Appendix H

Potential Adverse Change to Wetland Function Assessment

Introduction

As part of North Florida Regional Water Supply Plan (NFRWSP) development, the St. Johns River Water Management District (SJRWMD) and Suwannee River Water Management District (SRWMD) (Districts) assessed the extent to which water resources and related natural systems may be impacted in the projected increase in groundwater use through 2045. Adverse Change to wetland function is one component of the water resource assessment, along with saltwater intrusion/upwelling, minimum flows and levels (MFLs), waterbodies without adopted MFLs, and water reservations. This information helps guide the delineation of water resource caution areas and the formulation of project options.

This document details the methods used to assess wetlands in the NFRWSP area associated with projected groundwater demand at the planning horizon (2045) and the assessment results. Although significantly altered wetlands have occurred in the past due mainly to farmland conversion and urbanization, wetlands can be altered by factors other than groundwater withdrawals (e.g., modification of surface water hydrology). However, this analysis focused exclusively on assessing the potential for adverse change to existing wetlands only due to predicted changes in groundwater levels resulting from projected increases in groundwater demand. The outcome of this assessment was used with other factors in determining whether traditional water supply (i.e., fresh groundwater) sources are sufficient to meet future water demands.

Background

In previous Water Supply Plans and Assessments, the probability of adverse change in wetland functions was determined using variations of the Kinser-Minno method incorporated into a GIS model (Kinser and Minno, 1995; Kinser et. al., 2003). The Kinser-Minno method provides an estimation of the magnitude (acres), degree (high, moderate, low), and spatial distribution of the potential for future adverse change to wetlands throughout the planning region. The GIS model conducts a matrix analysis utilizing conditional statements dependent on soil permeability, sensitivities of plant communities to dewatering, and modeled declines in the surficial aquifer (SA) to estimate the potential adverse change to individual plant communities that may occur if future water demands were met with traditional sources. The model was updated in 2003 and 2008, which included the depth to the Upper Floridan Aquifer (UFA) potentiometric surface as an additional screening parameter for the areas of unconfined UFA. The additional steps of incorporating the depth to the UFA potentiometric surfaces with respect to the unconfined UFA provide further analysis depending on whether or not the area is hydraulically connected to the UFA and therefore, would or would not be influenced by changes in UFA levels. Since then, the model has received many minor updates such as the inclusion of a digital elevation model (DEM).

The Kinser-Minno GIS Model was reviewed and updated in 2022. The soils data, vegetation layer, and the Digital Elevation Model (DEM) data were updated. Another screening parameter, depth to water table or SAS, was introduced for the areas where the UFA is confined. An additional tool was added to the workflow to make the thresholds for depth to water table and depth to potentiometric surfaces adjustable. The updates to the model are described in detail in Attachment A.

Methodology

The 2022 Kinser-Minno tool (Attachment A) was used to simulate potential adverse change in wetlands based on increased groundwater withdrawals (drawdown) between current pumping (CP) and 2045 projected withdrawals. Due to the way in which the Kinser-Minno applies the screening criteria, the tool was run using the 2009 “pumps-off” (PO) baseline conditions. Therefore, the tool used both PO to CP drawdown, and PO to 2045 drawdown. The difference in spatial and numerical results were subsequently used to estimate the effects of CP to 2045 drawdown. The area of potential adverse change to wetlands was summarized by county for the NFRWSP area. Furthermore, the Kinser-Minno tool predicts low, moderate, and high potential for adverse change, but only the moderate and high potentials for adverse change were considered in the analysis. Areas with a low potential for adverse wetland change were not included in the results because this classification indicates that plants are drought tolerant or the soils are not susceptible to dewatering (Kinser and Minno, 1995). Descriptions of the moderate and high classifications can be found in Attachment A.

Results of CP to 2045 Assessment

Out of over 900,000 acres assessed in the NFRWSP area (Figure H1), the analysis identified a total of 8,129 acres of wetlands with a moderate to high potential for adverse change based on increased groundwater withdrawals between CP and the 2045 projection (Table H1 & Figure H2). Of the total area, 1,828 acres were in the SRWMD, and 6,303 acres were in the SJRWMD. Flagler county had the highest potential for adverse wetland change with 4,201 acres identified. No potential adverse change to wetlands was predicted for Baker, Bradford, Duval, or Union counties.

