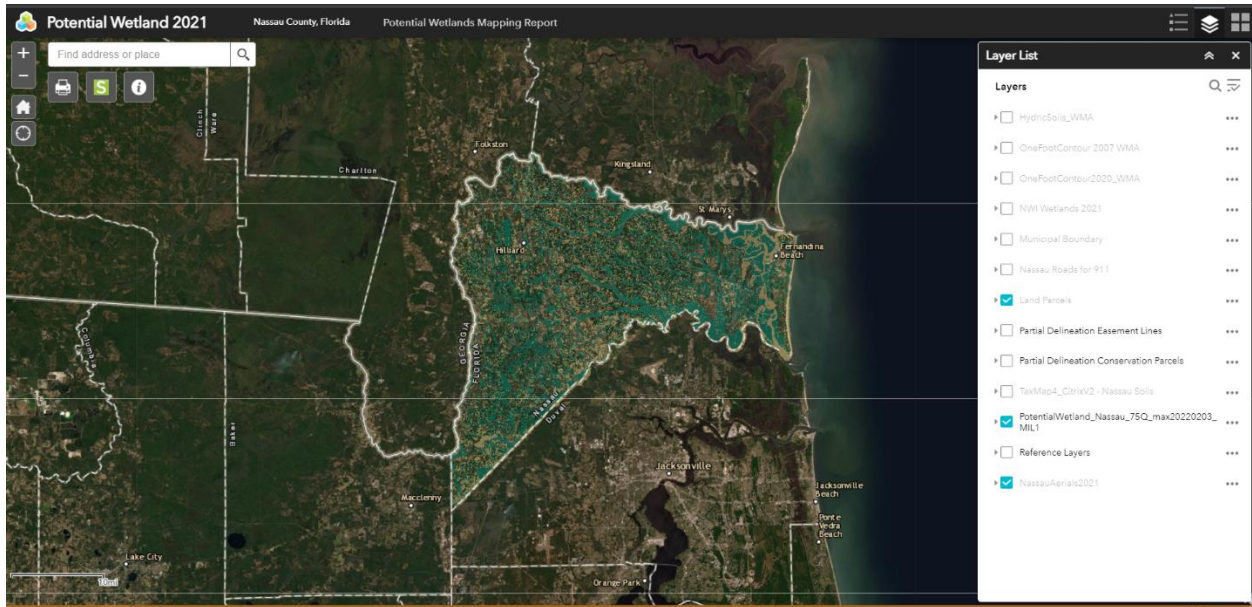
By default, the Potential Wetland layer as a .tif file show up at the current extent.

2 Layer List.

This is the Layer List Display control. Additional reference layers are included to help professionals to understand the physical geographic environment better.

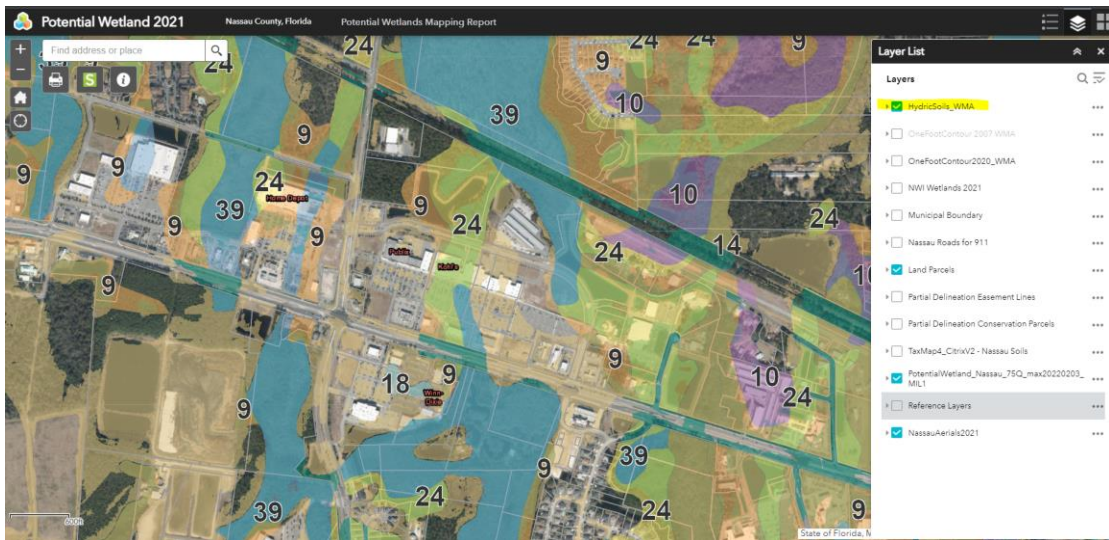


Click this icon to bring the layer list as the screenshot shown below:

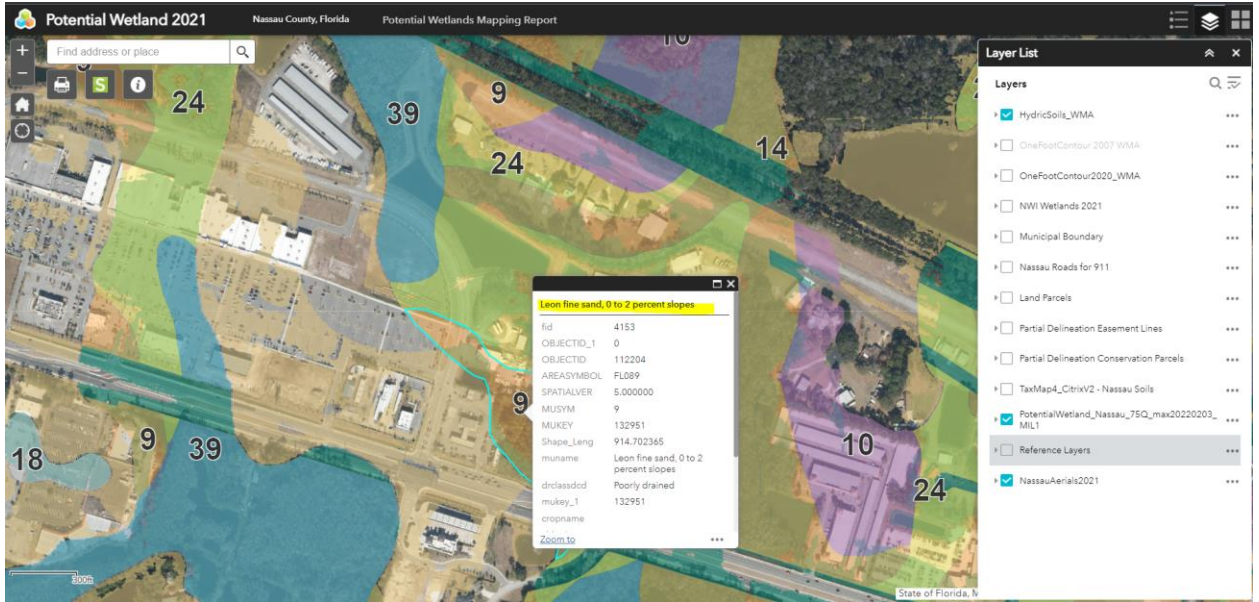


By default, only three layers are turn on as the blue check mark in the square boxes. Note that for the display performances to avoid on-the-fly projection, some layers are projected into Web Mercator Auxiliary WMA. Layers without WMA remains in State Plane Florida East). The layers that are greyed out means the layer will be display at the current extent. If checked, the greyed out layers will appear when you zoom in. The layers are listed as:

