TECHNICAL MEMORANDUM

Alachua County Vulnerability Analysis

TO: Shane Williams, PE;

FROM: Michelle Hays, MS, PG; Justin Gregory, PE

DATE: October 24, 2023

SUBJECT: Changes to Groundwater Hydrology
Jones Edmunds Project No. 01560-157-01

1 INTRODUCTION

Jones Edmunds used the North-Florida Southeast Georgia (NFSEG) model developed by the St. Johns River Water Management District (SJRWMD) (Durden et al., 2019) to develop dry, wet, and average model scenarios to assess potential changes in aquifer levels and impacts to water resources, water supply wells, and sinkhole risk across the County. The NFSEG is a regional model covering 60,000 square miles of south Georgia and north Florida developed to support water supply planning. We used the Alachua County climate change data to modify recharge, evapotranspiration (ET), and well withdrawals in the model files across the model domain. We used the NFSEG 2010 verification simulation as the baseline model. For each assessment year and the baseline year (2010, 2030, 2040, 2070, and 2100), we created dry, wet, and average year scenarios. The results of this groundwater analysis account for climate change driven impacts, the effects of population growth on water demand was addressed in the water supply analysis that was completed as a part of this project.

2 MODEL CHARACTERISTICS

The NFSEG model is an application of the MODFLOW-NWT (Niswonger et al. 2011) formulation of the MODFLOW 2005 (Harbaugh 2005) groundwater flow simulation software. The model is a product of the North Florida Regional Water Supply Partnership and is used in the Florida Regional Water Supply Planning process. The model is a fully three-dimensional, steady-state model with aquifers and explicitly modeled confining layers. The model has the following seven active layers:

- Layer 1 – the Surficial Aquifer System (SAS).
- Layer 2 – the intermediate aquifer or intermediate confining unit (ICU/IAS).
- Layer 3 – the Upper Floridan Aquifer (UFA).
- Layer 4 – the middle confining unit (MCU) or UFA, where the MCU is absent.
- Layer 5 – the Lower Floridan aquifer (LFA) or the UFA where the MCU is absent or the upper zone of the LFA within the extent of the Fernandina Permeable zone.
- Layer 6 – the lower semi-confining unit.

- Layer 7 – the Fernandina Permeable zone of the LFA.

SJRWMD developed the NFSEG recharge and ET packages using surface water hydrology information from 55 Hydrological Simulation Program – FORTRAN (HSPF) models. The NFSEG recharge package simulates the net recharge (rainfall – unsaturated ET – runoff) to each model cell, and the NFSEG ET package simulates ET from the saturated groundwater system. The package includes an array of the maximum rate of saturated ET, the surface elevation of the maximum rate of ET, and an ET extinction depth (the depth where saturated ET is zero). The NFSEG well package simulated single aquifer well withdrawals and aquifer recharge from effluent disposal sites, such as rapid infiltration basins or injection wells.

3 DEVELOPMENT OF CLIMATE CHANGE SCENARIOS

We used the 2010 NFSEG verification simulation as the baseline model scenario and modified the model Recharge and ET packages to simulate dry, wet, and average year scenarios. To establish the recharge and ET for the scenarios, we determined each assessment year's minimum, maximum, and average annual net recharge (rainfall minus ET) within a 9-year period (4 years before/4 years after). We selected this timeframe to approximate a 10-year drought event used by the water management districts for permitting agricultural water use. For the 2100 assessment year, we used 2092 through 2100 data because rainfall and ET data have only been estimated through 2100.

We modified the recharge package to account for changes in crop demand using information for crop modeling scenarios evaluated in separate tasks (Agsilico, 2023). To estimate changes in crop demand, we developed a spreadsheet model dependent on plant type, soil type, and climate to calculate the net recharge to the surficial aquifer for each simulated year. We estimated crop demands for three land cover types: Forested, St. Augustine, and Bahia. The spreadsheet calculated the daily recharge amount based on rainfall, runoff, soil water capacity, and plant demand. We made the following assumptions for calculating net recharge:

- Arredondo fine sand is representative of Alachua County soils.
- St. Augustine grass has an available root zone of 1 foot.
- Bahia grass has an available root zone derived from the DSSAT model.
- Forested areas have an available root zone of 6 feet.
- Runoff occurs when daily rainfall exceeds 1 inch.

We totaled the annual net recharge for each simulated year and each land cover type. We weighted the total annual recharge by the percentage of each land cover within Alachua County. We compared the weighted recharge for each simulation year to the baseline (2010) to calculate the percent change in recharge. We multiplied the cell recharge by the percentages shown in Table 1. The simulated recharge value represents the amount of water that leaves the plant root zone to recharge the surficial aquifer and assumes no ET will occur if crop demand exceeds the available water.

Table 1 Model Simulated Change in Net-Recharge

Scenario	Climate Data Year	Net Recharge (Inches)	Percent of Baseline
NFSEG Baseline	2010	19.610	100
2010 Dry	2014	6.023	30.7
2010 Avg	2011	11.776	60.1
2010 Wet	2009	13.063	66.6
2030 Dry	2030	9.595	48.9
2030 Avg	2033	8.910	45.4
2030 Wet	2032	31.50	160.6
2040 Dry	2044	4.870	24.9
2040 Avg	2039	10.73	54.7
2040 Wet	2036	20.27	103.4
2070 Dry	2068	5.60	28.6
2070 Avg	2074	14.35	73.2
2070 Wet	2067	30.53	155.7
2100 Dry	2097	7.76	39.6
2100 Avg	2092	10.25	52.3
2100 Wet	2093	30.02	153.1

We also modified the model ET package to account for changes in saturated ET. The ET package simulates additional recharge when groundwater is near the surface. Where the simulated water table is at or above the land surface, ET will occur at the maximum specified saturated ET value. Where the water table is below the extinction depth, which is the depth to which plant roots extend and evaportranspirtation from the water table ceases, no saturated ET will occur. Table 2 shows the percent difference between the 2010 and simulated year actual ET (from the climate model). We modified the maximum rate of saturated ET in the ET package by the simulated year's percent of baseline. The ET surface elevation and extinction depths were not modified. Our NFSEG model mass balance review shows that saturated ET is a small percent (<3%) of the total ET.

We did not simulate irrigation in the initial model scenarios to account for crop demand greater than the available water. We created a second model scenario to simulate potential increases in well withdrawals to meet crop demand. For the increased irrigation scenarios, we compared the current (2010) crop need to the future crop need to derive a projected percent change in irrigation. We multiplied the percent change in irrigation shown in Table 3 by the well withdrawals in the model to simulate increased irrigation. We did not make changes to the return flows simulated by the well package (positive well values).

Table 2 Model Simulated Change in Saturated Maximum ET

Scenario	Climate Data Year	Irrigation Demand (Inches)	Percent of Baseline
NFSEG Baseline	2010	49.81	100
2010 Dry	2014	56.69	113.8
2010 Avg	2011	51.39	90.7
2010 Wet	2009	53.34	103.8
2030 Dry	2030	56.18	105.3
2030 Avg	2033	51.38	91.5
2030 Wet	2032	51.96	101.1
2040 Dry	2044	59.06	113.7
2040 Avg	2039	53.15	90.0
2040 Wet	2036	51.50	96.9
2070 Dry	2068	61.31	119.1
2070 Avg	2074	58.10	94.8
2070 Wet	2067	52.39	90.2
2100 Dry	2097	66.82	127.6
2100 Avg	2092	58.07	86.9
2100 Wet	2093	58.13	100.1

Table 3 Model Simulated Change in Well Withdrawals

Scenario	Climate Data Year	Irrigation Demand (Inches)	Percent of Baseline
NFSEG Baseline	2010	9.29	100
2010 Dry	2014	12.81	137.9
2010 Avg	2011	11.23	120.9
2010 Wet	2009	10.73	115.5
2030 Dry	2030	14.77	159.0
2030 Avg	2033	9.80	105.5
2030 Wet	2032	13.61	146.5
2040 Dry	2044	14.96	161.0
2040 Avg	2039	13.03	140.2
2040 Wet	2036	12.02	129.4
2070 Dry	2068	16.01	172.3
2070 Avg	2074	15.70	169.0
2070 Wet	2067	11.10	119.4
2100 Dry	2097	19.87	213.8
2100 Avg	2092	12.73	137.0
2100 Wet	2093	14.92	160.5

4 MODEL ASSUMPTIONS AND LIMITATIONS

Jones Edmunds made the following assumptions in developing the model scenarios:

- Recharge and ET parameters were modified across the model domain, assuming similar climate change effects to all areas of the model.
- Modifications to recharge assume changes based on Alachua County soils and crop cover. The model simulations do not account for land cover and soil variations across the model domain.
- Simulations do not account for changes in population or land use because of the high degree in uncertainty in their projections. The effects of population growth were considered in the projections of water demand that were made in the water supply report.
- Regulatory limits to withdrawals were not accounted for in the irrigation scenarios.

Additionally, the NFSEG is a steady-state model. The time to reach steady-state conditions is typically several years and exceeds the length of a dry or wet year; therefore, the dry/wet year scenarios likely overestimate potential impacts.

5 RESULTS OF CLIMATE CHANGE SCENARIOS

Jones Edmunds exported the Surficial Aquifer System ,SAS, (Layer 1) and Upper Floridan Aquifer, UFA, (Layer 3) heads and the change in stream flows from the model simulations to calculate the changes in heads and flows for each simulation. We ran two simulations for each model scenario – the first simulation accounted for differences in ET and recharge due to changes in crop demand without any changes to well withdrawals. The second simulation included changes to well withdrawals.

Tables 4 and 5 summarize the SAS minimum, maximum, mean, and median water elevations for cells within Alachua County for the scenarios with and without irrigation change, respectively. Figures 1 and 2 show the mean SAS water levels in Alachua County for the simulations with and without changes in irrigation, respectively. Figures 3 through 7 show the simulated SAS water levels for the model scenarios.

The maximum water levels in the SAS show extreme fluctuations in the wet year caused by flooded cells. The SAS is an unconfined aquifer, and the NFSEG does not simulate surface runoff. Therefore, water levels continue to rise regardless of ground surface elevation. For this reason, the maximum SAS levels are not accurate.

The minimum SAS water levels show minimal variation because the SAS is discontinuous across Alachua County, and water levels drop below the SAS in portions of the County. The minimum elevations, therefore, are influenced by the elevation where the SAS pinches out.

The predicted mean and median levels are similar to the current range (2010) in water levels. The most significant variation was shown in the wet year water levels, with future wet year water levels 4 to 15 higher than the current simulated wet year (2009). The flooded cells in the 2030, 2070, and 2100 wet years indicate the potential for more runoff.