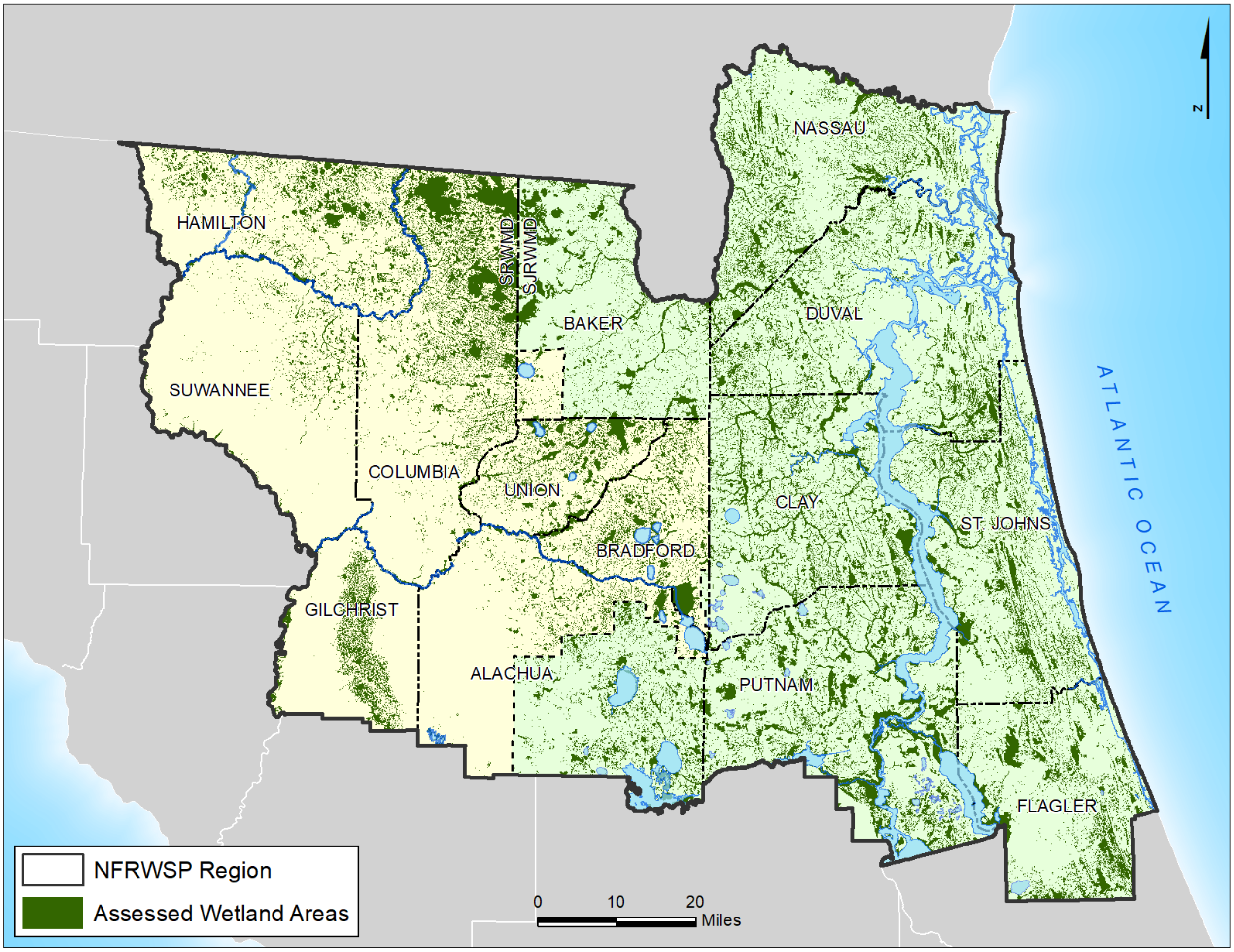

Figure H1. Total wetland acreage assessed in the NFRWSP area

Table H1. Wetland acreage identified as having moderate or high potential for adverse change to wetland function between CP and 2045 projected withdrawals

County	District	Potential Adverse Wetland Change (acres)
Alachua	SJR	557
Alachua	SR	168
Baker	SJR	0
Baker	SR	0
Bradford	SJR	0
Bradford	SR	0
Clay	SJR	494
Columbia	SR	68
Duval	SJR	0
Flagler	SJR	4,201
Gilchrist	SR	1,288
Hamilton	SR	157
Nassau	SJR	62

County	District	Potential Adverse Wetland Change (acres)
Putnam	SJR	309
St. Johns	SJR	680
Suwannee	SR	147
Union	SR	0
Total	NA	8,129

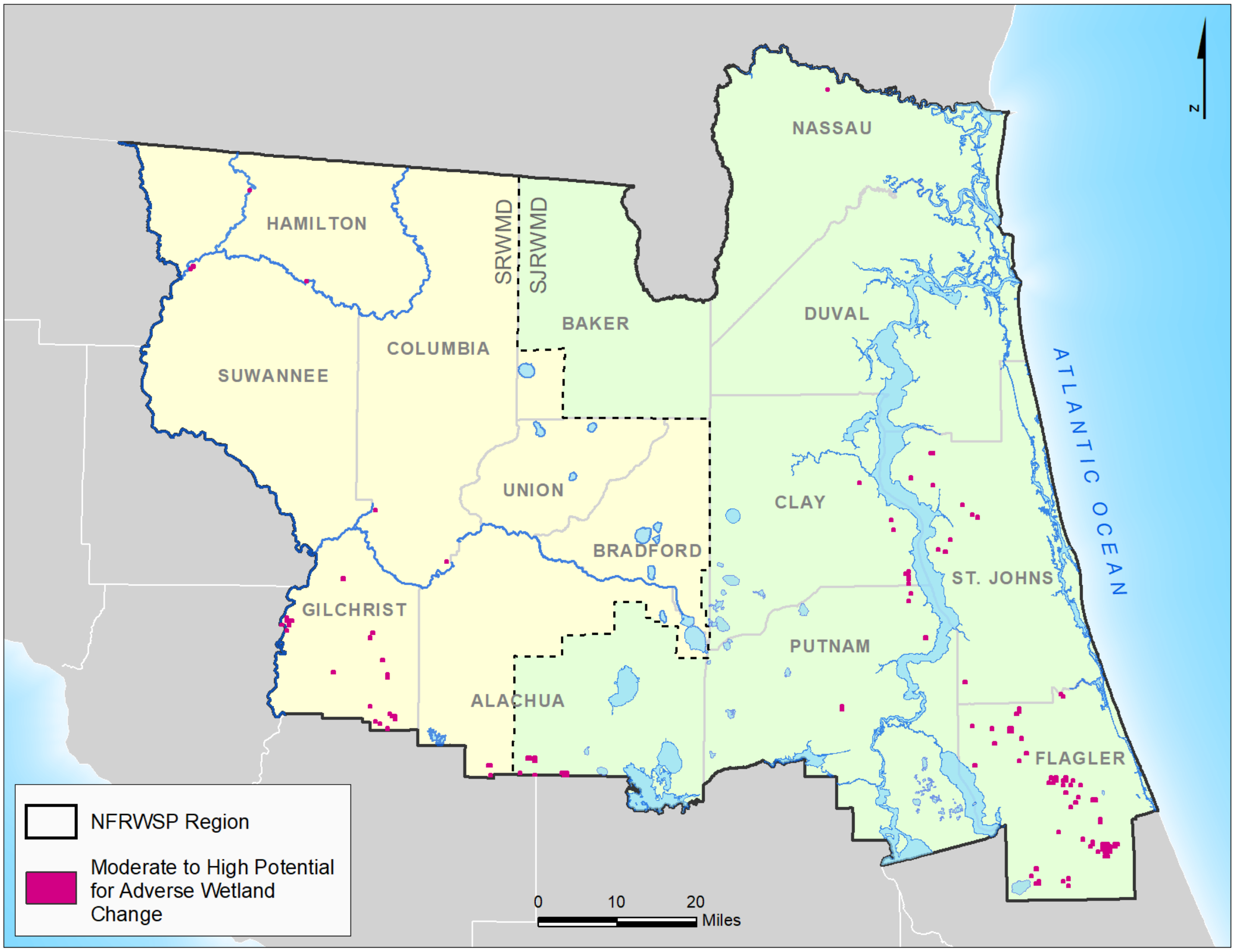

Figure H2. Locations with moderate to high potential for adverse change to wetlands

See Attachment A

2022 Kinser-Minno Wetland Assessment Tool

12/9/22 Update

Attachment A
2022 Kinser-Minno Wetland Assessment Tool

12/9/22 Update

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St. Johns River Water Management District
Palatka, Florida

2022

The St. Johns River Water Management District was created in 1972 by passage of the Florida Water Resources Act, which created five regional water management districts. The St. Johns District includes all or part of 18 counties in northeast and east-central Florida. Its mission is to preserve and manage the region's water resources, focusing on core missions of water supply, flood protection, water quality and natural systems protection and improvement. In its daily operations, the district conducts research, collects data, manages land, restores and protects water above and below the ground, and preserves natural areas.