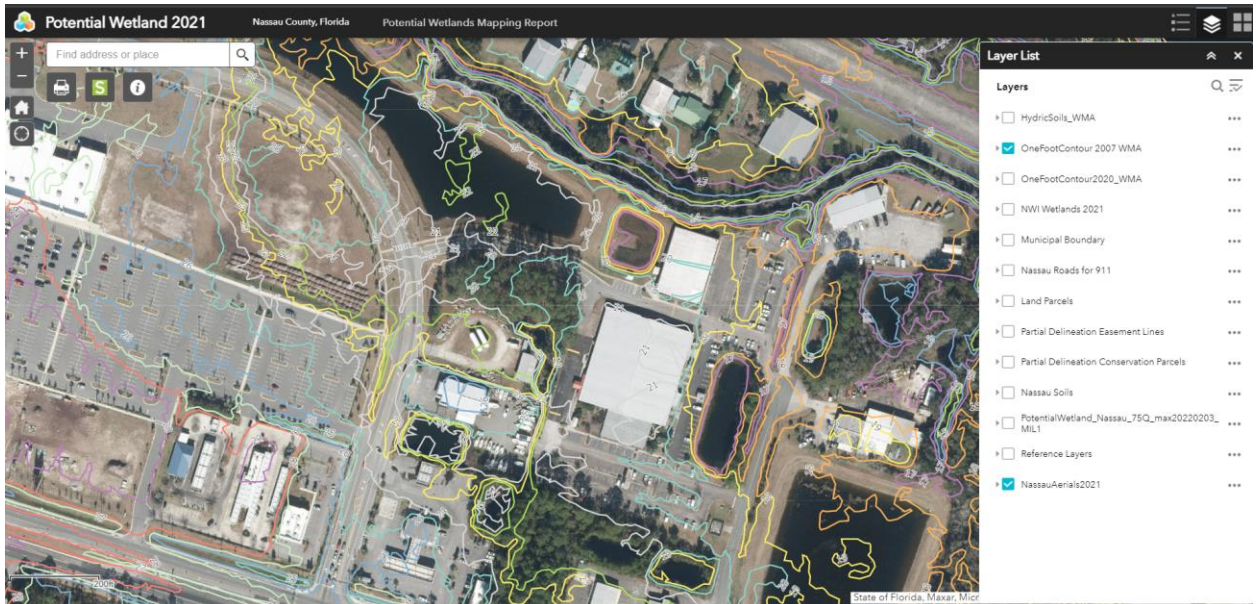
- **Hydric Soils _WMA** (Hydric Soils as the study classified and used in the modeling in this study)
To view this layer, zoom into street level, click the check box as highlighted in the screenshot below:



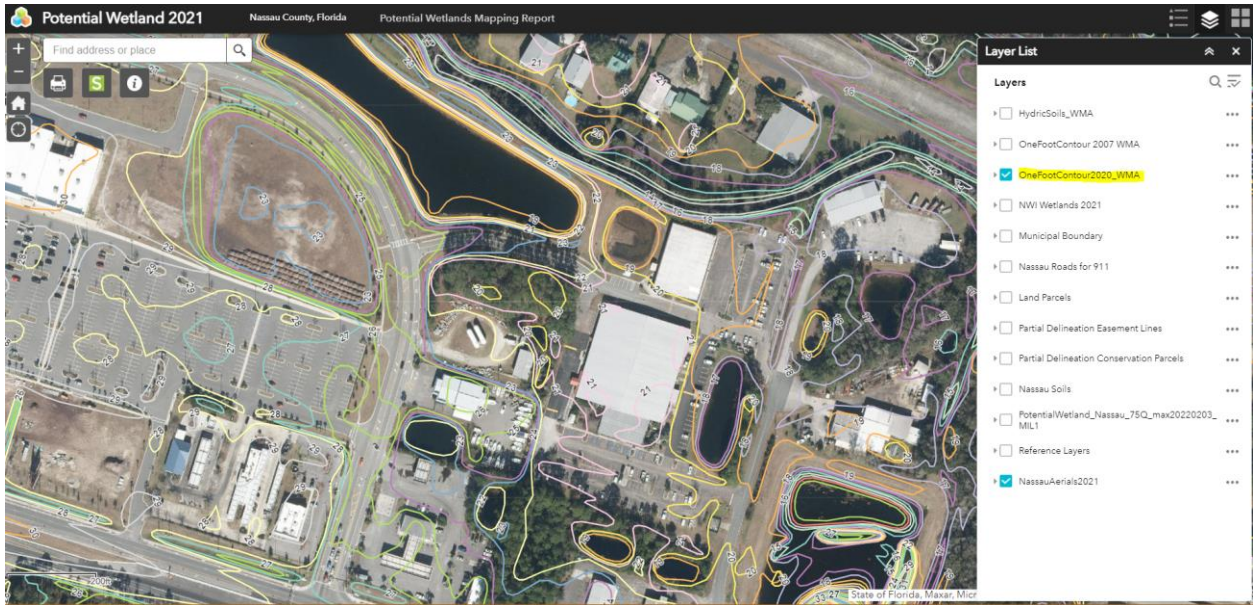
This layer allows a pop up window for detail attribute information, click the polygon as the screenshot shows below:



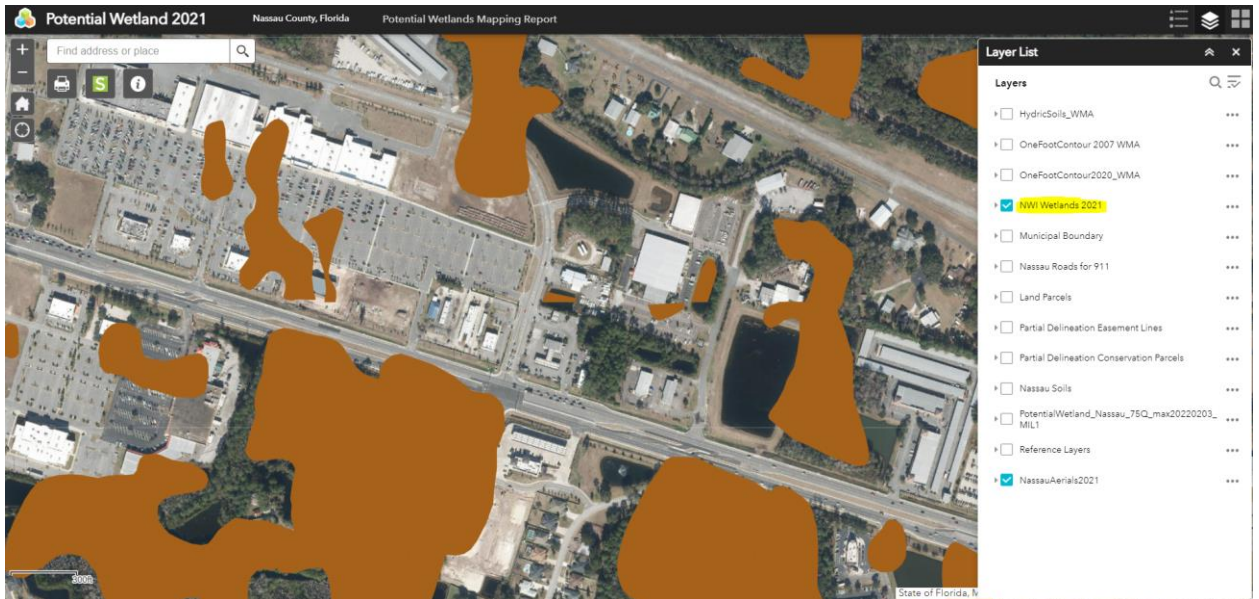
-
- **OneFootContour2007_WMA** (Processed professionally by Dewberry)
To view this layer, zoom into street level, click the check box as highlighted in the screenshot below:



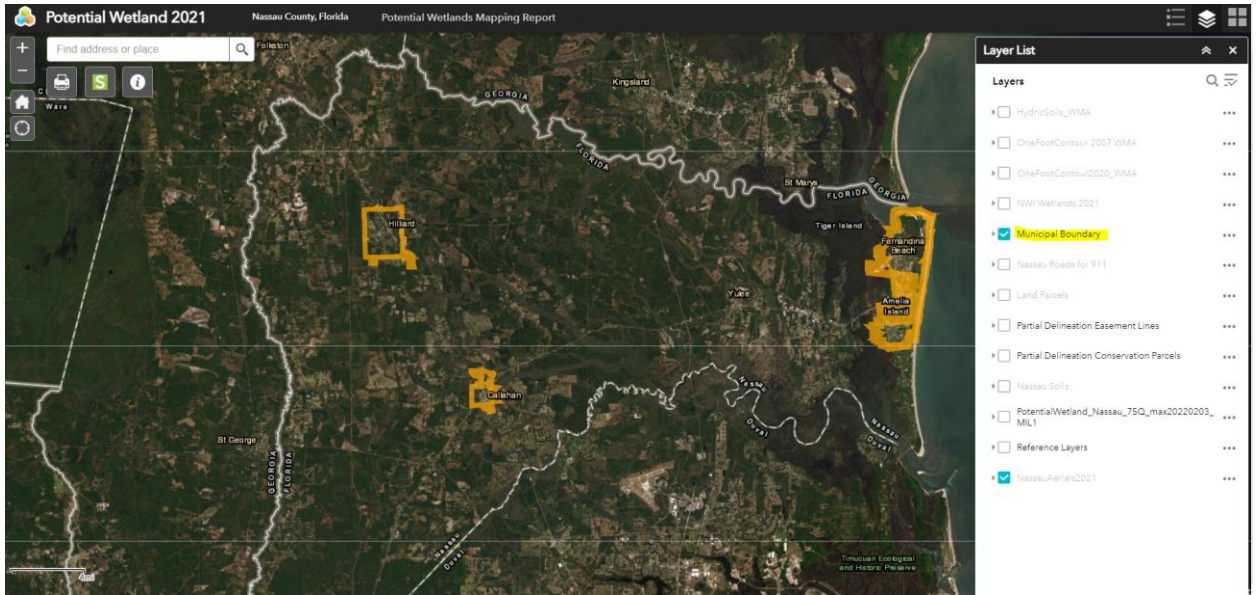
-
- **OneFootContour2020_WMA** (Processed within the office, highly simplified to improve the performance by reducing enormous vertices, it needs post-processing for Quality Assurance and Quality Control purposes, it only serves as a reference layer)



