SJRWMD and SWFWMD Responses to Stakeholder Comments on the Draft Central Springs Groundwater Flow Model (CSM) version 1.0

January 31, 2024

Introduction

The Central Springs Groundwater Flow Model (CSM) version 1.0 was developed collaboratively between the St. Johns River Water Management District (SJRWMD) and the Southwest Florida Water Management District (SWFWMD) (Districts). The CSM was designed to quantify the effects of current and future groundwater withdrawals on aquifer levels, river baseflows, and spring discharges and provide inputs for water supply planning, minimum flows and levels (MFL) evaluations, and regulatory decisions in north-central Florida.

Valuable input from independent modeling experts (peer reviewers) on the CSM conceptual and interim models allowed for the incorporation of peer reviewer recommendations in model development and report documentation. The final draft CSM was submitted to the peer reviewers, and their final comments and the Districts' responses are included in a separate document.

As the Districts value the input of stakeholders in the development of new assessment tools, the draft CSM was also presented to utilities, local governments, consultants, and other interested parties for their review and feedback. A recorded CSM overview presentation was posted online along with the draft model files and draft report on October 4, 2023, and stakeholders were notified via email of the start of the stakeholder comment period. Comments were submitted via an online comment tool and through a centralized email address accessible to the Districts. The stakeholder review and comment period ended on November 13, 2023.

The Districts received four separate comment submittals from stakeholders. The first submittal contained numerous editorial suggestions for the CSM report, which were incorporated into the final report as the Districts determined appropriate. The Districts are grateful for the time and effort of this stakeholder in their meticulous review of the draft report. Responses to this comment submittal are not included in this resolution document as the comments were exclusively editorial.

Three sets of substantive stakeholder comments were received and are included in this document with responses from the Districts. The Districts appreciate the level of stakeholder review regarding CSM performance in western Volusia County and in the vicinity of the Villages developments. It should be noted that the CSM is a regional groundwater flow model that covers a large area of north-central Florida. Although the CSM achieved the majority of the predetermined calibration criteria on a regional basis, as with other regional models, the model may not perform as well in certain localized areas. Any modifications made to District models (or external models previously approved for use by the Districts) as part of the water/consumptive use permit (WUP/CUP) application process, will be reviewed by regulatory and modeling staff on a case-by-case basis. The model development team thoroughly reviewed all submitted comments alongside the CSM and determined that refinements to the CSM in western Volusia County and near the Villages developments were necessary. The model development team is currently working on the next version of the CSM (version 1.1), which will address specific peer review comments and stakeholder comments as indicated in the responses below. It is anticipated that CSM v1.1 will be completed later this year.

The following sections of this document provide the Districts' responses to comments submitted on behalf of the West Volusia Water Suppliers (WVWS)[1], the City of Orange City, and the utilities collectively referred to as "the Villages."

Andreyev Engineering Inc. (through Mead & Hunt, Inc.) on behalf of the WVWS[2]

The following comments were submitted by Andreyev Engineering, Inc. (AEI) on November 8, 2023, and are included in their entirety in Appendix A.

Comment #1: *The statistical data presented in the table above [Summary of Calibration Data for the CSM Model] indicates that the CSM model has an average to low level of calibration for all aquifer layers and spring flows. The calibration target point data for various wells and spring flows included in Appendix B [WVWS/AEI report] confirm the relatively poor level of calibration.*

> **Response:** The referenced table (*Summary of Calibration Data for the CSM Model*), developed by AEI, shows a Spring Flows Mean Avg. Error value that is larger than the Mean Max Error value, which is not possible. According to calculations by the model development team, the mean average error for the three springs within western Volusia County (Blue, De Leon, and Gemini springs) is 1.45 cubic feet per second (cfs), which is much smaller than the value indicated in the table (9.20 cfs).
>
> The CSM meets the groundwater head and springflow calibration criteria for the model domain as described in the report. A regional model such as the CSM may not perform as well in specific local areas. However, based on input from stakeholders and a subsequent review of the CSM in western Volusia County, the Districts will be refining the model in this area and may recalibrate as part of the CSM v1.1 modeling effort.

Comment #2: *The CSM model was set up with a series of Drain cells across the west Volusia area. It is assumed that this option was selected in the model to account for surface runoff or discharge when the groundwater elevation in the surficial aquifer reaches ground surface or some overflow elevation. If that is the case, then it appears that the option was erroneously included in the west Volusia ridge area where all runoff or overflow is internally drained and does not discharge off-site. Any runoff or overflow that may occur would generally flow to the nearest depression, retention pond, or lake and be retained within the region of the west Volusia ridge.*

> **Response: T**he Districts will be re-evaluating the drain cells in western Volusia County as part of the CSM v1.1 modeling effort.

Comment #3: *The [layer 1] water balance summaries above [on pages 4 and 5 of AEI report in Appendix A] reveal the calibration concerns in relation to runoff/overflow and minimum transmission of water from the surficial aquifer to the UFA [Upper Floridan Aquifer]. Review of the highlighted values in the tables above reveals that the CSM model transmits only about 42% to 51% of the total inflowing water from the surficial aquifer to the upper Floridan aquifer within the West Volusia Ridge area. This is not a realistic calibration of the model where the internally drained ridge area should be transmitting close to 100% of*

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[1] The West Volusia Water Suppliers (WVWS) include Volusia County and the cities of DeLand, Deltona, and Orange City.

[2] The AEI comment report was also submitted to the Districts by the City of DeLand, one of the four members of the WVWS, on October 8, 2024. The signed cover letter is included in Appendix A.

the water entering the surficial aquifer to the upper Floridan aquifer (UFA). Furthermore, review of the vertical transmission of water (Bottom) for the increased recharge (~ 13 inches) with WVWS projects 2040 indicates that the net amount of water transmitted to the UFA is actual less than the scenario without the additional recharge, which does not make sense and suggests something is definitely wrong with the model calibration.

Response: The layer 1 water balance summaries in the two AEI tables are incorrect as presented. For table *CSM As-is West Volusia Ridge Water Balance*, according to the Groundwater Vistas (GWV) output shown in *CSM Water Balance As-Is/MODFLOW Mass Balance*, the Bottom Inflow should be 0 cfd (0 cfs); the Bottom Outflow should be 5,898,671 cfd (68.27 cfs); and the Lateral Flow values (calculated as the sum of Storage, X min, X max, Y min, and Y max) should be 12,280 cfd (0.14 cfs) for Inflow and 632,584 cfd (7.32 cfs) for Outflow. For table *CSM with WVWS Projects 2040 West Volusia Ridge Water Balance*, according to the GWV output shown in *CSM Water Balance with WVWS Projects 2040/MODFLOW Mass Balance*, the Lateral Flow values should be 12,262 cfd (0.14 cfs) for Inflow and 670,259 cfd (7.76 cfs) for Outflow. Corrected layer 1 water balance tables are provided below.

CSM As-Is West Volusia Ridge [Layer 1] Water Balance (corrected)

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	12,070,105	0	139.70	0.00
Evapotranspiration	0	6,008,835	0.00	69.55
Runoff (Drains)	0	222,820	0.00	2.58
Wells	220,455	525	2.55	0.01
River	555,036	94,430	6.42	1.09
Bottom	0	5,898,671	0.00	68.27
Top	0	0	0.00	0.00
Lateral Flow	12,280	632,584	0.14	7.32
Total	***12,857,876***	***12,857,865***	***148.82***	***148.82***

cfd = cubic feet/day
cfs = cubic feet/second

CSM with WVWS Projects 2040 West Volusia Ridge [Layer 1] Water Balance (corrected)

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	12,070,105	0	139.70	0.00
Evapotranspiration	0	6,820,180	0.00	78.94
Runoff (Drains)	0	470,700	0.00	5.45
Wells	1,372,697	525	15.89	0.01
River	552,072	100,211	6.39	1.16
Bottom	67,139	6,012,398	0.78	69.59
Top	0	0	0.00	0.00
Lateral Flow	12,262	670,259	0.14	7.76
Total	***14,074,274***	***14,074,274***	***162.90***	***162.90***

cfd = cubic feet/day
cfs = cubic feet/second

According to the corrected layer 1 water balance tables shown above, the vertical transmission of water (Bottom) for the increased recharge associated with WVWS projects 2040 indicates that the net amount of water transmitted to the UFA is larger than the scenario without the additional recharge. This result signifies that the CSM is conceptually sound; a portion of the project-related recharge (simulated via injection wells to the SAS) goes to the UFA, while the remaining portion goes to groundwater ET, lateral flow, and stream flow (RIV/DRN). It should be noted that the Districts will be reviewing the model's calibration in western Volusia County, which may be revised as part of the CSM v1.1 modeling effort.

Comment #4: *The table[s] above [CSM Model – Blue Springs Flow Simulations & Impacts and TWVGWM Model – Blue Springs Flow Simulations & Impacts] provides supporting data that the surficial aquifer has not been properly represented in the CSM model. The net recharge of 16.72 cfs into the surficial aquifer results in only 6.78% of the recharging water contributing to Blue Spring flows. This is not a realistic net increase as one would expect a considerably higher increase in spring flow. In contrast, the better calibrated TWVGWM [Transient West Volusia Groundwater Model] model shows about 50.5% of the recharging water contributing to Blue Spring flows, which is realistic.*

Response: As shown in the previous response, when water is injected into layer 1 of the CSM (the surficial aquifer) to simulate recharge, a portion goes to ET, lateral flow, and stream flow in addition to flow to the UFA. It may not be appropriate to compare net recharge in the CSM with net recharge in the TWVGWM, as the TWVGWM does not appear to account for groundwater ET. However, based on input from stakeholders and a subsequent review of CSM aquifer parameters in western Volusia County, the Districts will be re-evaluating the aquifer parameters in this region and may recalibrate the model as part of the CSM v1.1 modeling effort.

Comment #5: *…it is our opinion that the CSM model calibration has erroneously converged to excessively low vertical permeability along the west Volusia ridge area. This creates a condition where the recharging water is limited to flow laterally or mound sufficiently high to discharge via the Drain cells which are also erroneously selected for this model. This is also demonstrated above in the water balance analyses... Based on the CSM model response to recharge it appears that the vertical permeability (leakance) between the surficial aquifer and the UFA may be poorly calibrated. …when comparing vertical permeability of the surficial aquifer across the wet Volusia ridge areas, the calibrated values in the CSM model are about 2 orders of magnitude lower that the values in the TWVGWM model, i.e., 0.00016 to 0.0005 ft/day versus 0.025 to 0.032 ft/day. This further supports the concern that the vertical permeabilities (leakance) of the surficial aquifer in CSM model were erroneously calibrated to unrealistic low values due to the assumed runoff/overflow using the Drain cells and poor calibration in the west Volusia ridge area.*

Response: As part of the CSM v1.1 modeling effort, the Districts will be re-evaluating the aquifer parameters (including ICU leakance) and drain cell usage in this region.

Comment #6: *Review of the permeability values reveals a calibration concern in terms of the variation of the values in the CSM model. Where the horizontal permeability values are expected to be lower, i.e., low and wet areas, the values are high and where the values are expected to the higher, i.e., high and dry ridge areas, the values are very low [see Appendix C of the WVWS/AEI report].*

Response: As part of the CSM v1.1 modeling effort, the Districts will be re-evaluating the aquifer parameters in this region.

Comment #7: *The CSM model is not adequately calibrated in the west Volusia ridge area, the primary service areas of the WVWS.*

Response: The CSM meets the groundwater head and springflow calibration criteria for the CSM model domain as described in the report. It is understandable that a regional model such as the CSM may not perform as well in specific localized areas. However, based on input from stakeholders and a subsequent review of the CSM in western Volusia County, the Districts will perform refinements in this area and may recalibrate the model as part of the CSM v1.1 modeling effort.

Comment #8: *It is our recommendation that WVWS must request the Water Management Districts (WMDs) to recalibrate the model, specifically in the west Volusia ridge prior to using the model for permitting or water use planning. It is our opinion that the Drain cells in all internally drained areas of the west Volusia ridge should be removed from the model. We also recommend that the recalibration work should consider the calibrated aquifer parameters of the TWVGWM model which were achieved using a finer model grid and represent higher degree of calibration.*

Response: The Districts will perform refinements in western Volusia County and may recalibrate the model as part of the CSM v1.1 modeling effort.

Liquid Solutions Group, LLC (LSG) on behalf of the City of Orange City

The following comments were submitted by LSG on November 13, 2023, and are included in their entirety in Appendix B.

Comment #1: *Review the simulated vertical hydraulic conductivity of the Intermediate Confining Unit (CSM Layer 2) within and in the vicinity of the City's utility service area.*

- *Consider adjusting this aquifer parameter to better represent the aquifer recharge potential in the City; or please explain the reasoning for maintaining the existing values, and/or whether local model modifications to be made by stakeholders would be allowed for the purpose of Consumptive Use Permit (CUP) evaluations.*

Response: The Districts will be re-evaluating the aquifer parameters and drain cell usage in this region and may recalibrate the model as part of the CSM v1.1 modeling effort.

The CSM is a regional model, and similar to other regional models, may not perform as well in certain localized areas. Any modifications made to District models (or external models previously approved for use by the Districts) as part of the WUP/CUP application process, will be reviewed by regulatory and modeling staff on a case-by-case basis.

Comment #2: *Review the use of MODFLOW's Drain Package in the Surficial Aquifer System (CSM Layer 1) within and in the vicinity of the City's utility service area.*

- *Consider the use of MODFLOW's Drain Return Package to simulate routing of excess water in the Surficial Aquifer System (CSM Layer 1) to the Upper Floridan Aquifer (CSM Layer 3) in the City; or please explain the reasoning for maintaining the existing conceptualization, and/or whether local model modifications to be made by stakeholders would be allowed for the purpose of CUP evaluations.*

Response: Use of the Drain Return Package (DRT) requires specification of a return flow fraction of the simulated drain flow, which is difficult to estimate on a regional scale. The model development team agrees that it may not be conceptually appropriate to assign drain cells to certain physiographic areas, such as the ridge areas located in western Volusia County, and this will be reviewed as a part of the CSM v1.1 modeling effort.

As indicated previously, any modifications made to District models (or external models previously approved for use by the Districts) as part of the WUP/CUP application process, will be reviewed by regulatory and modeling staff on a case-by-case basis.

Comment #3: *Review Blue Spring's simulated contributing area (springshed).*

- *Consider model input changes that will result in a better match between simulated and documented Blue Spring's springsheds; or please explain the reasoning for maintaining the existing conceptualization.*

Response: A springshed is typically delineated using a UFA potentiometric surface and/or groundwater flow model simulation representing a hydrological "snapshot" of a certain time period. The boundary of a springshed can vary significantly due to changes in hydrological and climatic conditions. For this reason, the model development team does not think it is appropriate to use an estimated springshed boundary to inform a regional model calibration or verify model parameters.

Comment #4: *Review simulated dry cells in the Upper Floridan Aquifer (CSM Layers 3 and 4) in the vicinity of the City's utility service area and Blue Spring.*

- *Consider model input changes that will eliminate dry cells within the model domain; or please explain the reasoning for maintaining the existing conceptualization.*

Response: Areas in which layer 1 is dry generally correspond to regions where the SAS and/or ICU are thin or completely absent. The large areas of dry cells in the western part of the model domain are expected as the UFA in this area is unconfined and the water table can be greater than 100 feet below land surface. The occurrence of dry cells in the CSM outside of these areas and within other layers may be attributed to a lack of nearby water level observations available to guide the calibration process. Dry cell distribution in western Volusia County, which includes the City's service area, will be reviewed as a part of CSM v1.1 modeling effort.

LSG and AEI (through Vikus Water) on behalf of Village Center Community Development District; North Sumter County Utility Dependent District; Wildwood Utility Dependent District; Gibson Place Utility Company, LLC; Gibson Place Water Conservation Authority, LLC; Middleton Utility Company, LLC; Middleton Water Conservation Authority, LLC; Blue Goose Utility Company, LLC; and Blue Goose Water Conservation Authority, LLC (referred to collectively as "*the Villages*")

The following comments were submitted by Vikus Water on November 13, 2023, and are included in their entirety in Appendix C.

Comment #1 (LSG): *Review and modify the simulated layer used for several wells as described herein [Tables 1 and 2, LSG report].*

- *Due to the number of layer mismatches, evaluate the methodology used to assign layers in the WEL file.*
- *Provide additional documentation on the process used to assign layers in the WEL file since the report did not contain any details on this process.*

Response: The identified well layering errors will be corrected in CSM v1.1. Documentation was added to the CSM report regarding the assignment of model layers to permitted wells in the well file. If further discrepancies are discovered, please provide well construction documentation to the appropriate district so that information in the corresponding well construction database can be updated with the correct information. This will ensure accurate model layer assignment in future model well files.

Comment #2 (LSG): *Review and update historic water use data in the CSM and update as necessary for accuracy.*

Response: Historical water use data associated with the Villages permits will be reexamined in CSM v1.1. The model development team will compare the water use data submitted by the permittee and in the SWFWMD database to ensure that best available data is used in the model.

Comment #3 (LSG): *Consider the use of aquifer performance test (APT) data in the calibration process.*

- *Include additional information on the development of the model parameters in the CSM.*
- *Add a discussion regarding the significant localized parameter changes in the model that are coincident with observation wells.*

Response: APT data from WUP/CUP applicants served as guidance at the regional level during the CSM calibration process. Additional text was added to Chapter 4 regarding the reasoning behind the qualitative rather than quantitative comparison between APT-derived and model calibrated aquifer parameters. Although APT-based parameters were used qualitatively in the CSM, it is possible that parameters from selected APTs may be utilized as quantitative constraints in a future version of the model.

In the CSM v1.1 modeling effort, a more detailed analysis will be conducted to calibrate the UFA and LFA (Lower Floridan Aquifer) transmissivity in the Villages area. The initial and optimized parameters will be compared to the APT data and any bull's eye patterns will be scrutinized during recalibration.

Comment #4 (AEI): *LFA well and pump test data submitted by the Villages over the last 20 years were not used for CSM calibration. The calibrated target points for the LFA appear to be very limited and are located far away from the Villages development areas. Although there are a few calibration points in the eastern portion of the Villages that were relatively well calibrated, they do not represent the central and southwestern portion of the Villages.*

Response: The Villages LFA well and pump test data served as qualitative references during calibration of the CSM. The LFA water level data offered a snapshot of the LFA potentiometric surface in the local area. However, it lacked temporal variation and did not undergo the same QA/QC procedure as the monitoring wells in the networks maintained by the Districts. Consequently, the Villages LFA wells were not used as quantitative targets for CSM calibration. As part of the CSM v1.1 modeling effort, additional consideration will be given to the data submitted by the Villages to enhance the representation of the LFA in the Villages Development area.

Comment #5 (AEI): *The same aquifer characteristics that were used in the expanded and recalibrated NDM5 [Northern District Model version 5.0] (including UFA and LFA horizontal permeability and MCU*

[Middle Confining Unit] vertical permeability) need to be entered into the CSM to obtain a reasonable calibration in the southern portion of the Villages Development.

> **Response:** The horizontal transmissivity of the UFA and LFA in the CSM is in reasonable agreement with values in the expanded NDM5. Limited data was available for the vertical permeability of layer 5 (MCU). As part of the CSM v1.1 modeling effort, further refinement of localized aquifer parameters, including consideration of values from APT tests and from the expanded NDM5, will be undertaken to enhance the model representation around the Villages Development.

Comment #6 (AEI): *The CSM calibrated potentiometric elevations of the LFA are significantly off for the entirety of the Villages Development, most notable in the southern expansion area (area of interest) where the difference is as high as 8 ft. [see Figure 2 in Appendix, AEI report]*

> **Response:** The LFA potentiometric surface simulated by the CSM was in general agreement with the observed regional groundwater level. Localized adjustments will be performed in the Villages Development area to enhance the representation of the LFA as part of the CSM v1.1 modeling effort.

Comment #7 (AEI): *The CSM is not adequately calibrated in the southern expansion area of the Villages Development. It is our recommendation that the District's recalibrate the CSM in the area of existing and future Villages developments prior to using the model for permitting or water use planning in and around the Villages development. For this purpose, the District modelers shall collect all the Villages specific calibration target points data and APT data and recalibrate the model accordingly.*

> **Response:** Further calibration will be carried out in the CSM v1.1 modeling effort to enhance the representation of UFA and LFA in the Villages area. SWFWMD modeling staff will extensively compare the results of this refined model with the NDM5. A series of scenario runs will be conducted to assess the model's predictive capabilities. The model will be utilized by SWFWMD for regulatory purposes in the Villages area only after a thorough examination has been completed. In the meantime, the expanded NDM5 model can be utilized for the Villages SWFWMD WUP applications until the regulatory version of the CSM is finalized and adopted.

APPENDIX A – COMMENTS RECEIVED FROM ANDREYEV ENGINEERING, INC.[1] (THROUGH MEAD & HUNT, INC.) ON BEHALF OF THE WEST VOLUSIA WATER SUPPLIERS

Note: The Andreyev Engineering, Inc. comment report was also submitted by the City of DeLand. The city's comment submittal cover letter is included as the last page of the appendix.

November 2, 2023

Joy Kokjohn
Regional Water Supply Planning Coordinator
Bureau of Water Supply Planning
St. Johns River Water Management District
P.O. Box 1429 ● Palatka, FL 32178

Subject: WVWS RESPONSES TO SJRWMD and SWFWMD CENTRAL SPRINGS MODEL

Dear Ms Kokjohn :

On behalf of the West Volusia Water Supply (WVWS) utility providers, we would like to offer responses to the Central Springs Model (CSM) prepared by SJRWMD and SWFWMD (WMD's). The group's hydrogeologic consultant, Andreyev Engineering, Inc. (AEI) has reviewed the model and prepared a report with findings and recommendations. A copy of the report is attached. AEI has raised concerns regarding the CSM model calibration, assumptions and effectiveness of the model to be used for future CUP permitting.

Specific concerns and recommendations are described, and supported, in the AEI report. In general, the findings conclude that the current CSM is not adequately calibrated in the west Volusia ridge area, the primary service areas of the WVWS utilities. It is recommended that the model should be recalibrated prior to use for permitting or water use planning. The recalibration should also include modifications described within this report. If the District is not willing to recalibrate the CSM for the west Volusia area, it is recommended that the District allow CUP permitting and planning for the WVWS utilities to continue and proceed based upon the existing 'Transient' model or other suitable models which are calibrated to observed conditions.

Thank you for your consideration. The WVWS utilities have completed the final draft of the '2023 WVWS Coordinated Water Supply Plan Update' and the modeling assumptions used in the report have a direct impact upon the Supply Plan deficit estimates and project recommendations. We are immediately available to discuss this topic at your earliest convenience.

Sincerely,
MEAD & HUNT, Inc.

Brad T. Blais, PE
VP/Market Leader

Russell Ferlita, PhD, PE
Water Practice Leader

Attachment: AEI report
cc: WVWS Utility Representatives

November 10, 2023
AEI Project No.: GPGW-23-001

TO: **Mead & Hunt**
P.O. Drawer 290247
Port Orange, Florida 32129-6810

Attention: Mr. Brad Blais, P.E.

SUBJECT: Review of Central Springs Model, Evaluation of Model Calibration, Comparison to Transient WVWS Model and Recommendations
West Volusia Water Suppliers, Volusia County, Florida

Dear Mr. Blais:

Per your request and authorization, Andreyev Engineering, Inc. (AEI) has completed a review of the Central Springs Model (CSM) that was recently released by the SJRWMD/SWFWMD for public review. This review was intended to compare the CSM model to the Transient West Volusia Groundwater Model (TWVGWM), to evaluate the accuracy of the model calibration, to assess the model predicted spring flow impacts and provide recommendations for the West Volusia Water Suppliers (WVWS) concerning the use of the CSM model for future CUP modeling and permitting.

This report summarizes the calibrated parameters in the west Volusia area (area of interest) for both the TWVGWM model and the newly published CSM model and provides an evaluation of the data used to calibrate the new CSM model and the accuracy of calibration. In addition, this summary report provides our recommendations for the effectiveness of the model to be used for future CUP permitting.

Transient West Volusia Model

The latest TWVGWM model simulates a transient period of 10 years, divided into 16 stress periods, and provides calibrated transient conditions for the west Volusia region. The model was originally calibrated for the period 1996 through 2005 and was used for modeling regional impacts in support of CUP permitting for the WVWS. Subsequently, the model was extended (for verification purposes) to include 2015, 2016 and 2017, and now includes the periods 1996 to 2002 and 2015 to 2017. A complete summary report with the updated model calibration and verification was previously submitted to the SJRWMD and was accepted for CUP modeling and permitting.

The TWVGWM model was refined to a grid of 500 ft x 500 ft and calibrated to a relatively high degree for surficial aquifer, upper Floridan aquifer and spring flows. Table below summarizes the "Goodness-of-fit" RMSE and Nash Sutcliffe (NSE) values. Based on these statistical parameters, it can be concluded that the model has been calibrated to a higher degree than most regional groundwater flow models. As indicated by the NSE, the highest calibration was achieved for the upper Floridan aquifer and spring flows, NSE of 0.97. An NSE of 1.0 indicates a perfect agreement between simulated and observed, an NSE of 0 or less indicates that the mean of the observation series is as good a predictor as the numerical model. Generally, an NSE in excess of 0.8 is considered a good fit, and in this case, most NSE's are greater than 0.95, indicating an excellent model fit. The R2 estimates for each group are included in the table below and more or less mirrors the NSE results, confirming that a reasonable model fit has been achieved. The estimates of RMSE are also favorable for a regional groundwater model. Based on this statistical data, the overall agreement between simulated and observed is very good.

Goodness-of-fit Statistics

Target	RMSE	Nash Sutcliffe NSE	R^2
Lake Water Levels	2.0 ft	0.96	0.97
Layer 1 Heads	3.31 ft	0.97	0.97
Layer 2 Heads	1.58 ft	0.97	0.97
Layer 3 Heads	1.77 ft	0.87	0.90
Spring Flows	8.5×10^5 ft^3/d	0.97	0.98

The statistical data presented in the table above indicates that the TWVGWM model has a high level of calibration for the west Volusia area that includes all service areas of the WVWS. The model was developed to be used for all MFL/MFR water bodies and springs modeling in support of CUP permitting. To date, the model has been successfully used for CUP permitting since 2010 and the model predicted impacts have been verified by field monitoring data. It is our professional opinion that this model is the most accurate model available for the west Volusia water supply area. We have included the target point calibration data for the TVWGWM model in **Appendix A.**

Central Springs Model (CSM) Review and Evaluation

AEI has downloaded the CSM model, both transient and steady state versions. We have executed the models and reviewed both the model structure and the model calibration. Then we extracted the model simulated potentiometric elevation contours for comparison with the TWVGWM model. For the CSM model, several of the calibration target points were downloaded from the interactive maps provided by the District and the resulting plots of observed versus simulated data are included in **Appendix B**. The table below summarizes the goodness of fit for the calibrated target points as extracted from the documentation of the calibration data for CSM model:

Summary of Calibration Data for CSM Model

Targets	Mean Avg. Error	Mean Max Error	Mean Min Error	R^2
Surficial Aquifer	3.59	23.67	-12.14	0.47
Upper Floridan Aquifer	1.99	4.85	-6.36	0.64
Lower Floridan Aquifer	2.46	8.44	0.78	0.63
Spring Flows	9.20	6.78	3.55	0.41

The statistical data presented in the table above indicates that the CSM model has an average to low level of calibration for all aquifer layers and spring flows. The calibration target point data for various wells and spring flows included in **Appendix B** confirm the relatively poor level of calibration.

Comparative Modeling Evaluation

For the purpose of this review and evaluation, we have included the target point calibration data for the TWVGWM model in **Appendix A** and for the CSM model in **Appendix B**. We have also extracted the cell-by-cell data from both models and summarized the water balance data for the surficial aquifer system across the west Volusia ridge, where it is known that the area is internally drained without any discharging creeks or rivers. This is significant because any surface runoff in this ridge area is fully contained within the area, via runoff to adjacent depressions, retention ponds or lakes, without discharge off-site. The purpose of this comparative review was to assess the difference between the two models in terms of net recharge to the surficial aquifer and the resulting net recharge to the underlying Floridan aquifer, which is the primary aquifer of concern.

In review of the model structure and various packages used for the calibration, one significant model assumption was encountered. The CSM model was set up with a series of Drain cells across the west Volusia area. It is assumed that this option was selected in the model to account for surface runoff or discharge when the groundwater elevation in the surficial aquifer reaches ground surface or some overflow elevation. If that is the case, then it appears that the option was erroneously included in the west Volusia ridge area where all runoff or overflow is internally drained and does not discharge off-site. Any runoff or overflow that may occur would generally flow to the nearest depression, retention pond or lake and be retained within the region of the west Volusia ridge.

The water balance summaries generated for the west Volusia ridge in the CSM model includes the amount of water discharging from the Drain cells, which simulates water that is fully removed from the model domain and is not recharged back to the surficial aquifer. Another comparative parameter that is significant is the effectiveness of surficial aquifer to transmit water down into the upper Floridan aquifer (UFA) within the west Volusia ridge area.

The following two table/graphs present the water balance summaries for the TWVGWM and CSM models:

CSM As-Is West Volusia Ridge Water Balance

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	12,070,105	0	139.70	0.00
Evapotranspiration	0	6,008,835	0.00	69.55
Runoff (Drains)	0	222,820	0.00	2.58
Wells	220,455	525	2.55	0.01
River	555,036	94,430	6.42	1.09
Bottom	78,777	6,624,290	0.91	76.67
Top	0	0	0.00	0.00
Lateral Flow	26,526		0.31	0.00
Total	12,950,899	12,950,899	149.89	149.89

CSM with WVWS Projects 2040 West Volusia Ridge Water Balance

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	12,070,104	0	139.70	0.00
Evapotranspiration	0	6,820,180	0.00	78.94
Runoff (Drains)	0	470,700	0.00	5.45
Wells	1,372,697	525	15.89	0.01
River	552,072	100,211	6.39	1.16
Bottom	67,139	6,012,398	0.78	69.59
Top	0	0	0.00	0.00
Lateral Flow		657,998	0.00	7.62
Total	14,062,012	14,062,012	162.75	162.75

CSM Water Balance As-Is

MODFLOW Mass Balance

From Column 210 To Column 236 Graph
From Row 89 To Row 140 Export...
In Layer 1

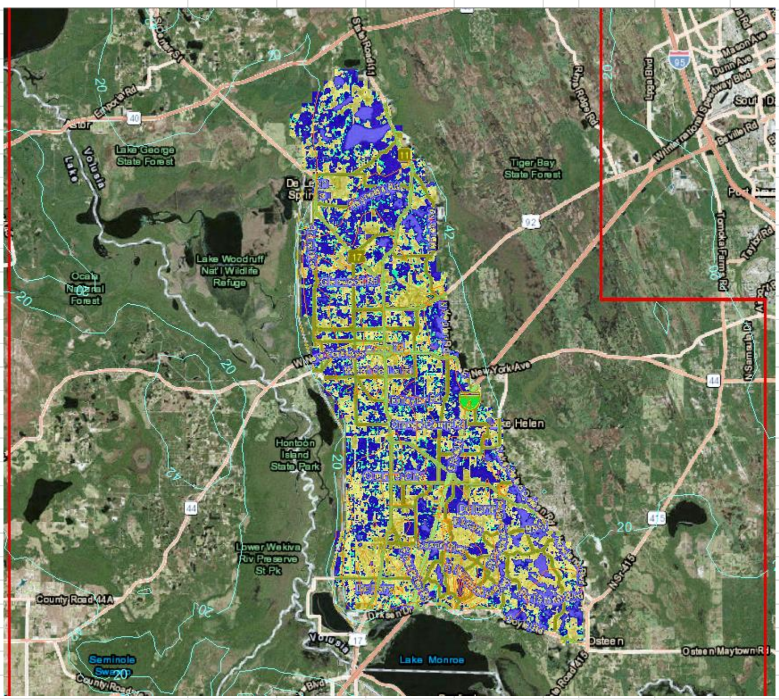
	INFLOWS	OUTFLOWS
Storage	0	0
X min	0	465518.100291252
X max	9409.94369411469	70050.9881091118
Y min	10.5856037735939	71400.9276866913
Y max	2859.808177948	25614.4198150636
Top	0	0
Bottom	0	5898671.48188782
Well	220455	524.799987792969
C.H.	0	0
GHB	0	0
River	555036.323791504	94429.6870117188
Drain	0	222819.591781616
Stream	0	0
Recharge	12070104.5371094	0
ET	0	6008835.13779449
Lake	0	0
TOTAL	12857876.1983767	12857865.1343656

CSM Water Balance with WVWS Projects 2040

MODFLOW Mass Balance

From Column 210 To Column 236 Graph
From Row 89 To Row 140 Export...
In Layer 1

	INFLOWS	OUTFLOWS
Storage	0	0
X min	0	487422.267379522
X max	9410.30803203583	71234.3603038788
Y min	9.49706554412842	83981.3099002839
Y max	2841.82179641724	27620.8238525391
Top	0	0
Bottom	67139.140625	6012398.24449158
Well	1372697.3755188	524.799987792969
C.H.	0	0
GHB	0	0
River	552071.711853027	100211.098617554
Drain	0	470700.498535156
Stream	0	0
Recharge	12070104.5371094	0
ET	0	6820180.12661743
Lake	0	0
TOTAL	14074274.3920002	14074273.5296857



Blue Spring Flows

12,148,788	BS Q			12,246,697	BS Q
		BS increase	97,909	cfd	
		BS increase	1.13	cfs	

TWVGWM EOP - West Volusia Ridge Water Balance

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	17,585,149	265,255	203.53	3.07
Evapotranspiration	0	0	0.00	0.00
Runoff (Drains)	0	0	0.00	0.00
Wells	225,920	18,959	2.61	0.22
River	0	46,373	0.00	0.54
GHB	0	316,273	0.00	3.66
Bottom	32,088	17,854,837	0.37	206.65
Top	0	0	0.00	0.00
Lateral Flow	658,540	0	7.62	0.00
Total	**18,501,697**	**18,501,697**	**214.14**	**214.14**

TWVGWM with WVWS Projects 2040
West Volusia Ridge Water Balance

Parameter	Inflow (cfd)	Outflow (cfd)	Inflow (cfs)	Outflow (cfs)
Recharge	17,585,149	265,255	203.53	3.07
Evapotranspiration	0	0	0.00	0.00
Runoff (Drains)	0	0	0.00	0.00
Wells	1,327,701	18,356	15.37	0.21
River	0	46,217	0.00	0.53
GHB	0	314,762	0.00	3.64
Bottom	31,932	18,779,399	0.37	217.35
Top	0	0	0.00	0.00
Lateral Flow	479,207	0	5.55	0.00
Total	**19,423,989**	**19,423,989**	**224.81**	**224.81**

TWVGWM Water Balance EOP C

MODFLOW Mass Balance

From Column 124 To Column 269 Graph
From Row 155 To Row 421 Export...
In Layer 1

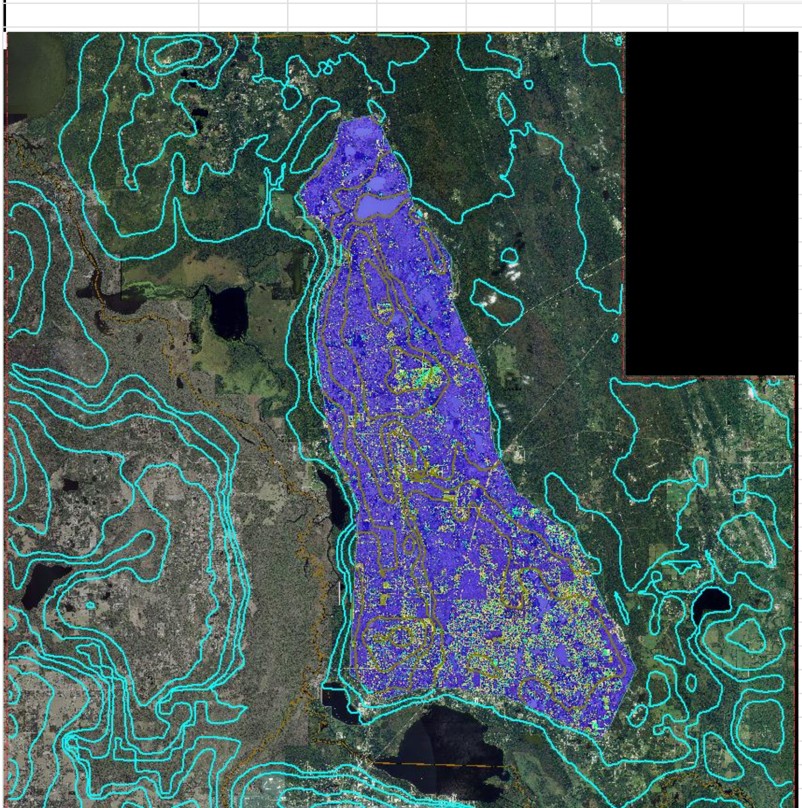
	INFLOWS	OUTFLOWS
Storage	2066176.55294582	749515.402273251
X min	3501.33318328857	433883.55645597
X max	45231.6426019669	144592.082429171
Y min	4542.09653669596	140951.095830917
Y max	16889.7235728502	49727.3137718439
Top	0	0
Bottom	32087.7210903168	17854836.6713004
Well	225920.136962891	18958.550907135
C.H.	0	0
GHB	0	316272.991943359
River	0	46373.4077148438
Drain	0	0
Stream	0	0
Recharge	17585148.7549067	265255.211149216
ET	0	0
Lake	0	0
TOTAL	19979497.9618005	20020366.2837761

TWVGWM Water Balance w/ WVWS Projects 2040

MODFLOW Mass Balance

From Column 124 To Column 269 Graph
From Row 155 To Row 421 Export...
In Layer 1

	INFLOWS	OUTFLOWS
Storage	2001359.72411222	774033.753341763
X min	5089.12904548645	470844.260882735
X max	43322.6309161186	149954.801535845
Y min	4905.75775909424	185913.490443707
Y max	16675.278423667	50493.0809614658
Top	0	0
Bottom	31932.0272989273	18779398.5327137
Well	1327700.91973495	18356.2608642578
C.H.	0	0
GHB	0	314761.779296875
River	0	46217.2045898438
Drain	0	0
Stream	0	0
Recharge	17585148.7549067	265255.211149216
ET	0	0
Lake	0	0
TOTAL	21016134.2221971	21055228.3757794



Blue Spring Flows

11,421,285		**12,150,765**	
	BS increase	**729,480**	**cfd**
	BS increase	**8.44**	**cfs**

The water balance summaries above reveal the calibration concerns in relation to runoff/overflow and minimum transmission of water from the surficial aquifer to the UFA. Review of the highlighted values in the tables above reveals that the CSM model transmits only about 42% to

51% of the total inflowing water from the surficial aquifer to the upper Floridan aquifer within the West Volusia Ridge area. This is not a realistic calibration of the model where the internally drained ridge area should be transmitting close to 100% of the water entering the surficial aquifer to the upper Floridan aquifer (UFA). Furthermore, review of the vertical transmission of water (Bottom) for the increased recharge with WVWS projects 2040 indicates that the net amount of water transmitted to the UFA is actual less than the scenario without the additional recharge, which does not make sense and suggests something is definitely wrong with the model calibration.