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Introduction

One of the responsibilities of the St. Johns River Water Management District (District) is to conduct "resource assessments, including identification of regionally significant water resource issues and problems within the "District" (Section 62-40.520, *Florida Administrative Code).* As part of this responsibility, the District developed a geoprocessing workflow as a ModelBuilder tool, an application to create and manage geoprocessing models within ArcGIS (ESRI, 2022), in 1995 to predict the likelihood of potential adverse change to wetlands, lakes and related vegetation due to predicted groundwater level changes resulted from projected groundwater withdrawals (Kinser and Minno 1995; Kinser et al. 2003). This geoprocessing tool, also known as Kinser-Minno Geographic Information System (GIS) tool, helps guide the delineation of water resource caution areas and the formulation of project options.

The Kinser-Minno GIS tool provides an estimation of the magnitude (acres), degree (high, moderate, low), and spatial distribution of the potential for future adverse change to wetlands throughout the District. In previous District water supply assessments, the probability of adverse change in wetland functions was determined using variations of the Kinser-Minno method. The tool was updated in 2003 and 2008, which included the depth to the Upper Floridan aquifer (UFA) potentiometric surface as an additional screening parameter for the areas of unconfined UFA. Since then, the tool received many minor updates such as the inclusion of a Digital Elevation Model (DEM). The most recent version prior to this update is the 2018 Kinser-Minno model builder found in the *Vegharm2018* GIS toolbox.

The Kinser-Minno GIS tool conducts a matrix analysis utilizing conditional statements dependent on soil permeability, sensitivities of plant communities to dewatering, and projected declines in the surficial aquifer system (SAS) to estimate the potential adverse change to individual plant communities that may occur if future water demands were met with traditional sources. The additional step of incorporating the depth to the UFA potentiometric surfaces with respect to the unconfined UFA provides further analysis depending on whether the area is hydraulically connected to the UFA and therefore, would or would not be influenced by changes in UFA levels.

This report describes the recent improvements including addition of another screening parameter, the depth to water table or SAS, for the areas of confined UFA, updating soil, vegetation and topographic layers and making the thresholds adjustable within the tool. These updates are referred to as the 2022 Kinser-Minno tool.

Existing Data Review

The most recent documentation and in-depth information regarding the development of the 2018 Kinser-Minno tool was found in Appendix H of the 2022 Central Springs/East Coast (CSEC) Regional Water Supply Plan (SJRWMD 2022). District staff reviewed the tool, input data, and other documentation to determine if updates to the tool were required. The reviewed tool was referred to as *vegharm2018* in the CSEC plan and is shown in Figure 1.

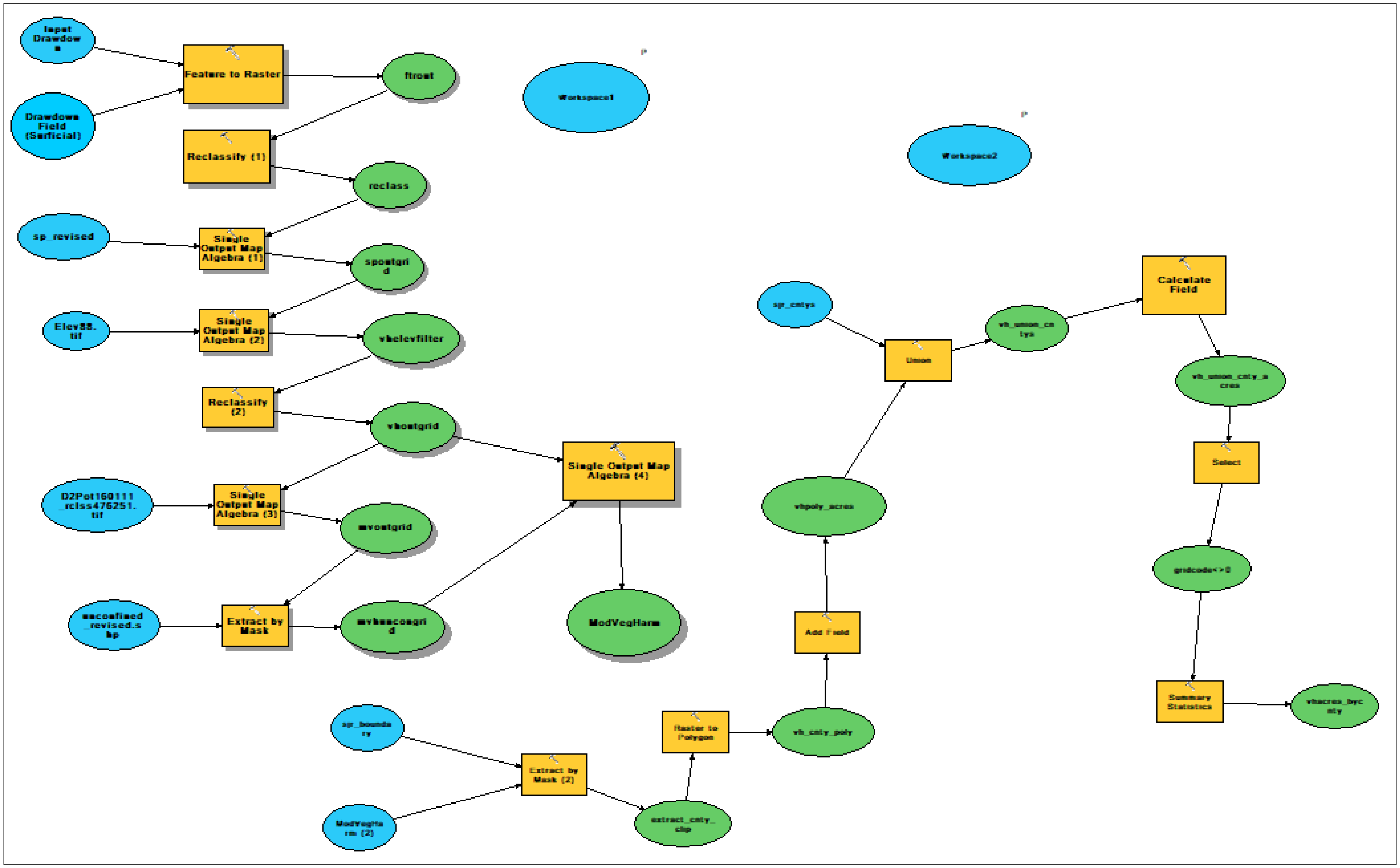

Figure 1. The 2018 Kinser-Minno model builder

The following GIS data, used in the tool listed in the CSEC Appendix H, was reviewed.