The irrigation scenarios showed little change in SAS levels; however, few water supply wells have been constructed in the SAS. SAS withdrawals in the 2010 baseline are approximately

0.5 percent of the UFA withdrawals, with only 147 withdrawals from Layer 1 versus over 470,000 withdrawals in Layer 3 (UFA). Alachua County has only five simulated SAS withdrawals compared to 211,876 UFA withdrawals.

Table 4 Model SAS Levels (feet NGVD) for Simulated Changes in Recharge and ET

Scenario	NFSEG 2010*	2010 Avg	2010 Dry	2010 Wet	2030 avg	2030 dry	2030 wet	2040 avg	2040 dry	2040 wet	2070 avg	2070 dry	2070 wet	2100 avg	2100 dry	2100 wet
Max	187	183	177	183	182	181	474	182	174	187	184	177	429	182	181	319
Min	25.4	25.3	25.2	25.3	25.2	25.0	26.0	25.2	25.2	25.5	25.3	25.2	25.9	25.2	25.2	25.9
Mean	82.5	77.0	71.6	77.9	74.4	71.9	102	76.0	70.1	82.9	78.7	71.0	99.7	75.5	73.2	93.6
Median	66.3	61.4	55.0	62.6	58.2	55.5	77.9	60.2	54.3	66.6	63.4	55.0	77.0	59.5	56.9	75.3

*NFSEG 2010 verification was used as the model baseline.

Table 5 Model SAS Levels (feet NGVD) for Simulated Changes in Recharge and ET and Irrigation

Scenario	NFSEG 2010*	2010 Avg	2010 Dry	2010 Wet	2030 avg	2030 dry	2030 wet	2040 avg	2040 dry	2040 wet	2070 avg	2070 dry	2070 wet	2100 avg	2100 dry	2100 wet
Max	187	183	177	183	181	181	473	182	174	187	184	176	428	182	181	317
Min	25.4	25.3	25.2	25.3	24.9	24.9	25.9	25.2	25.1	25.5	25.2	25.2	25.9	25.2	25.2	25.9
Mean	82.5	76.9	71.5	77.9	72.0	71.5	102	76.0	69.9	82.8	77.3	70.9	99.5	75.5	73.2	93.3
Median	66.3	61.3	55.0	62.5	55.6	55.2	77.9	60.1	54.2	66.5	62.1	54.9	76.9	59.4	56.8	75.1

*NFSEG 2010 verification was used as the model baseline.

Figure 1 SAS Mean Levels for Simulated Changes in Recharge and ET without Irrigation Change for Average, Wet, and Dry Years

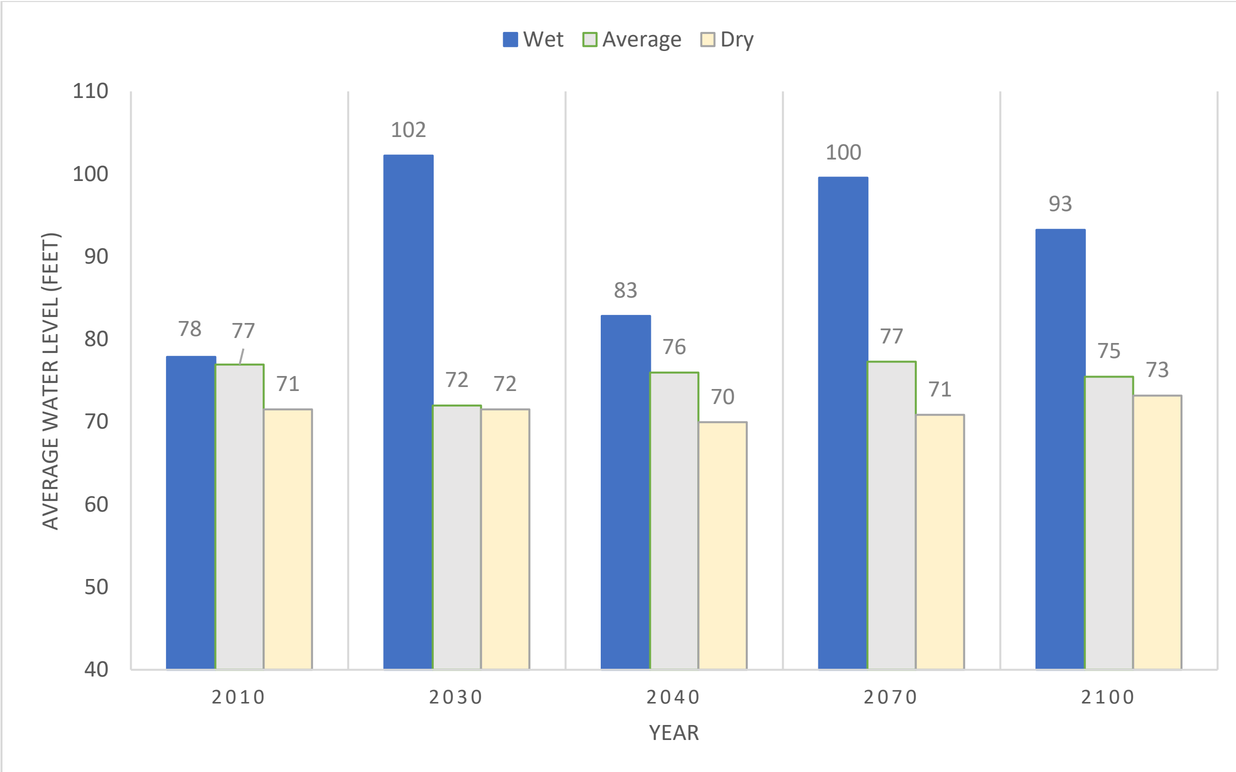


Figure 2 SAS Mean Levels for Simulated Changes in Recharge and ET with Irrigation Change for Average, Wet, and Dry Years