Review of the water balance components of the TWVGWM model, the highlighted values, indicate that about 96% of the water entering the surficial aquifer is transmitted to the UFA below. In addition, when the WVWS recharge projects 2040 are applied to the model, the net transmission of water from surficial aquifer to the UFA increases, as expected.

To assess the effectiveness of recharge to increase spring flow, we have compared the effects of the WVWS projects 2040 on Blue Spring flows. The following table presents a comparative Blue Spring flows for the two models with and without the WVWS recharge project 2040. This was conducted to assess the effectiveness of the surficial aquifer recharge to the UFA and then to the spring flows:

CSM Model - Blue Springs Flow Simulations & Impacts			
Model Scenario	**Flow (cfd)**	**Flow (cfs)**	**Percent of Net Recharge**
CSM Model Average 2005-2018	12,148,795	140.61	
CSM Model 2005-2018 with WVWS Projects 2040	12,246,697	141.74	
Flow Increase with WVWS Projects 2040		**1.13**	**6.78%**
Total Net Recharge of WVWS Projects 2040		**16.72**	
TWVGWM Model - Blue Springs Flow Simulations & Impacts			
Model Scenario	**Flow (cfd)**	**Flow (cfs)**	**Percent of Net Recharge**
Scenario A (all wells pumping at EOP)	11,421,285	132.19	
Scenario C with WVWS Projects 2040	12,150,765	140.63	
Flow Increase with WVWS Projects 2040		**8.44**	**50.50%**
Total Net Recharge of WVWS Projects 2040		**16.72**	

The table above provides supporting data that the surficial aquifer has not been properly represented in the CSM model. The net recharge of 16.72 cfs into the surficial aquifer results in only 6.78% of the recharging water contributing to Blue Spring flows. This is not a realistic net increase as one would expect a considerably higher increase in spring flow. In contrast, the better calibrated TWVGWM model shows about 50.5% of the recharging water contributing to Blue Spring flows, which is realistic.

Based on our review of the model and the observed minimum response at Blue Spring flow to the recharge in the surficial aquifer, it is our opinion that the CSM model calibration has erroneously converged to excessively low vertical permeability along the west Volusia ridge area. This creates a condition where the recharging water is limited to flow laterally or mound sufficiently high to discharge via the Drain cells which are also erroneously selected for this model. This is also demonstrated above in the water balance analyses.

Additional model parameters reviewed and compared include the horizontal and vertical permeabilities of the surficial aquifer. Based on the CSM model response to recharge it appears that the vertical permeability (leakance) between the surficial aquifer and the UFA may be poorly calibrated. The comparative water balance analyses presented above have already indicated the possibility of this problem. For this purpose, we have extracted permeability values from the surficial aquifer of both models at selected points across the west Volusia ridge and the resulting maps with superimposed horizontal and vertical permeability values are included in **Appendix C**.

Review of the permeability values reveals a calibration concern in terms of the variation of the values in the CSM model. Where the horizontal permeability values are expected to be lower, i.e., low and wet areas, the values are high and where the values are expected to the higher, i.e., high and dry ridge areas, the values are very low. In contrast, the calibrated horizontal permeabilities in the TWVGWM model are lower in the low and wet areas and higher in the high and dry ridge areas.

More importantly, when comparing vertical permeability of the surficial aquifer across the wet Volusia ridge areas, the calibrated values in the CSM model are about 2 orders of magnitude lower that the values in the TWVGWM model, i.e., 0.00016 to 0.0005 ft/day versus 0.025 to 0.032 ft/day. This further supports the concern that the vertical permeabilities (leakance) of the surficial aquifer in CSM model were erroneously calibrated to unrealistic low values due to the assumed runoff/overflow using the Drain cells and poor calibration in the west Volusia ridge area.

Conclusions and Recommendations

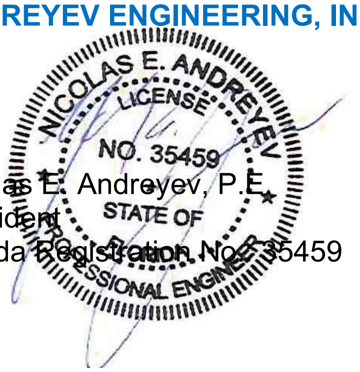
Based on the comparative data presented in this report, the CSM model is not adequately calibrated in the west Volusia ridge area, the primary service areas of the WVWS.

Based on the comparative data presented in this report and our review of the CSM model for potential future CUP permitting, it is our recommendation that WVWS must request the Water Management Districts (WMDs) to recalibrate the model, specifically in the west Volusia ridge prior to using the model for permitting or water use planning. It is our opinion that the Drain cells in all internally drained areas of the west Volusia ridge should be removed from the model. We also recommend that the recalibration work should consider the calibrated aquifer parameters of the TWVGWM model which were achieved using a finer model grid and represent higher degree of calibration.

If the WMDs are not willing to recalibrate the CSM model for the west Volusia area, then we recommend that the WVWS utilities continue to use the TWVGWM model for all future CUP permit modeling.

AEI appreciates the opportunity to participate in this project, and we trust that the information herein is sufficient for your purposes. If you have any questions or comments concerning the contents of this report, please do not hesitate to contact our office.

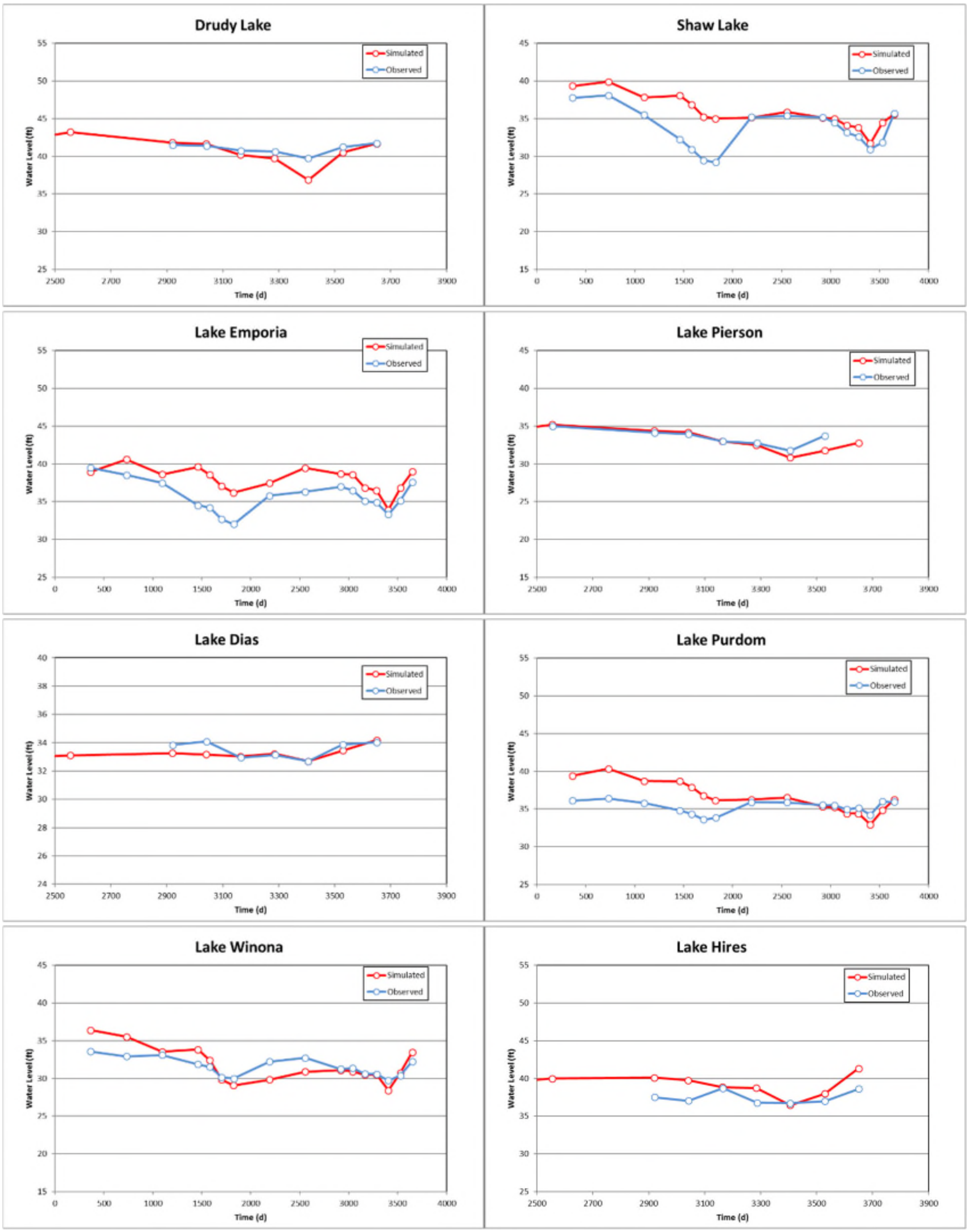
Sincerely,
ANDREYEV ENGINEERING, INC.



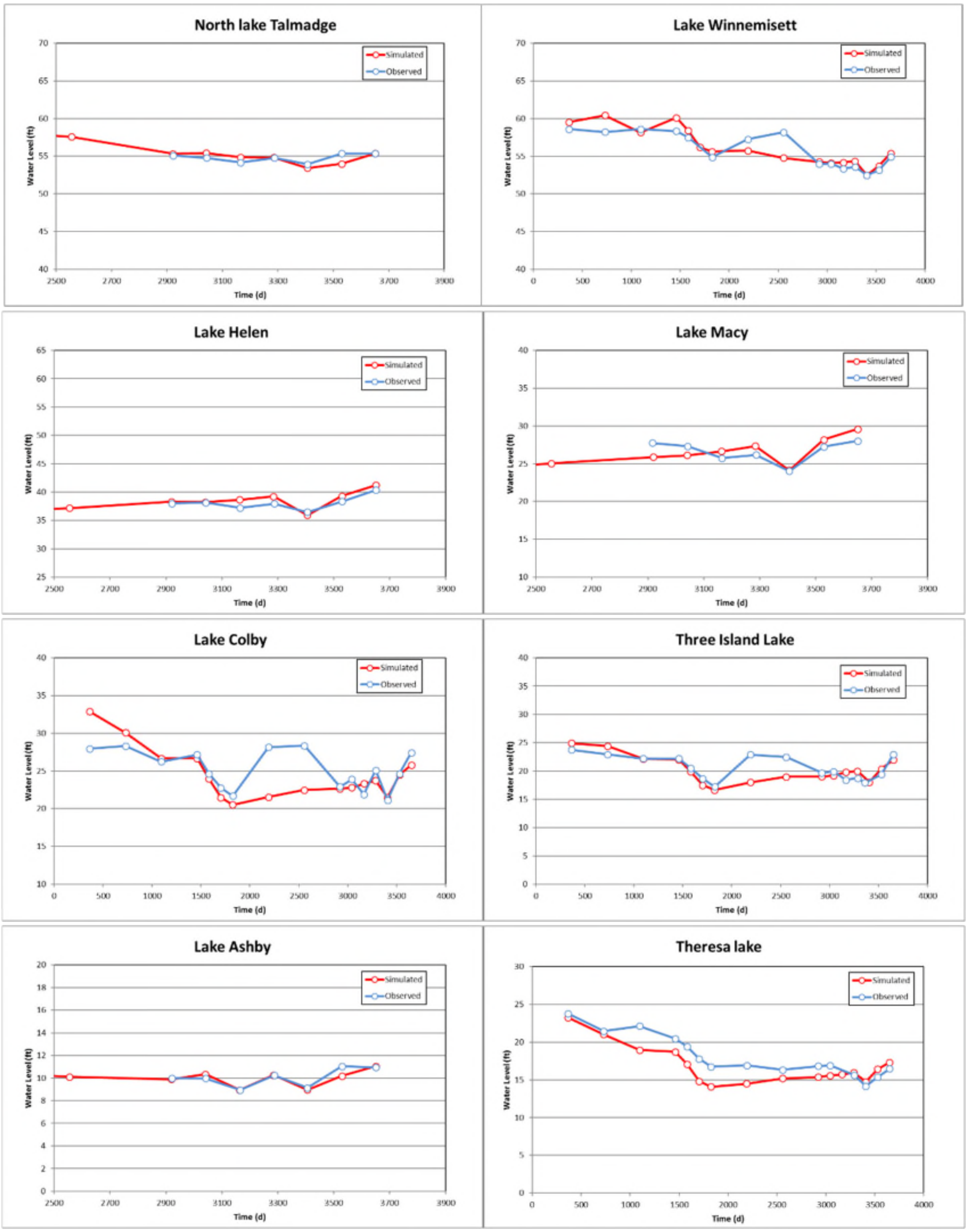
Nicolas E. Andreyev, P.E.
President
Florida Registration No. 35459

Nicolas E. Andreyev, P.E. State of Florida, Professional Engineer, License No. **35459**. This item has been electronically signed and sealed by Nicolas E. Andreyev, P.E. on November 4, 2023 using a *SHA* authentication code.

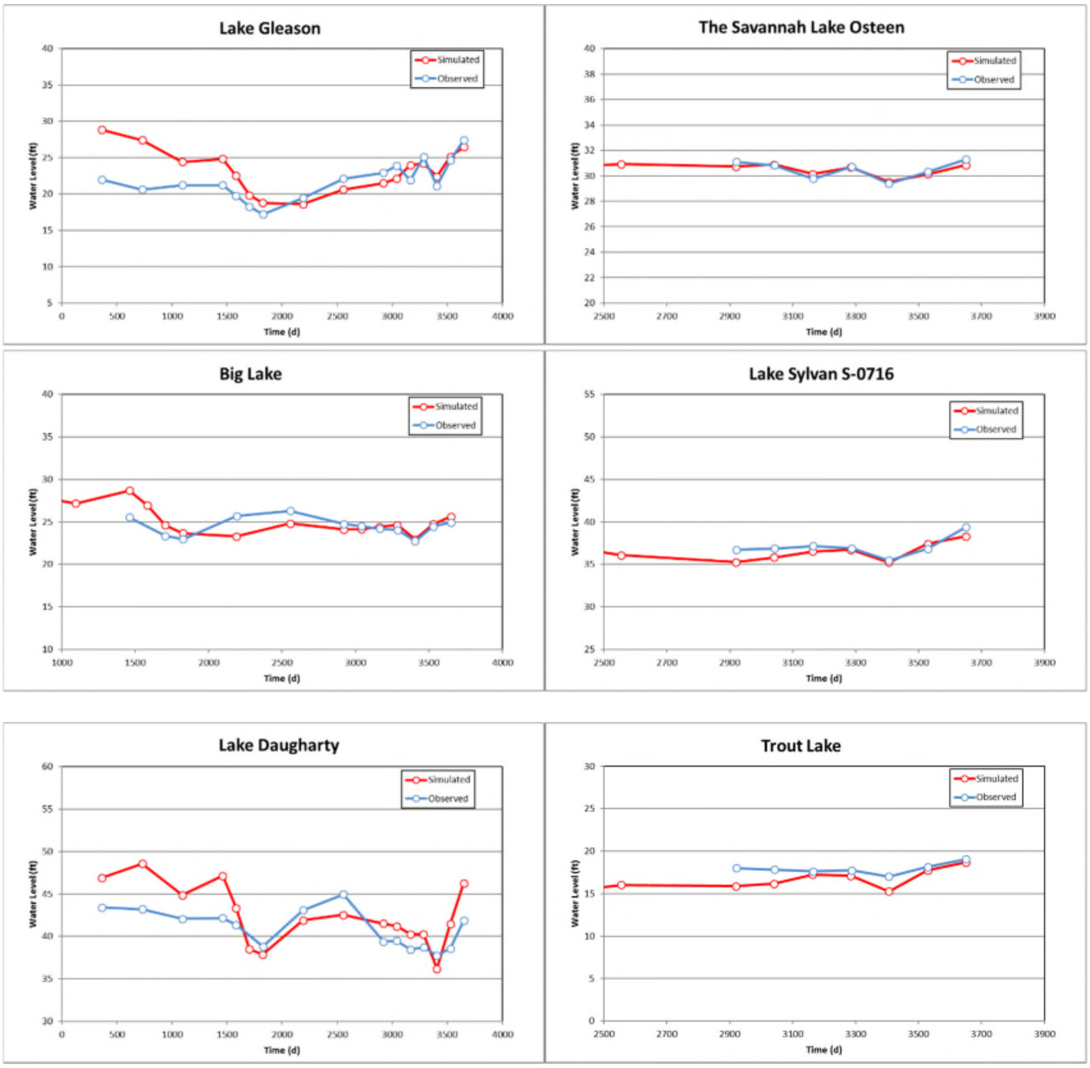
APPENDIX A



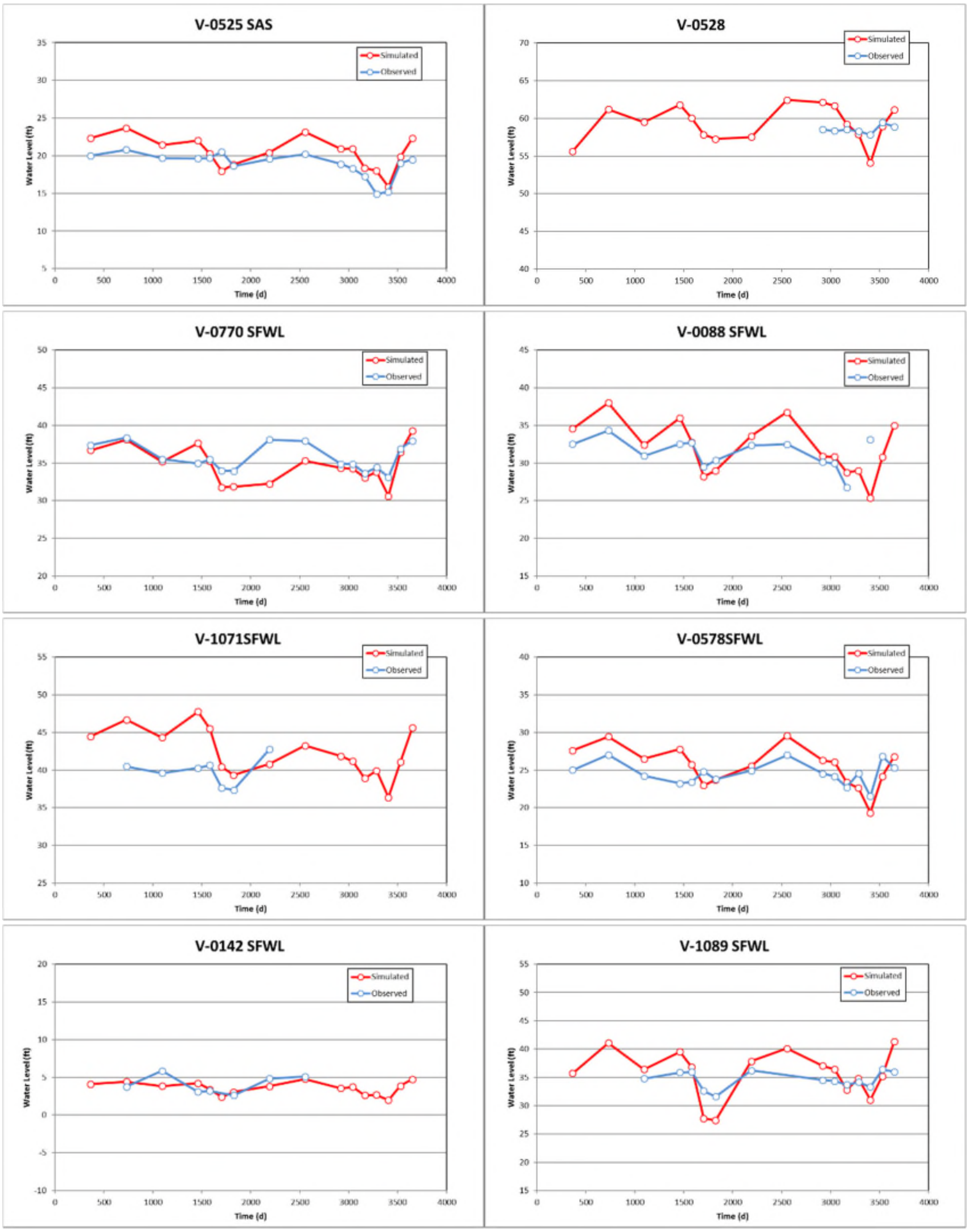
Calibration Results – Lake Water Levels (Part 1)



Calibration Results – Lake Water Levels (Part 2)

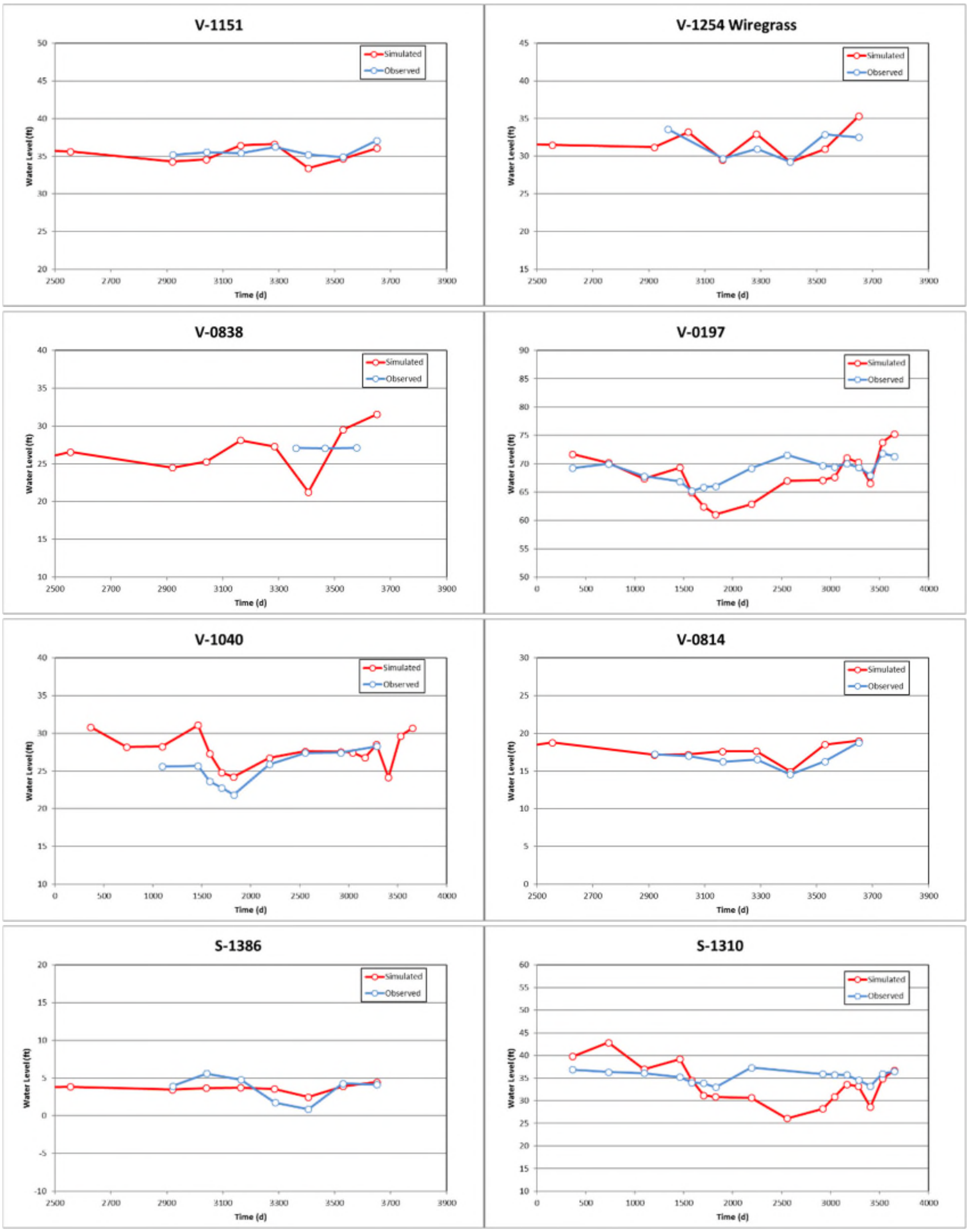


Calibration Results – Lake Water Levels (Part 3)

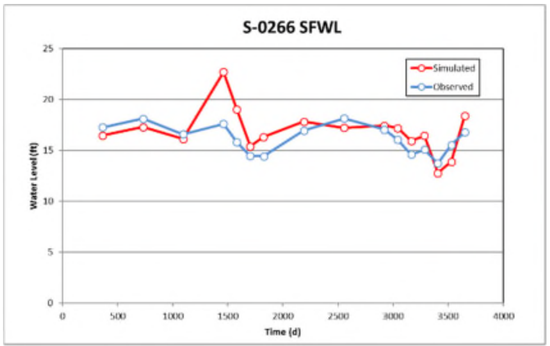


Calibration Results – Groundwater Levels – Layer 1 (Part 1)

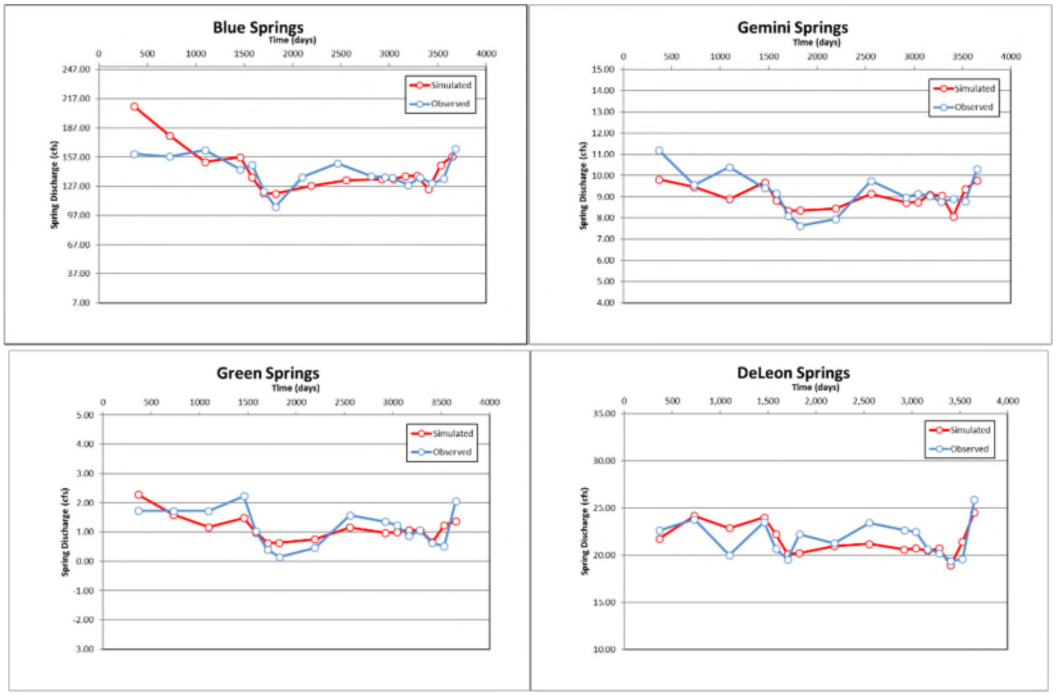
Calibration Results – Groundwater Levels – Layer 1 (Part 2)



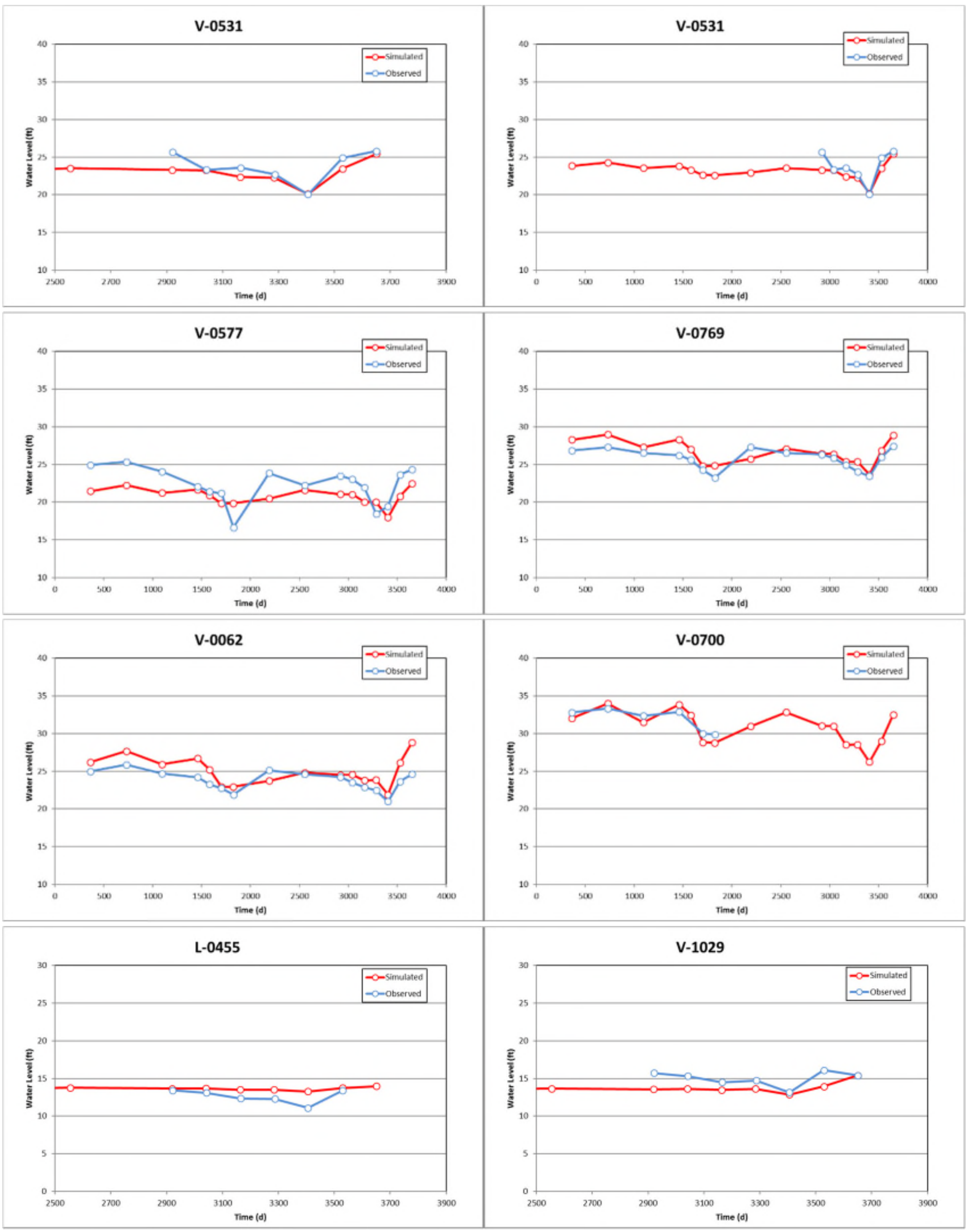
Calibration Results – Groundwater Levels – Layer 1 (Part 3)