1. 2012 Soil Survey Geographic Database for Florida (SSURGO)
2. 2009 Land Cover/Land Use GIS Data Layer, SJRWMD
3. Unconfined Floridan Aquifer System Boundary, United States Geologic Survey (Miller 1986)
4. 2008 Digital Elevation Model for the State of Florida, Florida Department of Environmental Protection (FDEP)
5. May 2014 UFA Potentiometric Surface GIS Data Layer, SJRWMD

Soil Permeability Classification

The 2012 Soil Survey Geographic Database for Florida (SSURGO) was reported to be used to derive the soil permeability classification layer. Soil permeability refers to the capacity of a soil to allow water to pass through. This is a key component for assessing wetlands because it dictates how quickly an area of sensitive vegetation is dewatered when the water table declines.

The soil permeability was used to create the integrated soil and vegetation layer as an input in the workflow. The National Resources Conservation Service (NRCS) provides estimates of the inches of water per hour that can move downward through a saturated soil based on laboratory measurements. The soil permeability layer was made into a raster and then grouped into high, moderate, and low categories based on infiltration rate, as shown in Table 1.

Table 1. Soil Permeability Classification

Soil Permeability Class	Soil Permeability Rate (inches/hour)	CSEC RWSP Class
Very Slow	Less than 0.06	Low sensitivity to drawdown (1)
Slow	0.06 – 0.2	Low sensitivity to drawdown (1)
Moderately Slow	0.2 – 0.6	Low sensitivity to drawdown (1)
Moderate	0.6 – 2.0	Moderate sensitivity to drawdown (2)
Moderately Rapid	2.0 – 6.0	Moderate sensitivity to drawdown (2)
Rapid	6.0 – 20	High sensitivity to drawdown (3)
Very Rapid	Greater than 20	High sensitivity to drawdown (3)

Vegetation Classification

The SJRWMD 2009 Land Cover/Land Use GIS Data Layer was used to create the integrated soil and vegetation layer as an input in the workflow. This layer was used to identify current wetland areas to be screened for sensitivity to SAS drawdown. Areas that are not wetlands are excluded from the screening process. The layer was first made into a raster. Then, the vegetation types were classified into high, moderate, or low sensitivity as seen in Table 2.

Table 2. Classification of Sensitive Vegetation Types

Land Use Code	**CSEC RWSP Class** 1 = Low Sensitivity 2 = Moderate Sensitivity 3 = High Sensitivity
4100: Upland Coniferous Forests	1
4110: Pine Flatwoods	1
4120: Longleaf Pine - Xeric Oak	1
4130: Sand Pine	1
4140: Pine - Mesic Oak	1
4190: Hunting Plantation Woodlands	1
4200: Upland Hardwood Forests	2
4210: Xeric Oak	1
4270: Live Oak	1
4271: Oak - Cabbage Palm Forests	1
4280: Cabbage Palm	2
4340: Upland Mixed - Coniferous / Hardwood	2
4400: Tree Plantations	1
4410: Coniferous Plantations	2
4420: Hardwood Plantations	1
4430: Forest Regeneration Areas	2
6100: Wetland Hardwoods Forests	3
6110: Bay Swamps	3
6111: Bayhead	3
6120: Mangrove Swamps	1
6130: Gum Swamps	3
6140: Titi Swamps	3
6150: Stream and Lake Swamps (bottomland)	3
6170: Mixed Wetland Hardwoods	3
6172: Mixed Shrubs	3
6180: Cabbage Palms	3
6181: Cabbage Palm Hammock	3
6182: Cabbage Palm Savannah	3
6200: Wetland Coniferous Forests	3
6210: Cypress	3
6215: Cypress- Domes/Heads	3

Land Use Code	CSEC RWSP Class 1 = Low Sensitivity 2 = Moderate Sensitivity 3 = High Sensitivity
6216: Cypress - Mixed Hardwoods	3
6220: Pond Pine	3
6240: Cypress - Pine - Cabbage Palm	3
6250: Hydric Pine Flatwoods	3
6260: Pine Savannah	3
6300: Wetland Forested Mixed	3
6400: Vegetated Non-Forested Wetlands	3
6410: Freshwater Marshes	3
6411: Freshwater Marshes – Sawgrass	3
6420: Saltwater Marshes	1
6430: Wet Prairies	3
6440: Emergent Aquatic Vegetation	3
6460: Mixed Scrub-shrub Wetland	3
6500: Non-Vegetated Wetlands	3
6510: Tidal Flats	1
6520: Shoreline	1
6530: Intermittent Ponds	3
6600: Salt Flats	1

Integrated Soil and Vegetation

The classified soil and classified vegetation layers were integrated to create a single raster file to be used as an input into the workflow. This method is shown in Table 3.

This layer assigns sensitivity ranks to vegetation communities that have high sensitivity to water table drawdown, which is the wetlands (Table 3).

Table 3. Potential for Wetland Change Classification (Integrated Soil Permeability and Vegetation Type Sensitivity)

	High Vegetation Sensitivity	Moderate Vegetation Sensitivity	Low Vegetation Sensitivity
High Soil Permeability	High	Low	Low
Moderate Soil Permeability	Moderate	Low	Low
Low Soil Permeability	Low	Low	Low

Drawdown and Potential for Wetland Change Classification in Unconfined Areas

Regional groundwater models are used to predict change in the SAS elevation (drawdown). The drawdown shapefile is rasterized and then reclassified as follows; greater than 1.2 ft as a 3 (high), 0.35 to 1.2 ft as a 2 (moderate), and less than 0.35 ft as a 1 (low). The integrated soil and vegetation classification layer and the projected drawdown in the SAS were combined into a layer for potential future wetland change classification (Table 4).