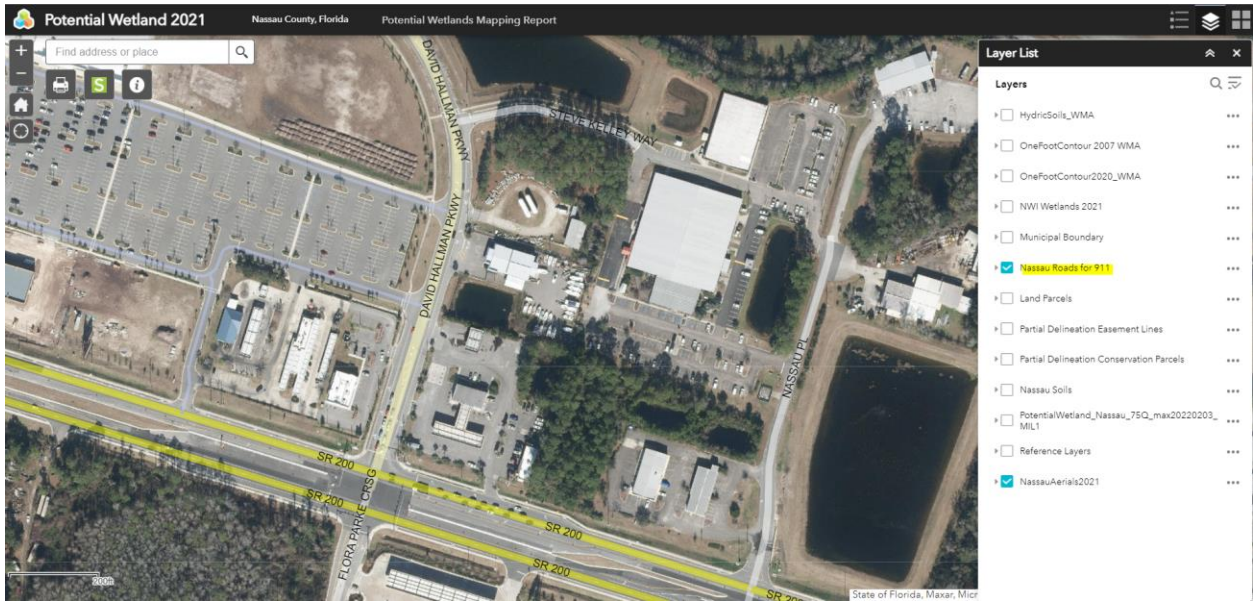
-
- **NWI Wetlands 2021** (Downloaded on 29th July 2021 from the U.S. Fish and Wildlife Service National Wetland Inventory (NWI))
To view this layer, zoom into street level, click the check box as highlighted in the screenshot below:



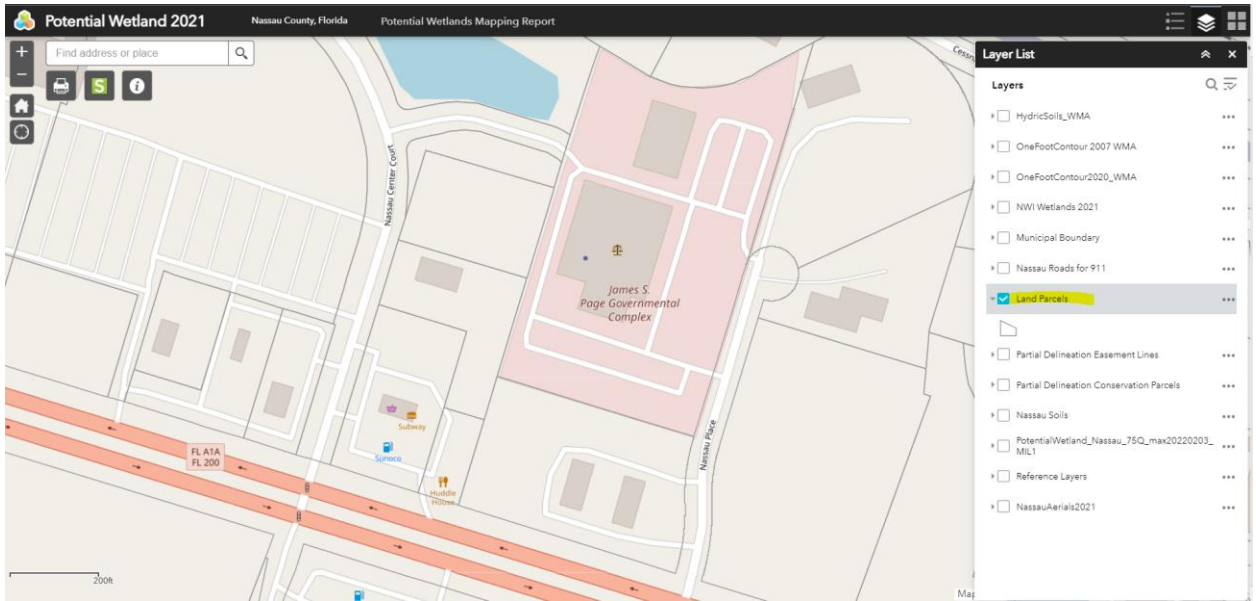
-
- **Municipal Boundary** (Actively managed by the Nassau County Property Appraisal office. As the new ordinance comes in, the layer will be updated)



-
- **Nassau Roads for 911** (Actively managed by the Nassau County Property Appraisal office)
To view this layer, zoom into street level, click the check box as it highlighted in the screenshot below:

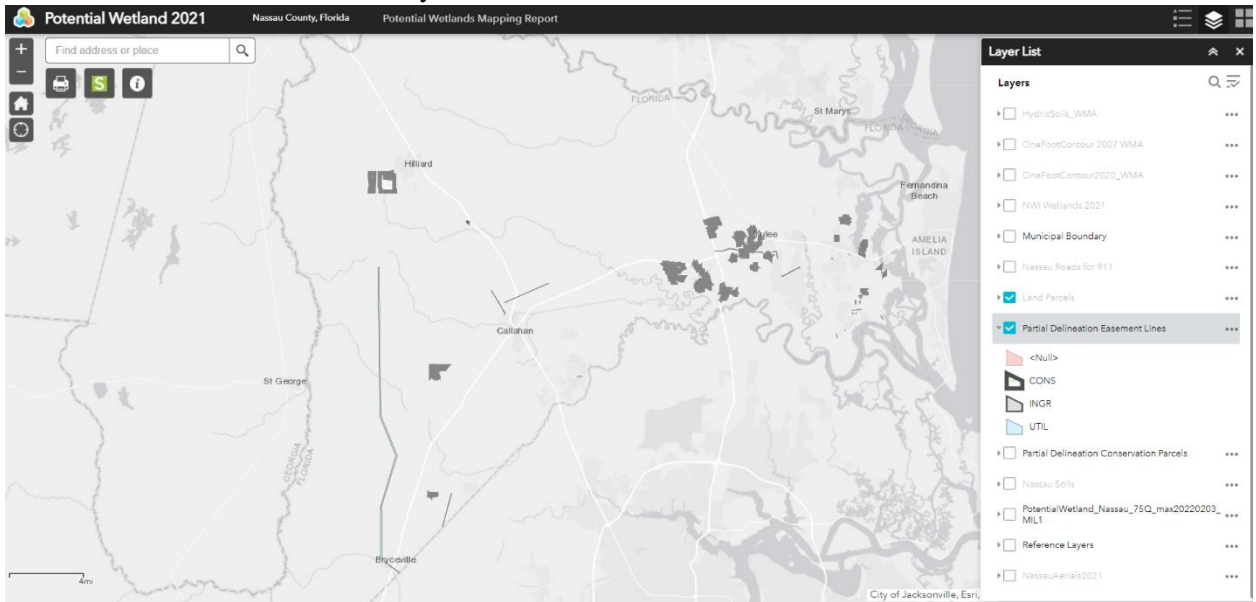


-
- **Land Parcels** (Actively managed by the Property Nassau County Appraisal office)
The screenshot below has all the layers turned off except the Land Parcels layer. Change the base map to “OpenStreetMap” to show an overview of the easement lines documented so far within the county.