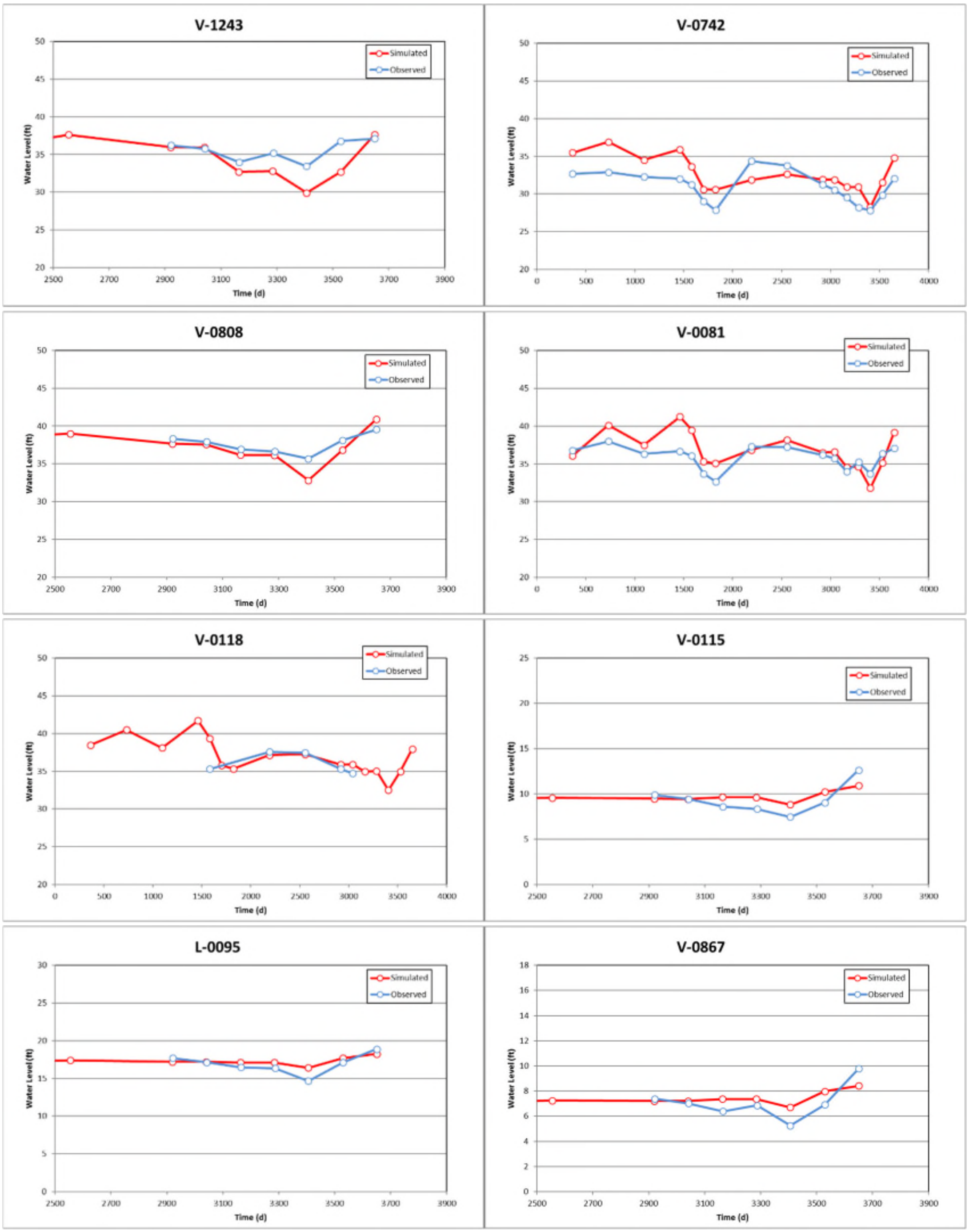
Calibration Results – Groundwater Levels – Layer 1 (Part 4)



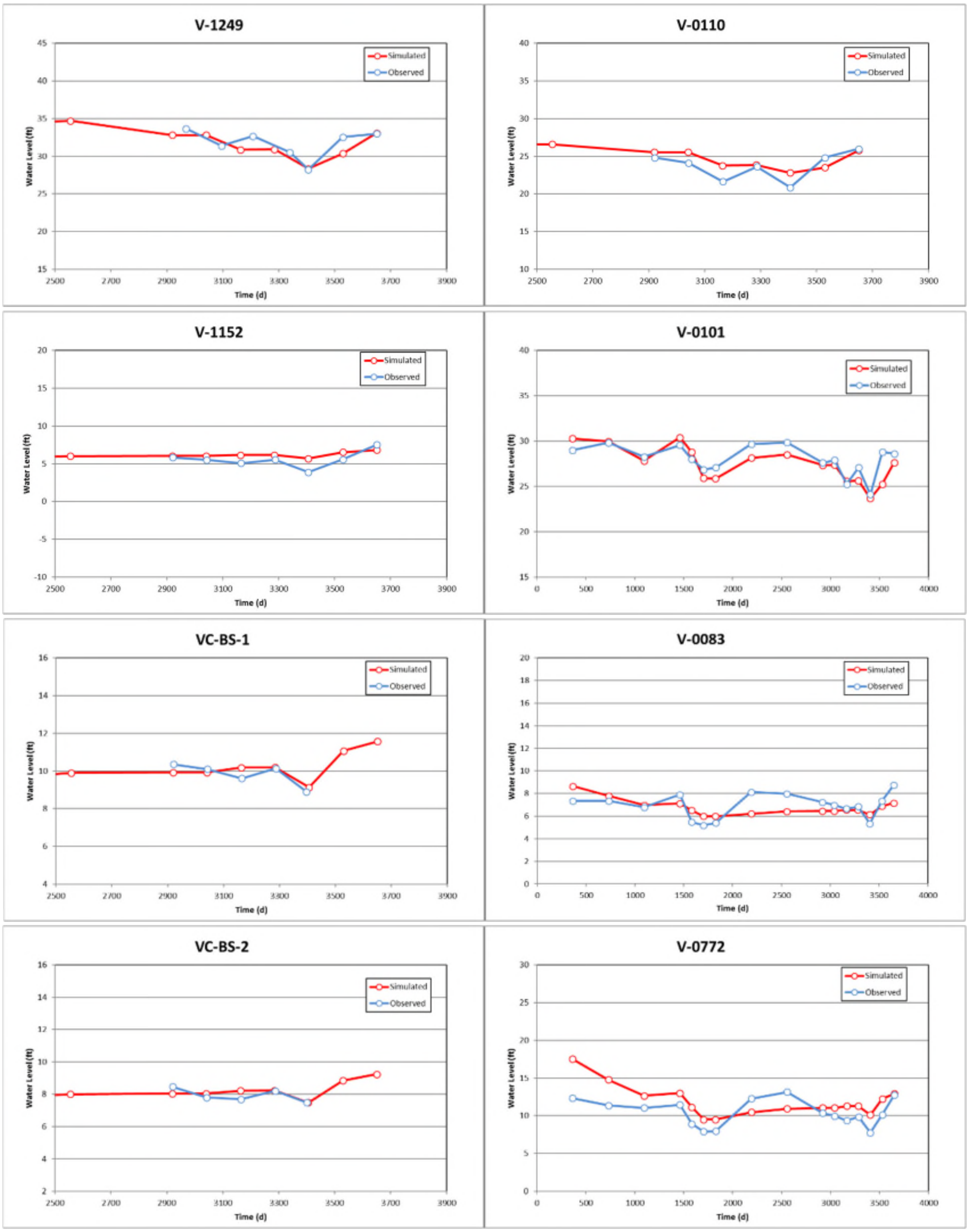
Calibration Results – Springs – Layer 2



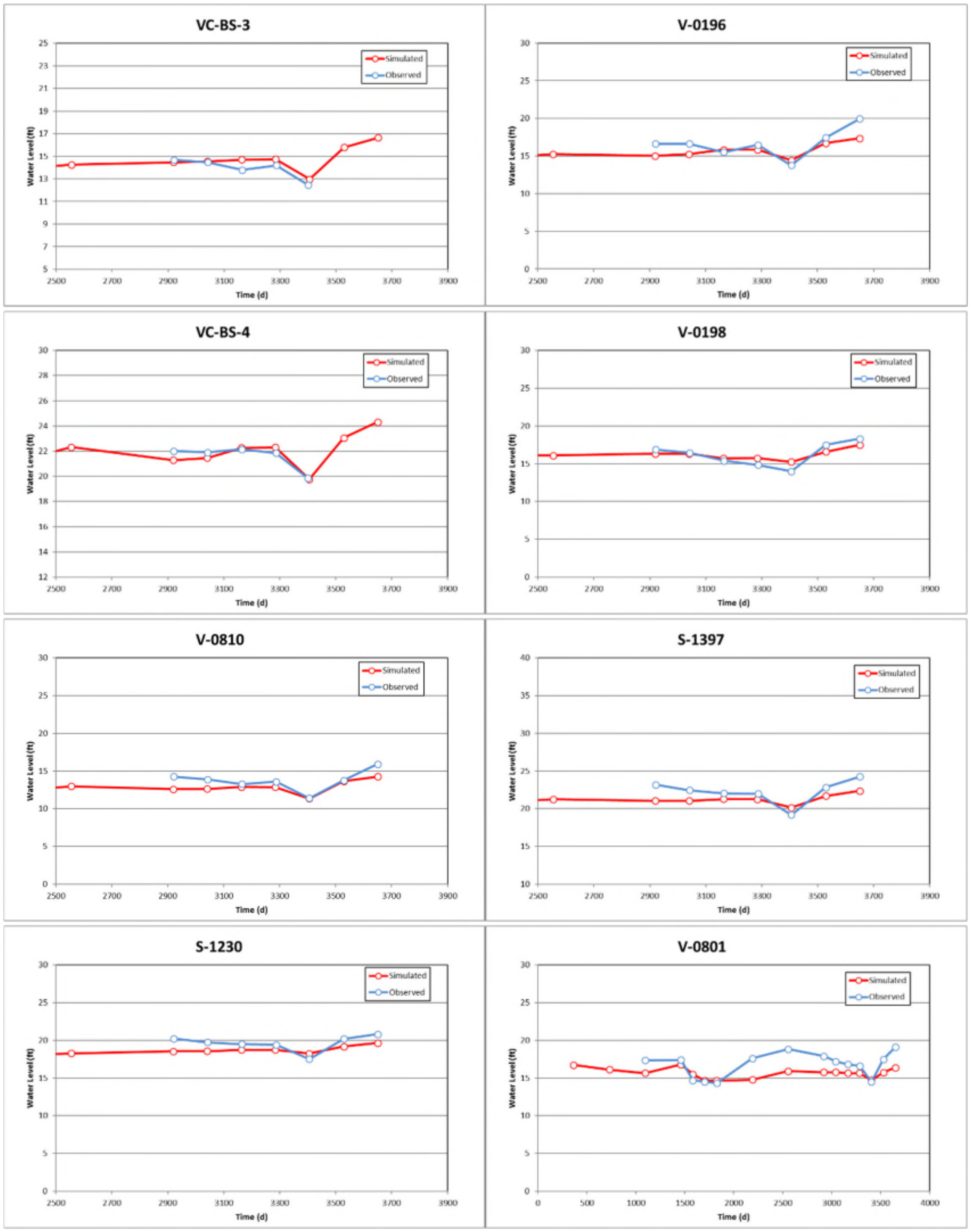
Calibration Results – Groundwater Levels – Upper Floridan Layer 2 (Part 1)



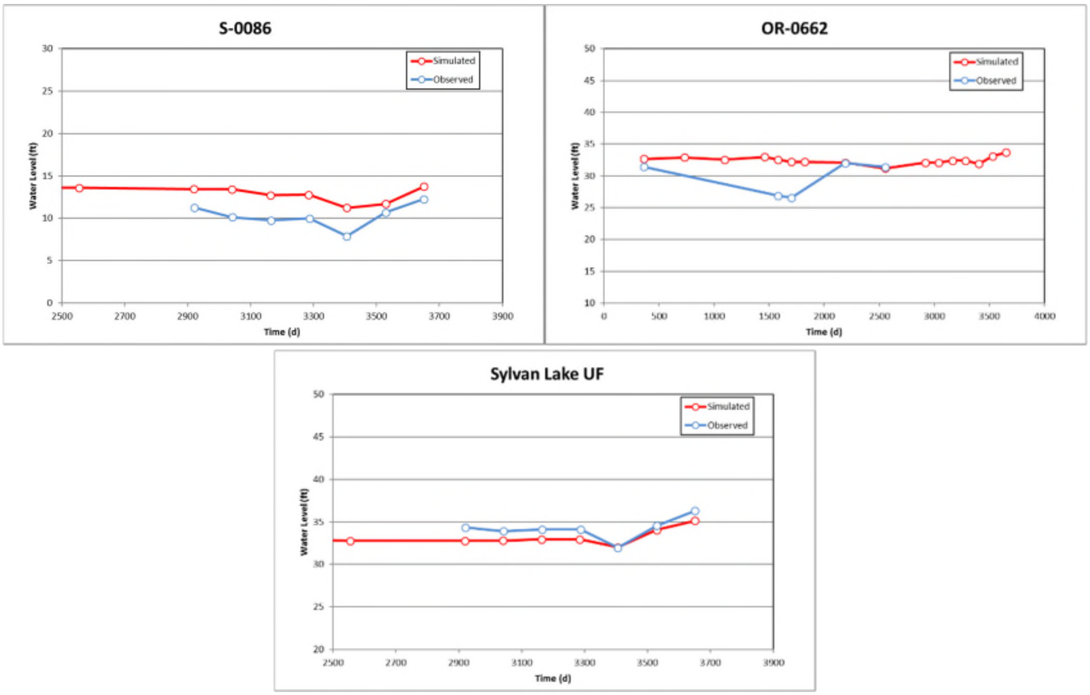
Calibration Results – Groundwater Levels – Upper Floridan Layer 2 (Part 2)



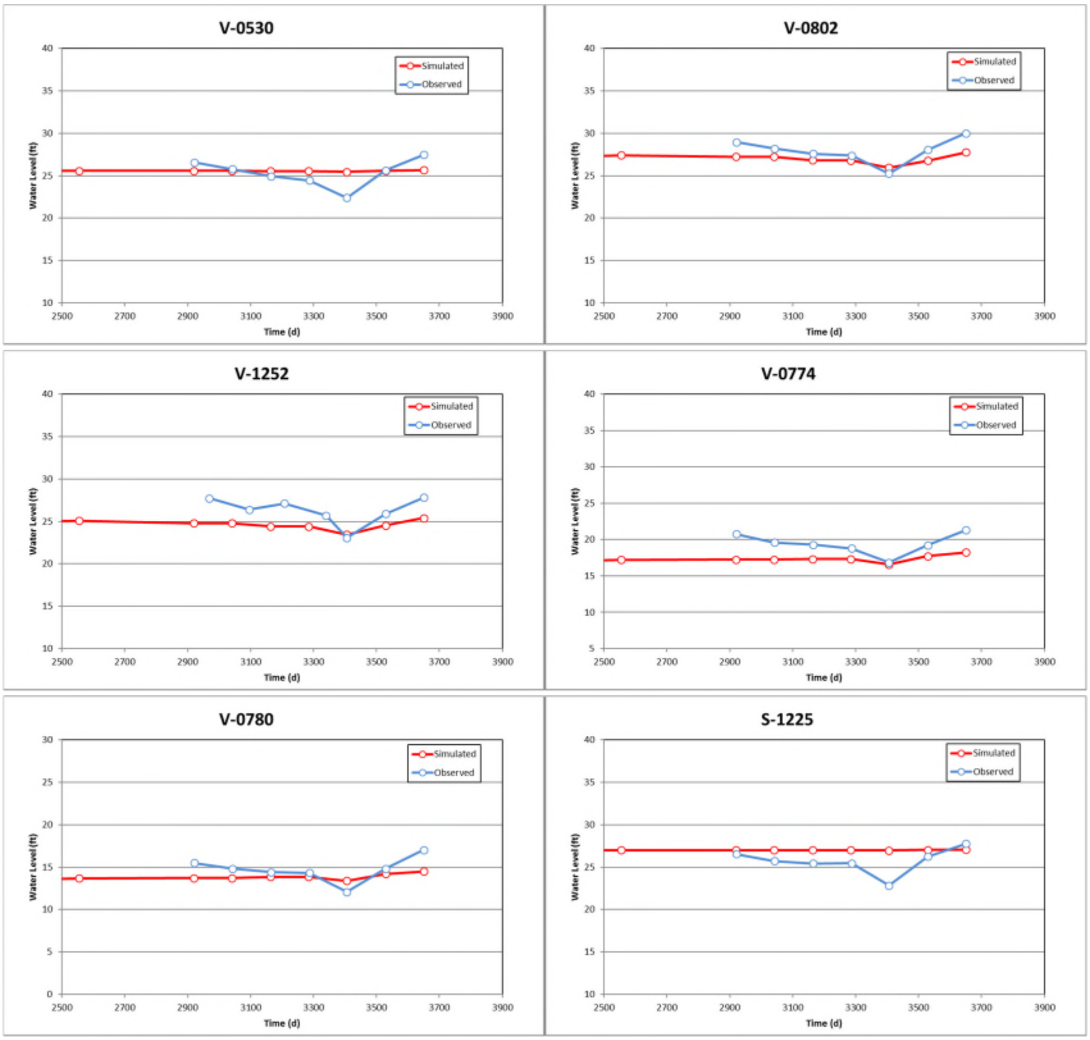
Calibration Results – Groundwater Levels – Upper Floridan Layer 2 (Part 3)



Calibration Results – Groundwater Levels – Upper Floridan Layer 2 (Part 4)

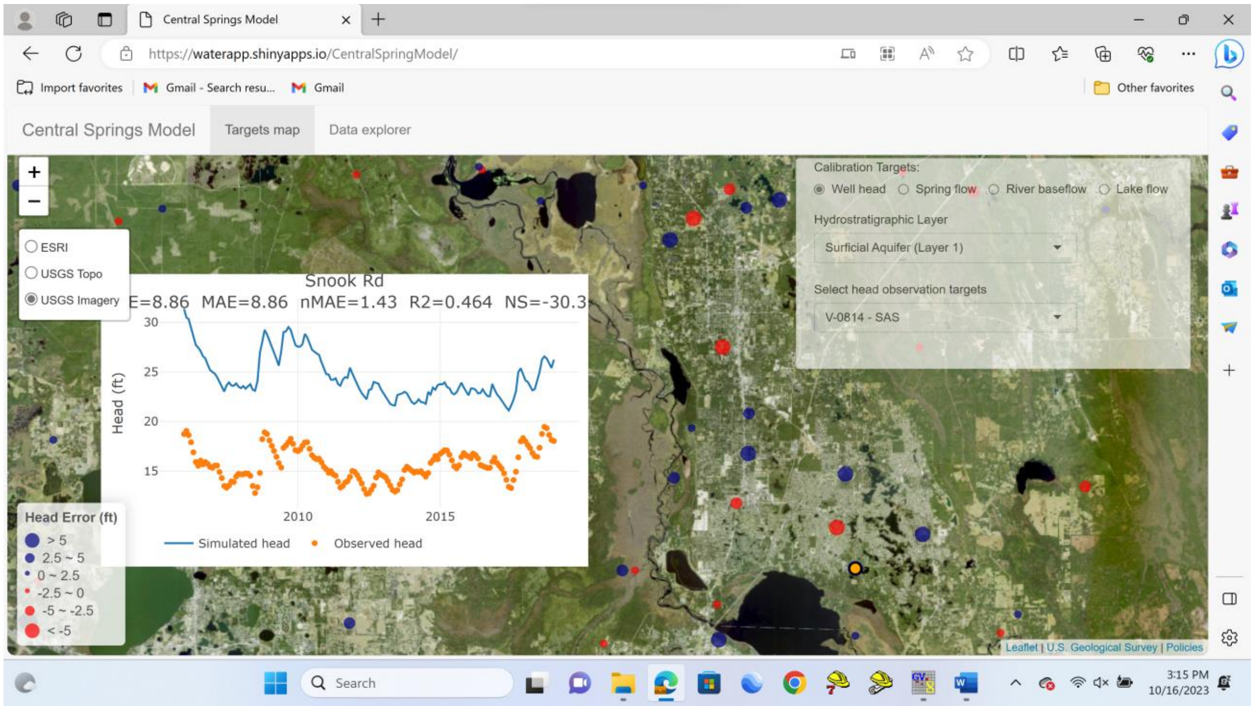


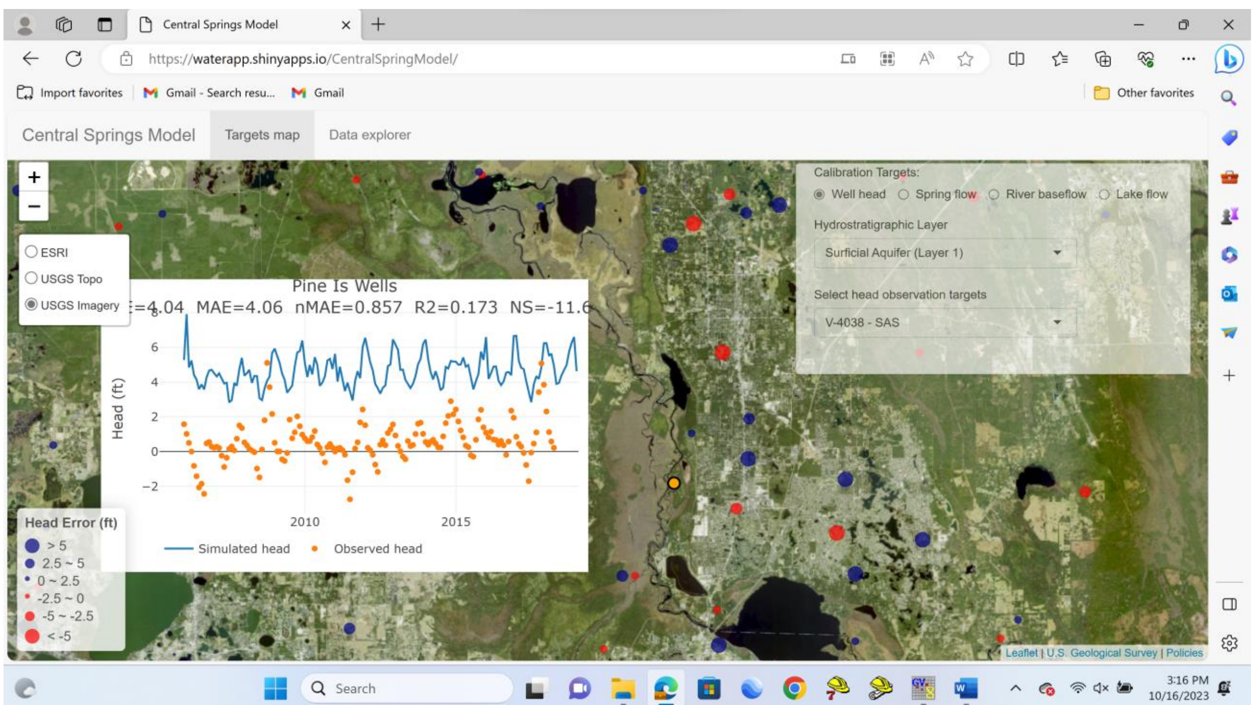
Calibration Results – Groundwater Levels – Upper Floridan Layer 2 (Part 5)



Calibration Results – Groundwater Levels – lower Floridan Layer 3 (Part 1)

APPENDIX B


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Snook Rd
E=8.86 MAE=8.86 nMAE=1.43 R2=0.464 NS=-30.3
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0814 - SAS
Leaflet | U.S. Geological Survey | Policies
3:15 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Pine Is Wells
=4.04 MAE=4.06 nMAE=0.857 R2=0.173 NS=-11.6
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-4038 - SAS
Leaflet | U.S. Geological Survey | Policies
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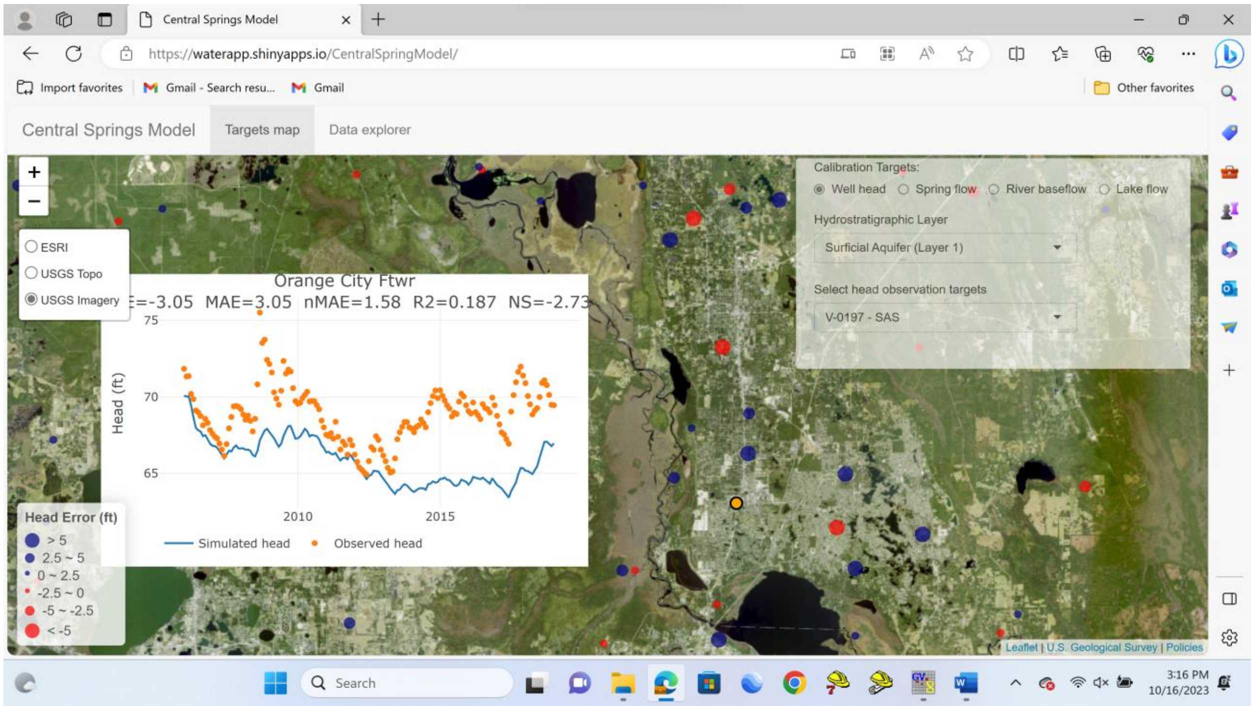
10/16/2023



Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Orange City Ftwr
E=-3.05 MAE=3.05 nMAE=1.58 R2=0.187 NS=-2.73
Head (ft)
Simulated head
Observed head
Head Error (ft)
Calibration Targets:
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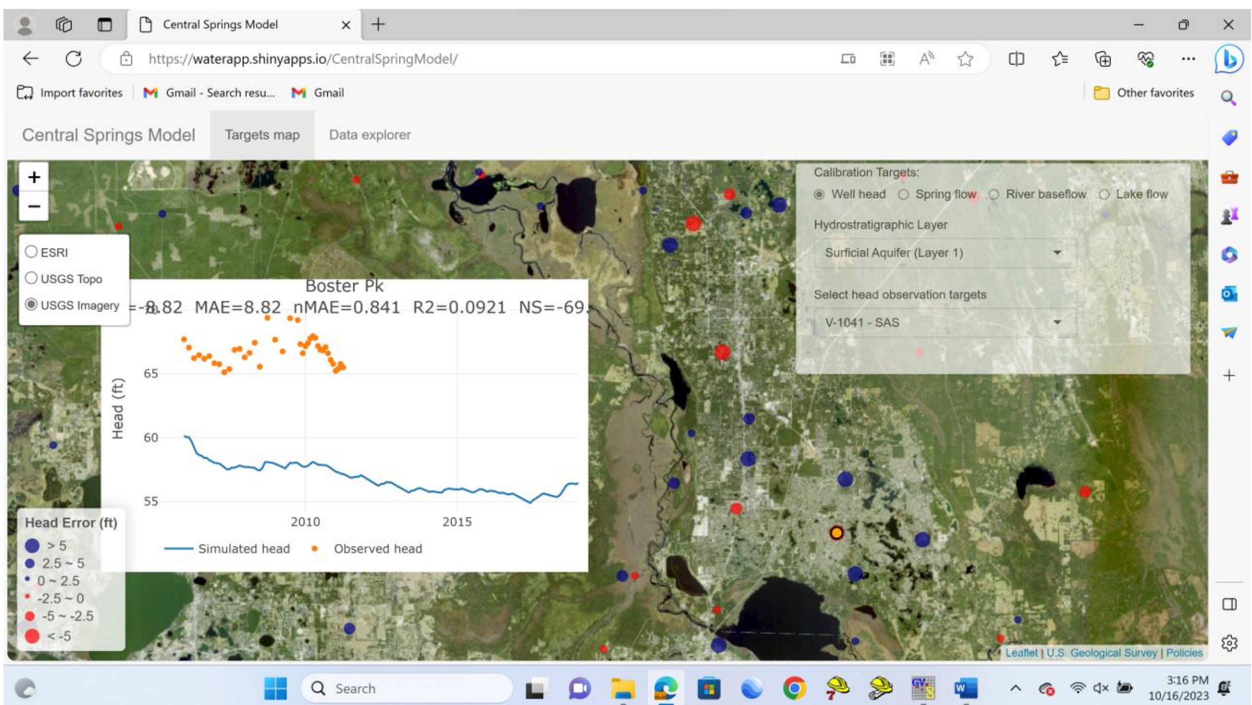
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0197 - SAS



Central Springs Model
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Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Boster Pk
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Head (ft)
Simulated head
Observed head
Head Error (ft)
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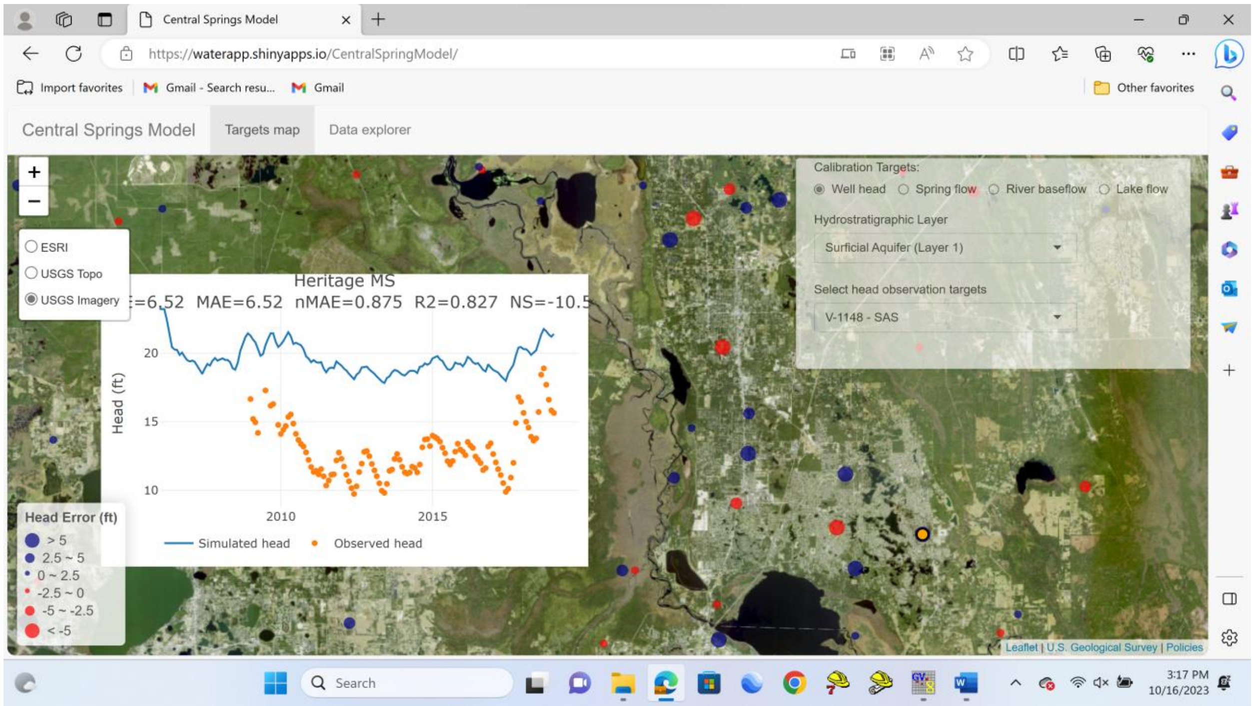
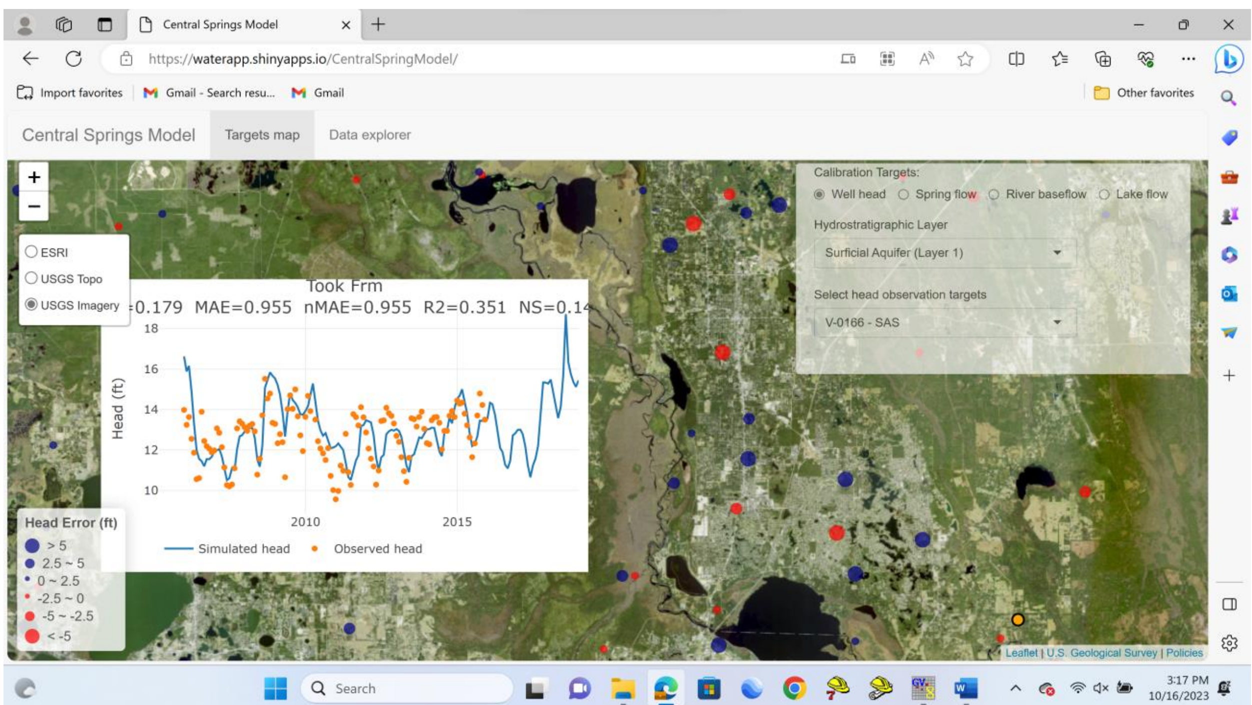
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1041 - SAS



Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Heritage MS
=6.52 MAE=6.52 nMAE=0.875 R2=0.827 NS=-10.5
Head (ft)
20
15
10
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1148 - SAS
Leaflet | U.S. Geological Survey | Policies
Search
3:17 PM
10/16/2023



Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Took Frm
=0.179 MAE=0.955 nMAE=0.955 R2=0.351 NS=0.14
Head (ft)
18
16
14
12
10
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0166 - SAS
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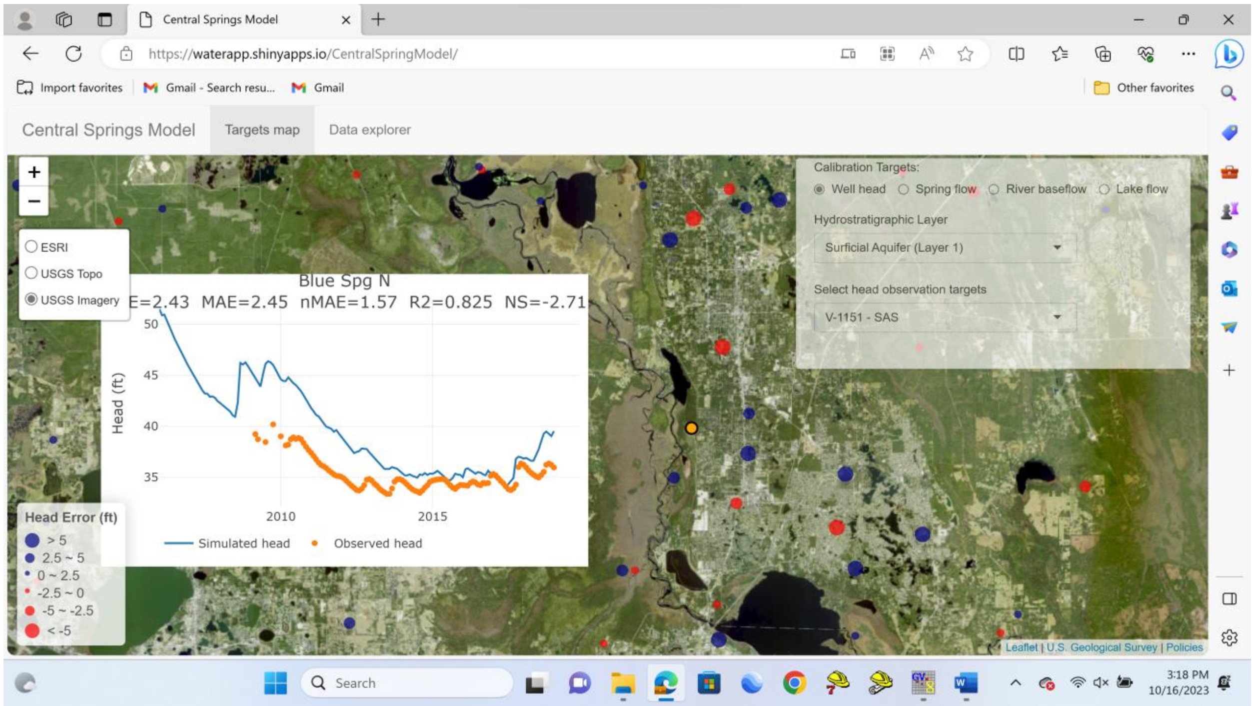
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Import favorites
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Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1151 - SAS
Blue Spg N
E=2.43 MAE=2.45 nMAE=1.57 R2=0.825 NS=-2.71
Head (ft)
50
45
40
35
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
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3:18 PM
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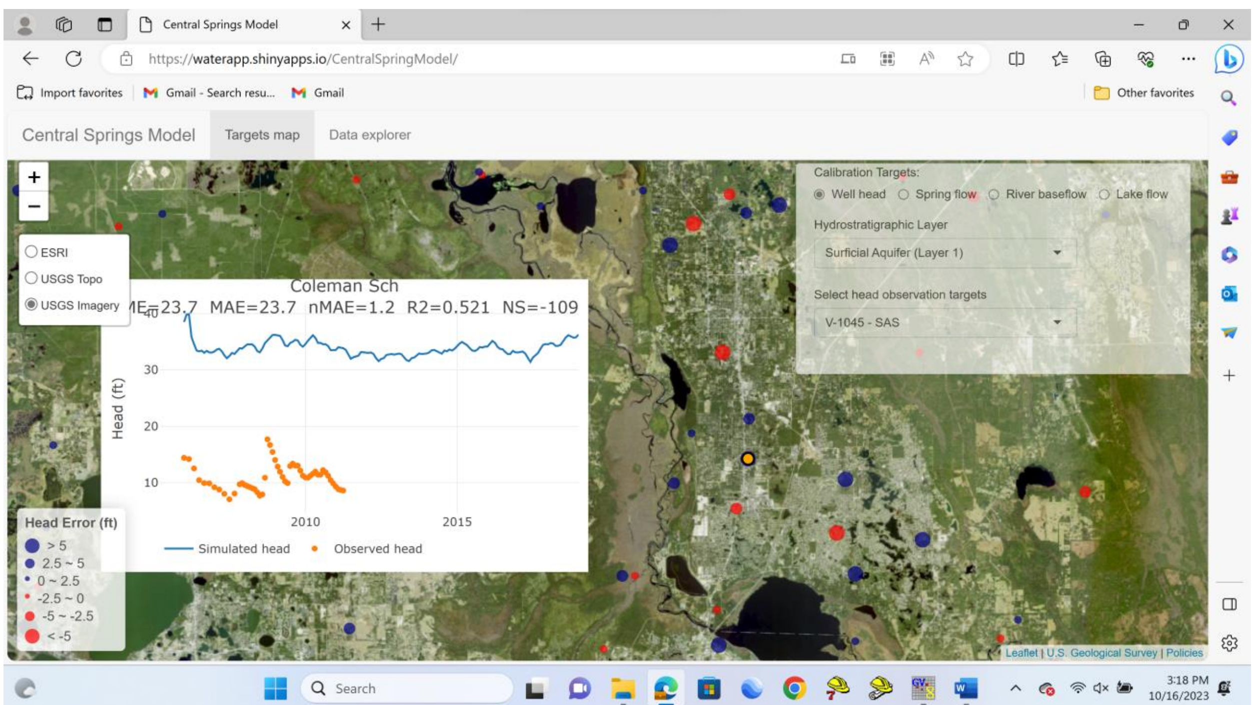
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Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1045 - SAS
Coleman Sch
ME=23.7 MAE=23.7 nMAE=1.2 R2=0.521 NS=-109
Head (ft)
40
30
20
10
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
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3:18 PM
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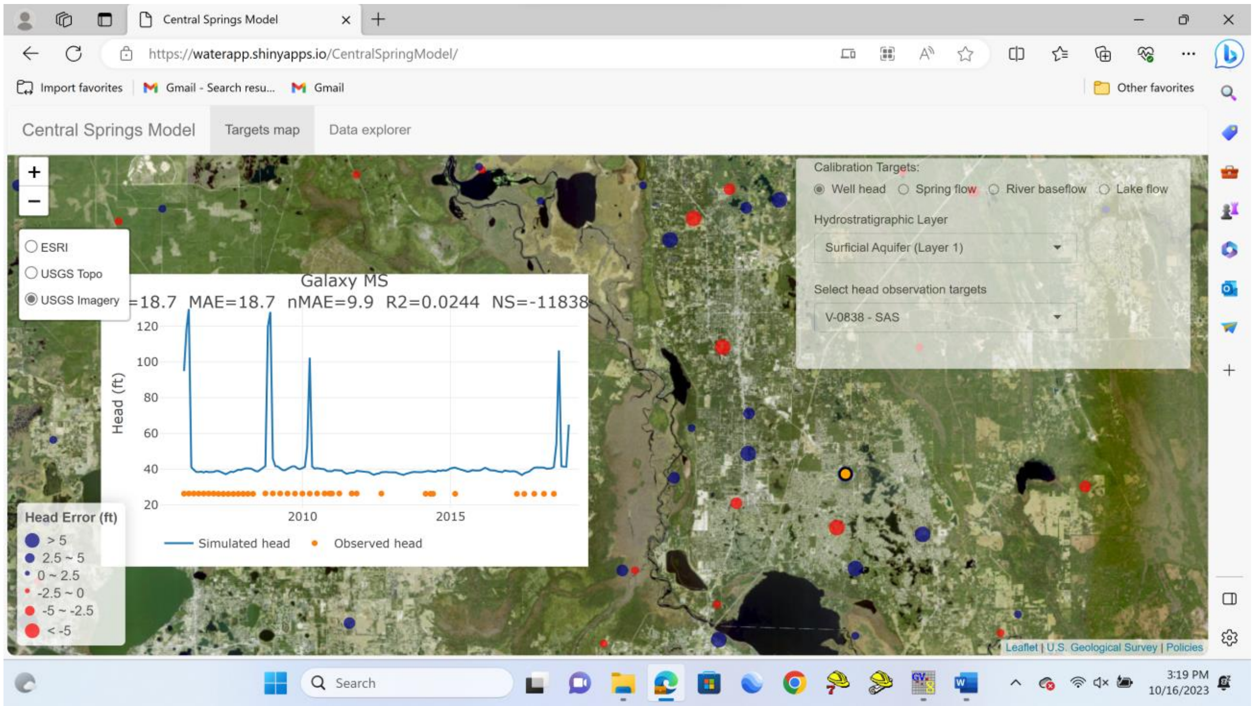
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Galaxy MS
=18.7 MAE=18.7 nMAE=9.9 R2=0.0244 NS=-11838
Head (ft)
Simulated head
Observed head
Head Error (ft)
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0838 - SAS
3:19 PM
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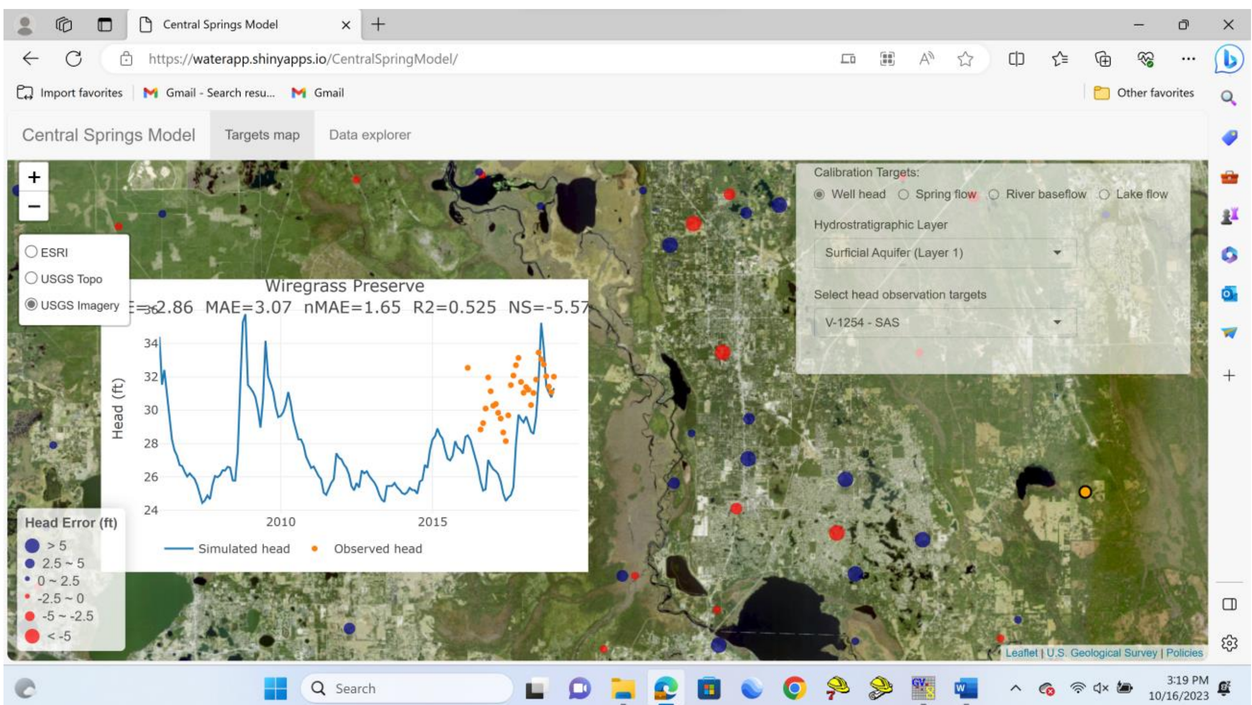
Central Springs Model
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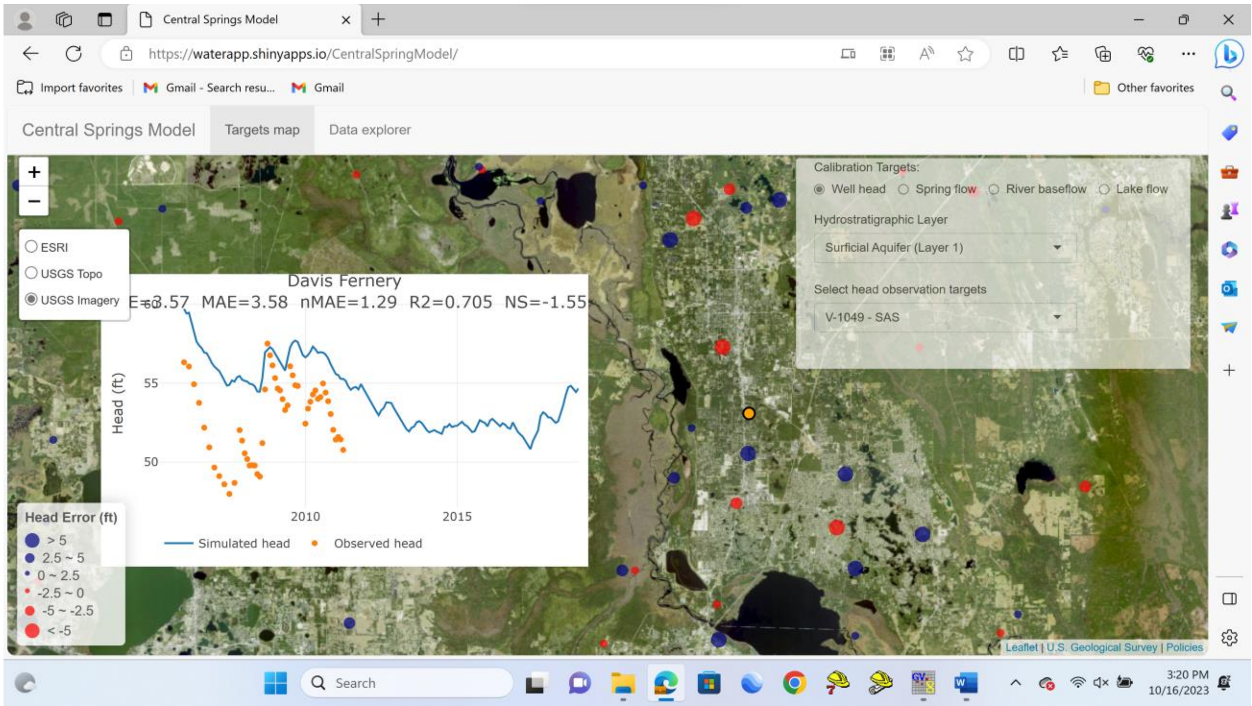
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Wiregrass Preserve
MAE=3.07 nMAE=1.65 R2=0.525 NS=-5.57
Head (ft)
Simulated head
Observed head
Head Error (ft)
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1254 - SAS
3:19 PM
10/16/2023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Import favorites
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Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Davis Fernery
E=3.57 MAE=3.58 nMAE=1.29 R2=0.705 NS=-1.55
Head (ft)
55
50
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1049 - SAS
Leaflet | U.S. Geological Survey | Policies
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3:20 PM
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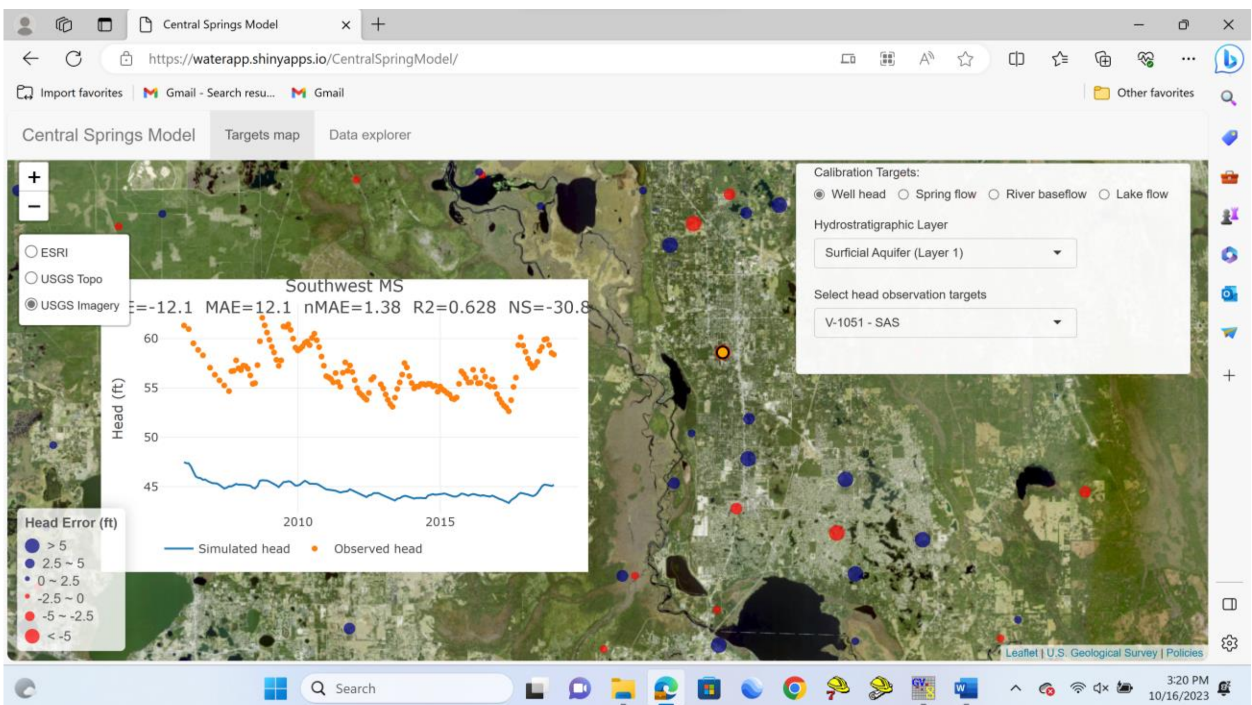
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Import favorites
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Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Southwest MS
E=-12.1 MAE=12.1 nMAE=1.38 R2=0.628 NS=-30.8
Head (ft)
60
55
50
45
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1051 - SAS
Leaflet | U.S. Geological Survey | Policies
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3:20 PM
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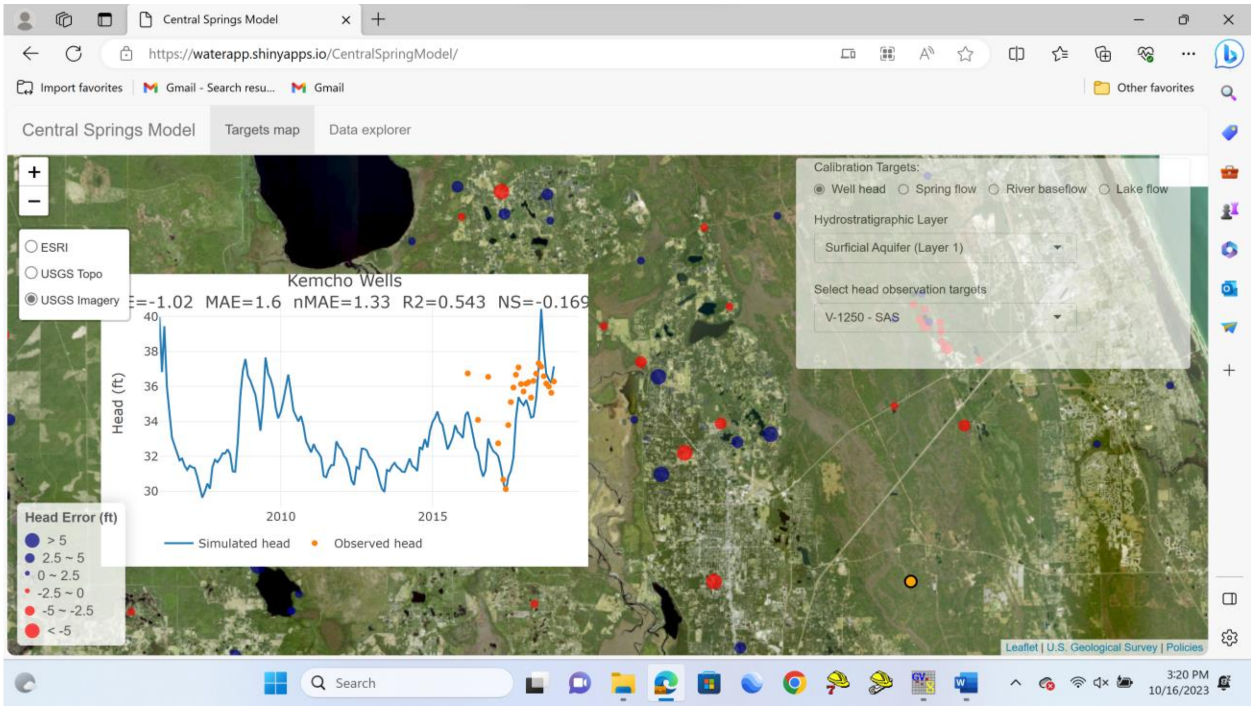
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Import favorites
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Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Kemcho Wells
=-1.02 MAE=1.6 nMAE=1.33 R2=0.543 NS=-0.169
Head (ft)
40
38
36
34
32
30
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1250 - SAS
Leaflet | U.S. Geological Survey | Policies
Search
3:20 PM
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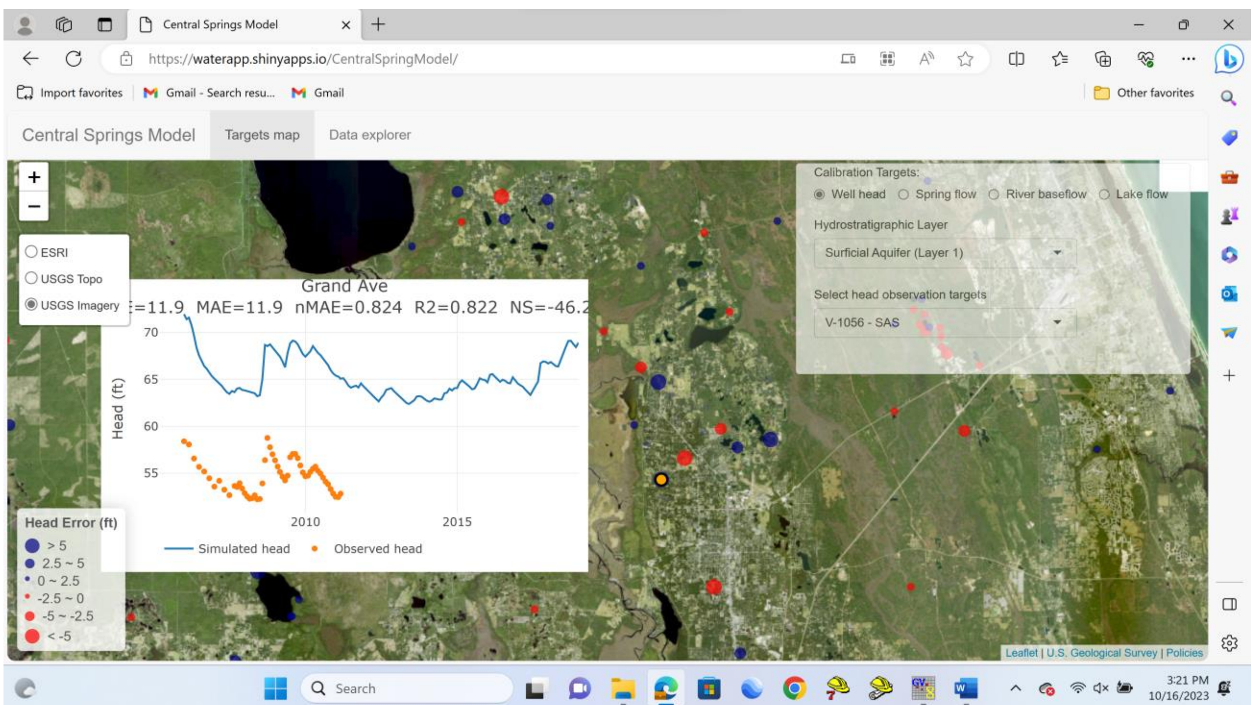
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Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Grand Ave
=11.9 MAE=11.9 nMAE=0.824 R2=0.822 NS=-46.2
Head (ft)
70
65
60
55
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1056 - SAS
Leaflet | U.S. Geological Survey | Policies
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3:21 PM
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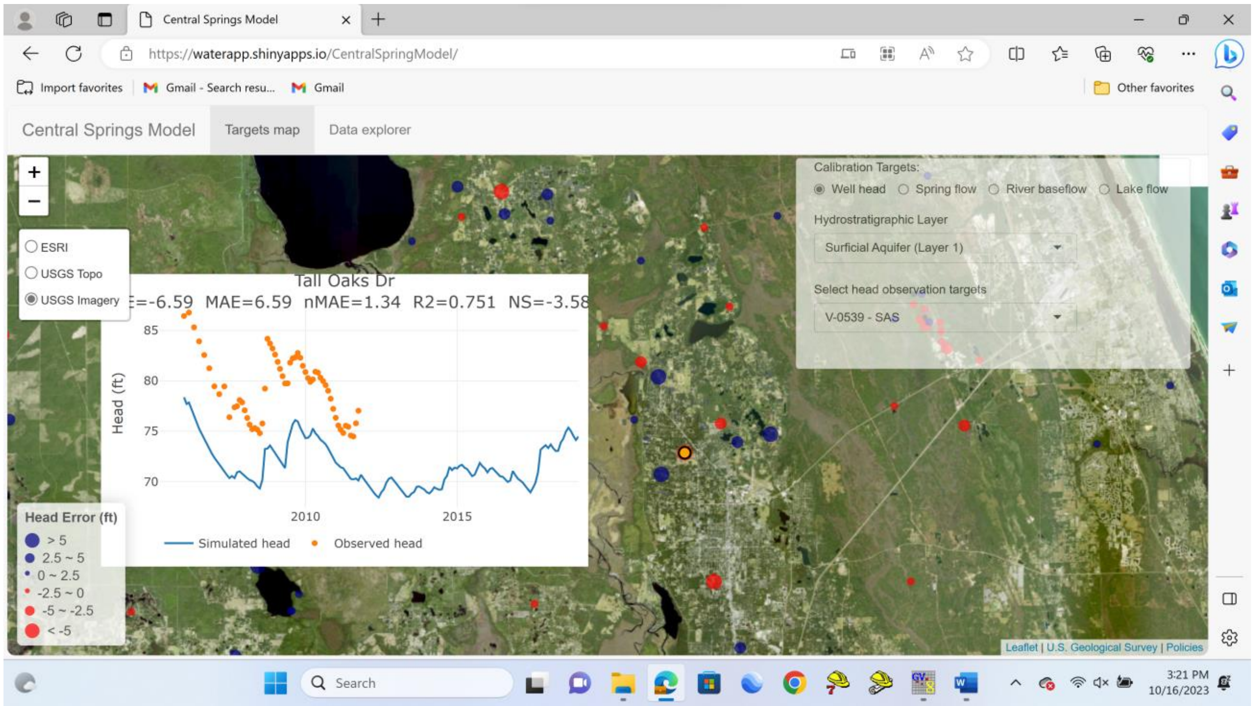
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Tall Oaks Dr
E=-6.59 MAE=6.59 nMAE=1.34 R2=0.751 NS=-3.58
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0539 - SAS
Leaflet | U.S. Geological Survey | Policies
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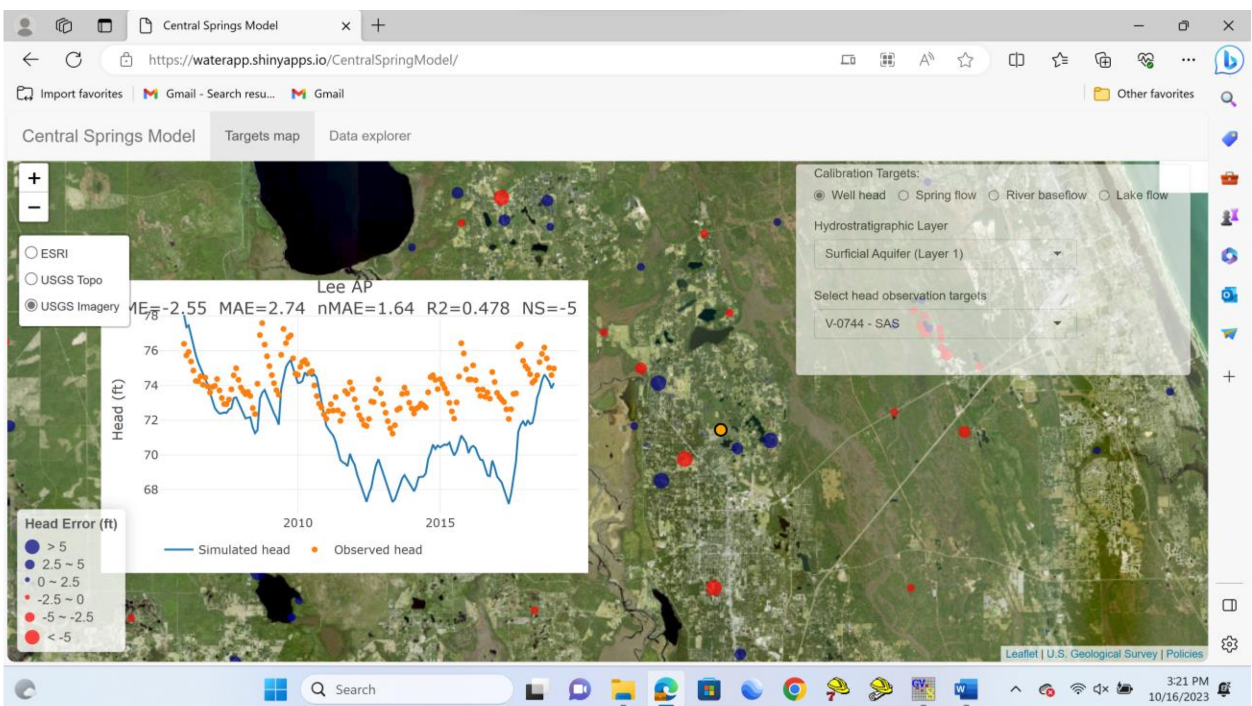
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Lee AP
ME=-2.55 MAE=2.74 nMAE=1.64 R2=0.478 NS=-5
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0744 - SAS
Leaflet | U.S. Geological Survey | Policies
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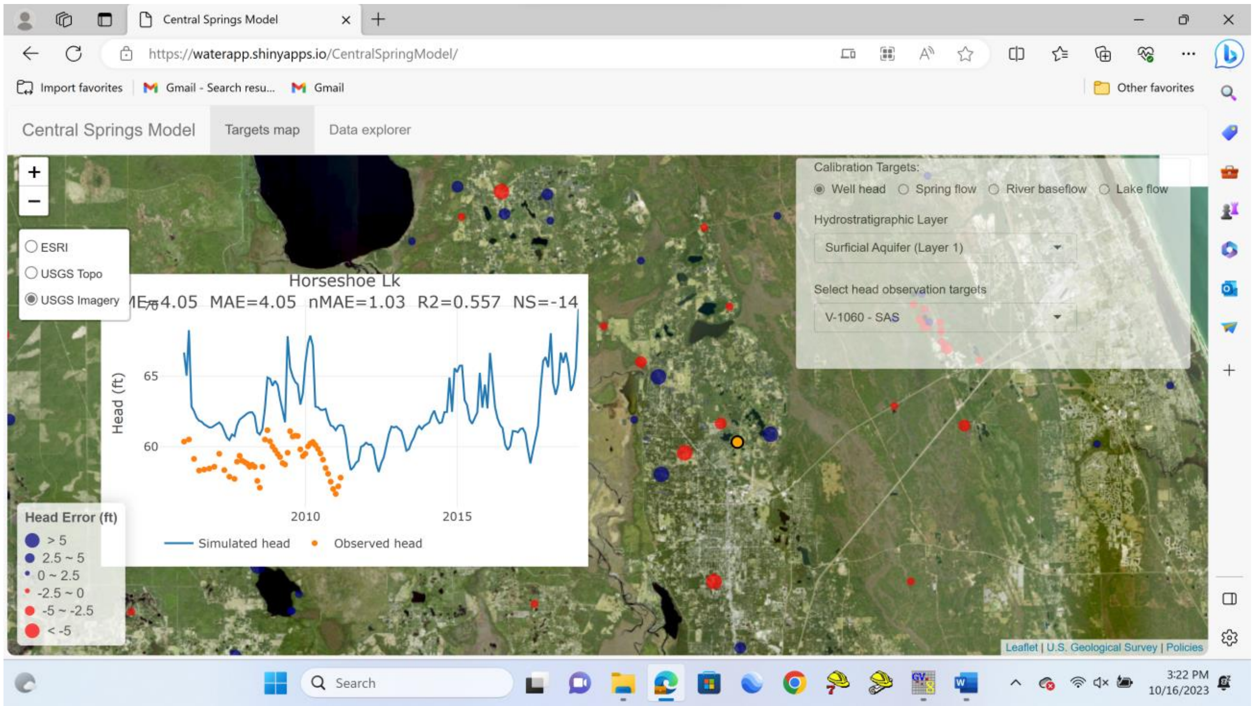
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https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1060 - SAS
ESRI
USGS Topo
USGS Imagery
Horseshoe Lk
MAE=4.05 nMAE=1.03 R2=0.557 NS=-14
Head (ft)
65
60
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:22 PM
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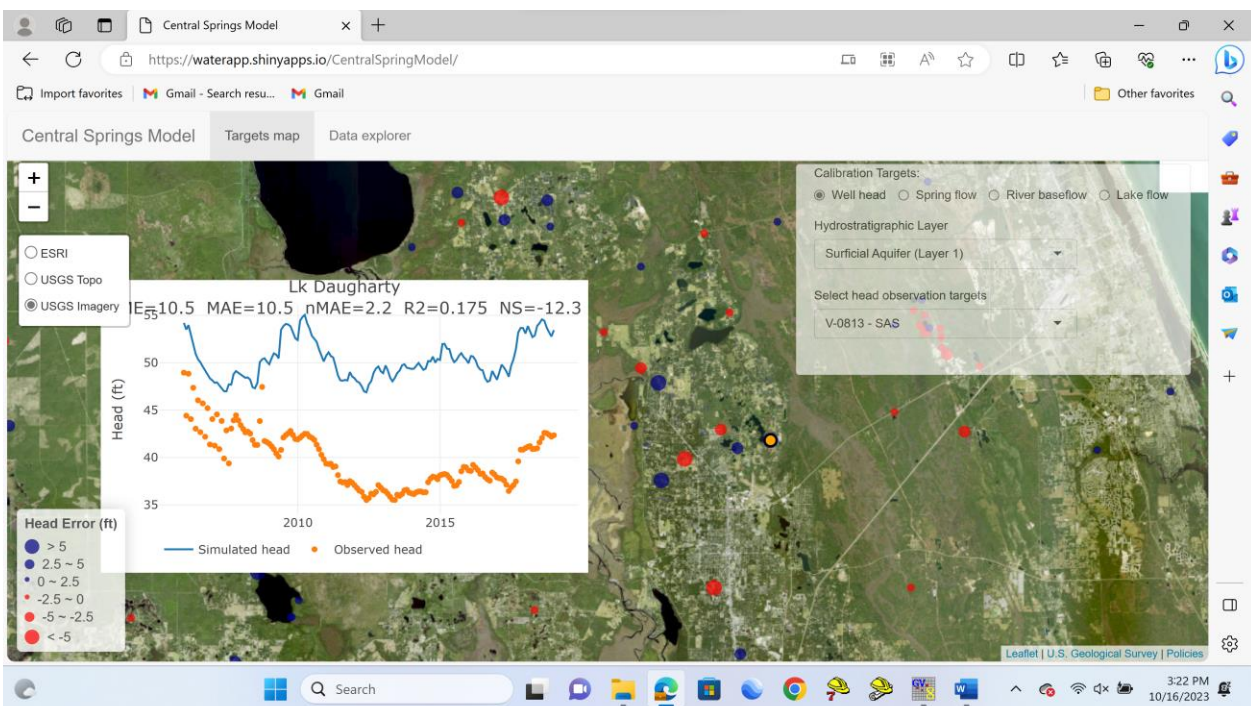
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0813 - SAS
ESRI
USGS Topo
USGS Imagery
Lk Daugharty
MAE=10.5 nMAE=2.2 R2=0.175 NS=-12.3
Head (ft)
50
45
40
35
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
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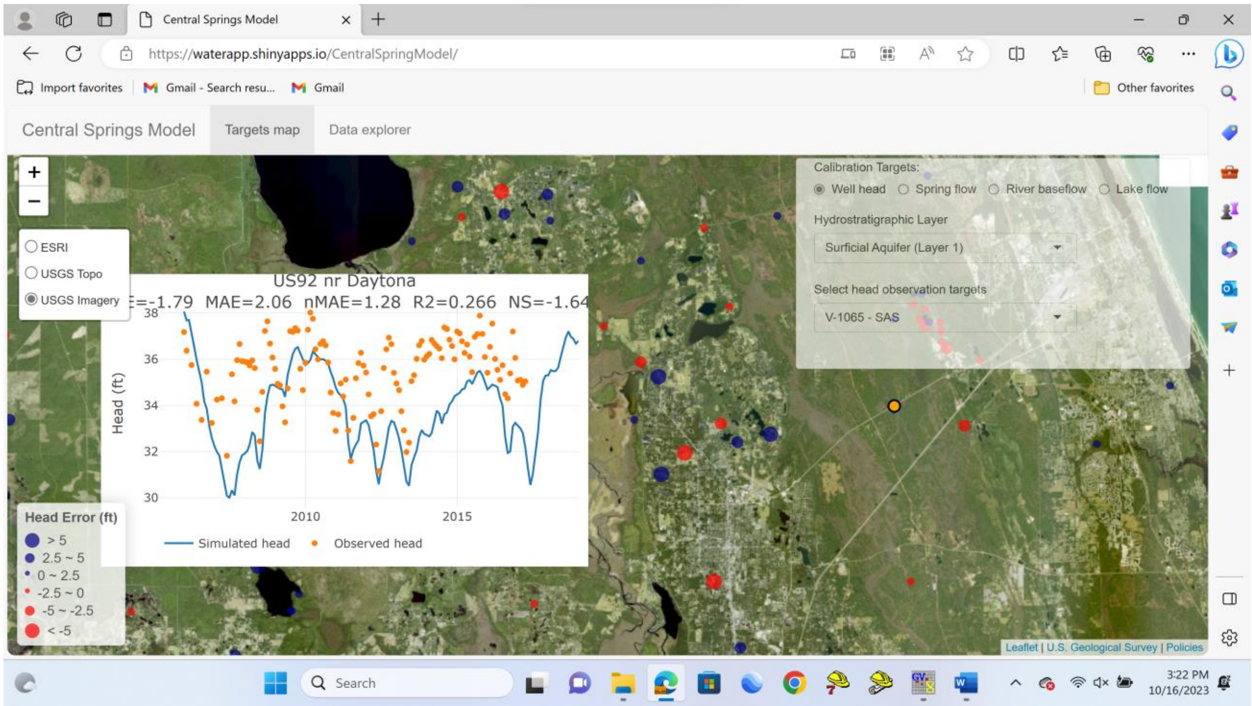
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
US92 nr Daytona
E=-1.79 MAE=2.06 nMAE=1.28 R2=0.266 NS=-1.64
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1065 - SAS
Leaflet | U.S. Geological Survey | Policies
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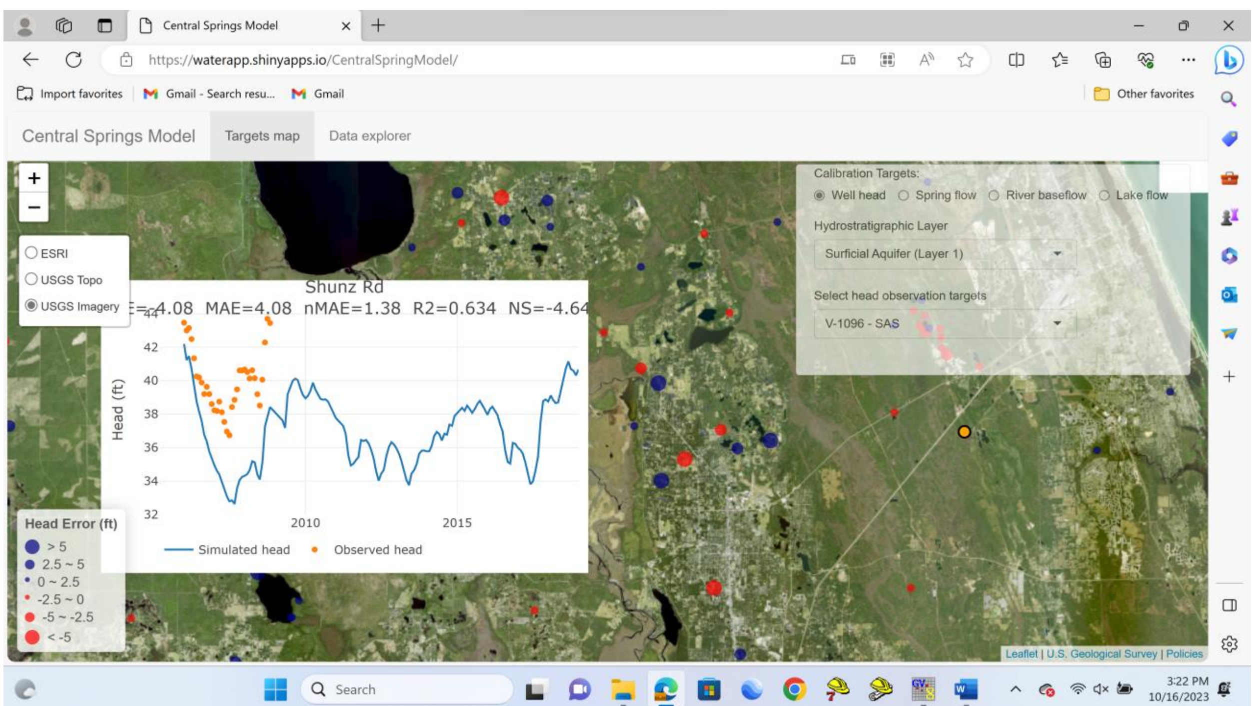
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Shunz Rd
E=-4.08 MAE=4.08 nMAE=1.38 R2=0.634 NS=-4.64
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1096 - SAS
Leaflet | U.S. Geological Survey | Policies
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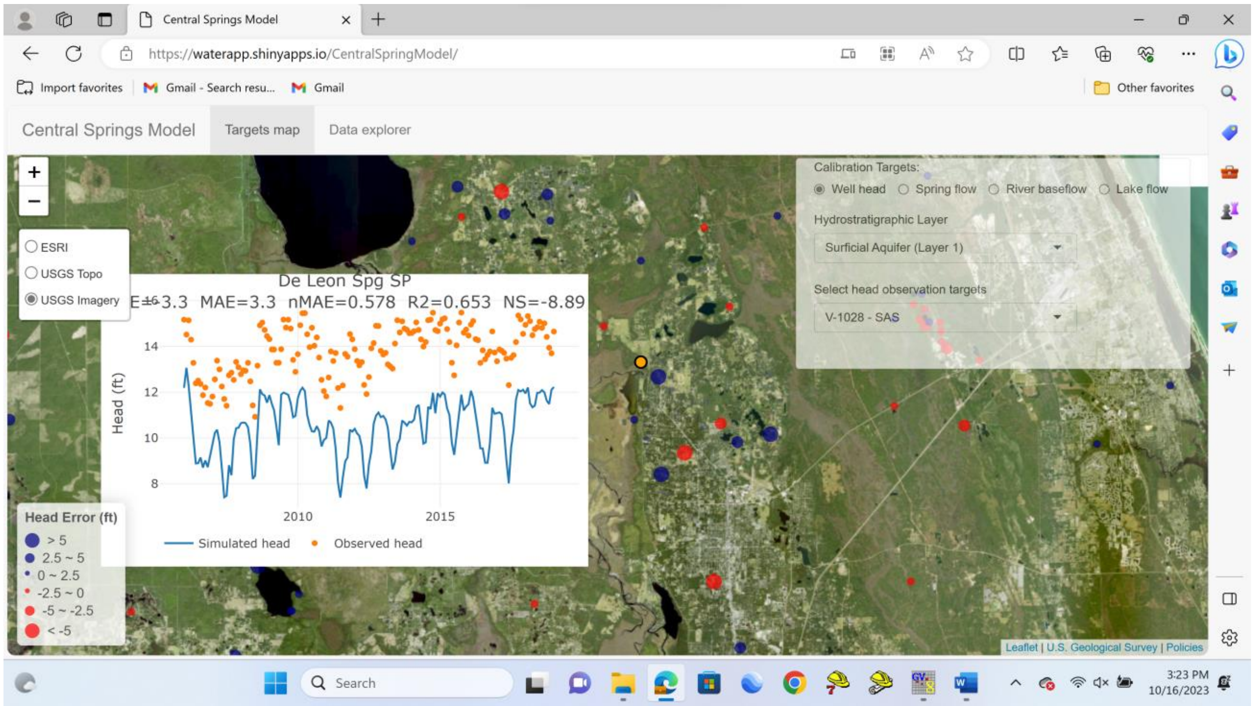
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
De Leon Spg SP
E=3.3 MAE=3.3 nMAE=0.578 R2=0.653 NS=-8.89
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1028 - SAS
Leaflet | U.S. Geological Survey | Policies
3:23 PM
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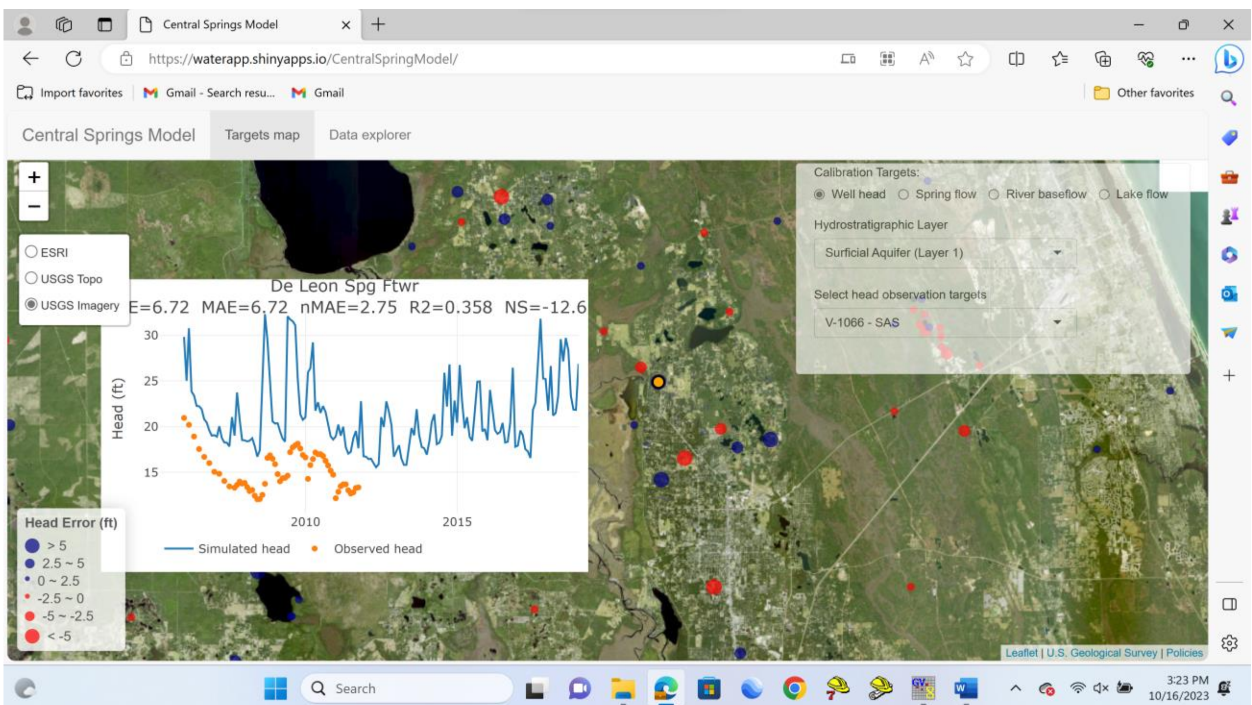
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
De Leon Spg Ftwr
E=6.72 MAE=6.72 nMAE=2.75 R2=0.358 NS=-12.6
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1066 - SAS
Leaflet | U.S. Geological Survey | Policies
3:23 PM
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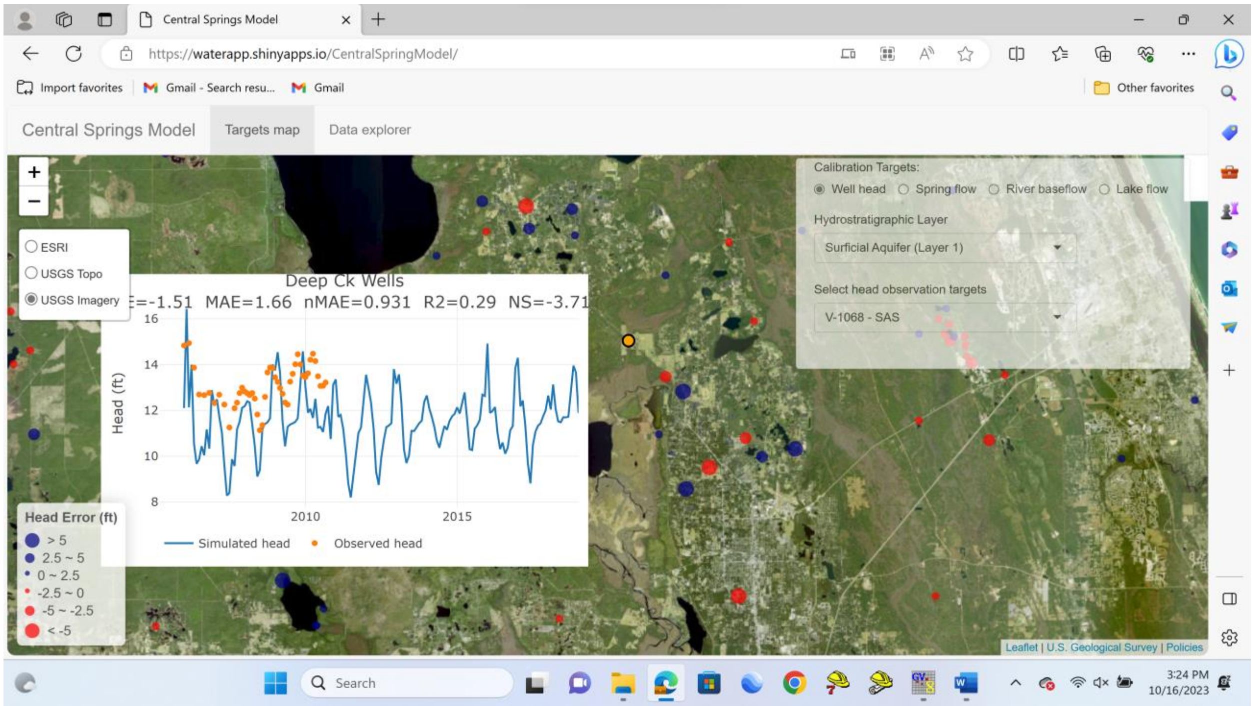
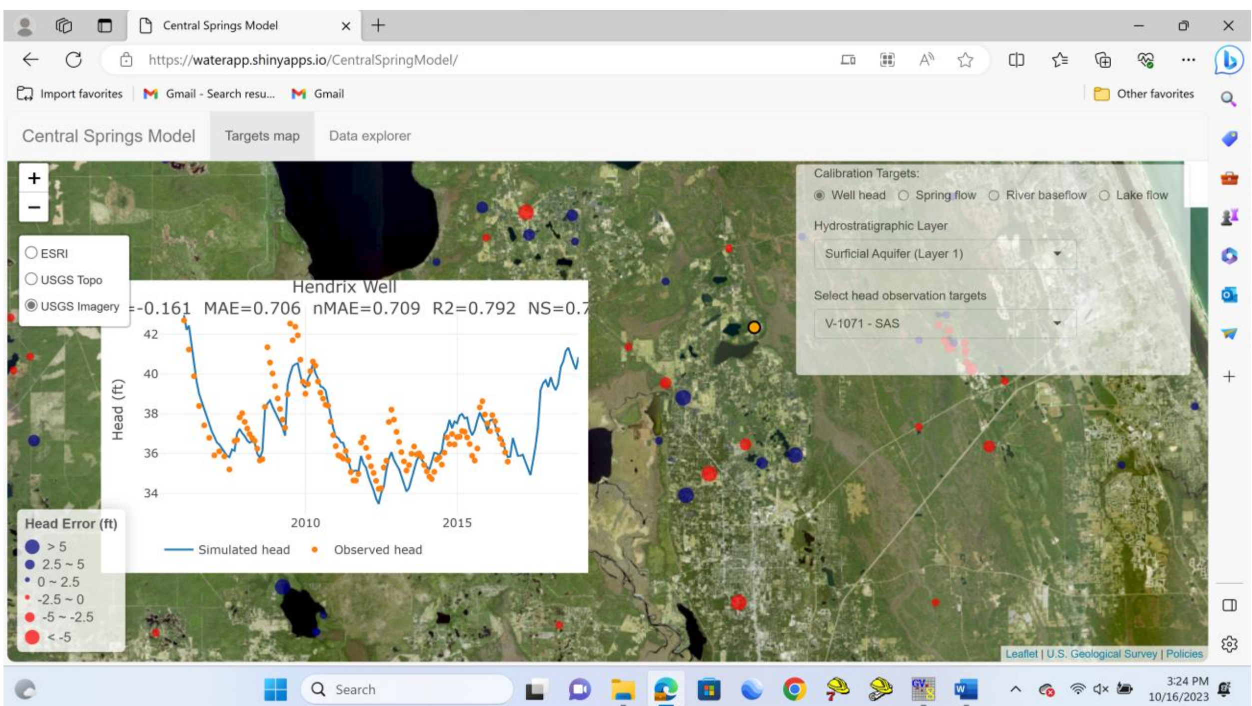
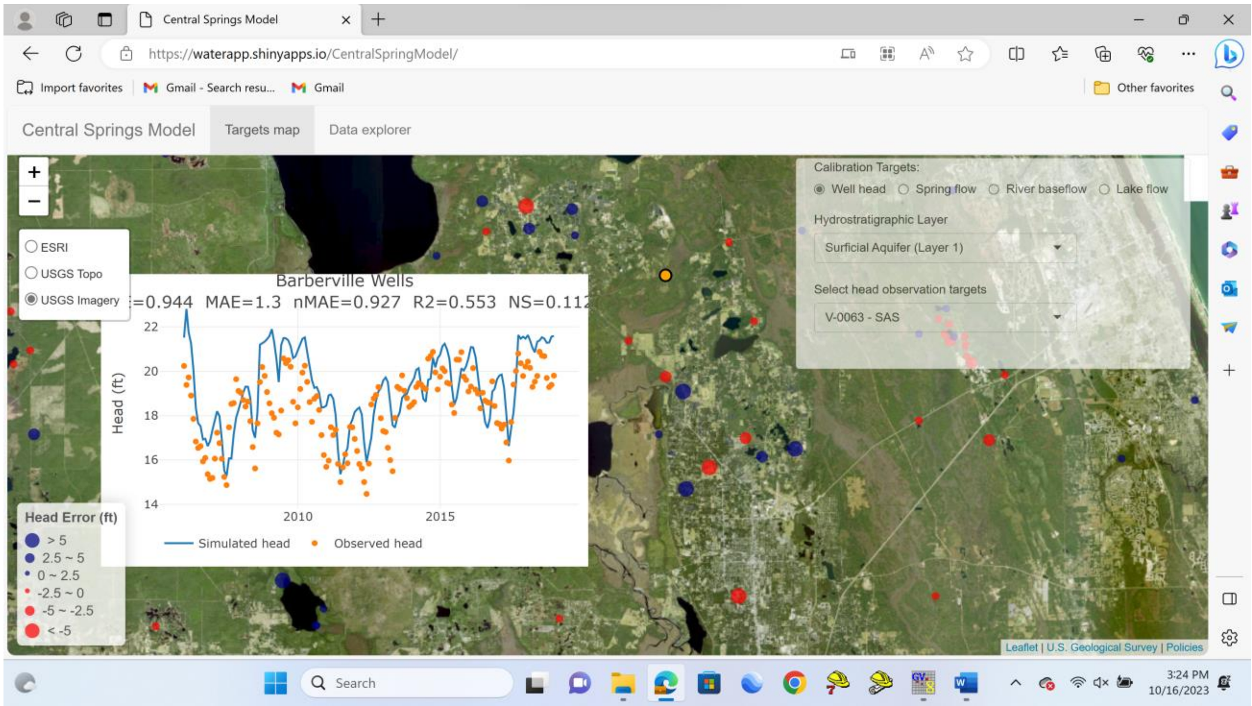