Table 4. Potential Future Wetland Change Classification (Confined) (Integrated Potential for Wetland Change and Projected SAS Drawdown

	High Potential for Wetland Change	Moderate Potential for Wetland Change	Low Potential for Wetland Change
Projected SAS Drawdown > 1.2 ft	High	High	Low
Projected SAS Drawdown from 0.35 – 1.2 ft	High	Moderate	Low
Projected SAS Drawdown < 0.35 ft	Low	Low	Low

Depth to Unconfined Aquifer

Within the areas where the UFA is unconfined or exposed at the surface, the depth from land surface to the 2014 potentiometric surface was calculated. The depth from land surface to the potentiometric surface layer is combined with the potential for wetland change layer (Table 5) to determine changes to wetlands in areas where the UFA is unconfined.

Table 5. Potential Future Wetland Change Classification above the Unconfined UFA (Integrated Potential for Future Change for Confined Areas and Depth to the Unconfined UFA) (Kinser and Minno 2003)

	High Potential for Future Change	Moderate Potential for Future Change
0 – 15 ft to Unconfined UFA	High	Moderate
15 – 30 ft to Unconfined UFA	Moderate	Low
>30 ft to Unconfined UFA	Low	Low

Output

The final output of these combined layers was a raster file titled *modvegharm*. This file shows the areas for potential adverse change to wetland function with respect to drawdown. Areas that are classified as three have the highest potential for adverse change while areas classified as one have the lowest potential for adverse change (Table 6). This raster output is put into the second portion of the model builder.

The second portion of the tool uses the SJRWMD boundary and the county boundaries to determine the acreage in each county for each classification. The output from the second portion of the tool is presented in a geodatabase table.

Table 6. Classification of the potential for adverse wetland change (Kinser and Minno, 1995)

Potential for Adverse Change	Description
Low (1)	Plants are drought tolerant or the soils are not susceptible to dewatering
Moderate (2)	Plants are moderately sensitive to drought or the soils are only moderately susceptible to dewatering
High (3)	Plants are drought sensitive and the soils are susceptible to dewatering

Tool Updates

After completing a thorough review of the tool that was presented in the 2022 CSEC Appendix H, SJRWMD determined updates were needed, including an additional screening parameter to further refine the results to better determine which wetlands had the highest potential for adverse change due to future groundwater drawdown. The section below outlines the updates that were made to the 2018 tool version.

Data Updates

As shown in Table 7, the soils data, vegetation layer, and DEM were updated. The soils and vegetation classifications were unchanged and are still grouped based on infiltration rate (high, moderate, low). The new soils and the vegetation layer were integrated to create the new input (Figure 2).

Table 7. GIS Data Updates Made to the Kinser-Minno Tool

	2018 Model	2022 Model
SSURGO Soils	2012 SSURGO soils	2017 SSURGO soils layer
Vegetation Layer	2009 Statewide Cooperative Land Cover	Compilation of of datasets 2019-2020 SRWMD and 2013-2016 SJRWMD
DEM	2008 Florida DEM	15m Florida DEM

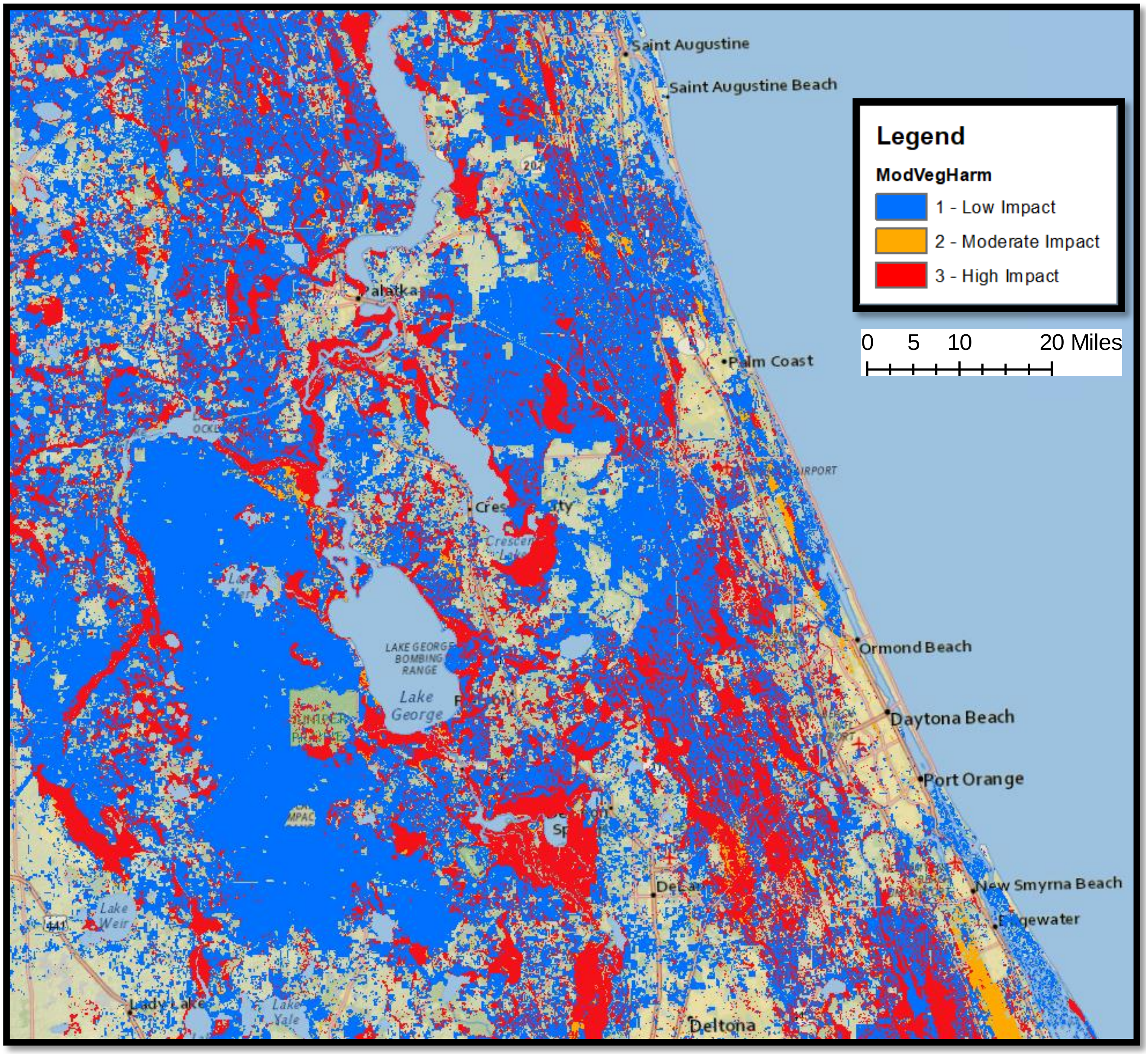

Figure 2. A portion of the District showing the updated integrated soils and vegetation layer. Three indicates high potential for adverse change to wetlands, two for moderate potential, and one for low potential.