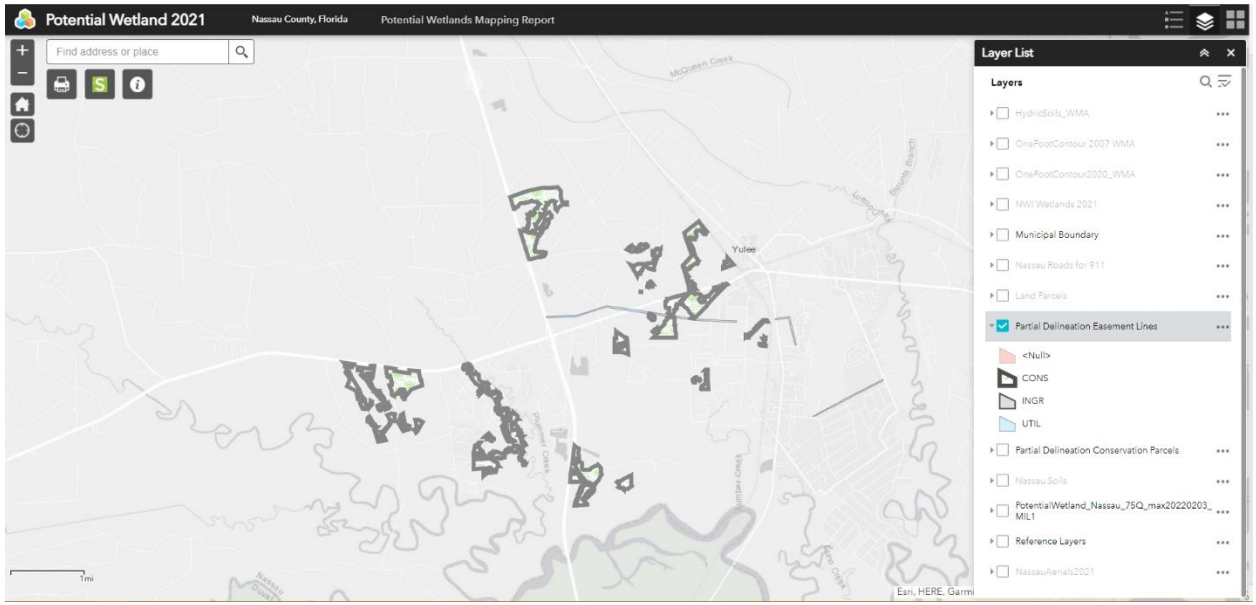


- **Partial Delineation Easement Lines** (Actively managed by the Property Nassau County Appraisal office, current available documented)

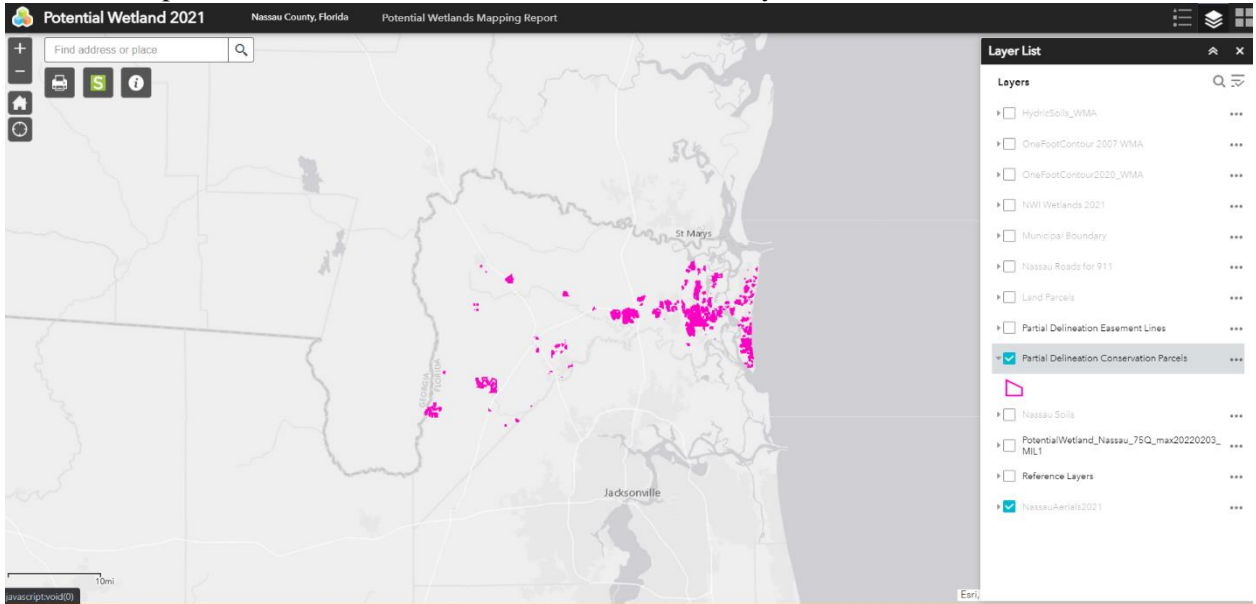
The screenshot below has all the layers turn off except the Partial Delineation Easement Lines layer. Change the base map to “Light Gray Canvas” to show an overview of the easement lines documented so far within the county.



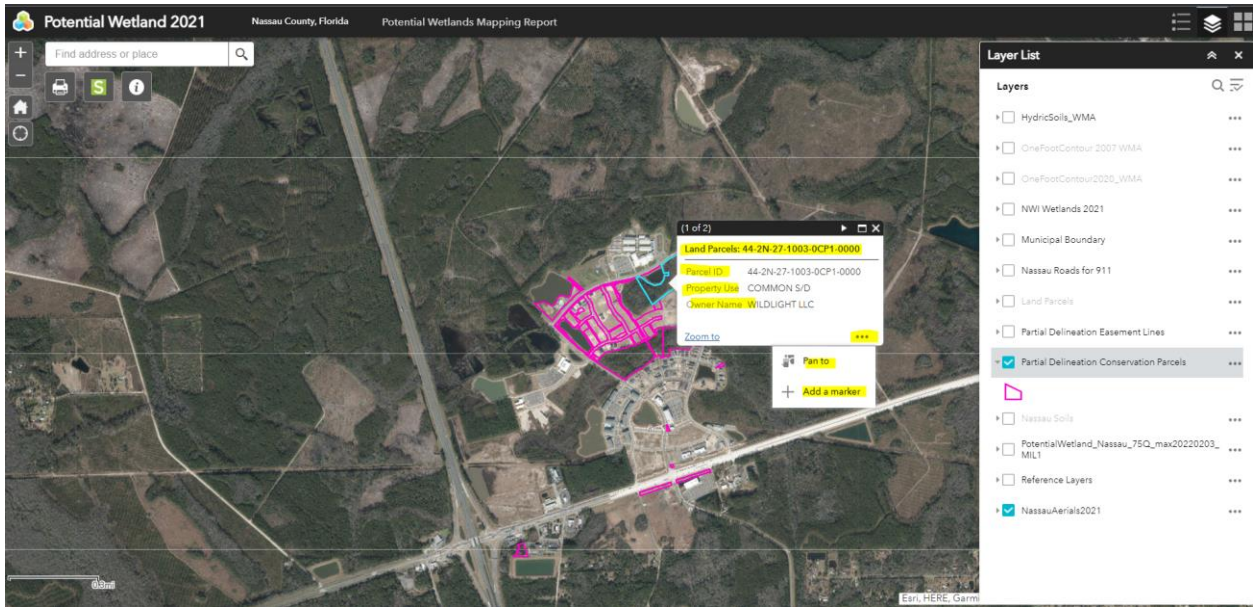
The example below is zoomed in to see the subdivisions near Interstate 95 (I95):