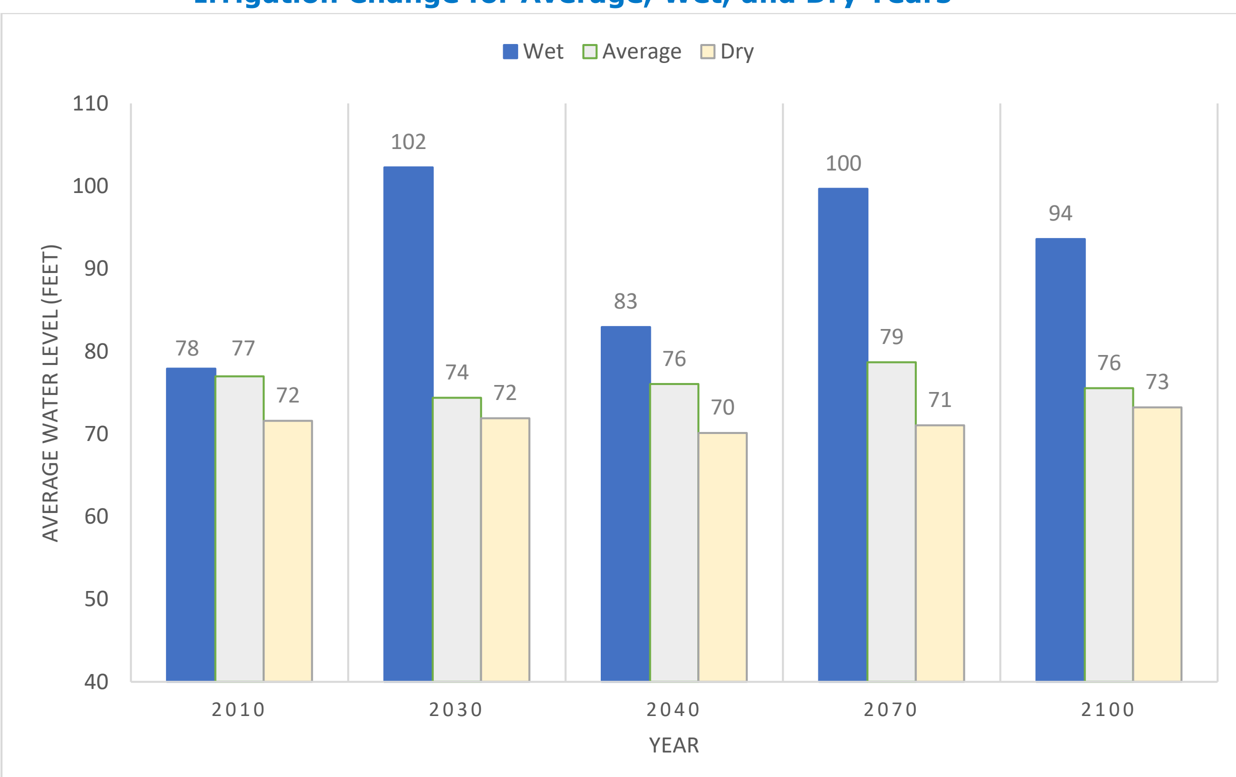


Figure 3 2010 SAS Simulated Water Levels

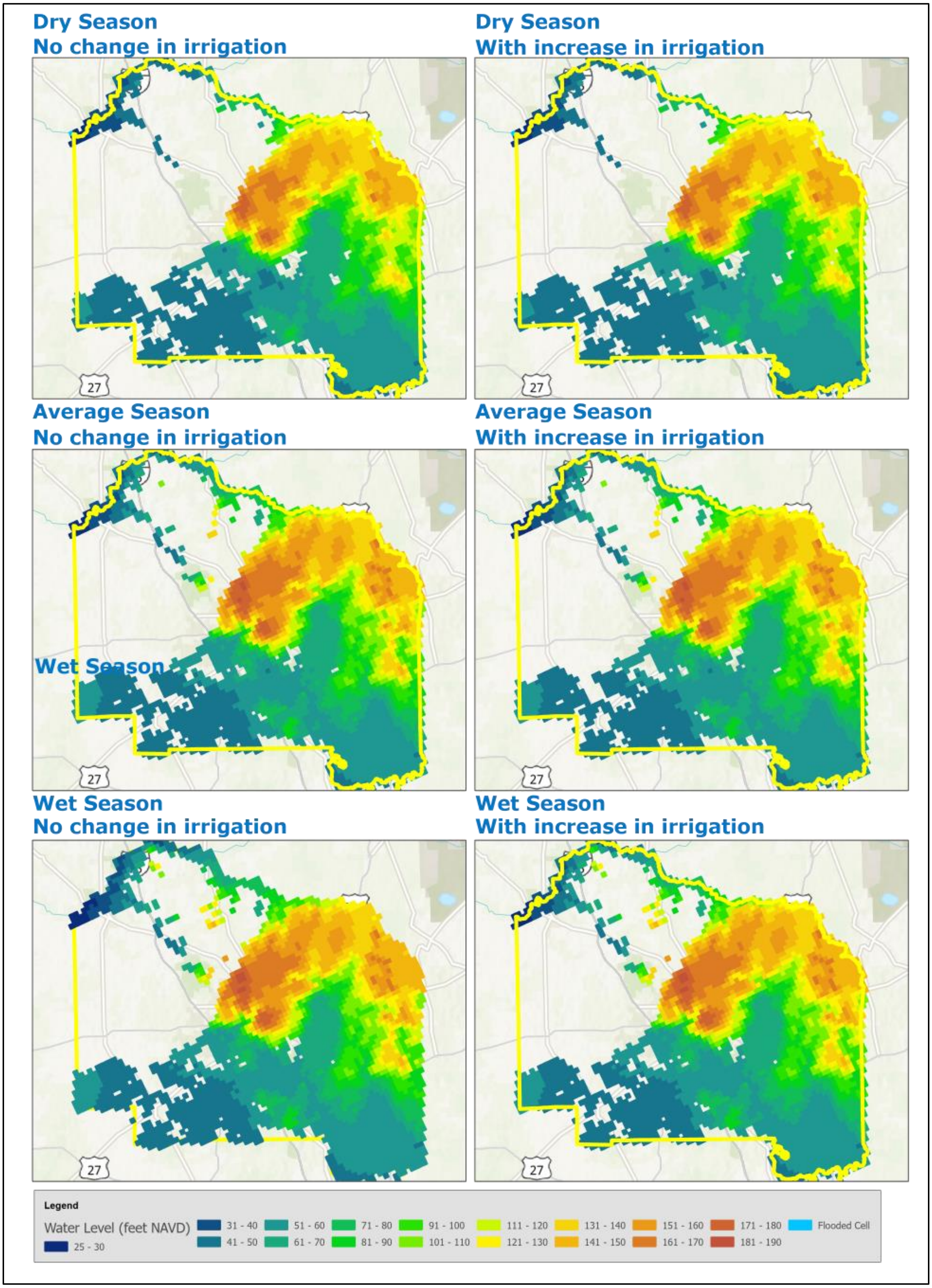


Figure 4 2030 SAS Simulated Water Levels

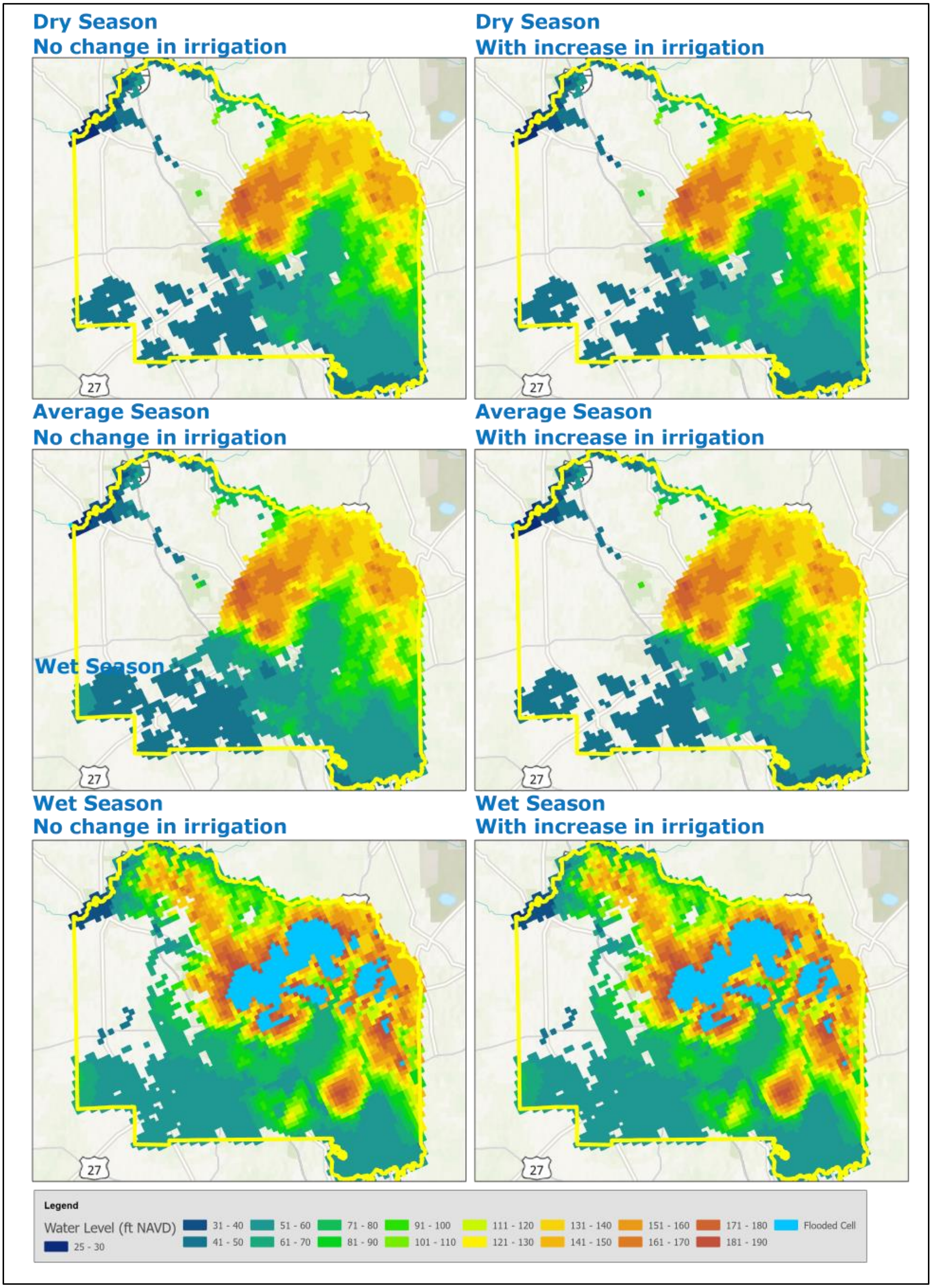


Figure 5 2040 SAS Simulated Water Levels

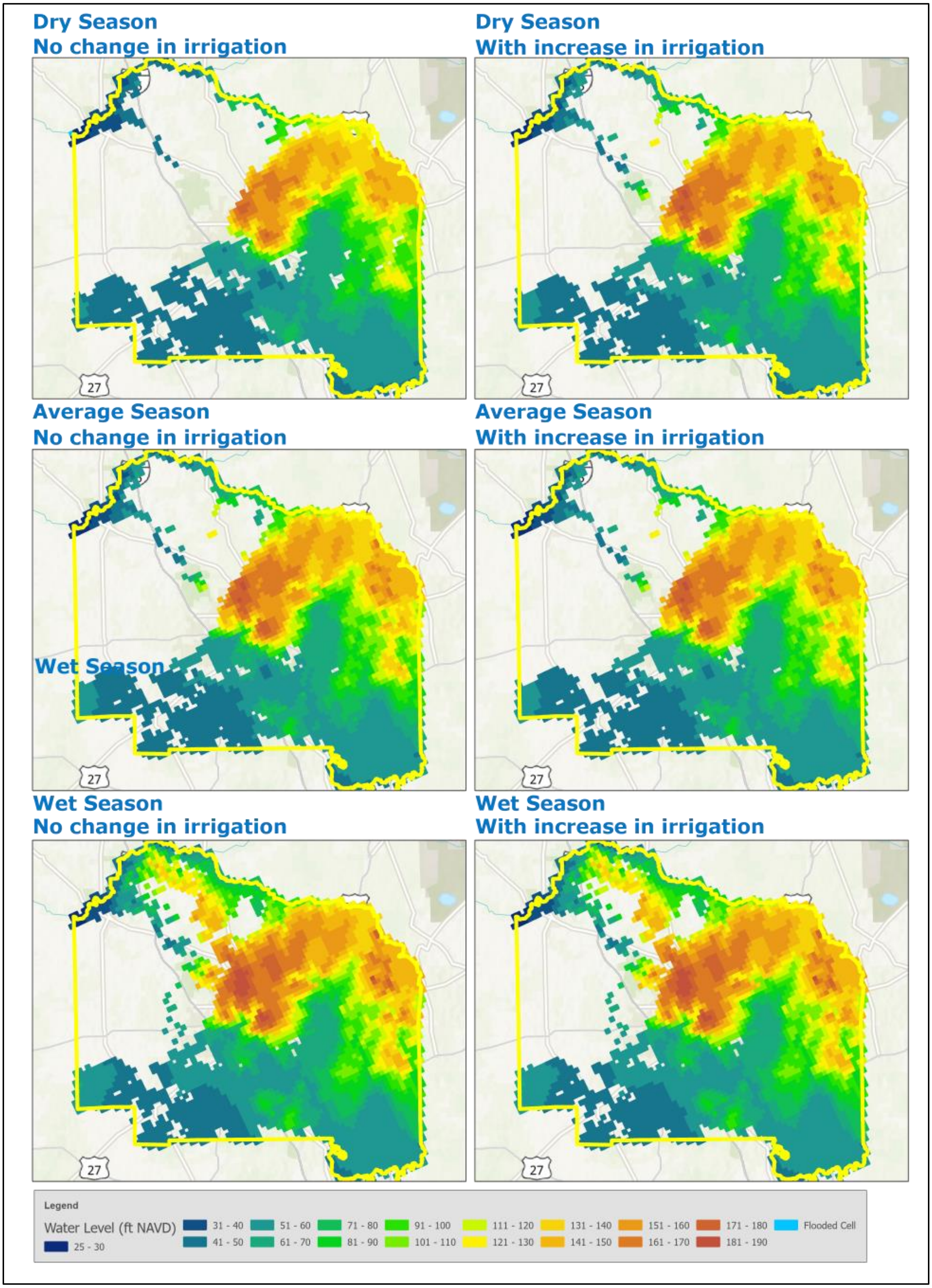


Figure 6 2070 SAS Simulated Water Levels

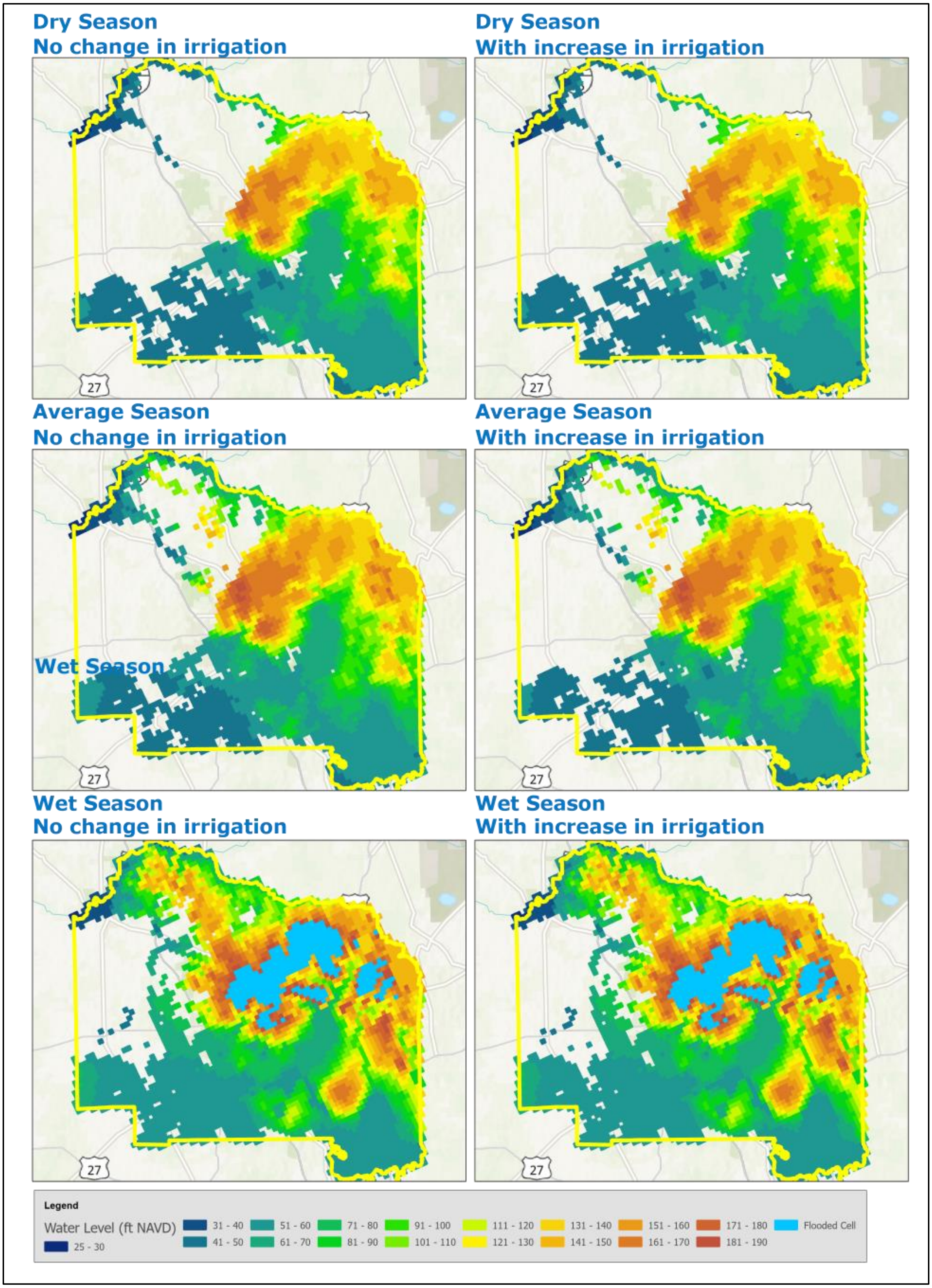
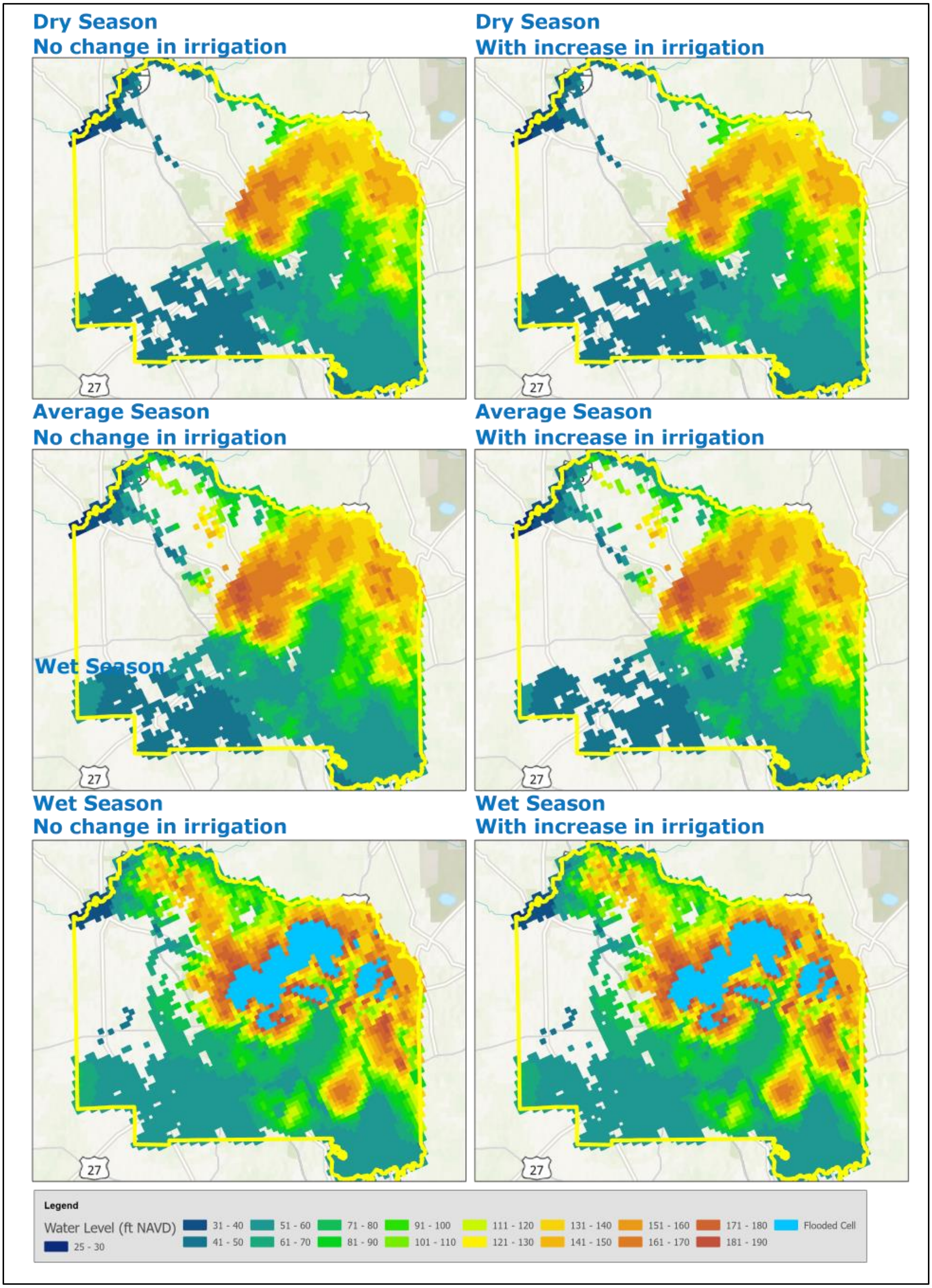


Figure 7 2100 SAS Simulated Water Levels



Tables 6 and 7 summarize the UFA minimum, maximum, mean, and median water elevations for cells within Alachua County for the scenarios with and without irrigation change, respectively. Figures 8 and 9 show the mean UFA water levels in Alachua County for the simulations with and without changes in irrigation, respectively. Figures 10 through 14 show the simulated UFA water elevations.

The average year water levels in the UFA are comparable to the 2010 simulated levels. The wet year water levels in the UFA show the most variation from the current scenarios, with higher levels predicted in all future scenarios. The dry year levels were generally consistent with current levels except for 2030. The 2030 scenario shows how rainfall timing could significantly impact the range in aquifer levels with larger rain events followed by dry periods. The model scenarios used the daily predicted climate data to calculate crop need for each day. If the rainfall exceeded the crop need, the remaining rainfall (up to one inch) is available to recharge the aquifer. If more than one inch of rainfall occur swithin 24 hours, it is assumed to runoff and the water is removed from the water balance. Therefore, if there is an increase in larger rain events, the amount of runoff becomes more significant, and the groundwater recharge may be less even though annual rainfall is greater.