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Deep Ck Wells
E=-1.51 MAE=1.66 nMAE=0.931 R2=0.29 NS=-3.71
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1068 - SAS
Leaflet | U.S. Geological Survey | Policies
3:24 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Hendrix Well
E=-0.161 MAE=0.706 nMAE=0.709 R2=0.792 NS=0.7
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-1071 - SAS
Leaflet | U.S. Geological Survey | Policies
3:24 PM
10/16/2023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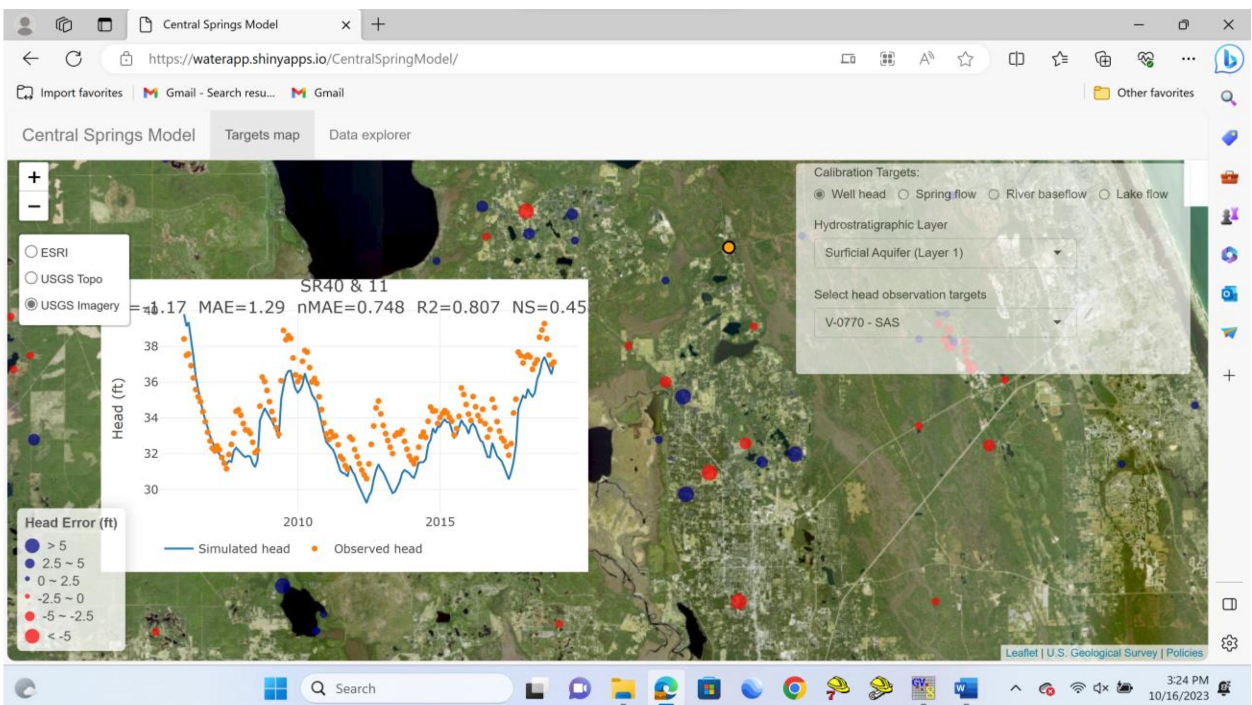
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Barberville Wells
=0.944 MAE=1.3 nMAE=0.927 R2=0.553 NS=0.112
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0063 - SAS
3:24 PM
10/16/2023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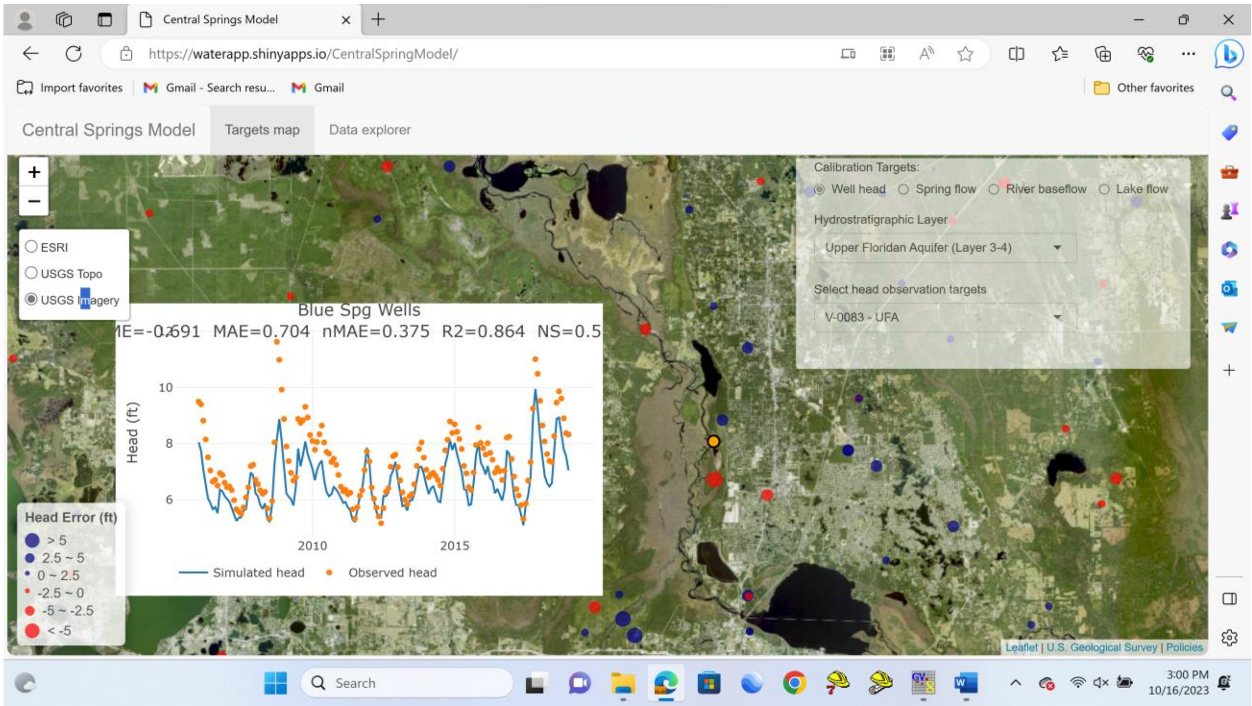
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
SR40 & 11
=1.17 MAE=1.29 nMAE=0.748 R2=0.807 NS=0.45
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
V-0770 - SAS
3:24 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Blue Spg Wells
ME=-0.691 MAE=0.704 nMAE=0.375 R2=0.864 NS=0.5
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0083 - UFA
Leaflet | U.S. Geological Survey | Policies
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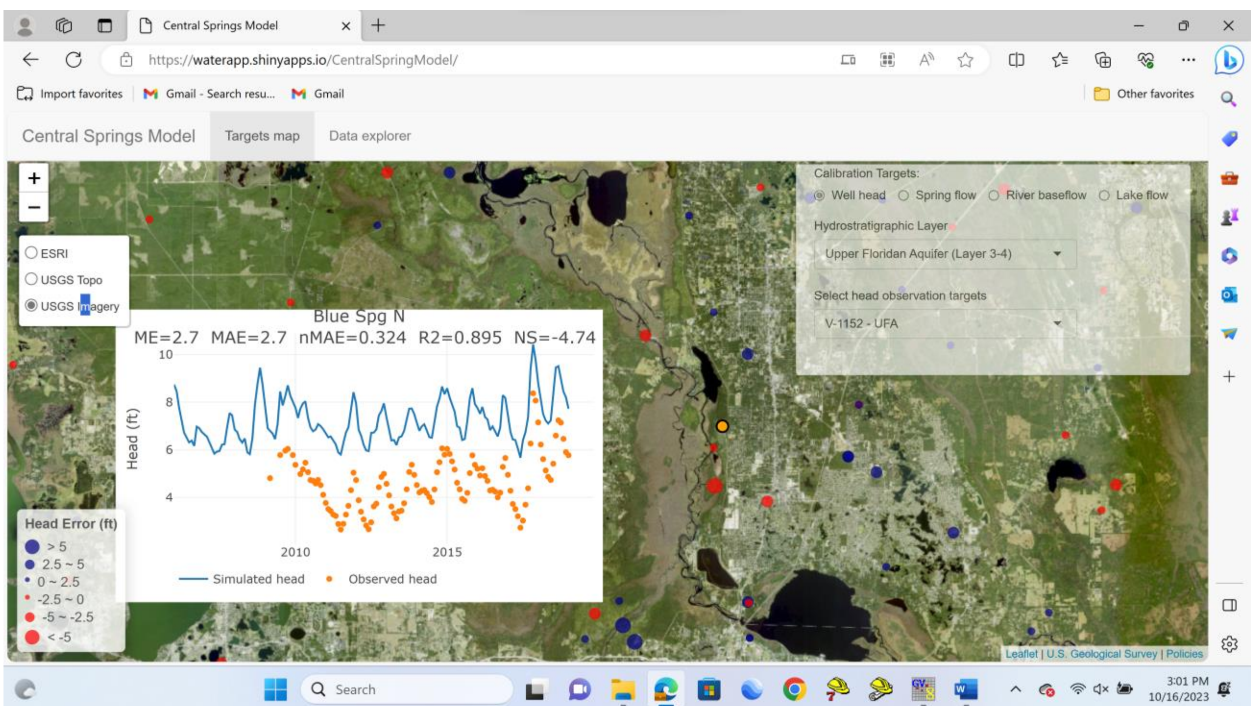
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https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Blue Spg N
ME=2.7 MAE=2.7 nMAE=0.324 R2=0.895 NS=-4.74
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1152 - UFA
Leaflet | U.S. Geological Survey | Policies
3:01 PM
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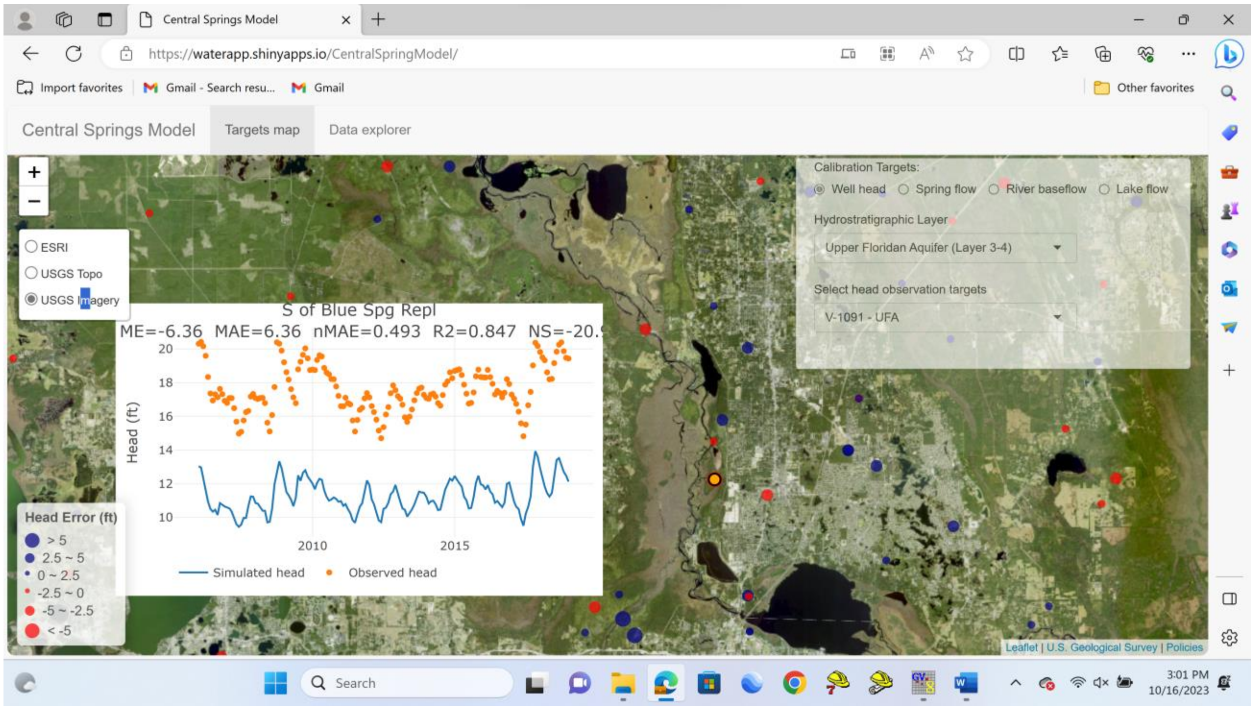
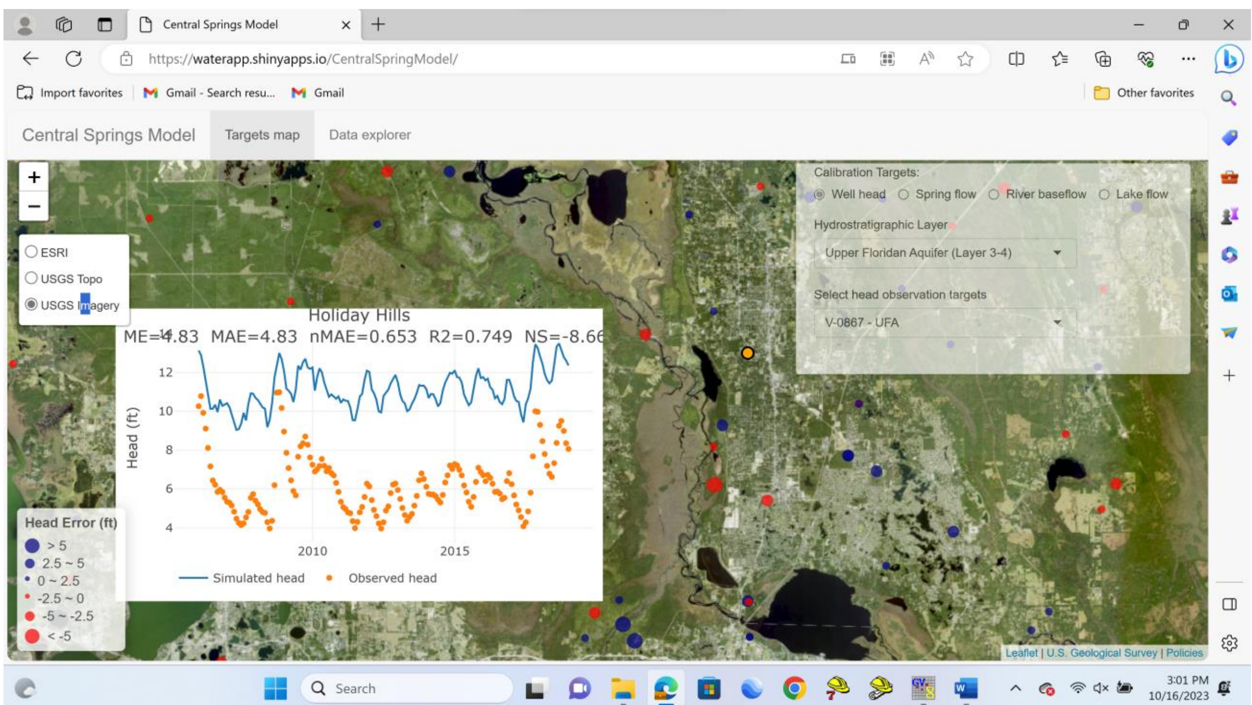
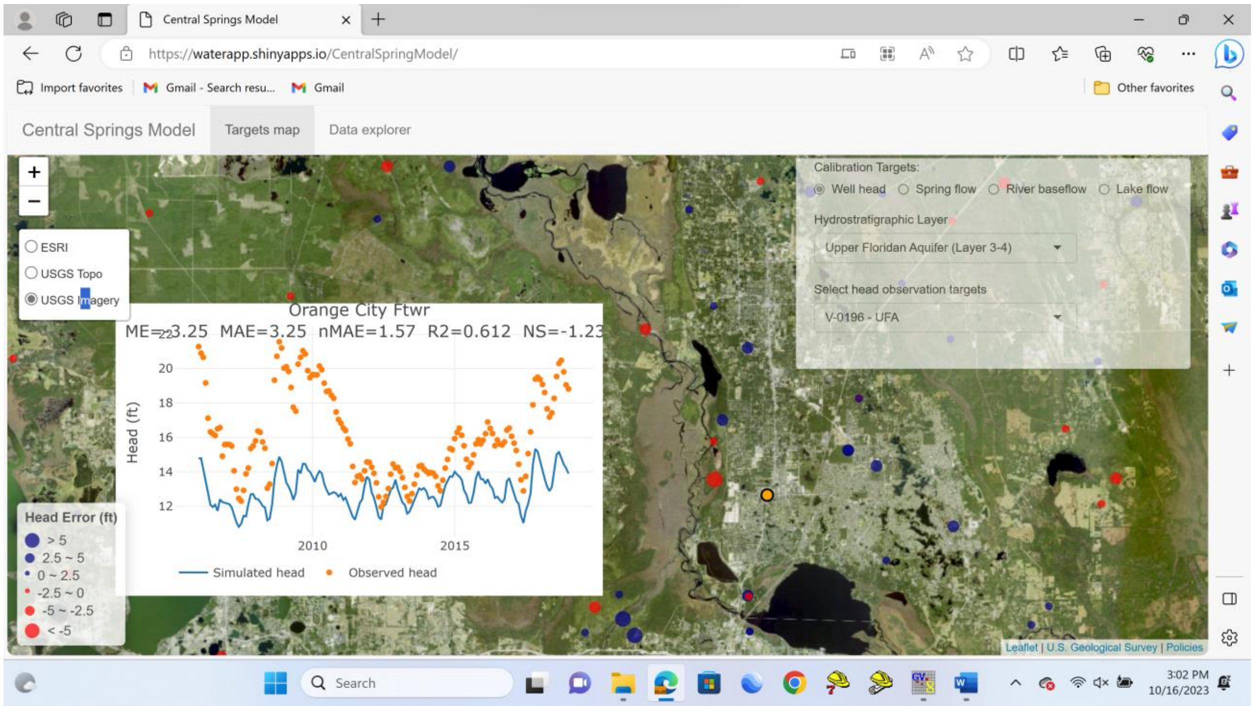
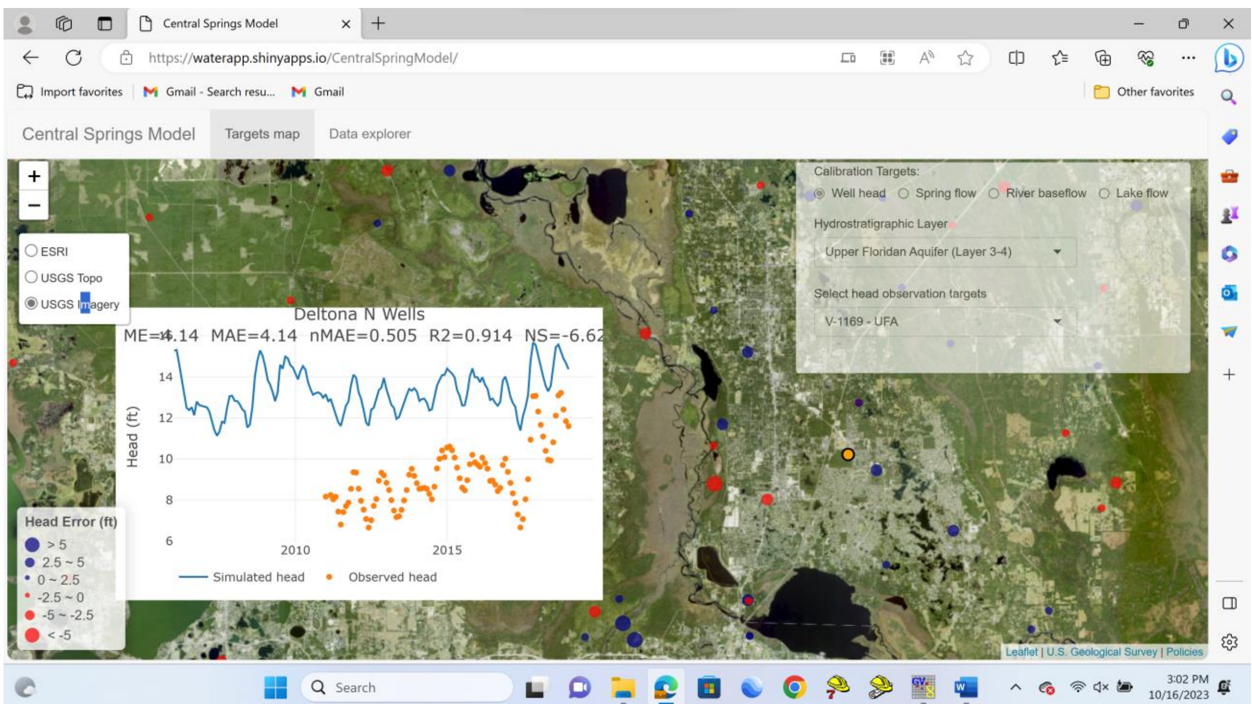
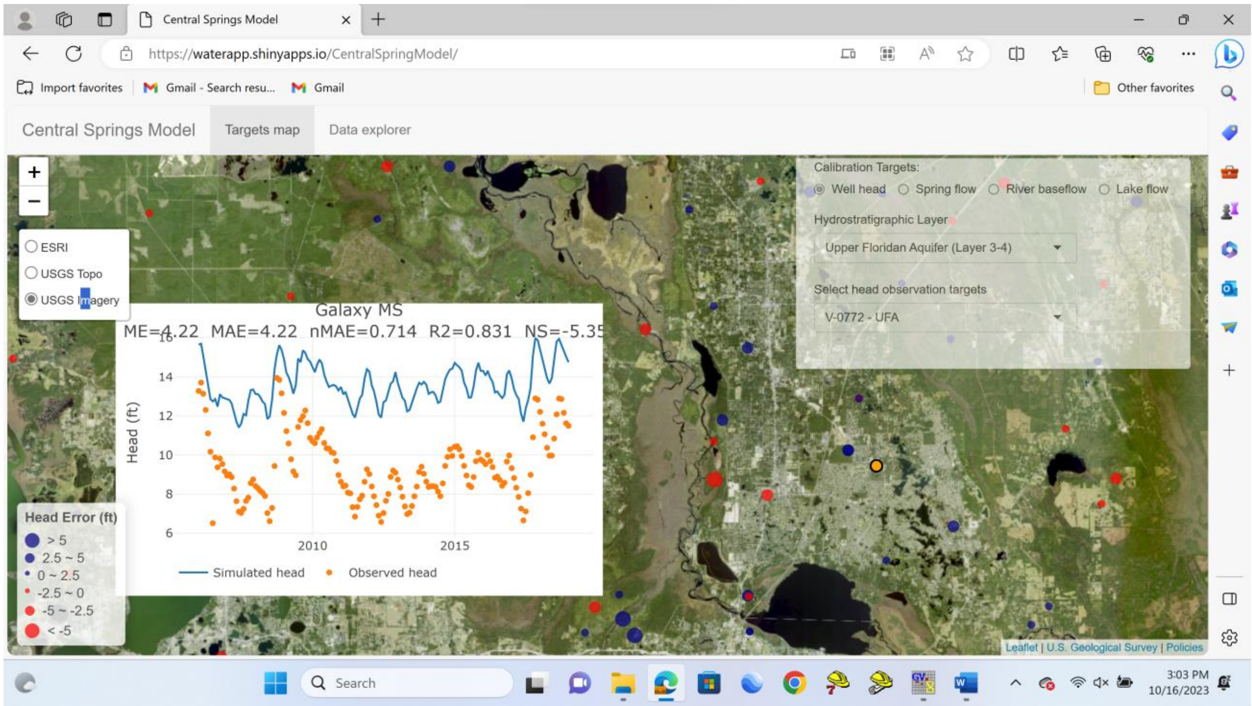
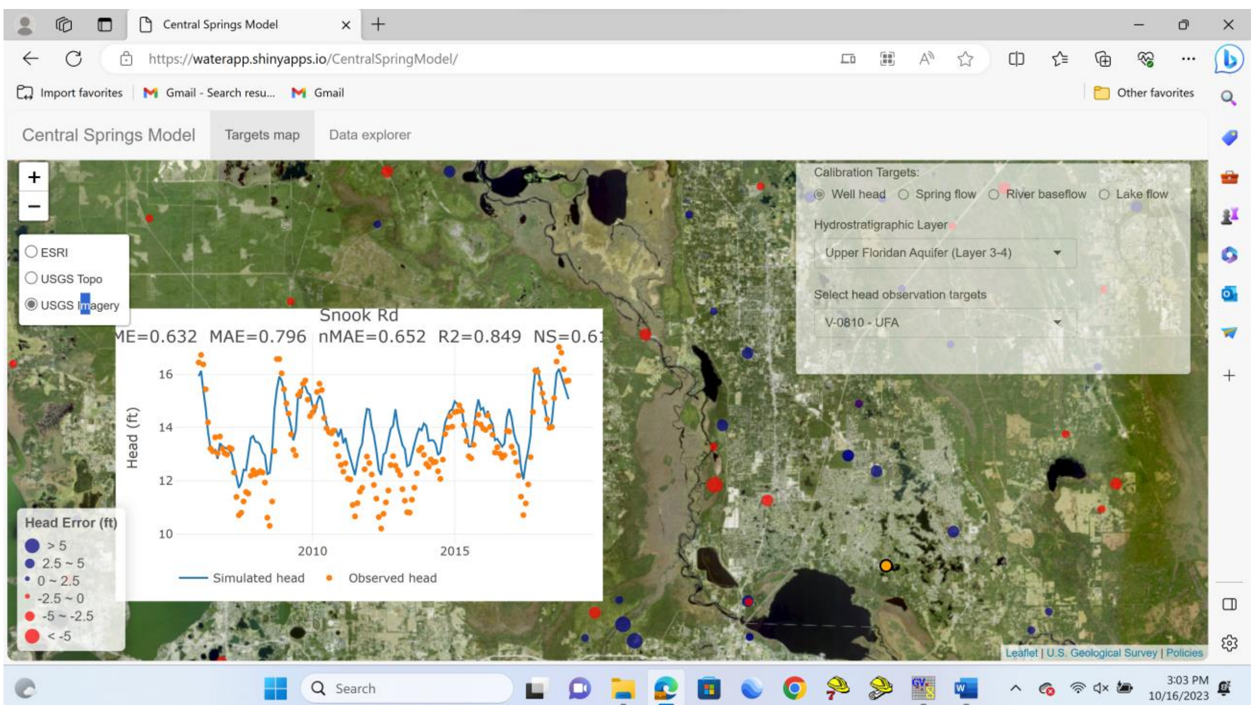