Depth to Water Table Update

The 2022 Kinser-Minno tool incorporated an additional screening parameter for the areas where the UFA is confined. Wetland vulnerability was further classified based on depth to water table or SAS (Table 8). This additional step of incorporating the depth to water table in the areas of confined UFA provides further screening to ensure the area is hydraulically connected to the SAS and therefore, would or would not be influenced by changes in SAS levels. The depth to water table used in this analysis was calculated using the simulated SAS levels from the 2009 simulation of North Florida Southeast regional groundwater model (NFSEG v1.1).

Vulnerability classes of High, Moderate and Low were set based on a review of extinction depths for different soil and land cover types estimated by Shah et al. (2007). Vulnerability thresholds of "Moderate" and "High" are set for sites where the water table is below 20 and 10 ft, respectively.

Vulnerability classes are also different for wetlands with high versus moderate potential for future change based on other criteria (i.e., soil permeability and vegetation type; Table 8). A feature was added to the workflow to allow users to adjust the depth to water table threshold.

Table 8. Potential Future Wetland Change Classification above the Confined UFA (Integrated Potential for Future Change for Confined Areas and Depth to water table)

	High Potential for Future Change	Moderate Potential for Future Change
0 – 10 ft to Water Table	High	Moderate
10 – 20 ft to Confined UFA	Moderate	Low
>20 ft to Confined UFA	Low	Low

2022 Kinser-Minno Workflow

Figure 3 shows the 2022 updated Kinser-Minno tool, which includes the updated soils data, vegetation layer, DEM, and depth to water table. This tool used the drawdown shapefile to create a raster. The raster is reclassified, which means having the values grouped, into three classes. These three classes are the basis for the computations in the model. The rasterized drawdown layer is then combined with the integrated soils and vegetation raster which is also reclassified into three classes. The two are combined based on a conditional statement to create a new output raster. This new output is then combined with the digital elevation data (DEM) to remove areas of 10ft or less.

This process step is where the tool branches off into two sections. One section is for the unconfined aquifer. This portion reclassifies the depth to the UFA potentiometric surfaces. The other section is for the confined aquifer. This portion of the workflow reclassifies the depth to water table (surficial aquifer). After each of these layers are reclassified within their respective areas, they are merged based on a conditional statement to create a raster layer that depicts the areas with potential for adverse wetland change. The output raster goes into the next portion of the model builder, which takes the potential for adverse wetland change raster, and creates a table that calculates the acreage of the potential for adverse wetland change (high, moderate, low) within each county in the area of interest.

Results

The North Florida Regional Water Supply Plan was the first project for which the updated tool was utilized. The tool utilized the output from the NFSEG v1.1 model simulation. The Kinser-Minno tool results include the updated soils, vegetation, DEM inputs and depth to water table. Table 9 shows the results for utilizing the Pumps Off (PO) to 2045 pumping scenario results as input to the 2022 Kinser-Minno tool. Figure 4 displays the results of the scenario.

Table 9. Comparison of the results for acres of potential adverse wetland change for each county in the of the NFRWSP region. The results are for the PO to 2045 NFSEG shapefile.

County	Low	Moderate	High	Moderate/High
Alachua	103,618	540	247	787
Baker	2,273	0	0	0
Bradford	1,937	0	0	0
Clay	38,545	1,544	371	1,915
Columbia	42,656	62	62	124
Duval	27,964	0	0	0
Flagler	133,114	7,413	432	7,846
Gilchrist	76,807	1,050	1,473	2,523
Hamilton	26,101	424	758	1,182
Nassau	35,662	62	0	62
Putnam	114,352	2,222	185	2,408
St. Johns	98,782	1,114	494	1,608
Suwannee	108,109	317	1,034	1,351
Union	3,478	0	0	0
Total	813,397	14,950	5,251	20,201