The irrigation scenarios show 0.26 foot to 1.35 feet of change in average UFA levels due to increased withdrawals to meet crop demand. We simulated increased withdrawals for all well types (domestic supply, public supply, and irrigation). We did not account for regulatory permit limits in withdrawal changes; however, the water management districts have the authority to limit withdrawals through water use restrictions and individual water use permits. Permit requirements and changes in land use and crop cover to more climate-tolerant crops may mitigate additional withdrawals.

Table 6 Model UFA Levels (feet NGVD29) for Simulated Changes in Recharge and ET**

Scenario	NFSEG 2010*	2010 Avg	2010 Dry	2010 Wet	2030 avg	2030 dry	2030 wet	2040 avg	2040 dry	2040 wet	2070 avg	2070 dry	2070 wet	2100 avg	2100 dry	2100 wet
Max	77.7	75.9	74.7	76.1	77.7	68.6	86.3	75.4	74.5	78.0	76.3	74.7	85.5	75.4	74.9	83.2
Min	24.9	24.2	23.8	24.3	24.9	18.9	27.5	24.1	23.8	25.1	24.4	23.8	27.4	24.1	23.9	27.4
Mean	51.8	50.9	50.3	51.0	51.8	46.2	57.0	50.7	50.2	52.0	51.1	50.3	56.9	50.6	50.4	56.0
Median	49.1	48.7	48.4	48.7	49.1	42.6	54.6	48.6	48.3	49.4	48.8	48.4	54.7	48.6	48.5	54.3

*NFSEG 2010 verification was used as the model baseline.

**NGVD29 varies from 0.78 to 0.98 feet lower than NAVD88

Table 7 Model UFA Levels (feet NGVD29) for Simulated Changes in Recharge and ET and Irrigation**

Scenario	NFSEG 2010*	2010 Avg	2010 Dry	2010 Wet	2030 avg	2030 dry	2030 wet	2040 avg	2040 dry	2040 wet	2070 avg	2070 dry	2070 wet	2100 avg	2100 dry	2100 wet
Max	77.7	75.6	74.2	75.9	74.9	65.6	85.0	74.8	73.6	76.6	75.9	74.2	84.7	74.8	74.5	80.8
Min	24.9	18.8	13.9	20.2	22.4	-0.5	15.9	13.3	7.7	15.5	5.8	5.9	24.1	14.2	14.1	9.6
Mean	51.8	50.7	50.0	50.9	50.4	44.9	56.5	50.3	49.7	51.4	50.6	49.8	56.5	50.3	50.1	54.8
Median	49.1	48.6	48.3	48.7	48.5	42.1	54.9	48.5	48.2	49.2	48.7	48.3	54.6	48.5	48.4	53.8

*NFSEG 2010 verification was used as the model baseline.