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
S of Blue Spg Repl
ME=-6.36 MAE=6.36 nMAE=0.493 R2=0.847 NS=-20.
Head (ft)
20
18
16
14
12
10
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1091 - UFA
Leaflet | U.S. Geological Survey | Policies
Search
3:01 PM
10/16/2023

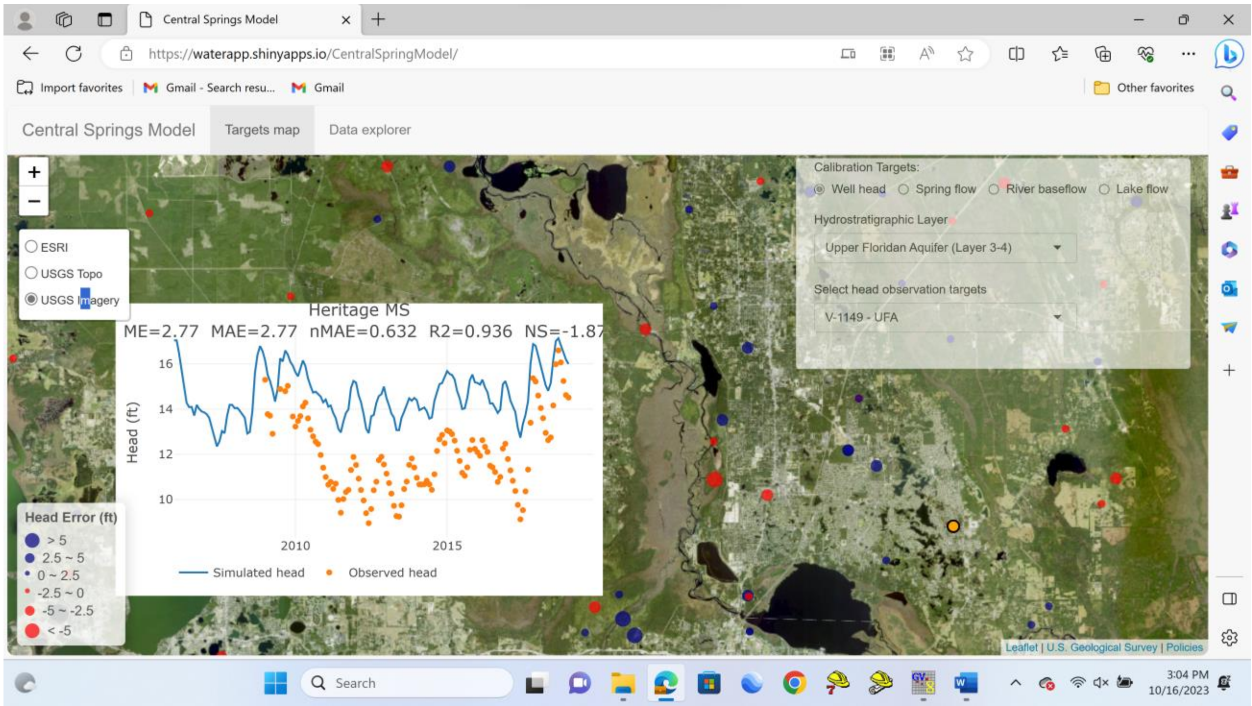

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Holiday Hills
ME=4.83 MAE=4.83 nMAE=0.653 R2=0.749 NS=-8.66
Head (ft)
12
10
8
6
4
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0867 - UFA
Leaflet | U.S. Geological Survey | Policies
Search
3:01 PM
10/16/2023

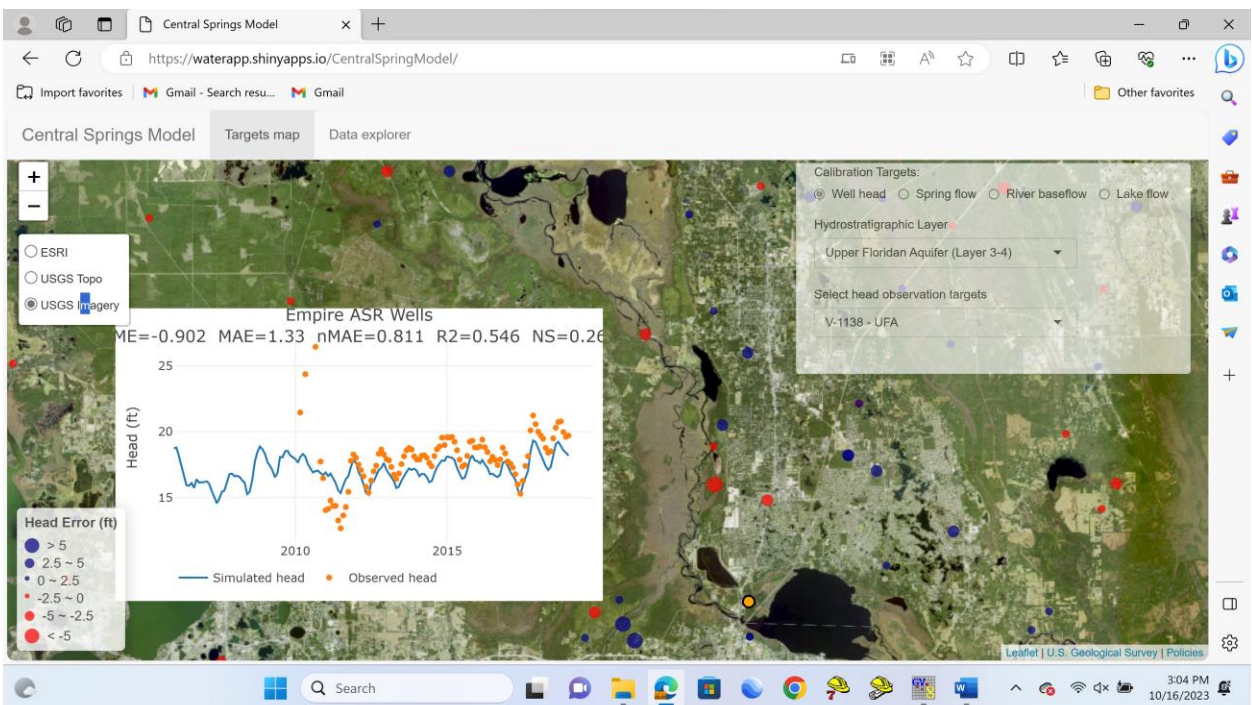

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0196 - UFA
Orange City Ftwr
ME=3.25 MAE=3.25 nMAE=1.57 R2=0.612 NS=-1.23
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
ESRI
USGS Topo
USGS Imagery
3:02 PM
10/16/2023

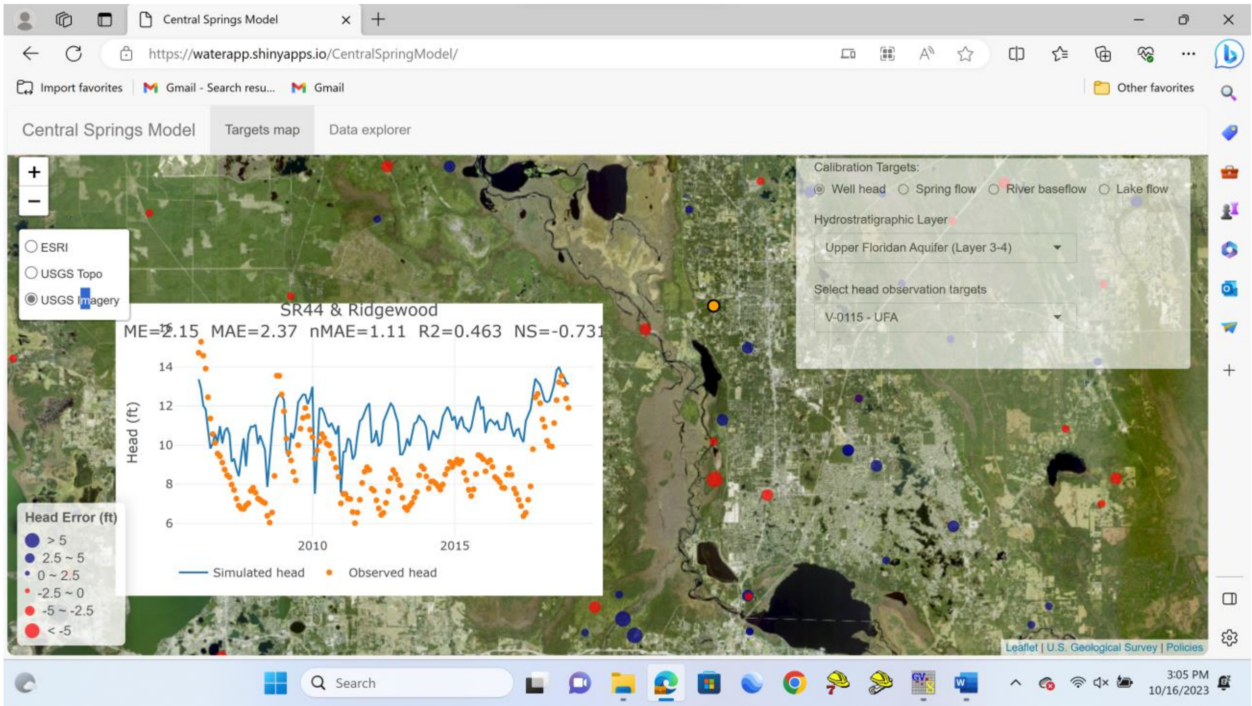

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1169 - UFA
Deltona N Wells
ME=4.14 MAE=4.14 nMAE=0.505 R2=0.914 NS=-6.62
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
ESRI
USGS Topo
USGS Imagery
3:02 PM
10/16/2023


Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0772 - UFA
ESRI
USGS Topo
USGS Imagery
Galaxy MS
ME=4.22 MAE=4.22 nMAE=0.714 R2=0.831 NS=-5.35
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies

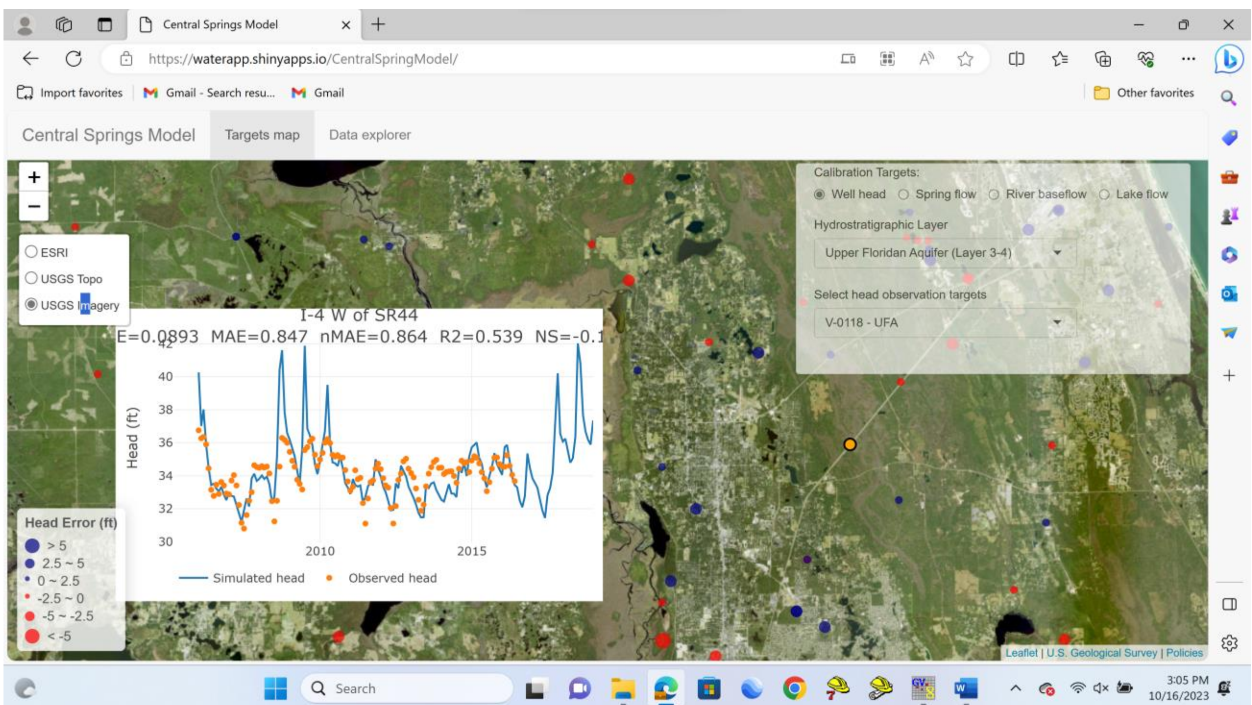

Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0810 - UFA
ESRI
USGS Topo
USGS Imagery
Snook Rd
ME=0.632 MAE=0.796 nMAE=0.652 R2=0.849 NS=0.61
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1149 - UFA
ESRI
USGS Topo
USGS Imagery
Heritage MS
ME=2.77 MAE=2.77 nMAE=0.632 R2=0.936 NS=-1.87
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:04 PM
10/16/2023

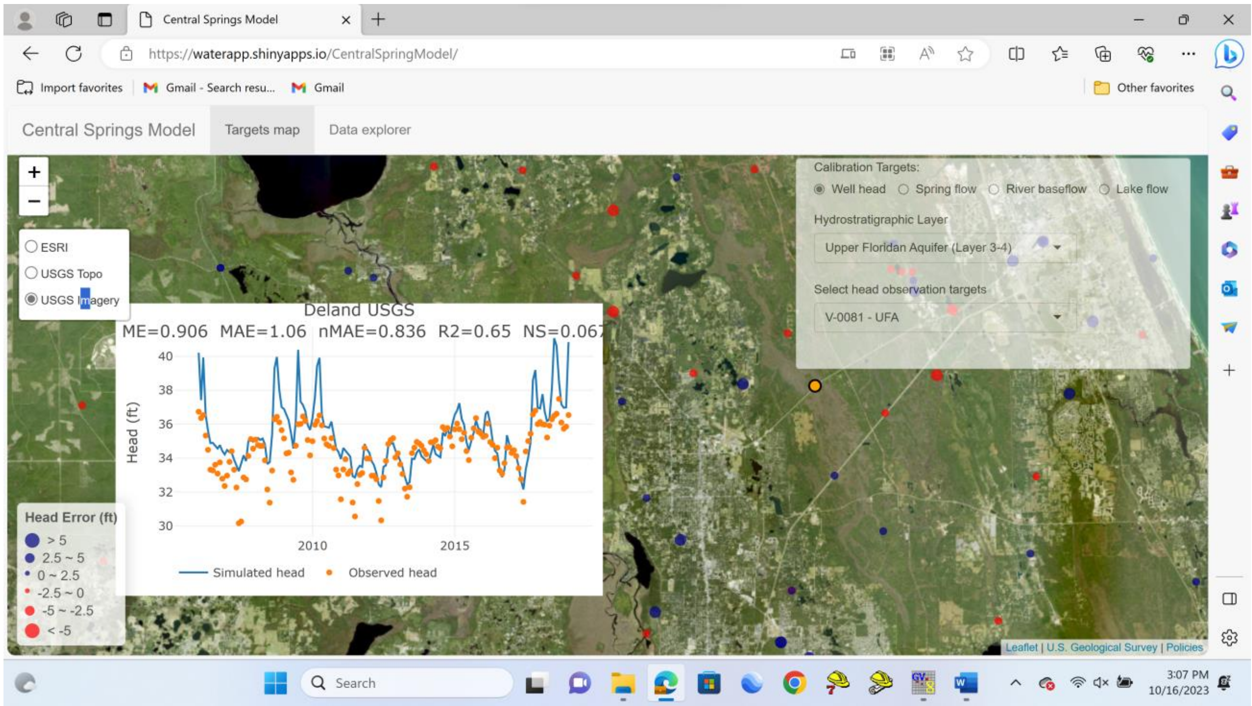

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1138 - UFA
ESRI
USGS Topo
USGS Imagery
Empire ASR Wells
ME=-0.902 MAE=1.33 nMAE=0.811 R2=0.546 NS=0.26
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:04 PM
10/16/2023

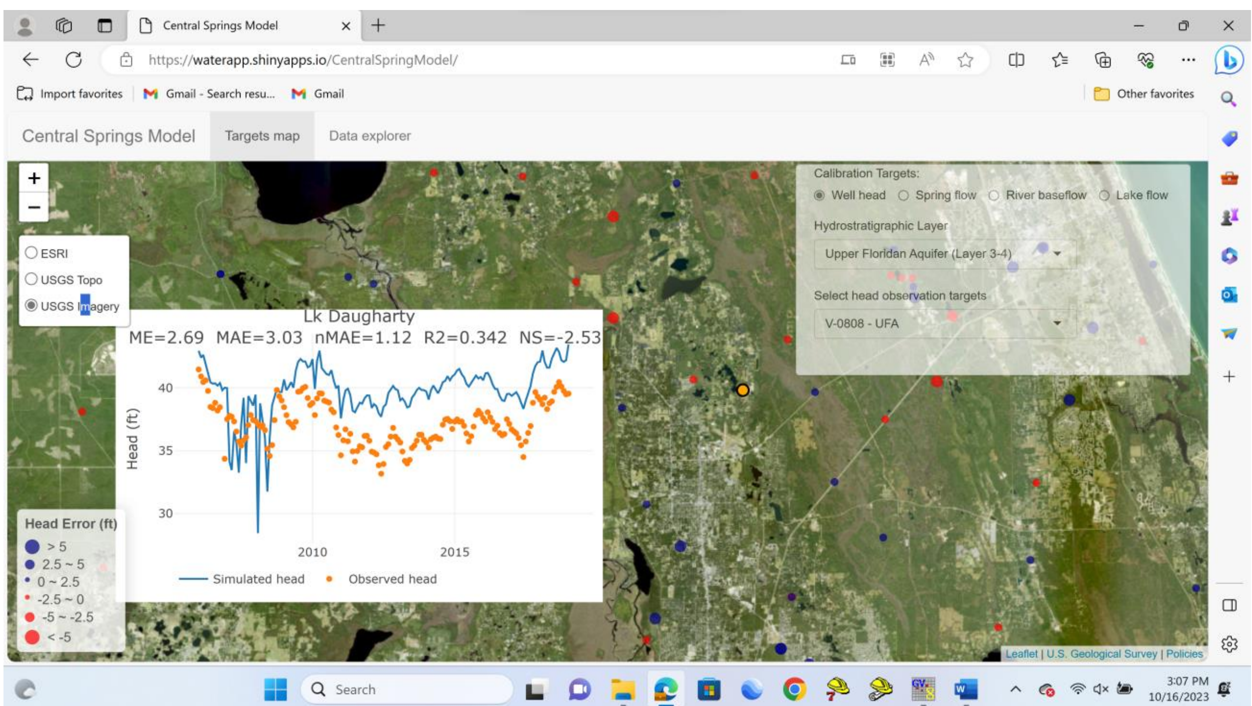


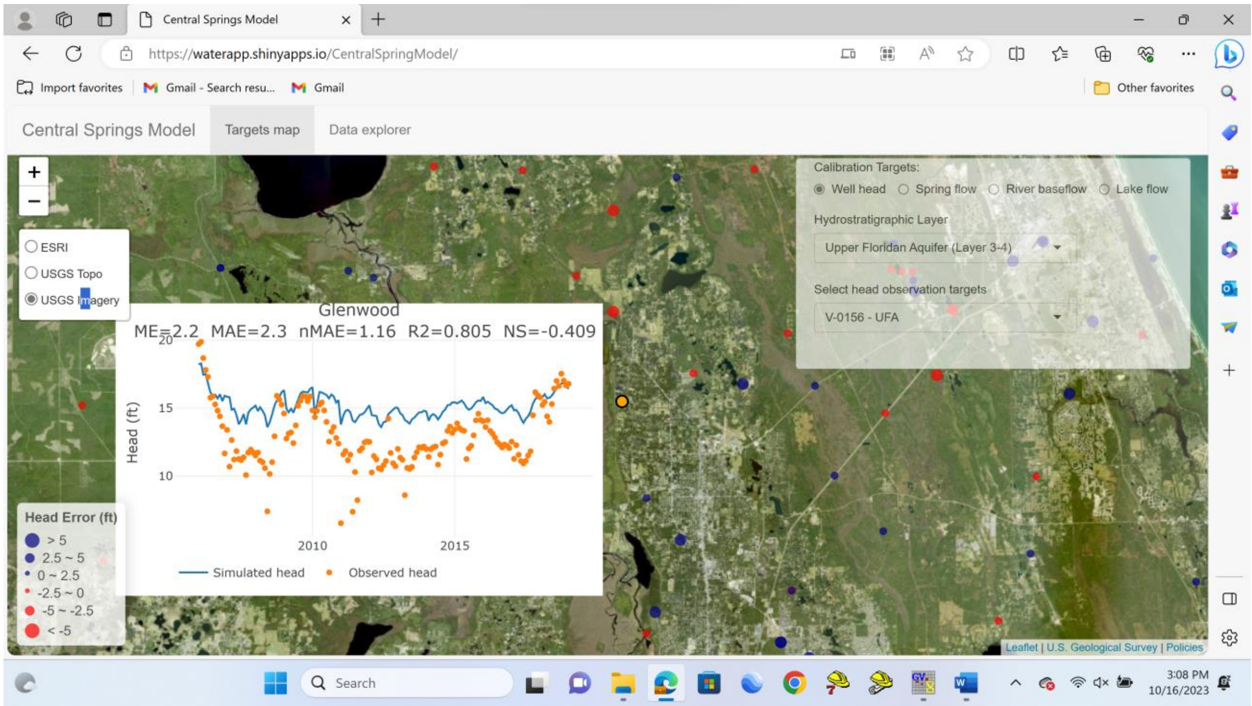
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
SR44 & Ridgewood
ME=2.15 MAE=2.37 nMAE=1.11 R2=0.463 NS=-0.731
Head (ft)
Simulated head
Observed head
Head Error (ft)
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0115 - UFA