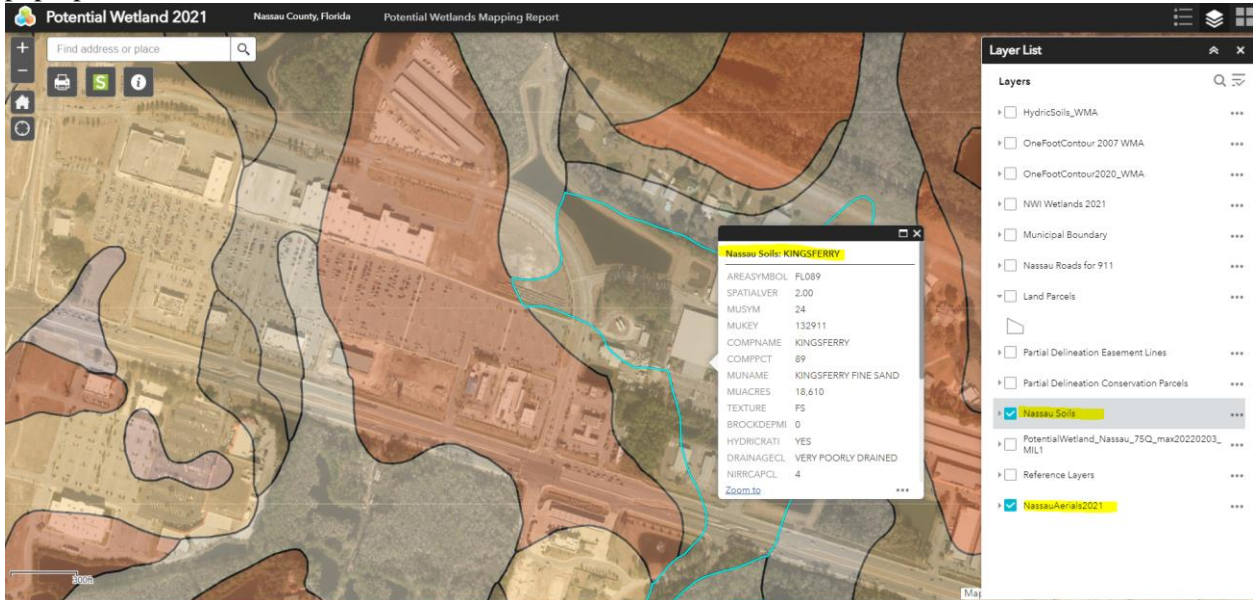
-
- **Partial Delineation Conservation Parcels** (Actively managed by the Property Nassau County Appraisal office, current available documented)
The screenshot below has all the layers turn off except the Partial Delineation Conservation Parcels layer. Change the base map to “Light Grey Canvas” to show an overview of the conservation parcels that are documented so far within the county.



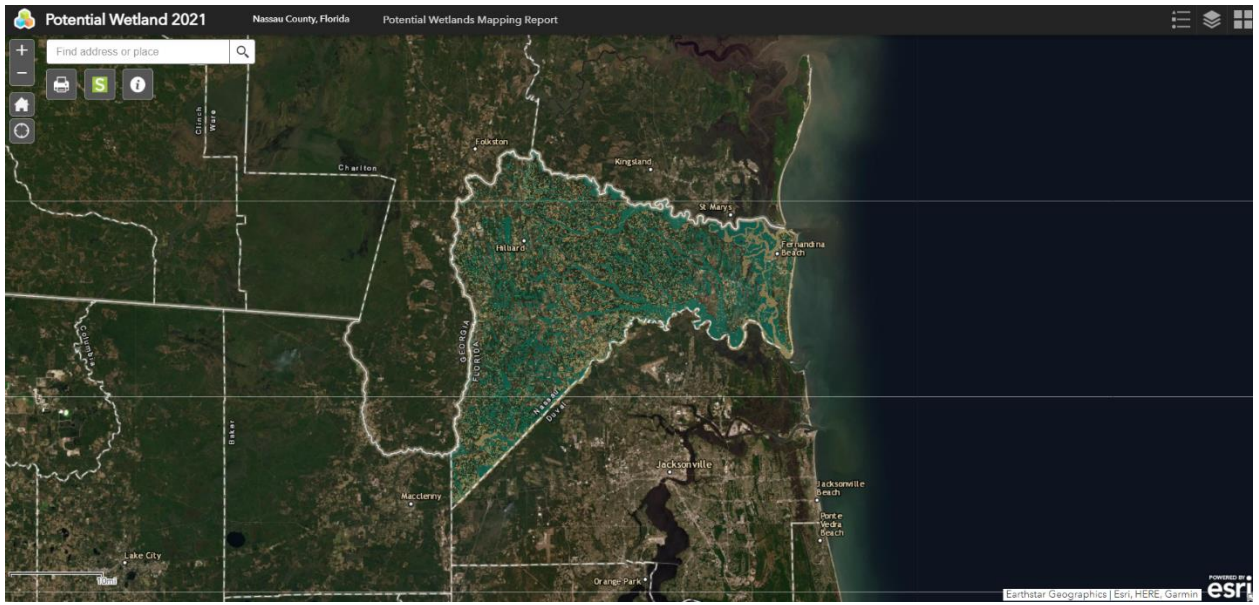
Turn on the NassauAerials2021 and zoom in. The Partial Delineation Conversation Parcels has pop-up information to show the parcel ID, property use, and owner name as the screenshot shows below. Click on the three dots (ellipses: ...) to access "Pan to" and "Add a marker" functions.



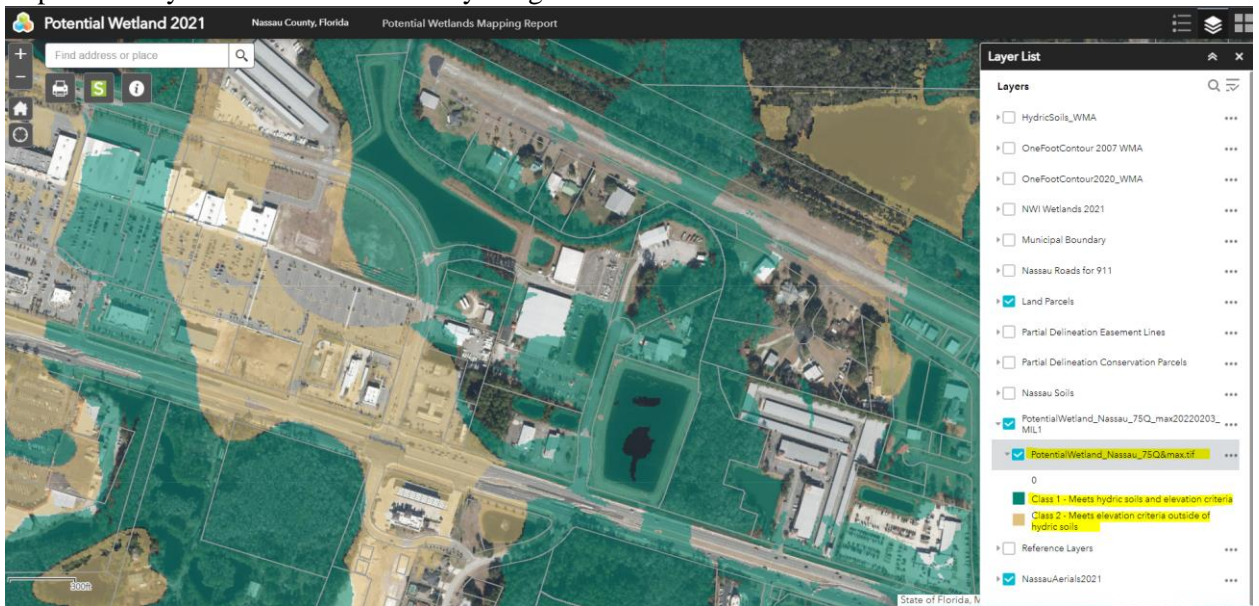
-
- **Nassau Soils** (Data Source: USDA)
Turn on the NassauAerials2021 and zoom in. Query and view the soil information through the pop-up window as the screen shot shows below:



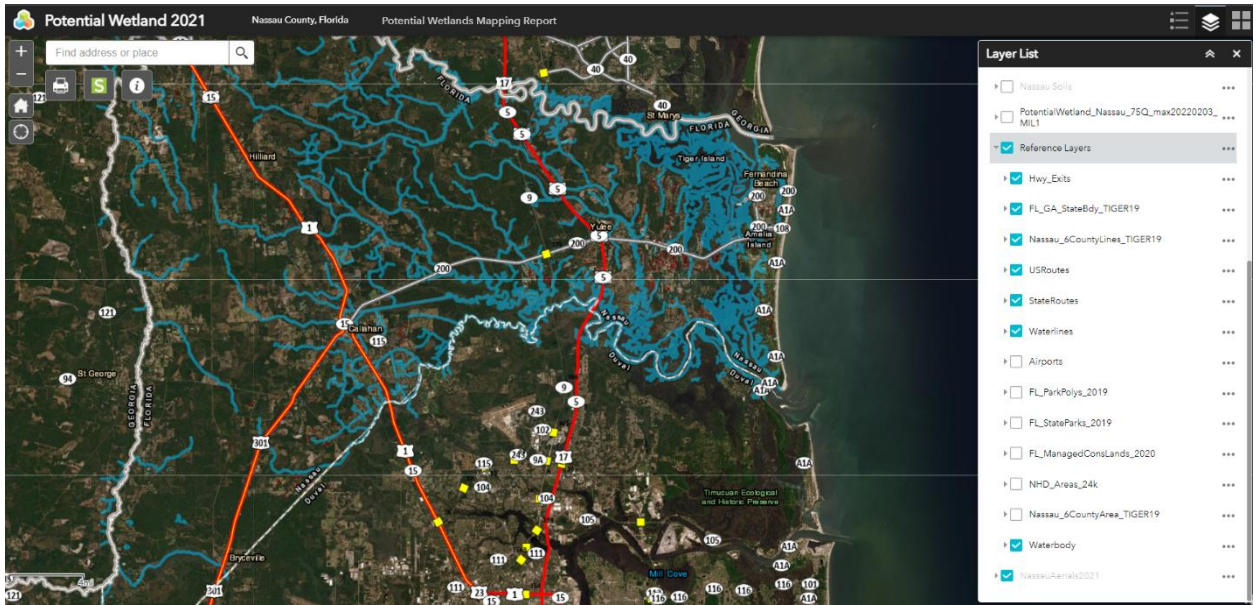
-
- **Potential Wetland 2021** (Default layer, zoom in to explore)



Expand the layer information for the layer legend:

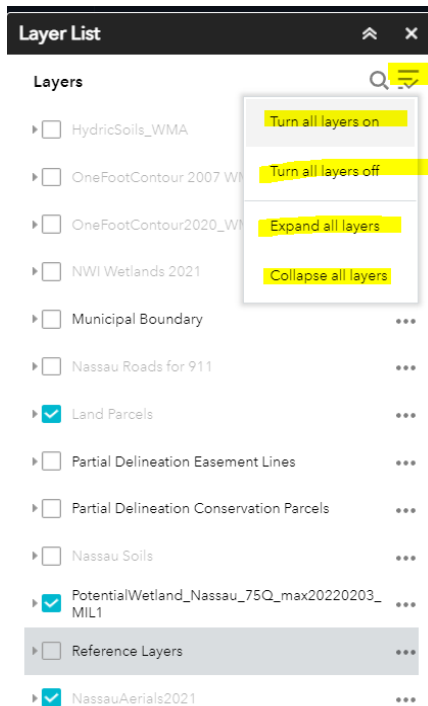


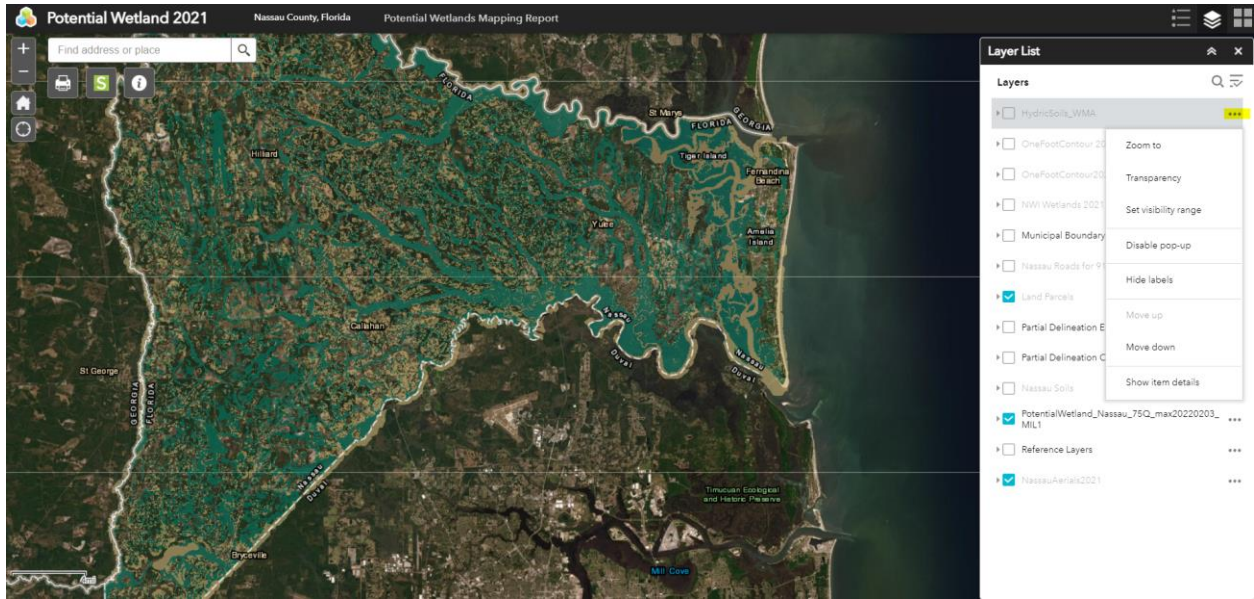
- **Reference Layers** (This set of layers contains additional layers for: highway exists, state boundary, US routes, water body, airports, state parks and so forth. Please allow 15 to 30 minutes to load all the layers in this group.)



- **NassauAerials 2021**(six inch collected by Sanborn Company, January 2021)

Additional functions included in the icon with three lines and a check mark on top it. There are four functions as highlighted below: Turn all layers on, Turn all layers off, Expand all layers, and Collapse all layer.

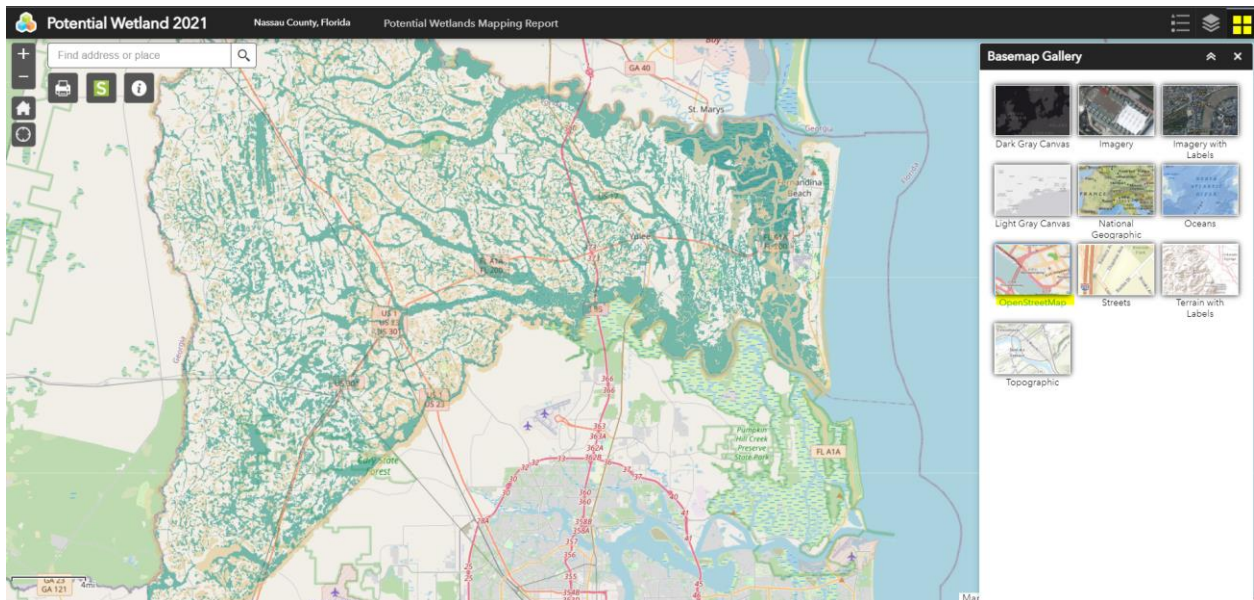




3 Basemap Gallery



Before clicking this icon to bring the base map option list, please make sure the above mentioned layer list Nassau Aerials2021 layers is turn off. The basemap options in the screenshot shown below has the OpenStreetMap selected:



4 Zoom in



5 Zoom out



6 Default extent

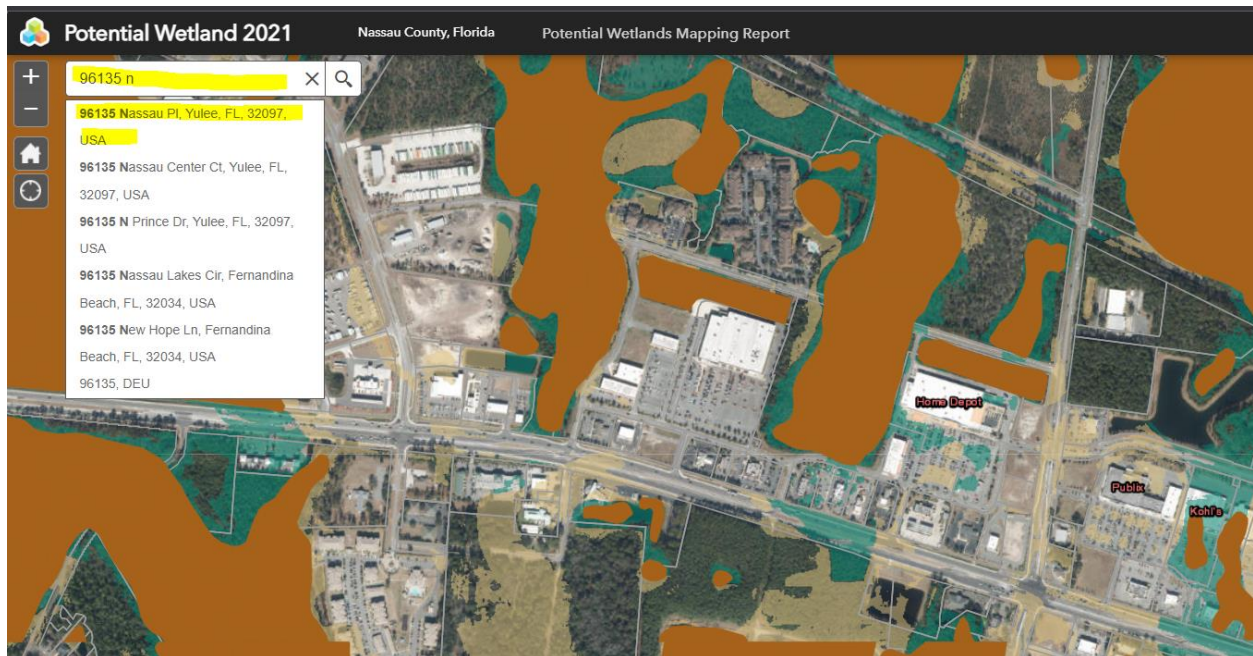


Click the default extent icon will bring the maps back to the default extent to view the whole county.

7 My Location



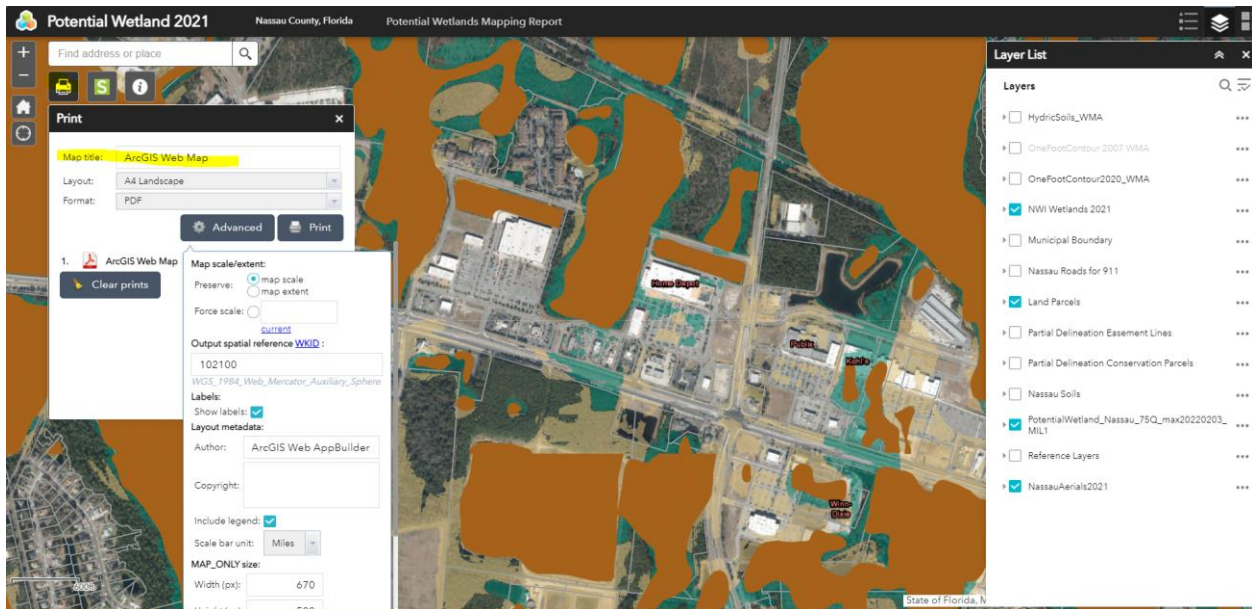
8 Search and Find address or place: type in the address you know, the ESRI Geocoding database will pop up hints for the suggested addresses as the screenshot shows below:



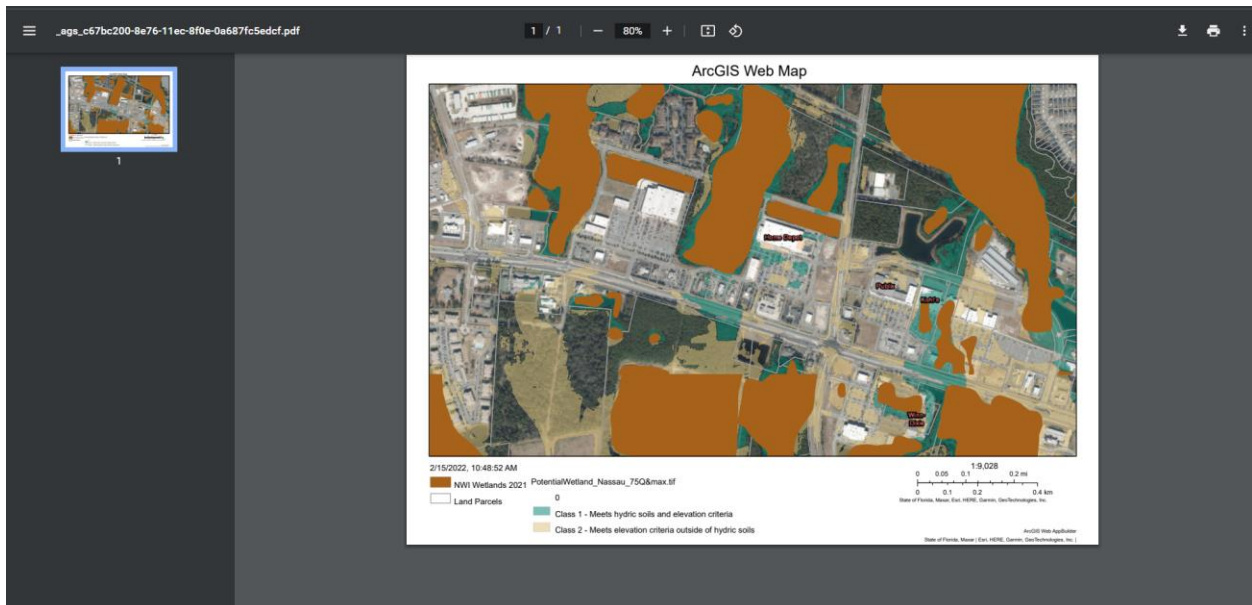
9 Print



To create a map for the layer, zoom in to the area of your interest. Select the layers. Use the function to change the title. Or click the advance function to have more settings to get your final layout of the map you want to print.