**NGVD29 varies from 0.78 to 0.98 feet lower than NAVD88

Figure 8 UFA Mean Levels for Simulated Changes in Recharge and ET without Irrigation Change

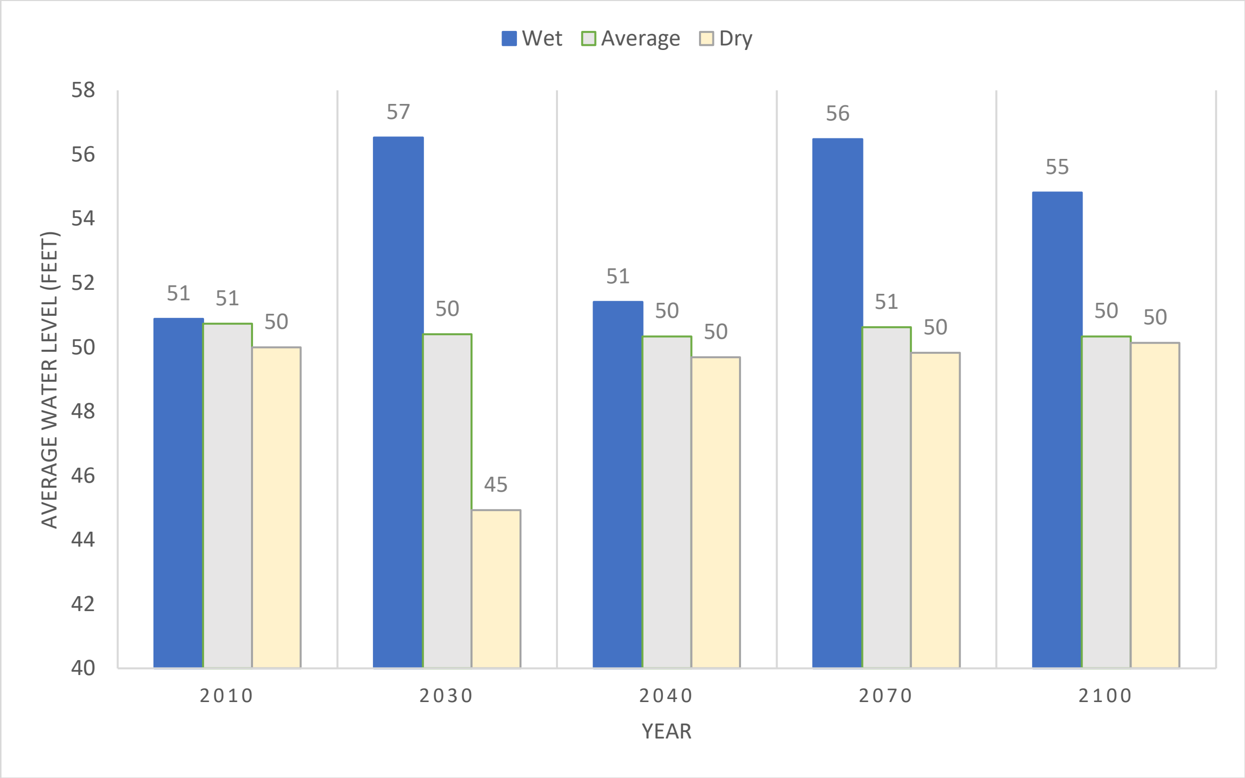


Figure 9 UFA Mean Levels for Simulated Changes in Recharge and ET with Irrigation Change