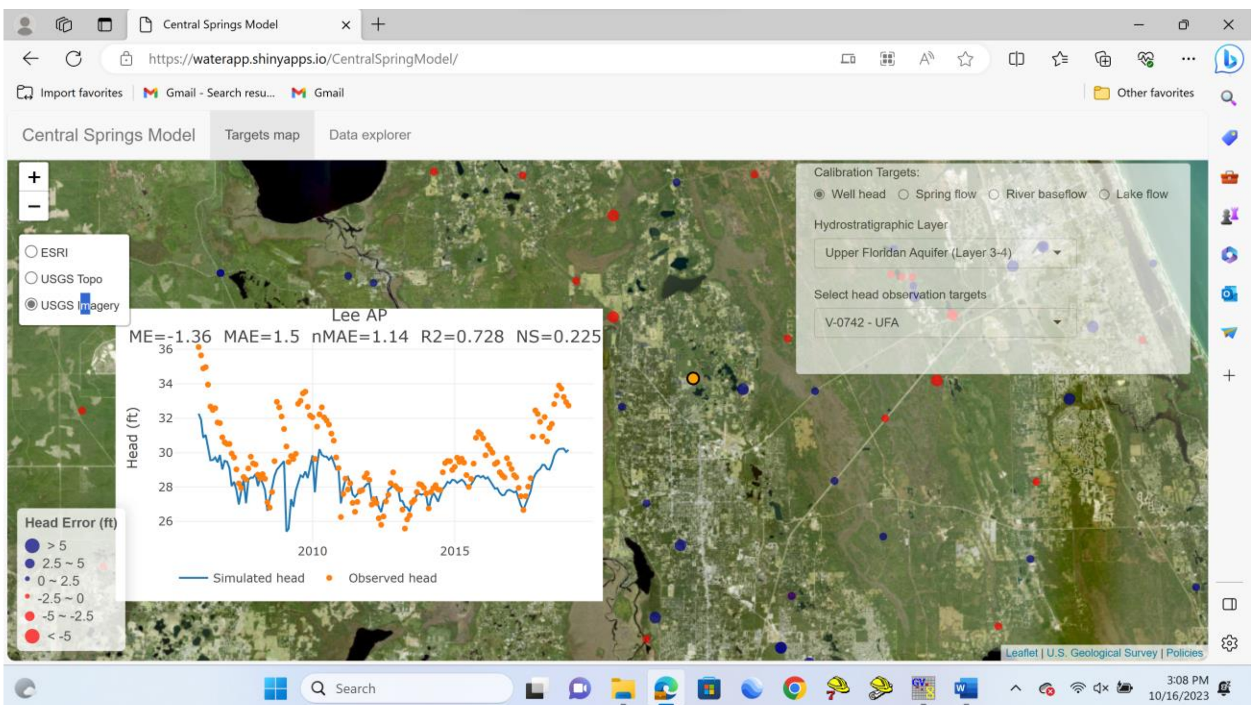


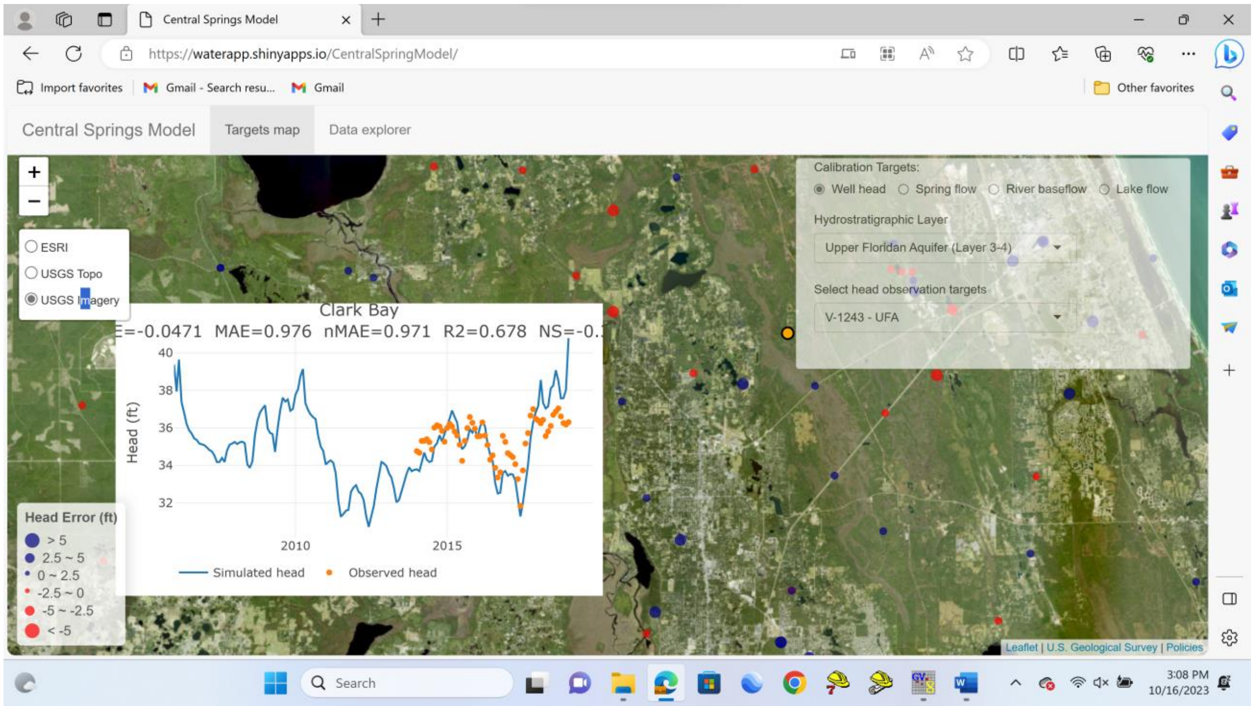
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
I-4 W of SR44
E=0.0893 MAE=0.847 nMAE=0.864 R2=0.539 NS=-0.1
Head (ft)
Simulated head
Observed head
Head Error (ft)
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0118 - UFA


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0081 - UFA
ESRI
USGS Topo
USGS Imagery
Deland USGS
ME=0.906 MAE=1.06 nMAE=0.836 R2=0.65 NS=0.067
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:07 PM
10/16/2023

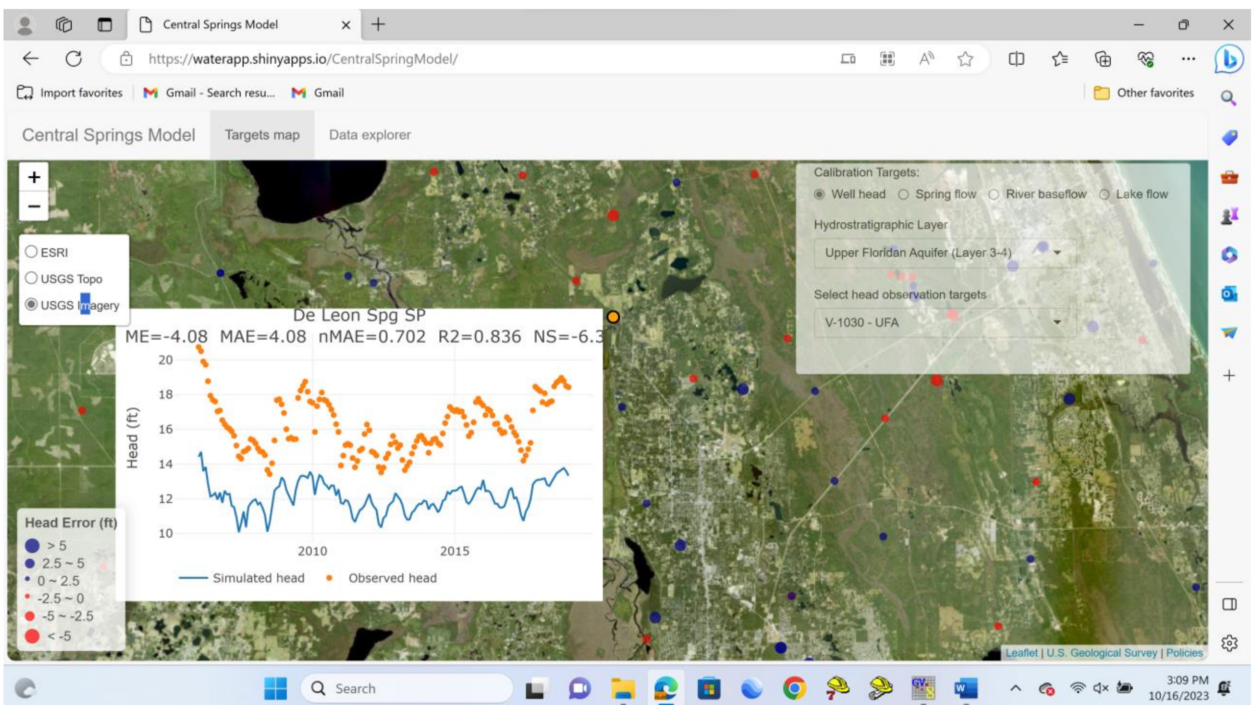

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0808 - UFA
ESRI
USGS Topo
USGS Imagery
Lk Daugharty
ME=2.69 MAE=3.03 nMAE=1.12 R2=0.342 NS=-2.53
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:07 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0156 - UFA
ESRI
USGS Topo
USGS Imagery
Glenwood
ME=2.2 MAE=2.3 nMAE=1.16 R2=0.805 NS=-0.409
Head (ft)
20
15
10
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies

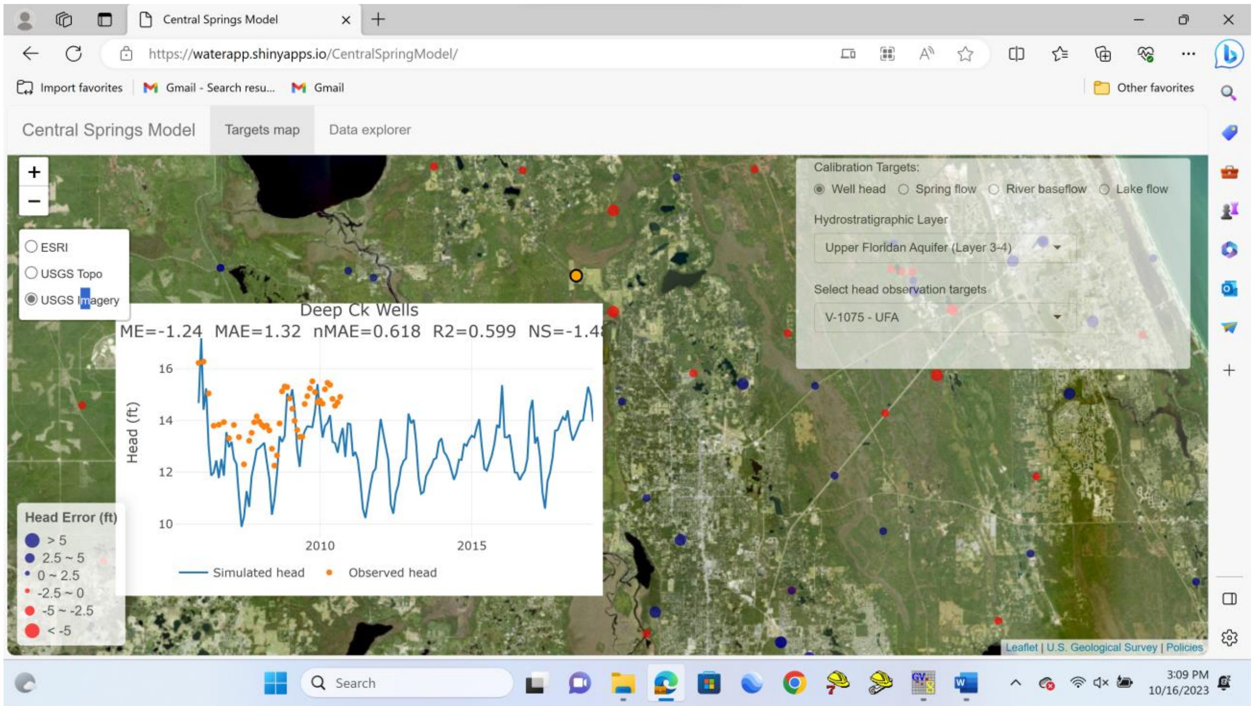

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0742 - UFA
ESRI
USGS Topo
USGS Imagery
Lee AP
ME=-1.36 MAE=1.5 nMAE=1.14 R2=0.728 NS=0.225
Head (ft)
36
34
32
30
28
26
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies

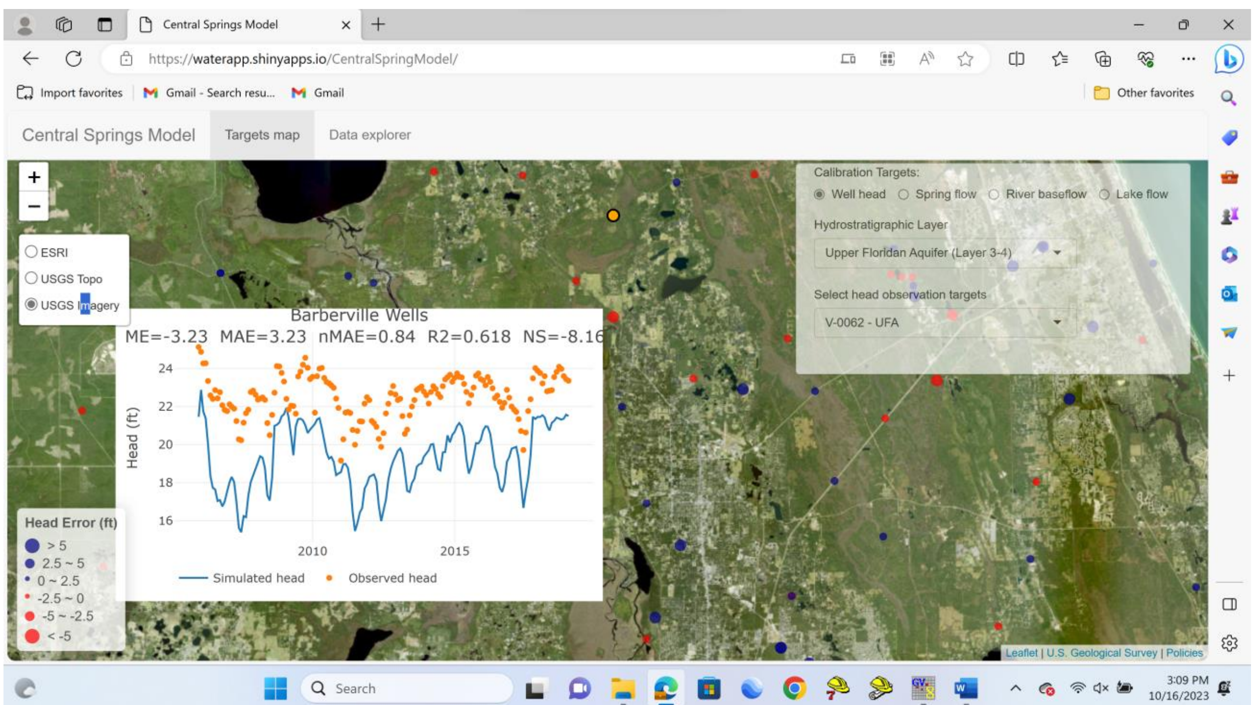


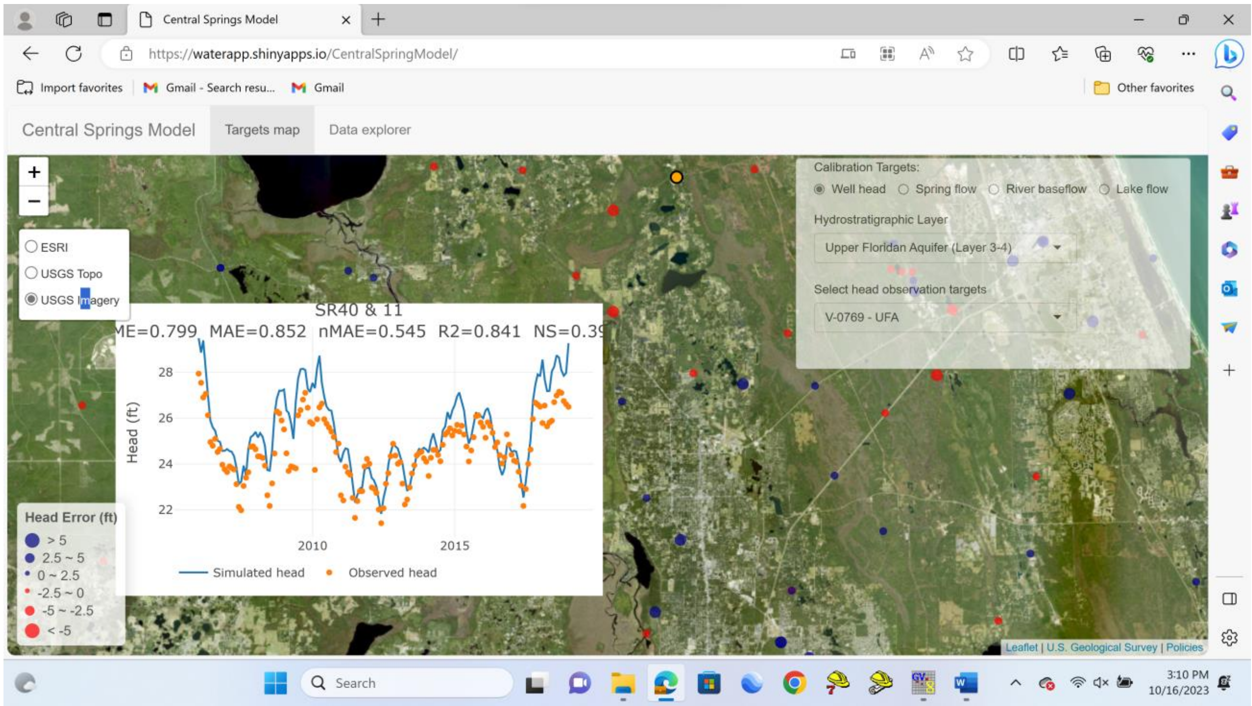
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1243 - UFA
Clark Bay
=-0.0471 MAE=0.976 nMAE=0.971 R2=0.678 NS=-0.
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:08 PM
10/16/2023

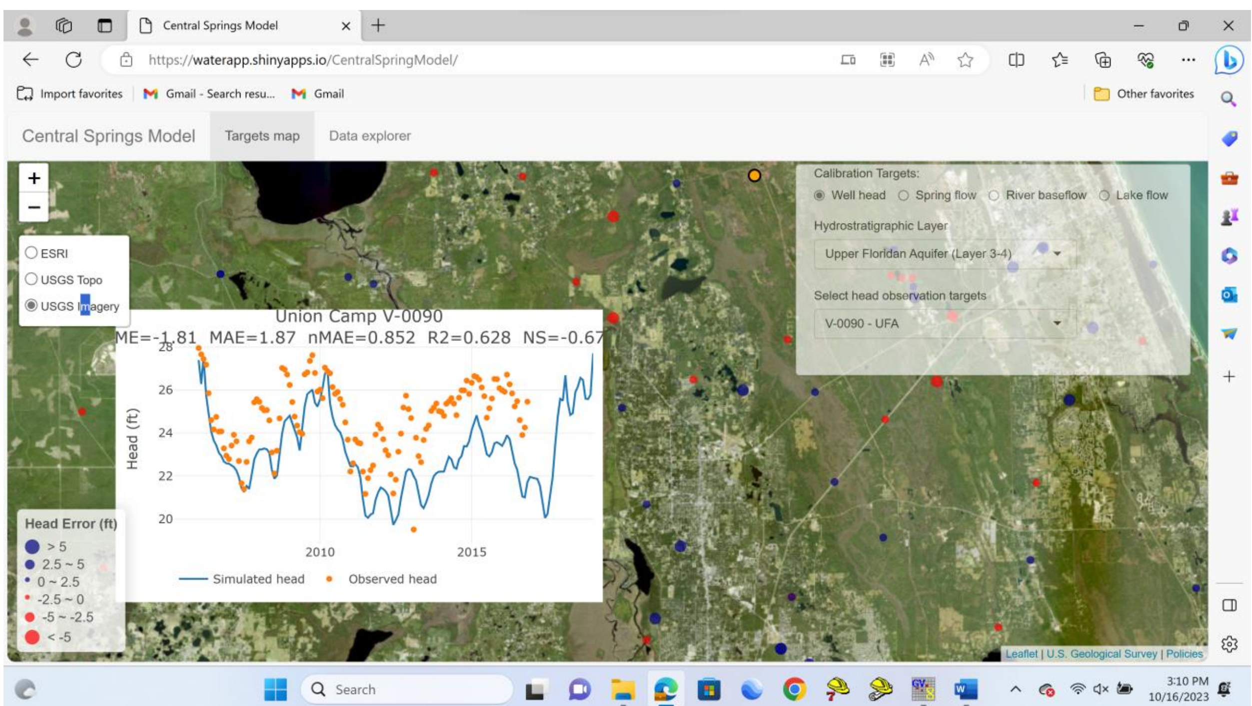


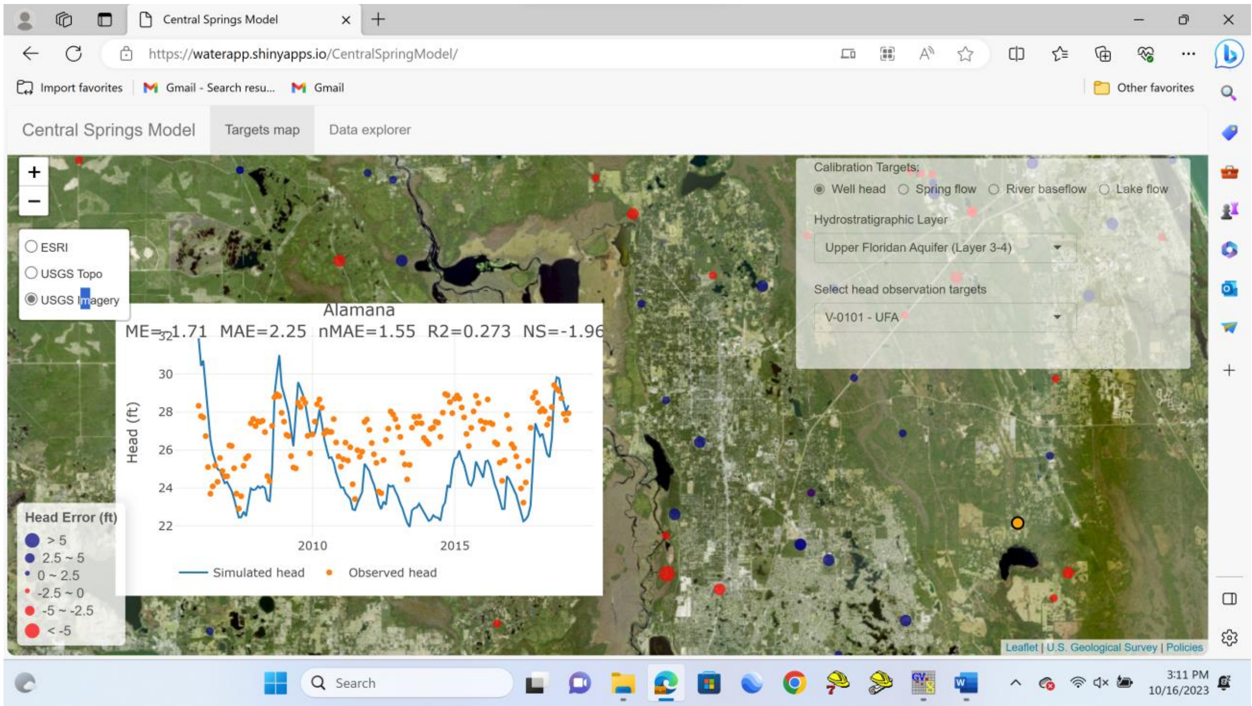
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1030 - UFA
De Leon Spg SP
ME=-4.08 MAE=4.08 nMAE=0.702 R2=0.836 NS=-6.3
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
3:09 PM
10/16/2023

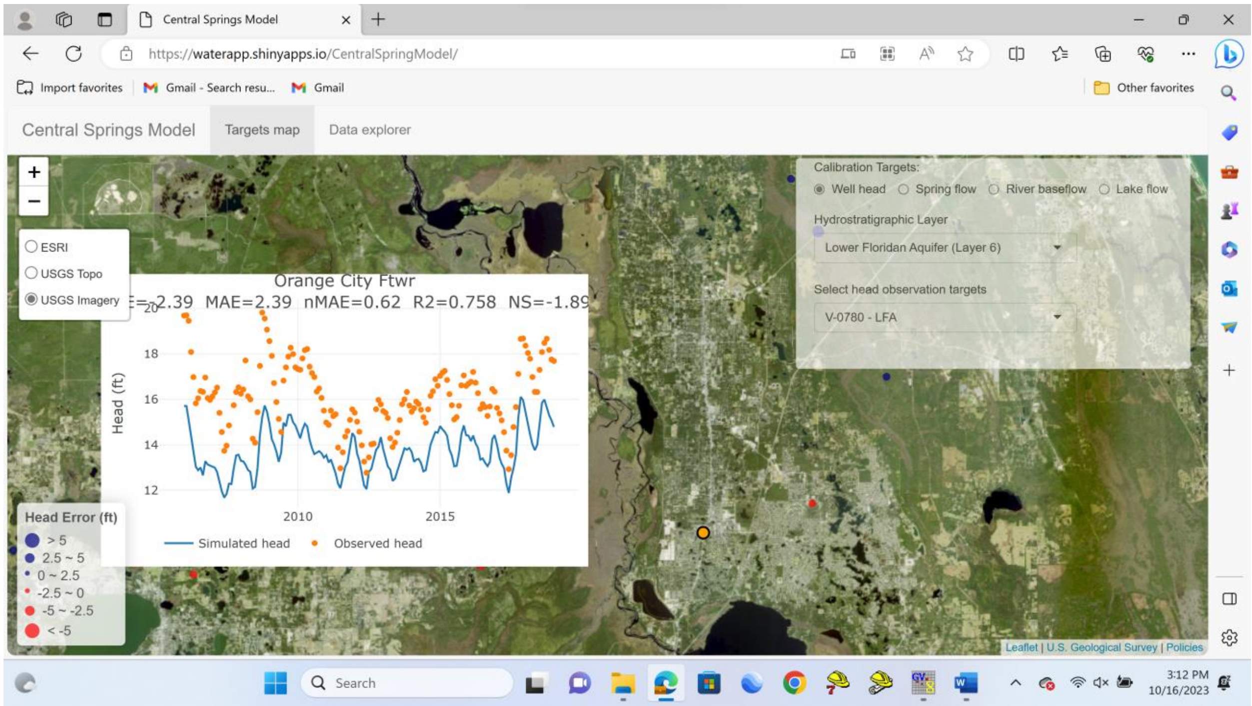

Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-1075 - UFA
Deep Ck Wells
ME=-1.24 MAE=1.32 nMAE=0.618 R2=0.599
Head (ft)
Simulated head
Observed head
Head Error (ft)
ESRI
USGS Topo

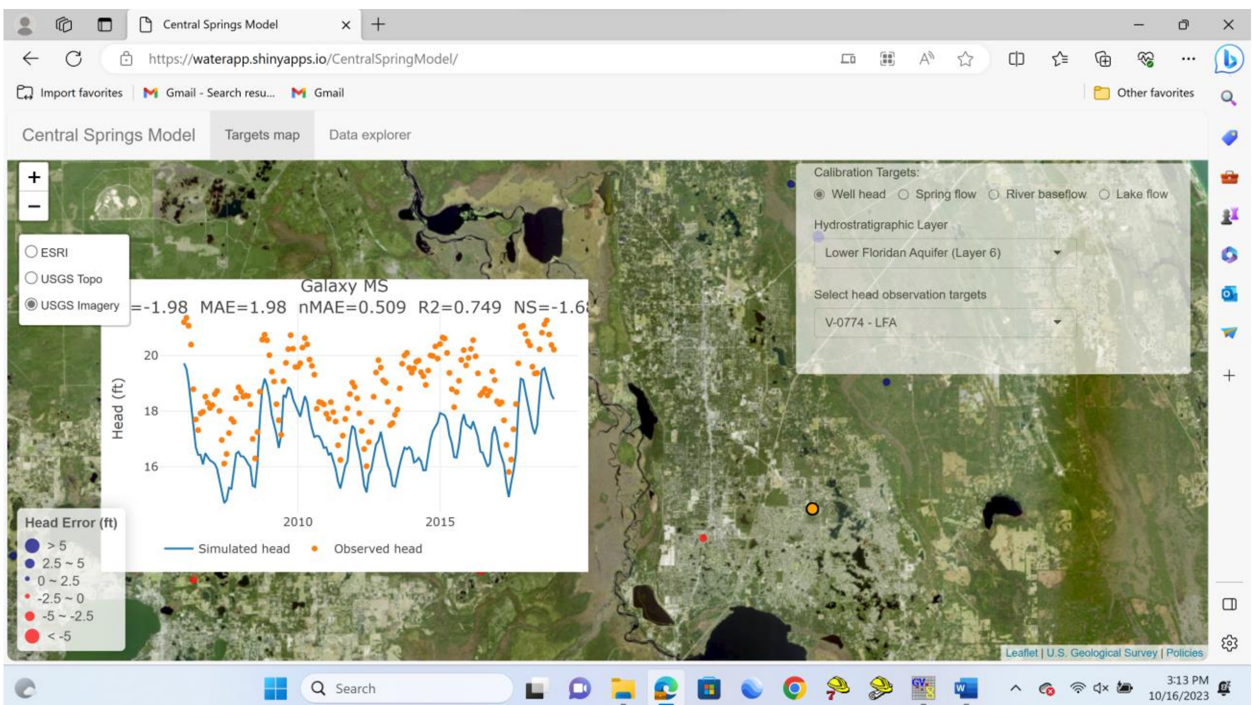

Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0062 - UFA
Barberville Wells
ME=-3.23 MAE=3.23 nMAE=0.84 R2=0.618
Head (ft)
Simulated head
Observed head
Head Error (ft)
ESRI
USGS Topo

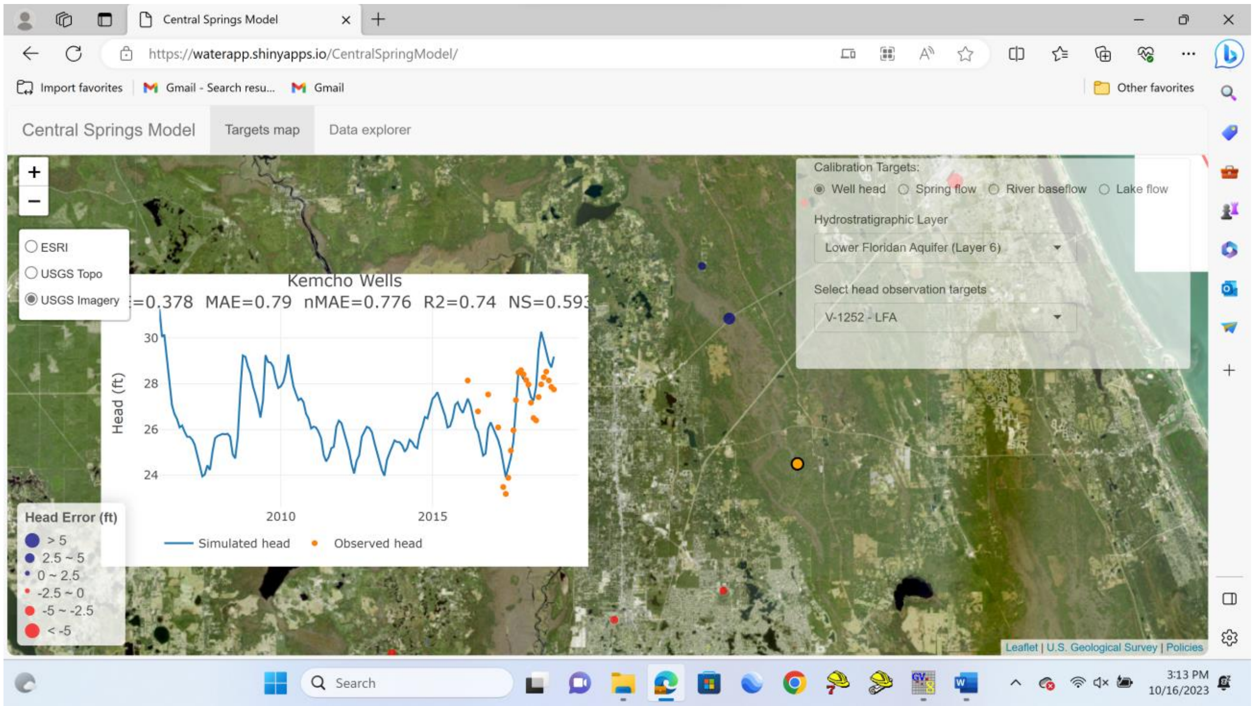

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0769 - UFA
ESRI
USGS Topo
USGS Imagery
SR40 & 11
ME=0.799 MAE=0.852 nMAE=0.545 R2=0.841 NS=0.39
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
3:10 PM
10/16/2023