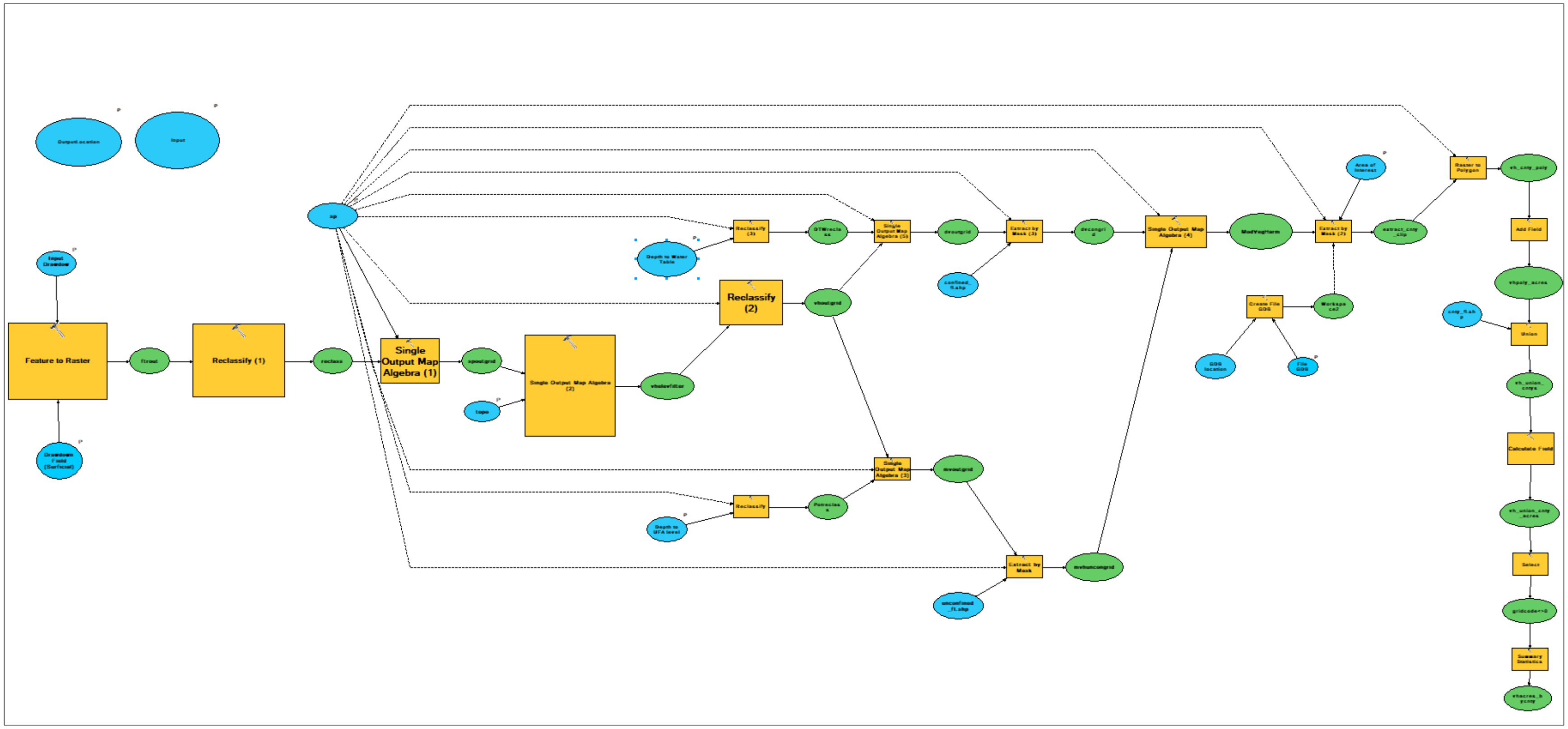

Figure 3. The updated 2022 Kinser-Minno Model Builder.