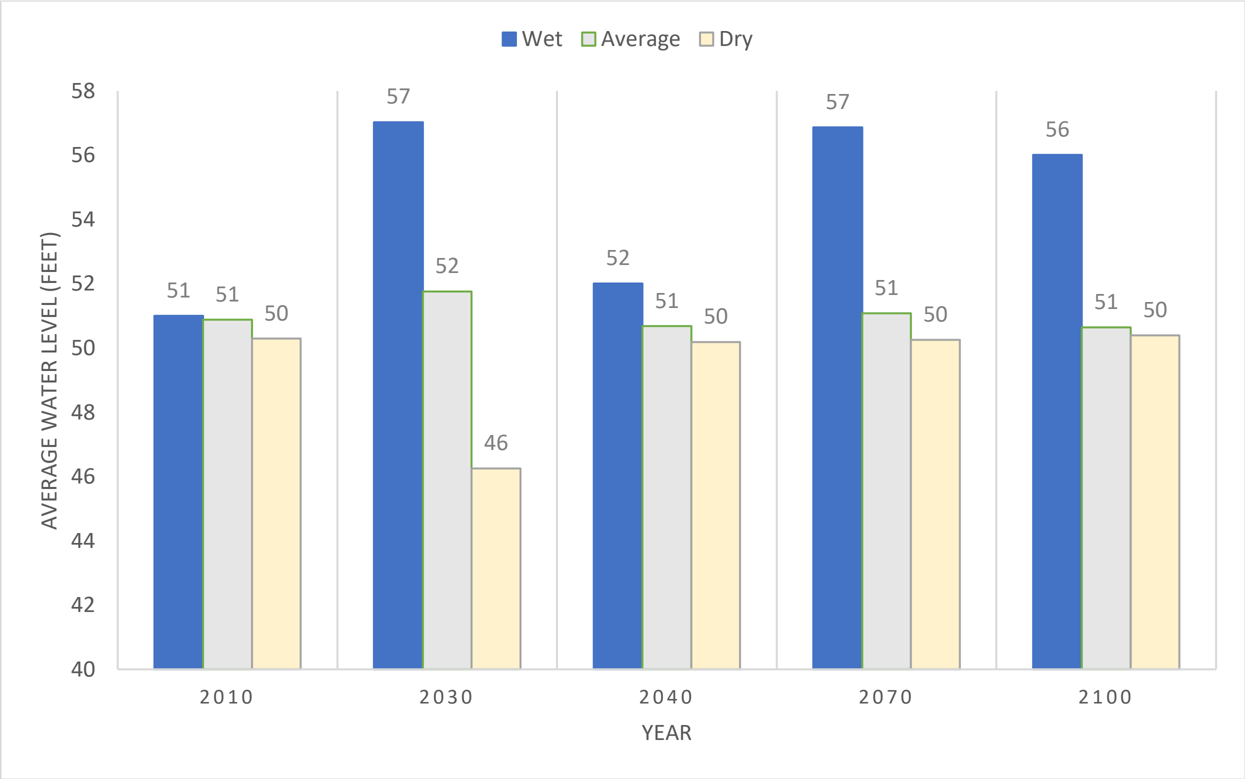


Figure 10 2010 UFA Simulated Water Levels

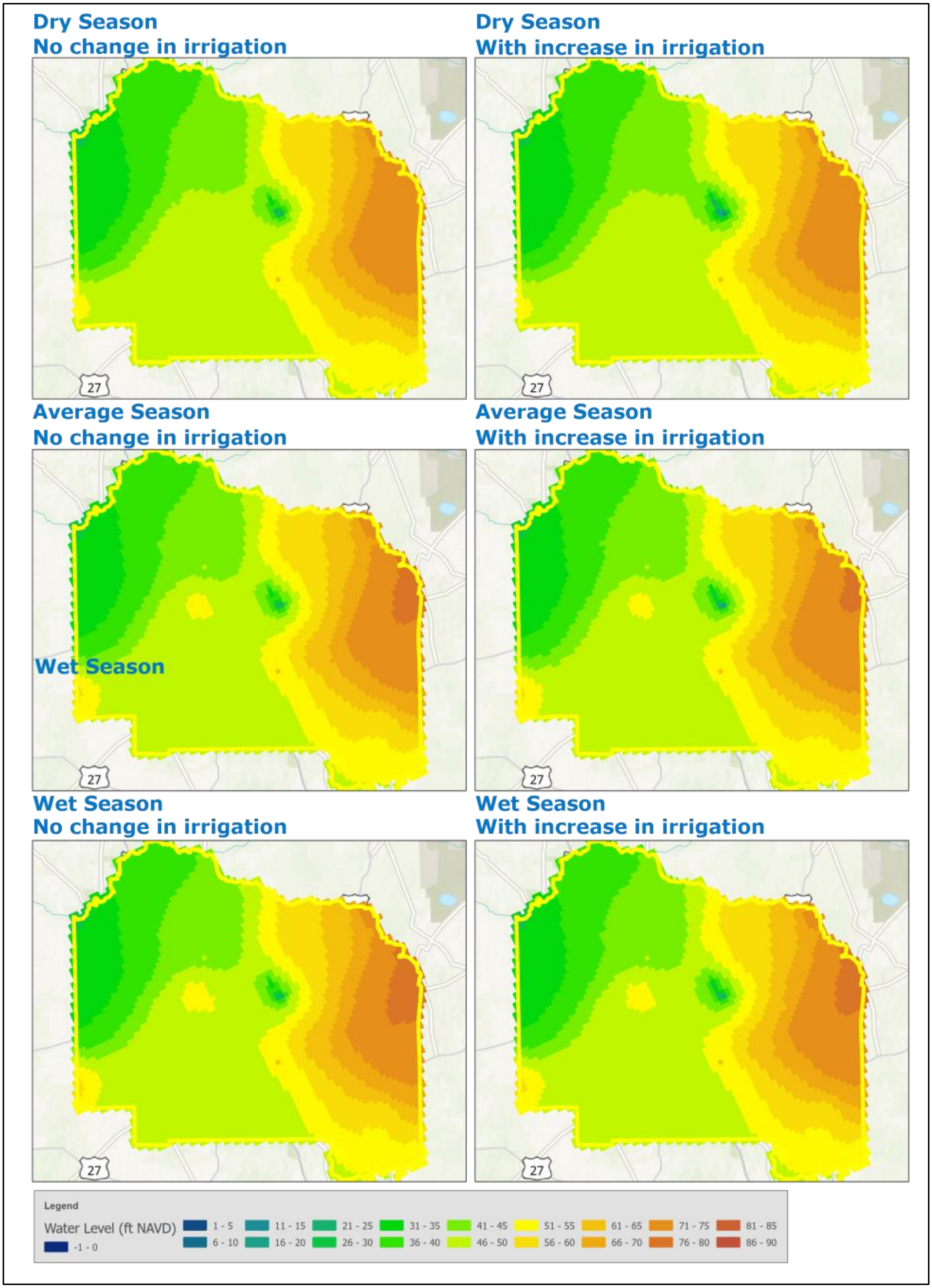


Figure 11 2030 UFA Simulated Water Levels

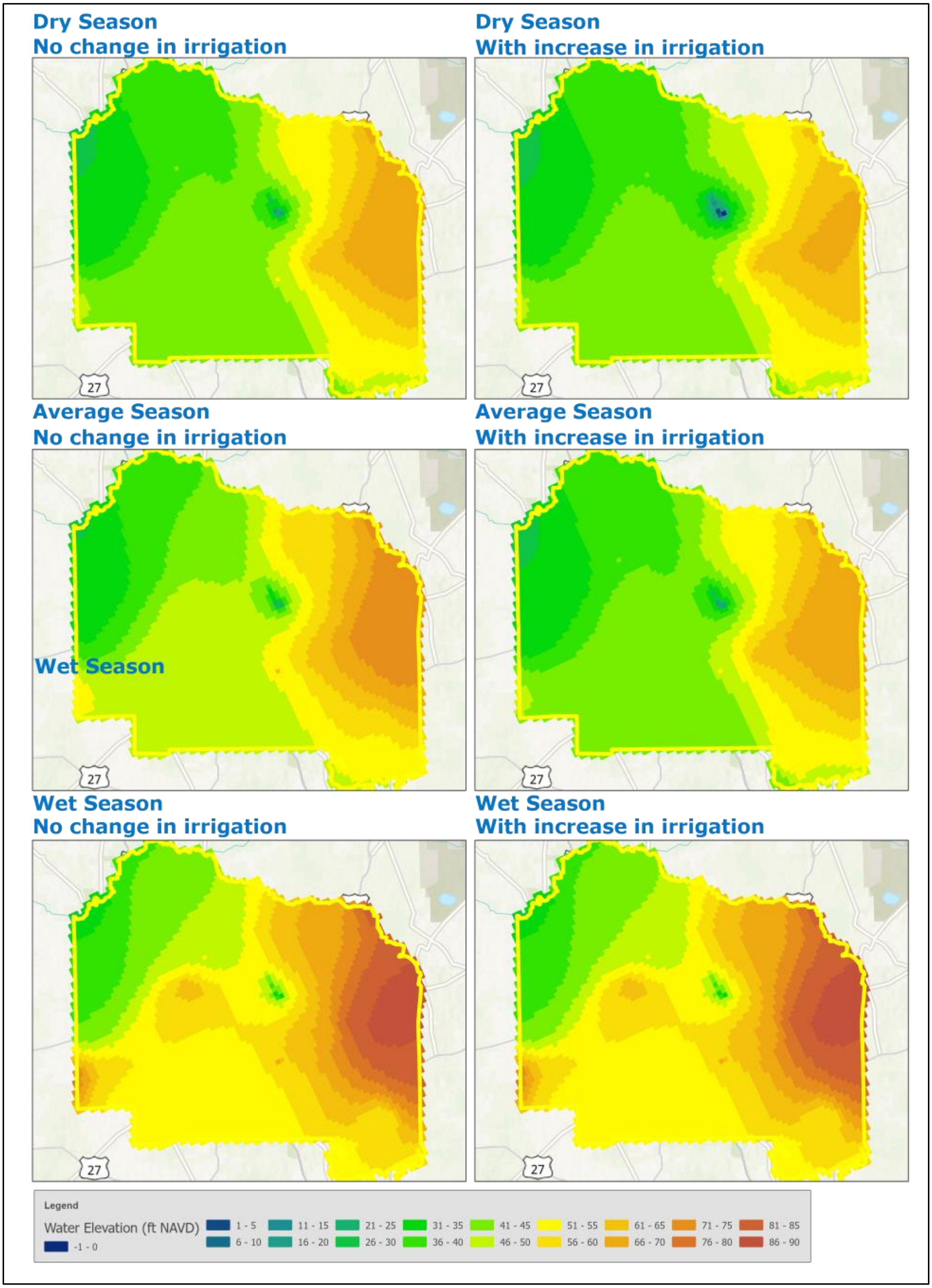


Figure 12 2040 UFA Simulated Water Levels

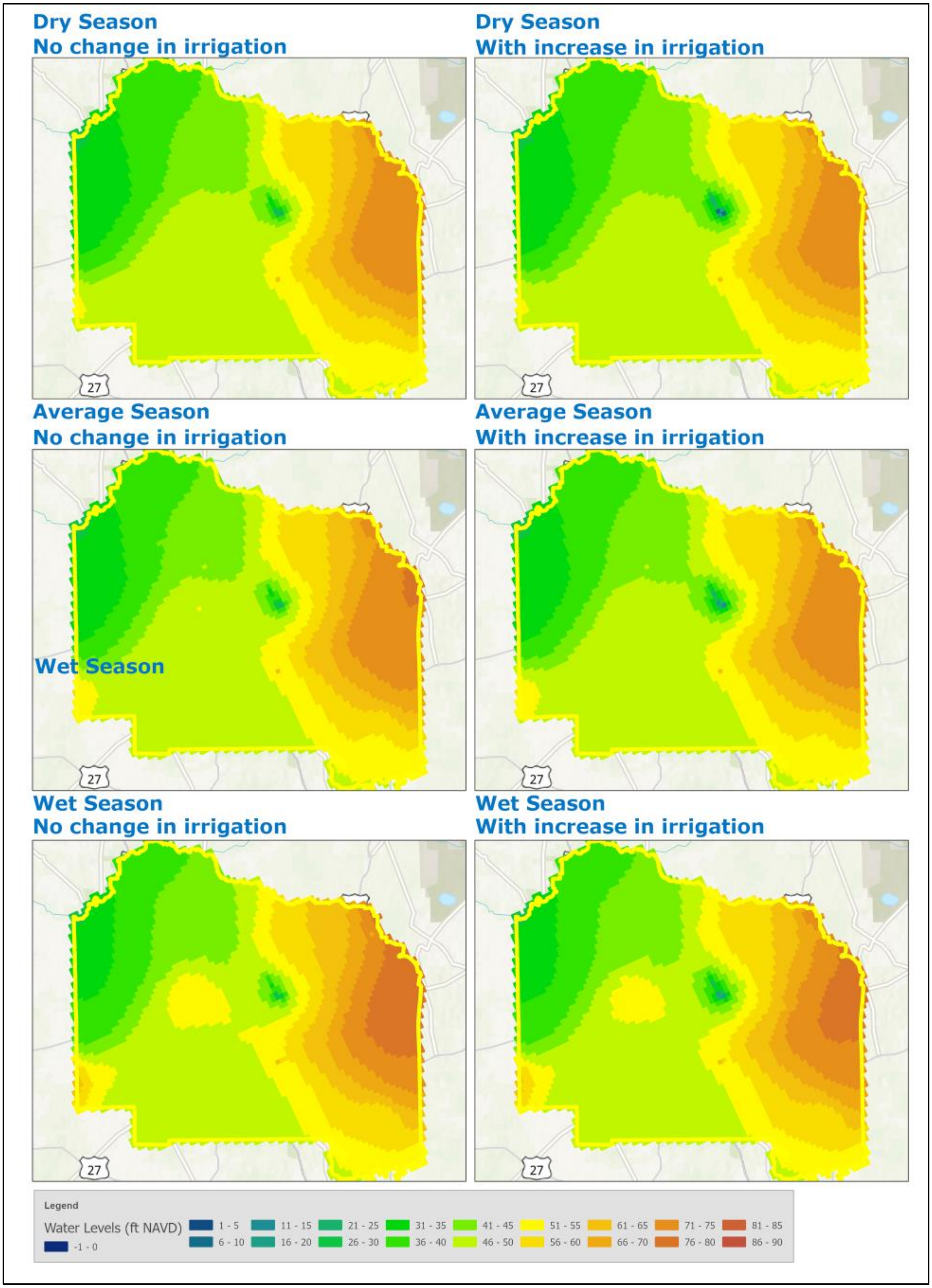


Figure 13 2070 UFA Simulated Water Levels

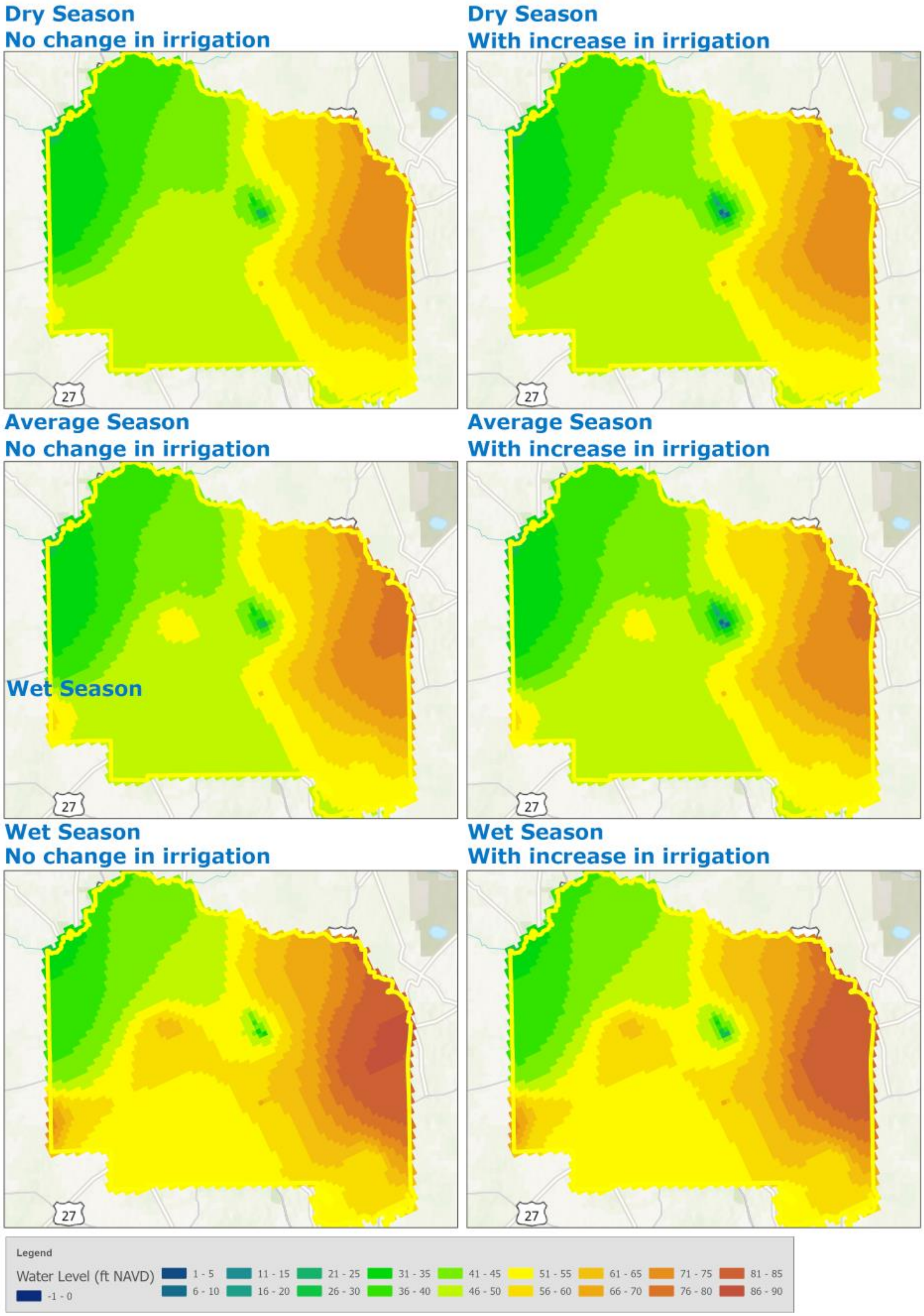
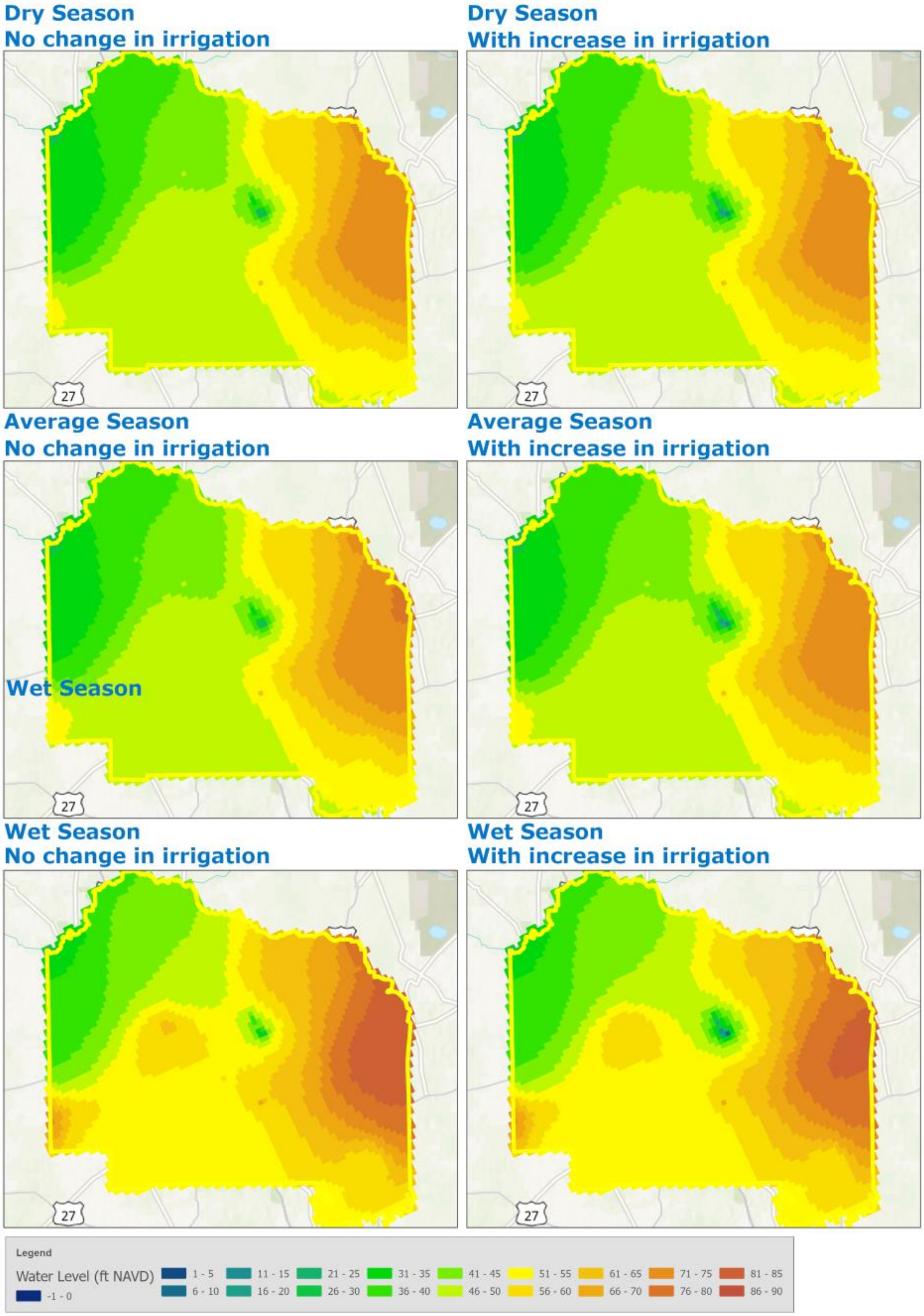


Figure 14 2100 UFA Simulated Water Levels



6 POTENTIAL IMPACTS TO EXISTING USERS

We obtained Well Completion Reports (WCRs) from SJRWMD and the Suwannee River Water Management District (SRWMD) to identify potential impacts on existing users from changes in water levels. The SJRWMD database provided latitude/longitude information for the wells; however, the SRWMD database only provided the Section, Township, and Range (STR) for each well. Therefore, the SRWMD wells are plotted based on the center of each STR.

We compared the well casing and total depths to the SAS thickness to identify SAS and UFA wells. Water supply wells typically have pumps placed within the casing column. If water levels drop below the pump, the pump will need to be reset at a lower elevation, or a deeper well will need to be drilled. For the existing user analysis, we estimated the number of wells that might require replacement, assuming 10 feet of water were needed within the casing column to use the existing well. Wells without casing depths were omitted from the analysis. We estimated casing elevations using the WCR depth and ground