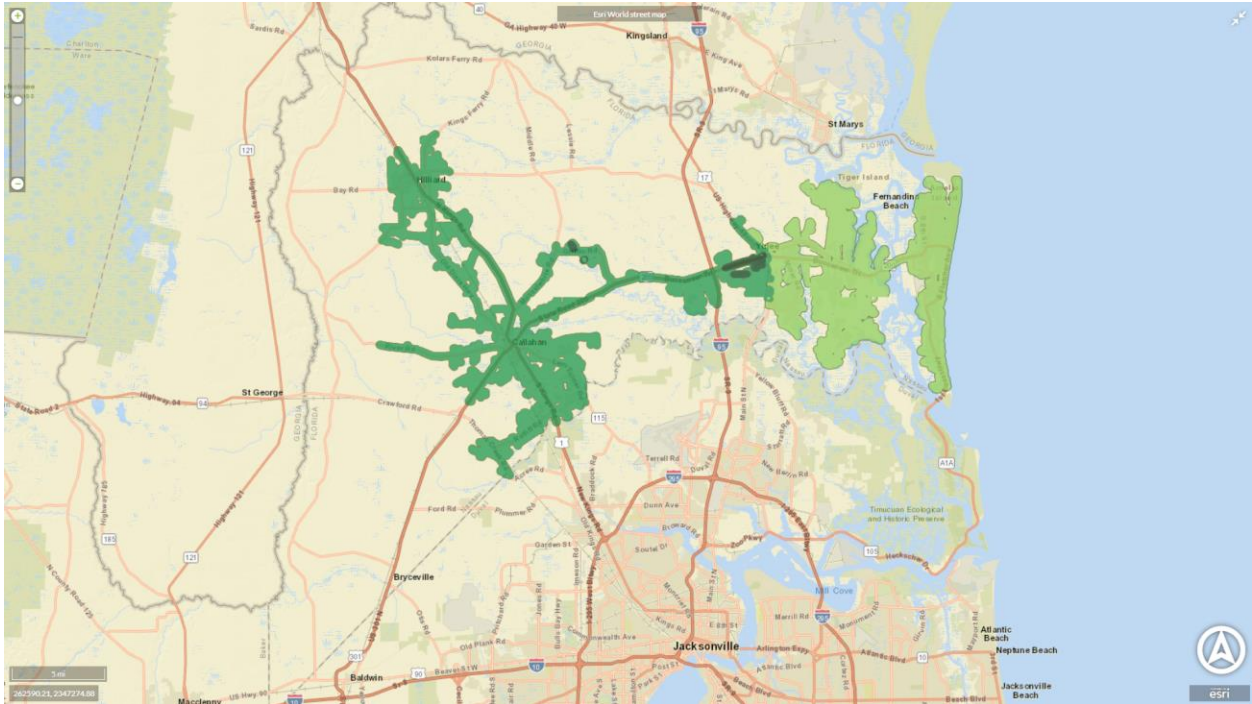
The screenshot below shows the map product through this print function. The map will include a title, GIS data layers, legend, scale bar, date and time of the printing, and data source.



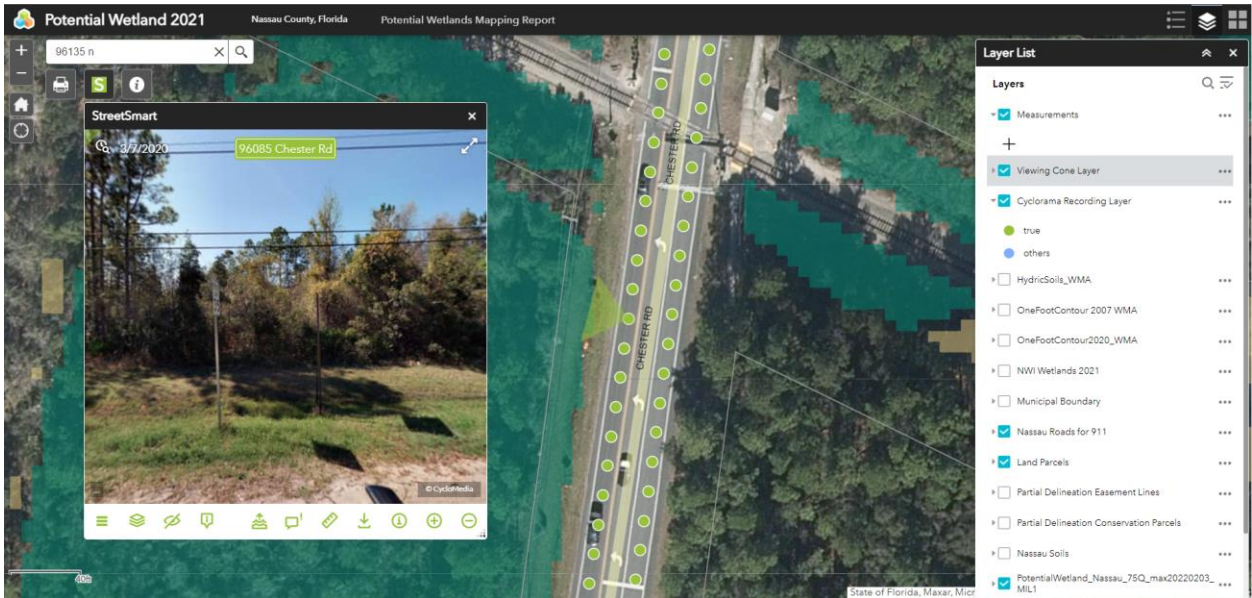
10 Street smart

Street Smart is powered by Cyclomedia company. The lighter green color symbols means the street view in the east part of the county, which represents that data was collected in 2020. The darker green color symbols are the street view in the west side of the U.S. Highway 17, which represents that data was collected in 2021. It is important to note that the collection in the county is only partial. The street view

collection does not cover all the roads within the county. Only the data along the roads in the screenshot below is included.

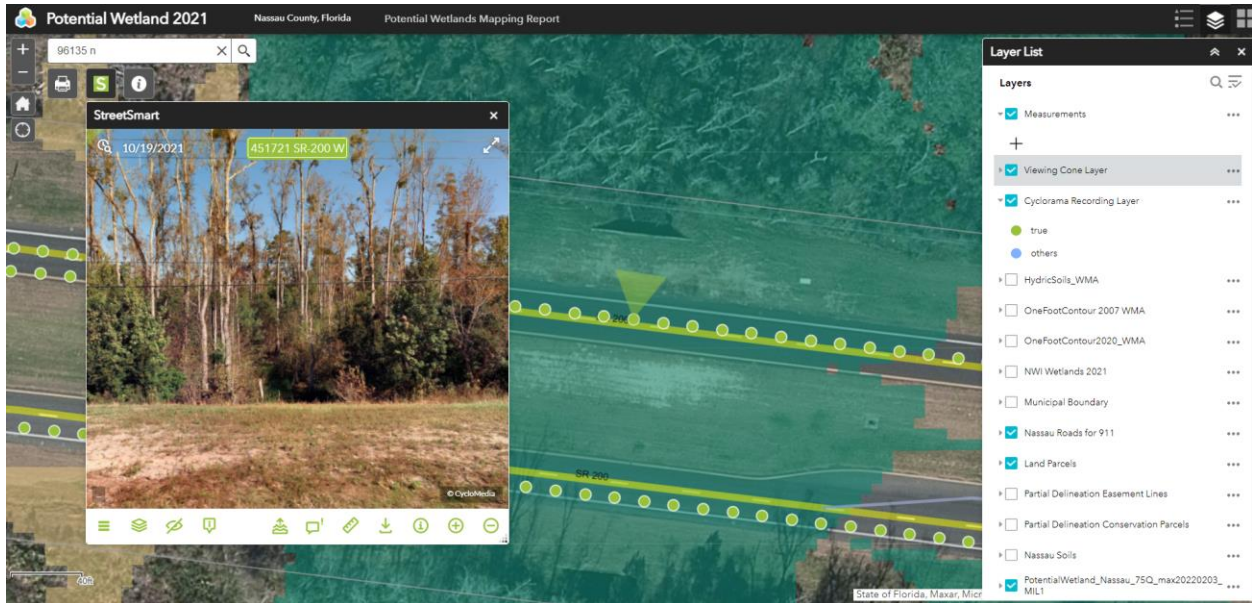


To use this widget, click the “S” green icon, the viewing cone will show which side of the road you are viewing. The layer list will show the legend when using this widget. The screenshot shows one example collected in 2020 near 96085 Chester Road. The StreetSmart view window will float on the screen, and you can zoom in and zoom out. The green dots are the spot where the cyclorama recording took place.



The screenshot below shows an example of how this tool may aid spotting wetland through the streetsmart widget. The screenshot shows the collection for 2021 on the west part of the county along the state road 200. The view is facing a forested area that are potentially identified through the model as

wetland. Through the aerial image, you can see that part could be identified as wetland. However, it is important to note that, the potential wetland layer did not exclude areas of altered land.



11 About

About icon offers an access to read the Potential wetlands mapping report and the Nassau County Potential Wetlands White Paper hyperlinks.

Please read the [Potential Wetlands Mapping Report](#) for appropriate use of this product!

Additional Documents:

[Supplemental Materials](#) for the potential wetlands mapping procedures,
and

[Nassau County Potential Wetlands White Paper](#)
by Buchanan & Weisenborn (2019)

Helpful Tip:



Clicking on these buttons found in the upper right-hand corner will display the legend and other data layers that can be added to the map.