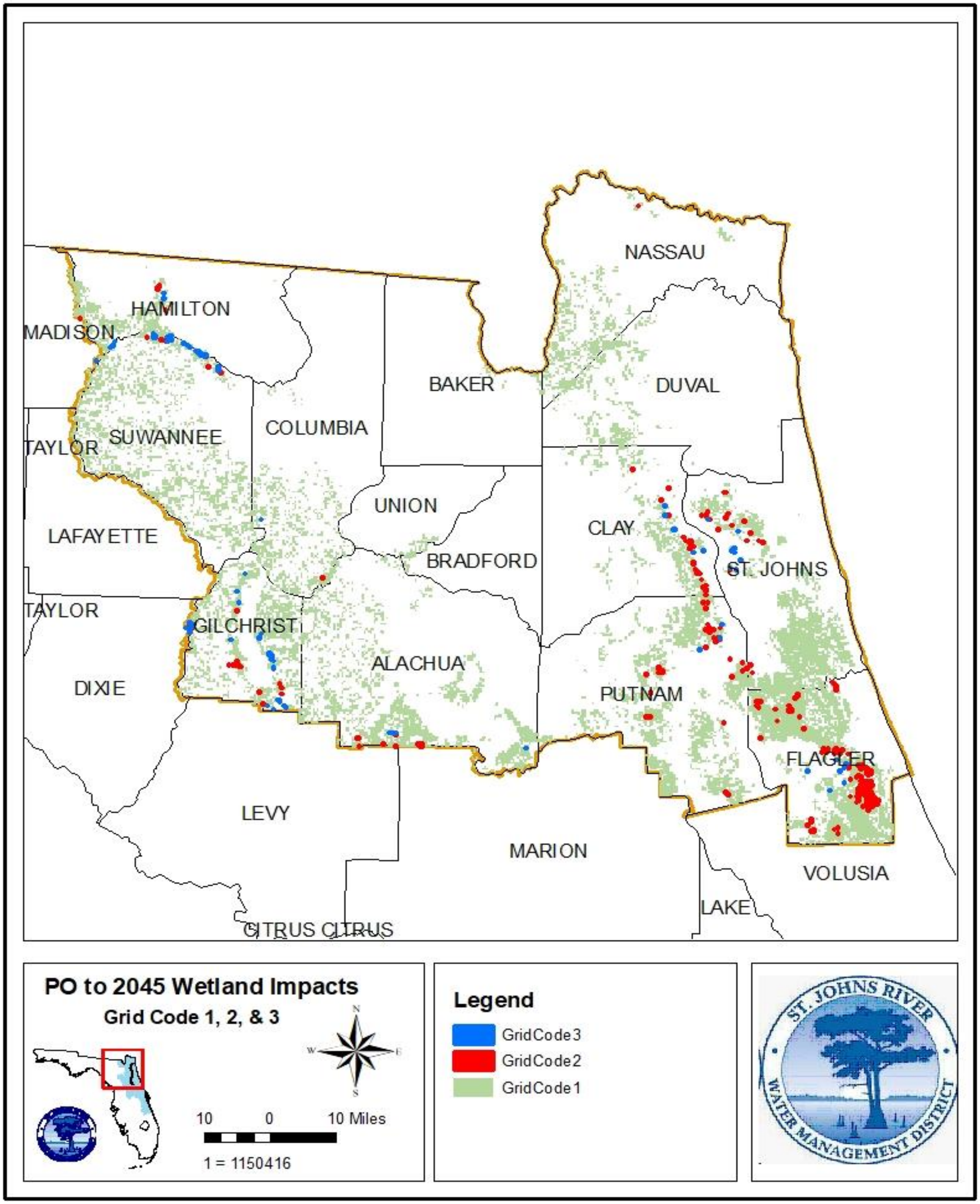

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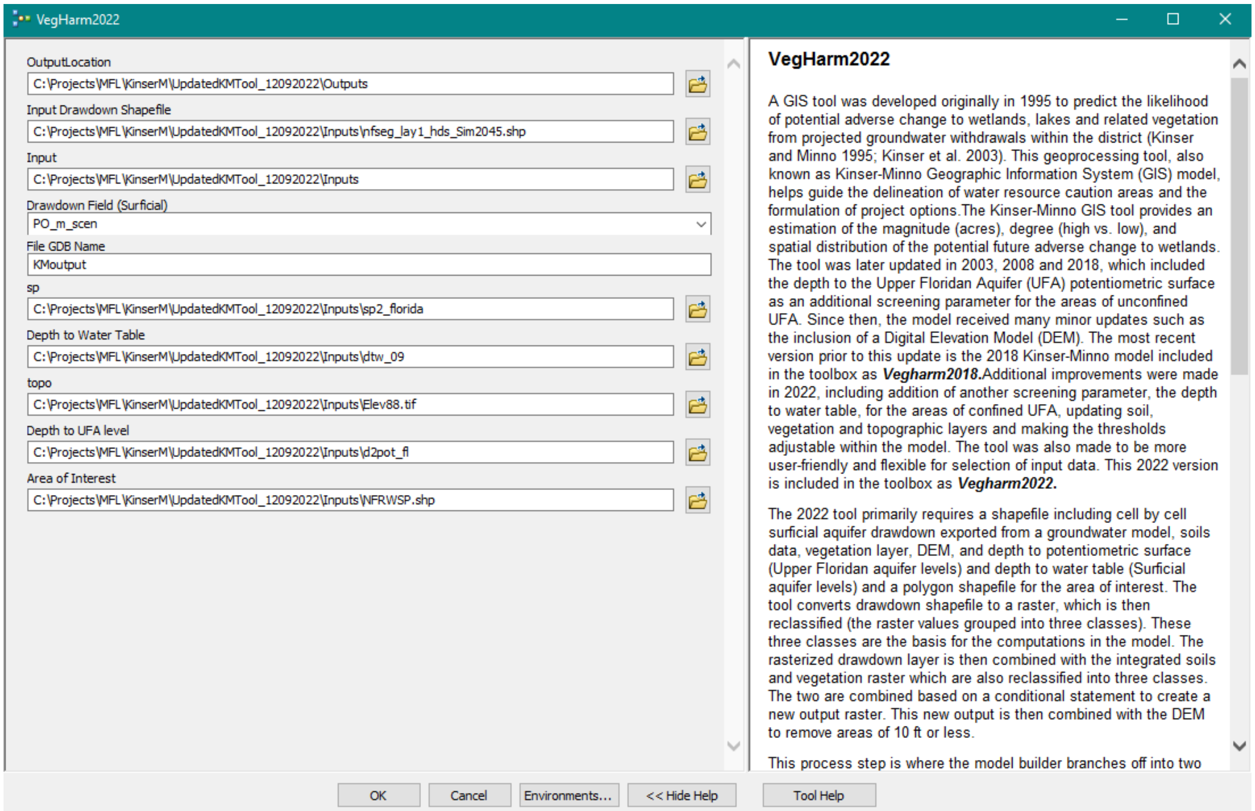
Figure 4. PO to 2045 Potential for Adverse Wetland Change (PO to 2045 NFSEG drawdown shapefile for the NFRWSP area) (Note: GridCode 1= Low; GridCode 2=Moderate; GridCode 3= High).

Kinser Minno Wetland Assessment Tool 2022 12/9/22 Revision

1. Open KM Tool.mxd
2. Add “KMVegharm2022.tbx” to Arctoolbox if it is not already there.
3. Activate spatial analyst extension if it is not already active.
4. Double click “VegHarm2022”. The following window will pop up.



5. Enter the output folder location where the results will be stored. You can create your own folder or use “Outputs” folder already created.
6. Enter the surficial aquifer system (SAS) drawdown file location. The SAS drawdown from NFSEG model already exists in the input folder.
7. Enter the input folder location. This folder already exists so you just need to put the path there.
8. Choose the SAS drawdown scenario. For NFRWSP, *PO_m_scen* is for pumps off minus 2045 and CP*_m_scen* is Current Pumping minus 2045 in “*nfseg_lay1_dd_nfrwsp.shp*”.
9. Enter the name of the output geodatabase file the tool will create and save into output folder. You can keep the name as it is or change it if you want.
10. Enter soil permeability layer location. This layer already exists in the input folder. Change it if you want to use a different one.
11. Enter depth to water table layer location. This layer already exists in the input folder. Change it if you want to use a different one.
12. Enter DEM location. This layer already exists in the input folder. Change it if you want to use a different one
13. Enter depth to UFA level layer location. This layer already exists in the input folder. Change it if you want to use a different one

14. Enter the location of a shapefile including the area of interest. NFRWSP region layer already exists in the input folder. Change it if you want to run the tool for a different area
15. Hit OK.
16. Once it is successfully run, add the output files stored in the output gdb file into the mxd.

Important Note

Due to the way the screening criteria are applied, the input SAS drawdowns should be based on pumps off condition. The tool will not correctly predict the likelihood of potential adverse change to wetlands from projected groundwater withdrawals if drawdowns are calculated using a baseline other than pumps-off condition. If a different baseline is desired, the following steps should be followed:

For example, assume the prediction of likelihood of potential adverse change to wetlands from 2020 to 2045 is desired:

1. Run the tool using the drawdown from pumps-off to 2020 (2020 results)
2. Run the tool using the drawdown from pumps-off to 2045 (2045 results)
3. Calculate the difference between the 2045 results and the 2020 results

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References

CH2M HILL. 1996. Water Supply Needs and Sources Assessment, Alternative Water Supply Strategies Investigation, Wetlands Impact, Mitigation, and Planning-level Cost Estimating Procedure. SJRWMD Special Publication SJ96-SP7.

CH2M HILL. 1998. Water 2020 Constraints Handbook. SJRWMD Special Publication SJ2005-SP8.

Dunn, W., P. Burger, S. Brown, and M. Minno. 2008. Development and Application of a Modified Kinser-Minno Method for Assessing the Likelihood of Harm to Native Vegetation and Lakes in Areas with an Unconfined Aquifer. SJRWMD Special Publication SJ2008-SP24.

Kinser, P. and M. Minno. 1995. Estimating the Likelihood of Harm to Native Vegetation from Groundwater Withdrawals. SJRWMD Technical Publication SJ95-8.

Kinser, P., M. Minno, P. Burger, and S. Brown. 2003. Modification of Modeling Criteria for Application in the 2025 Assessment of Likelihood of Harm to Native Vegetation. SJRWMD Professional Paper SJ2003-PP3.

Miller, J. 1986. Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina. U.S. Geological Survey Professional Paper no. 1403-B. 91 p.

St. Johns River Water Management District. 2022. Central Springs/East Coast Regional Water Supply Plan (2020-2040). Appendix H. SJRWMD, Palatka, Florida.