surface elevations from LiDAR. The inaccuracy of the well location and the casing depths in the WCRs affect the estimate of dry wells; therefore, we omitted wells calculated to be dry in the 2010 scenarios to eliminate wells with potentially inaccurate data.

Tables 8 and 9 show the number of UFA wells predicted to require replacement. We did not identify a need to replace wells in the scenarios not listed, and no SAS wells were predicted to require replacing. The estimates are based on data available in the well completion report databases. Additional wells that may not have been entered in the database are not evaluated. The well types presented in Table 9 are from the well completion report; however, private well use does not require repermitting to change domestic wells to irrigation wells. Figure 15 shows the predicted dry wells and UFA drawdown for the 2030 dry year with increased irrigation, the most extreme year simulated.

The UFA aquifer drawdown is most significant near the City of Gainesville's public supply wellfield. The increased irrigation scenario assumes that public supply will rise to meet crop demand; however, we did not consider water use restrictions and costs, so the increase in irrigation may be overestimated.

Table 8 UFA Wells Predicted to Require Replacement

Scenario	No Irrigation Change	Increased Irrigation
2030 Dry	244	315
2040 Dry	8	22
2040 Avg	0	4
2070 Dry	5	14
2070 Avg	0	3
2100 Dry	0	4
2100 Avg	0	4

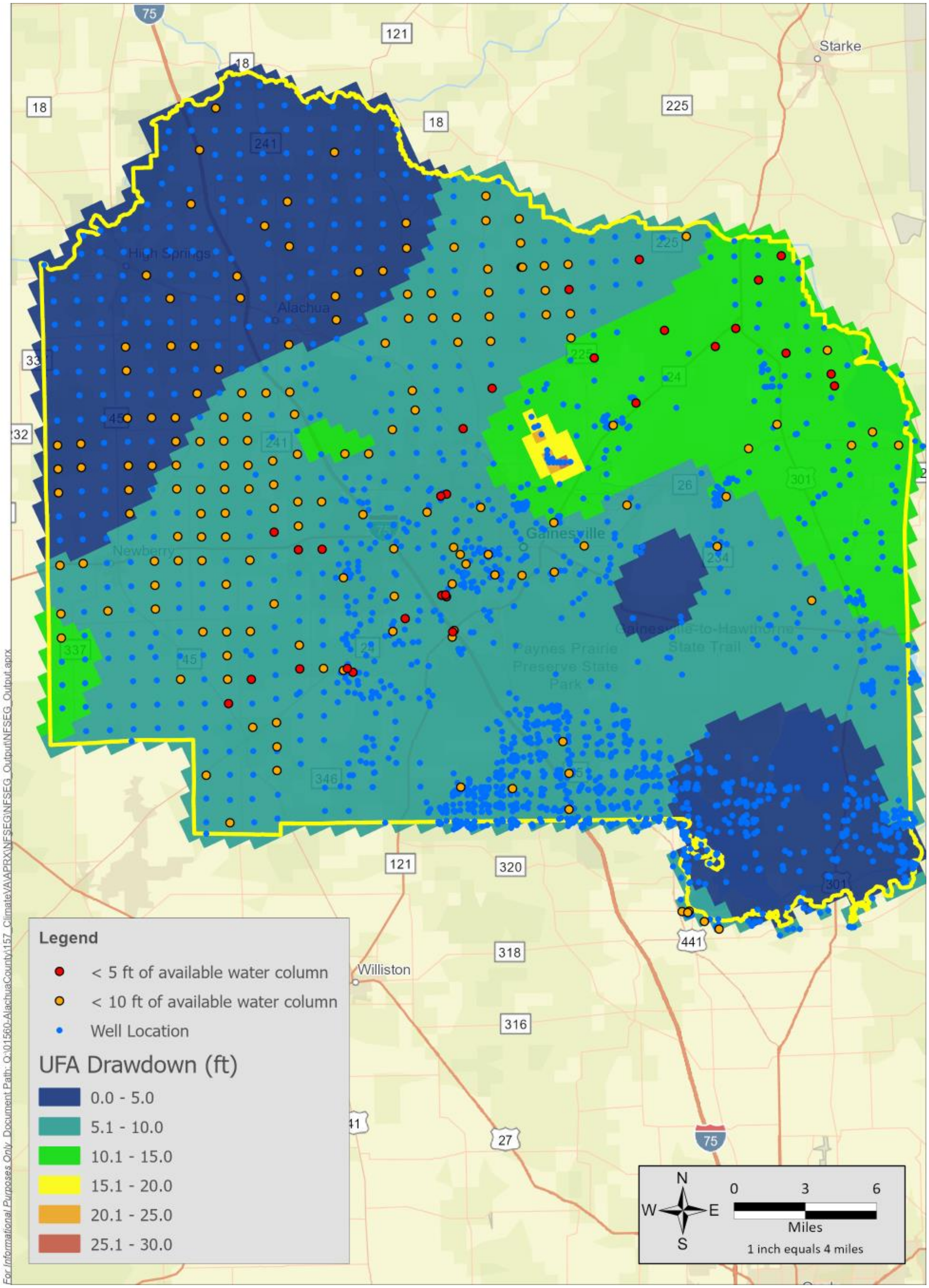
*NFSEG 2010 verification was used as the model baseline.

Table 9 UFA Wells Predicted to Require Replacement by Well Type

Well Type	Predicted Dry Wells
Domestic	271
Irrigation	15
Commercial/Industrial	2
Public Supply	2
Monitor	8
Remediation - Recovery	1
Essential Services (Fire Protection)	1
Type not Specified	12
Other	3

*Based on 2030 Dry Scenario with Irrigation

Figure 15 Estimated Dry Wells, 2030 Dry Scenario with Increased Irrigation



7 SINKHOLE RISK

The Florida Geological Survey (FGS) lists the following types of sinkhole areas within Florida:

- Area I. Bare or thinly covered limestone. Sinkholes are few, generally shallow and broad, and develop gradually. Solution sinkholes dominate.
- Area II. Cover is 30 to 200 feet thick. Consists mainly of incohesive and permeable sand. Sinkholes are few, shallow, of small diameter, and develop gradually. Cover-subsidence sinkholes dominate.
- Area III. Cover is 30 to 200 feet thick. Consists mainly of cohesive clayey sediments of low permeability. Sinkholes are most numerous, of varying size, and develop abruptly. Cover-collapse sinkholes dominate.
- Area IV. Cover is more than 200 feet thick. Consists of cohesive sediments interlayered with discontinuous carbonate beds. Sinkholes are very few, but several large-diameter deep sinkholes occur. Cover-collapse sinkholes dominate.

Most of Alachua County is characterized as Area I or Area III. Figure 16 shows the FGS sinkhole areas. Area I is characterized by solution sinkholes that form by the dissolution of karst rocks at or near the surface. Area III is characterized by the collapse of overlying material into subsurface cavities. The dissolution of carbonate rocks over a human timescale is typically negligible (Gutierrez, 2016). Subsidence processes are not necessarily related to active dissolution but occur above pre-existing voids where natural or anthropogenic alternation processes cause ground instability.

In Alachua County, sinkholes most commonly form in west and central Alachua County, where limestone is exposed or thinly covered (Area I). An increase in the amplitude of water level variations and the frequency of water level variations will increase the risk of sinkholes. Factors related to climate change that may accelerate or trigger sinkhole development include (Gutierrez, 2016; Newton, 1984):

- Increased water input
- Impoundment of water
- Water table decline
- Vegetation removal

Although climate models predict a slight decrease in annual rainfall (Jones Edmunds, 2023), the wet years are expected to have more extreme water level variations. Increased water input from large storm events will increase percolation and downward movement of cover material (raveling), will increase the weight of overlying materials, and may reduce the mechanical strength and bearing capacity of sediments.

Larger storm events will also require changes to stormwater management. The impoundment of additional water can potentially increase sinkhole risk through increases in the cover load, high hydraulic gradients leading to rapid turbulent flows increasing erosion and dissolution, changes in groundwater flow paths and discharge zones, and repeated flooding and draining of karst conduits. Sinkhole formation in stormwater ponds compromises their ability to provide water quality treatment until repair.

More extreme dry years or lowering the water table from increased withdrawals also increases sinkhole risk. Lowering the water table generally to below the soil–rock contact results in a loss of buoyant support and increased pore pressure gradients (and thus water velocities). Where pumping is the cause of water level decline, groundwater flow is accelerated around cones of depression, and fine materials may be entrained with pumped water.

The predicted increases in ET may result in die-off of cover crops without increases in irrigation. Without replacement with a more suitable cover crop, vegetation removal will reduce cover deposits' mechanical strength and increase infiltration and potential for raveling.

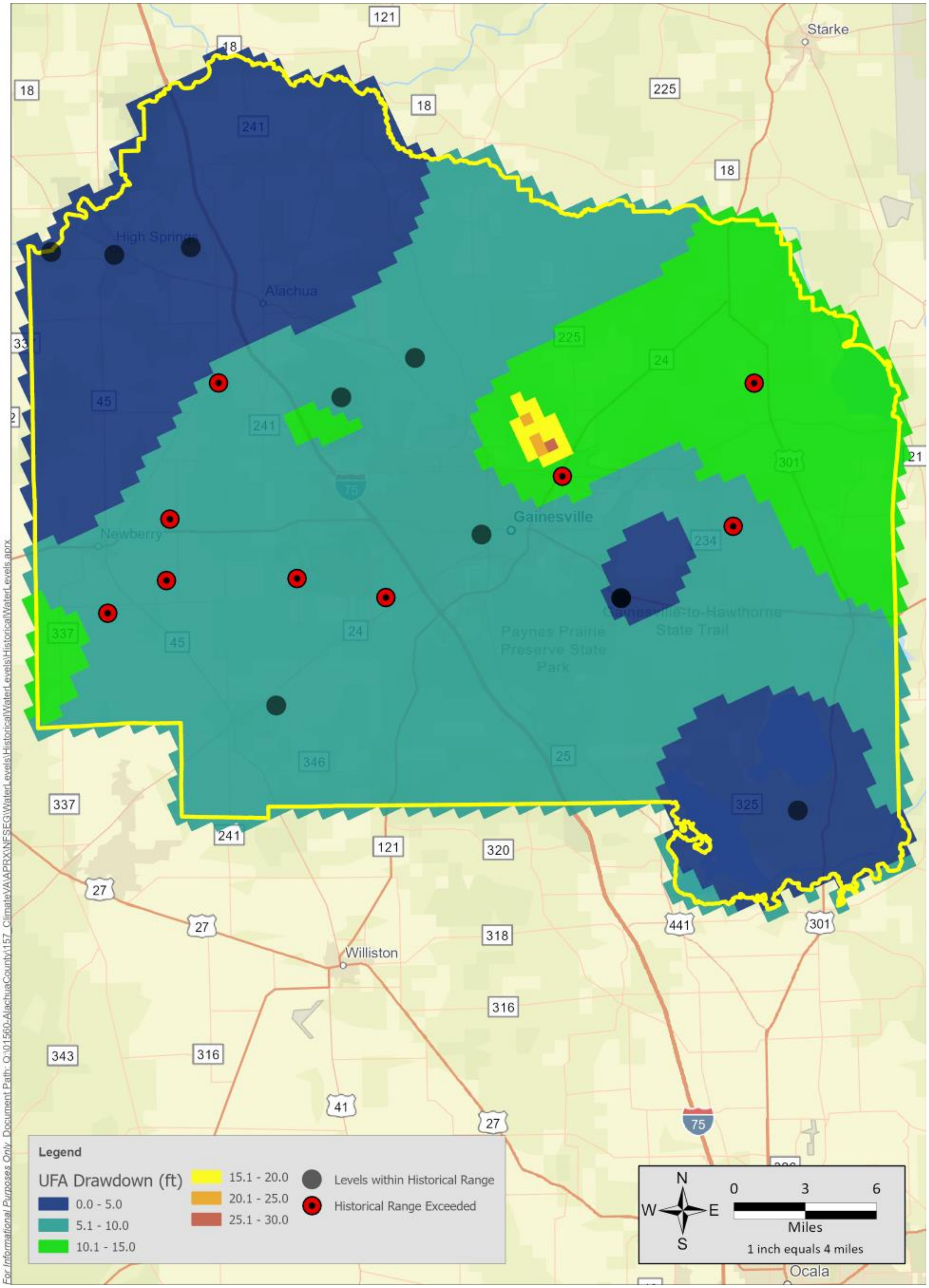
We compared historical water levels from monitor wells maintained by SRWMD and SJRWMD to the range in water levels predicted by the model scenarios to identify areas where an increased amplitude in water level variation may increase sinkhole risk. Table 10 compares the period of record (POR) water level range to the simulated heads from the model scenarios. The levels highlighted in bold exceed the historical range in water levels. Figure 16 shows the water level monitoring stations. The sinkhole risk may increase in the southwest part Alachua County where the historical water level range is exceeded, and in central Alachua County, where the predicted drawdown is most significant.

Table 10 Historical Water Levels

Station ID	Source	POR	POR Minimum Elevation*	POR Maximum Elevation	Model Predicted Minimum Elevation	Model Predicted Maximum Elevation
S081703001	SRWMD	1964–2023	29.3	42.8	31.2	36.0
S081806005	SRWMD	2004–2023	10.4	40.5	34.7	40.5
S081833003	SRWMD	2000–2012	29.2	43.5	34.3	**44.1**
S091938002	SRWMD	1980–2015	37.6	74.0	41.6	54.8
S081926001	SRWMD	1978–2023	35.5	47.4	37.2	47.3
S101722001	SRWMD	1958–2023	33.5	53.8	40.1	**57.2**
S091736001	SRWMD	2000–2012	33.0	48.1	36.3	**49.4**
S101713003	SRWMD	2000–2012	33.6	45.8	39.3	**53.7**
S111811001	SRWMD	1981–2023	36.0	55.5	41.9	54.2
S102006001	SRWMD	1976–2023	36.5	56.1	42.1	55.0
S081706009	SRWMD	2009–2023	24.3	38.6	27.9	30.9
260030	SJRWMD	1995–2023	35.6	55.4	**34.9**	50.6
2742330	SJRWMD	1999–2023	47.6	59.5	52.2	58.0
7385224	SJRWMD	2014–2023	56.2	66.9	56.8	63.8
7392376	SJRWMD	1989–2015	38.6	53.0	42.2	**54.9**
7432368	SJRWMD	1979–2013	34.2	51.3	42.0	**55.2**
35935468	SJRWMD	2001–2001	65.2	81.0	**64.5**	**81.2**
260031	SJRWMD	1995–2023	150.0	161.9	**142.5**	157.5
7385226	SJRWMD	2014–2023	59.1	69.5	64.8	65.0
32644069	SJRWMD	2013–2023	144.4	151.8	**138.3**	**245.1**
35935472	SJRWMD	2016–2023	90.4	103.8	**89.3**	**129.9**

*Elevations are in feet NAVD88.

Figure 16 Comparison of Historical to Model Simulated Water Level Range



8 REFERENCES

Agsilico. (2023). *Alachua County Agricultural Risk Assessment – Task 3*.

Durden, D., F. Gordu, D. Hearn, T. Cera, T. Desmarais, L. Meridth, A. Angel, C. Leay, J. Oseguera. 2019. *North Florida Southeast Georgia groundwater Model (NFSEG v1.1)* Technical Publication SJ2019-01.

Gutiérrez, F. 2016. Sinkhole Hazards, published online https://doi.org/10.1093/acrefore/9780199389407.013.40.

Jones Edmunds, 2023, Critical Infrastructure and Land Use Climate Vulnerability Analysis – Task 3.1 – Climate Data Review Technical Memorandum. October 10, 2023.

Newton, J. G., 1984, Sinkholes resulting from groundwater withdrawals in carbonate terrains: An overview. Reviews in Engineering Geology of the Geological Society of America, 6, 195-202.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, *MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods* 6–A37, 44 p.