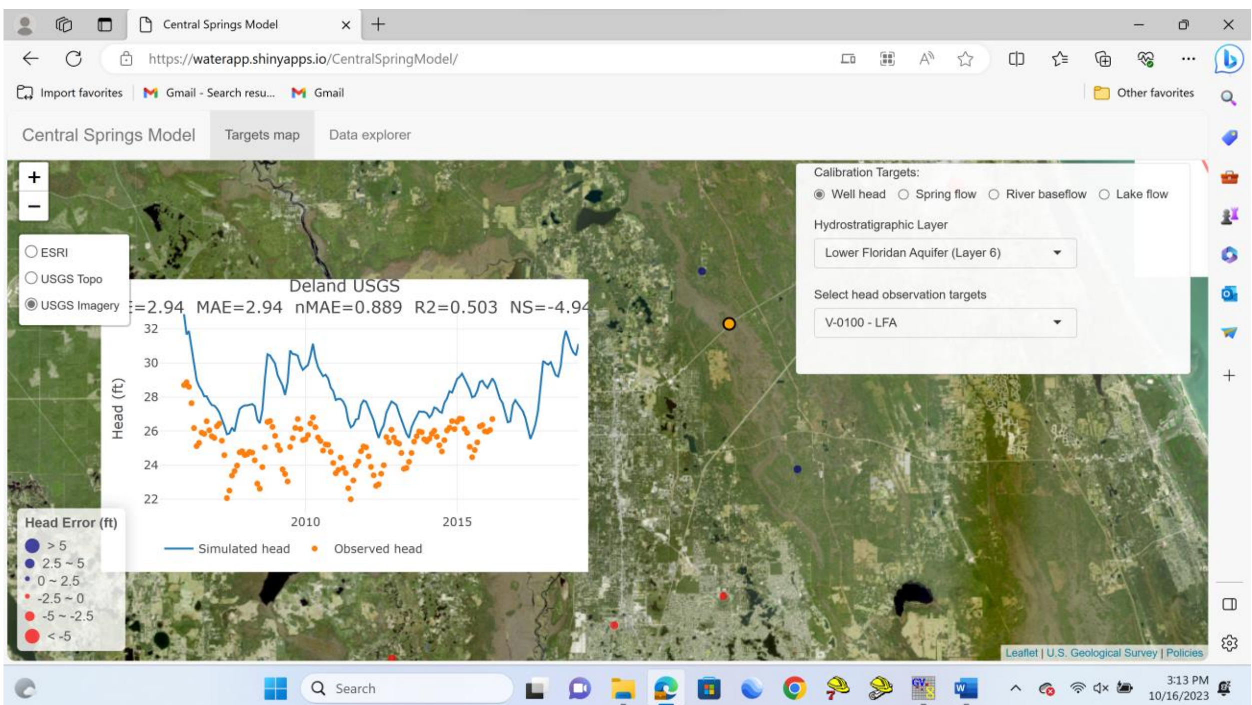

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0090 - UFA
ESRI
USGS Topo
USGS Imagery
Union Camp V-0090
ME=-1.81 MAE=1.87 nMAE=0.852 R2=0.628 NS=-0.67
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
3:10 PM
10/16/2023

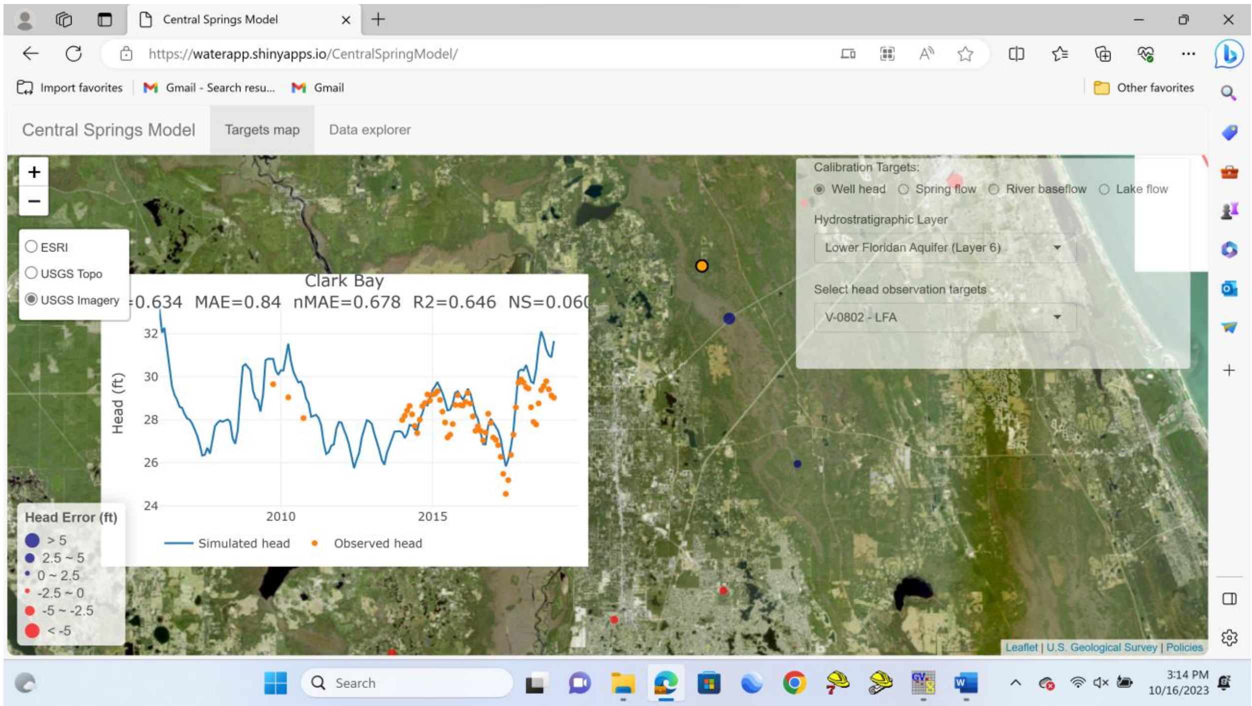

Central Springs Model
Targets map
Data explorer
https://waterapp.shinyapps.io/CentralSpringModel/
ESRI
USGS Topo
USGS Imagery
Alamana
ME=-1.71 MAE=2.25 nMAE=1.55 R2=0.273 NS=-1.96
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
V-0101 - UFA
3:11 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Orange City Ftwr
=2.39 MAE=2.39 nMAE=0.62 R2=0.758 NS=-1.89
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
V-0780 - LFA
Leaflet | U.S. Geological Survey | Policies
3:12 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Galaxy MS
=-1.98 MAE=1.98 nMAE=0.509 R2=0.749 NS=-1.6
Head (ft)
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
V-0774 - LFA
Leaflet | U.S. Geological Survey | Policies
3:13 PM
10/16/2023

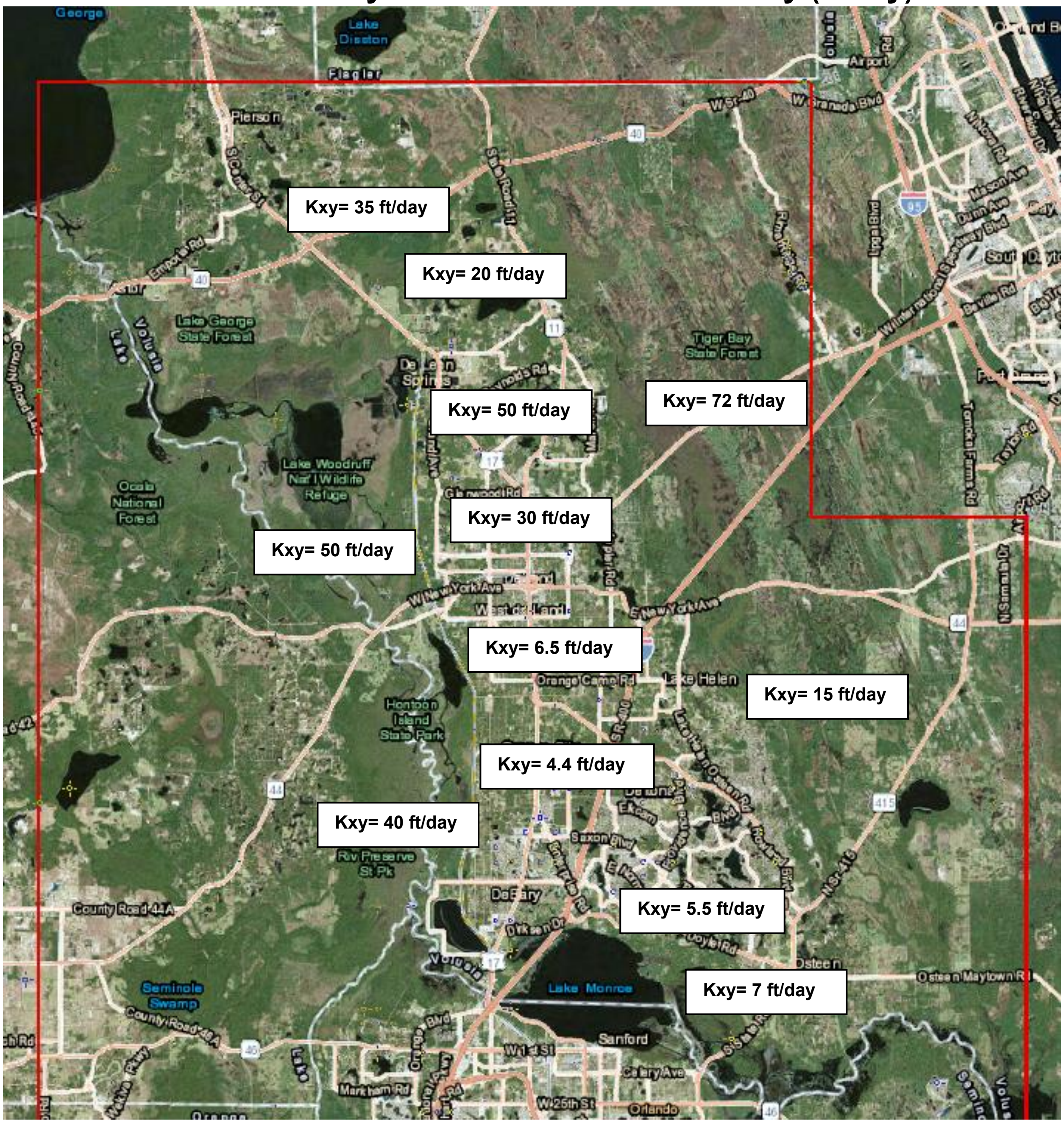

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Kemcho Wells
=0.378 MAE=0.79 nMAE=0.776 R2=0.74 NS=0.59
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
V-1252 - LFA
Leaflet | U.S. Geological Survey | Policies
3:13 PM
10/16/2023


Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Deland USGS
=2.94 MAE=2.94 nMAE=0.889 R2=0.503 NS=-4.94
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
V-0100 - LFA
Leaflet | U.S. Geological Survey | Policies
3:13 PM
10/16/2023

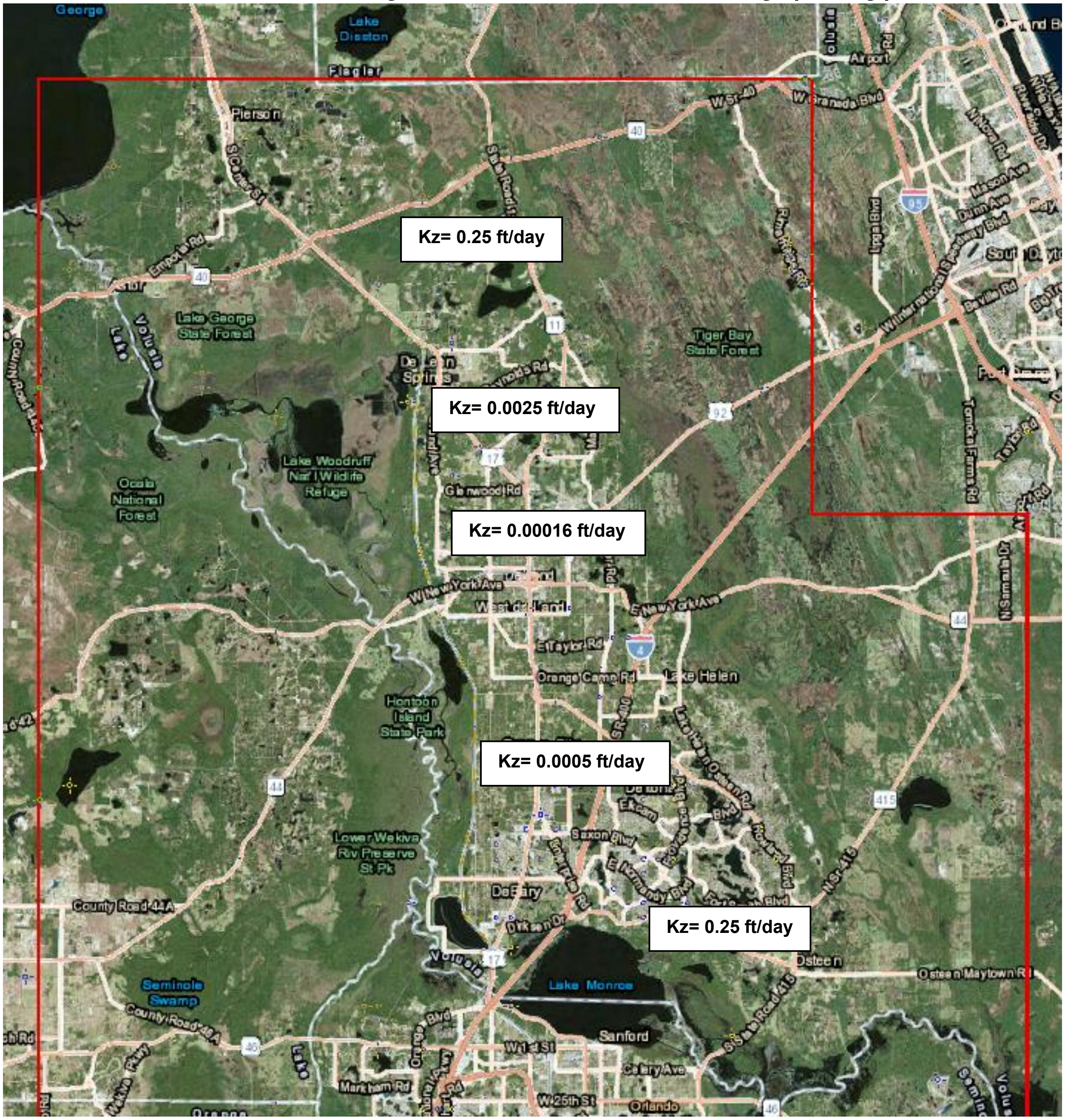

Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Clark Bay
=0.634 MAE=0.84 nMAE=0.678 R2=0.646 NS=0.06
Head (ft)
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
V-0802 - LFA
Leaflet | U.S. Geological Survey | Policies
3:14 PM
10/16/2023

APPENDIX C

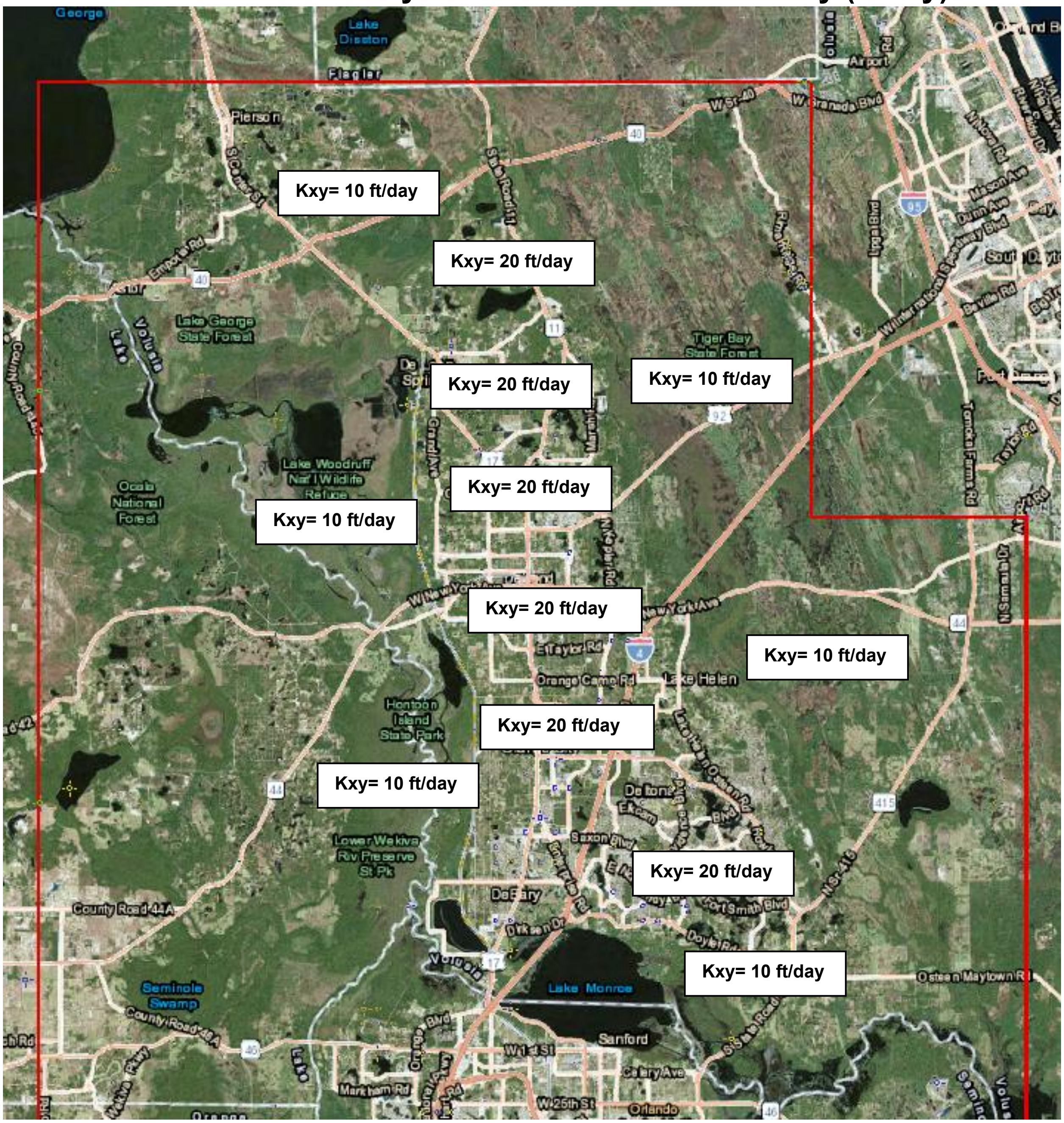
CSM Model Layer 1 Horizontal Permeability (ft/day)



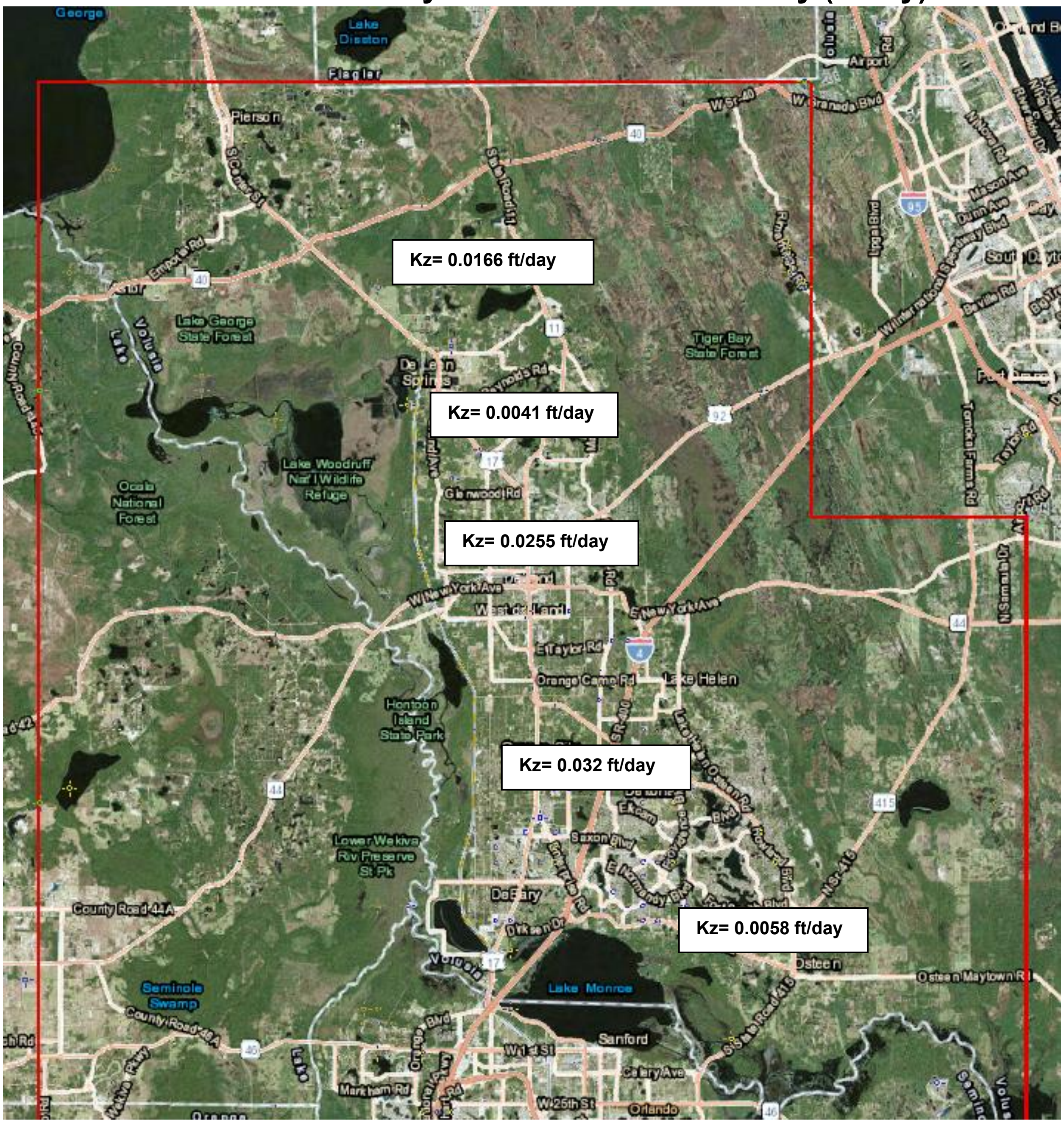
CSM Model Layer 1 Vertical Permeability (ft/day)



Transient Model Layer 1 Horizontal Permeability (ft/day)



Transient Model Layer 1 Vertical Permeability (ft/day)



CITY OF DeLAND

DeLAND, FLORIDA 32724

Utilities Department
1101 S. AMELIA AVE.
TELEPHONE (386)626-7252
FAX (386)740-6851

November 8, 2023

Joy Kokjohn
Regional Water Supply Planning Coordinator
Bureau of Water Supply Planning
St. Johns River Water Management District
P.O. Box 1429 • Palatka, FL 32178

Subject: City of DeLand Utilities Comments to SJRWMD and SWFWMD on Central Springs Model

Dear Ms. Kokjohn :

On behalf of the City of DeLand Utilities, we would like to offer comments on the Central Springs Model (CSM) prepared by SJRWMD and SWFWMD (WMD's). Our hydrogeologic consultant, Andreyev Engineering, Inc. (AEI), has reviewed the model and prepared a report with findings and recommendations. A copy of the report is attached. AEI has raised concerns regarding the CSM model calibration, assumptions and effectiveness of the model to be used for future CUP permitting.

Specific concerns and recommendations are described and supported in the AEI report. In general, the findings conclude that the current CSM is not adequately calibrated in the west Volusia ridge area, the primary service areas of the WVWS utilities. It is recommended that the model be recalibrated prior to use for permitting or water use planning. The recalibration should also include modifications described within this report. If the District does not recalibrate the CSM for the west Volusia area, it is recommended that the District allow CUP permitting and planning for the WVWS to continue and proceed based upon the existing 'Transient' model or other suitable models which are calibrated to observed conditions.

Thank you for your consideration. We and our consultants are available to discuss this topic at your earliest convenience.

Sincerely,

City of DeLand
James Ailes, Deputy Public Services Director/Utilities Director
Attachment: AEI report
cc: WVWS Utility Representatives

APPENDIX B – COMMENTS RECEIVED FROM LIQUID SOLUTIONS GROUP, LLC ON BEHALF OF THE CITY OF ORANGE CITY

Review Comments on the Central Springs Model
Draft Version Released on October 4, 2023
City of Orange City
November 13, 2023

Liquid Solutions Group, LLC (LSG), on behalf of the City of Orange City (City), appreciates the opportunity to review the draft version of the Central Springs Model (CSM) released by the St. Johns River Water Management District (SJRWMD), and the Southwest Florida Water Management District (SWFWMD), herein referred as the “Districts”; on October 4, 2023. More specifically, LSG has reviewed the draft CSM in reference to model conceptualizations and hydrogeologic characteristics within and in the vicinity of the City’s utility service area.

The CSM is the result of a significant collaborative effort between the SJRWMD and SWFWMD. LSG and the City commend both Districts for their continued work over the years striving to develop a user friendly and reliable tool to be used by both the Districts and stakeholders, for planning and regulatory purposes. The CSM covers a geographical area of Florida that is very complex and challenging to represent due to a wide array of hydrogeologic features that vary substantially among different regions within the model domain. Furthermore, the use of HSPF and MODFLOW to account for both surface water and groundwater systems, provides the opportunity for a better representation of the overall water balance controlling flows and levels of the water resources within north-central Florida.

Based on LSG’s review, LSG has developed comments on the CSM for consideration by the Districts, and the CSM Technical Team. In summary, we request that the Districts perform the following actions:

- Review the simulated vertical hydraulic conductivity of the Intermediate Confining Unit (CSM Layer 2) within and in the vicinity of the City’s utility service area.
    - Consider adjusting this aquifer parameter to better represent the aquifer recharge potential in the City; or please explain the reasoning for maintaining the existing values, and/or whether local model modifications to be made by stakeholders would be allowed for the purpose of Consumptive Use Permit (CUP) evaluations.
- Review the use of MODFLOW’s Drain Package in the Surficial Aquifer System (CSM Layer 1) within and in the vicinity of the City’s utility service area.
    - Consider the use of MODFLOW’s Drain Return Package to simulate routing of excess water in the Surficial Aquifer System (CSM Layer 1) to the Upper Floridan Aquifer (CSM Layer 3) in the City; or please explain the reasoning for maintaining the existing conceptualization, and/or whether local model modifications to be made by stakeholders would be allowed for the purpose of CUP evaluations.
- Review Blue Spring’s simulated contributing area (springshed).
    - Consider model input changes that will result in a better match between simulated and documented Blue Spring’s springsheds; or please explain the reasoning for maintaining the existing conceptualization.
- Review simulated dry cells in the Upper Floridan Aquifer (CSM Layers 3 and 4) in the vicinity of the City’s utility service area and Blue Spring.
    - Consider model input changes that will eliminate dry cells within the model domain; or please explain the reasoning for maintaining the existing conceptualization.

Specific comments for consideration by the Districts and the CSM Technical Team are summarized in more detail below.

Based on LSG's review of the CSM Model, we believe that the draft CSM requires important modifications to make it better suitable for use in regulatory determinations such as consumptive use permit (CUP) evaluations for the City, or in the evaluation of impacts or benefits to Minimum Flow and Levels (MFLs) due to the City's operations (pumping or recharge).

Review Comments

Vertical Hydraulic Conductivity of the Intermediate Confining Unit

1. The simulated vertical hydraulic conductivity (K_V) of the Intermediate Confining Unit (ICU) (CSM's Layer 2), within and in the vicinity of the City's utility service area, is remarkably low. For example, the CSM ICU K_V is up to 100 times lower than the simulated ICU K_V in SJRWMD's Volusia Groundwater Flow Model (a.k.a., Volusia Model), the existing official groundwater flow model used by the SJRWMD for regulatory purposes in the Volusia County region (See **Figure 1**). Furthermore, the CSM ICU K_V is also up to 100 times lower than the simulated ICU K_V in the Transient West Volusia Groundwater Model (TWVGWM), an existing locally refined and calibrated model developed for and used by the West Volusia Water Suppliers (WVS) utilities, and accepted by the SJRWMD as a tool for CUP evaluation purposes, herein referred as the "WVWS Model" (see **Figure 2**).

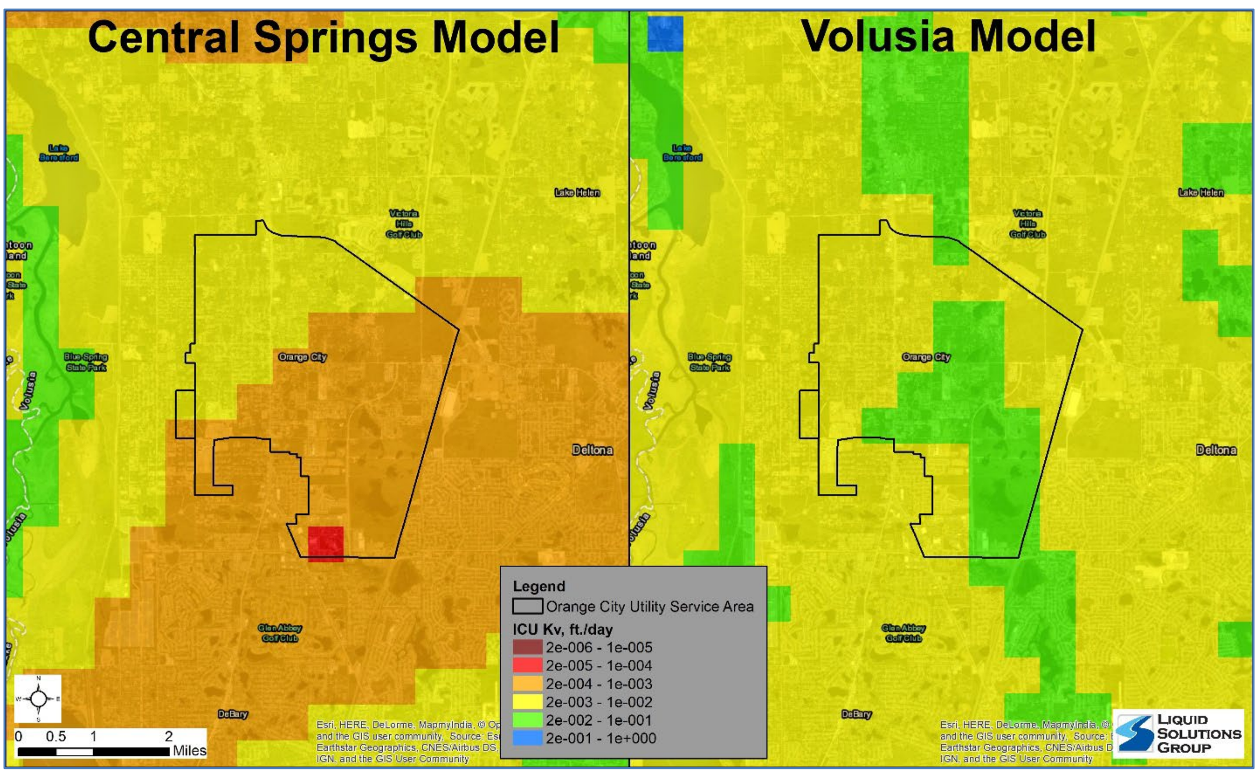


Figure 1. Simulated ICU K_V in CSM and Volusia Model.

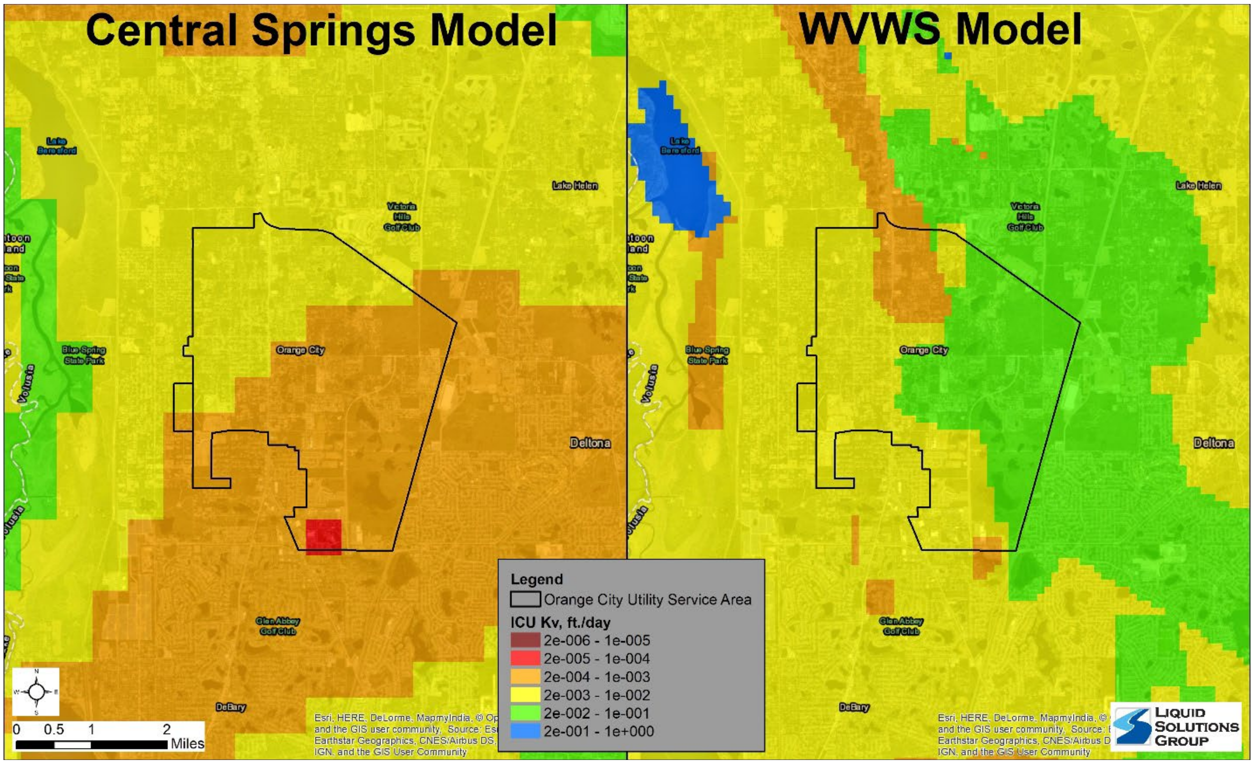


Figure 2. Simulated ICU K_V in CSM and WVWS Model.

A water balance review of simulated groundwater flows within the City's utility service area reveals that the existing conceptualization of the ICU K_V in the CSM substantially limits and minimizes aquifer recharge of the Upper Floridan Aquifer (UFA) in this region. About 85 percent of the recharge water entering the Surficial Aquifer System (SAS) (CSM layer 1) within the City is lost to evapotranspiration and "drains". Only about 15 percent of the recharge water in the SAS flows to the UFA. This restriction contrasts substantially not only with aquifer recharge rates simulated by the Volusia Model and the WVWS Model, but with hydrogeologic data documented by the SJRWMD, the Florida Department of Environmental Protection (FDEP), the Florida Geological Survey (FGS), and the United States Geological Survey (USGS); which describe the area within and in the vicinity of the City, as a region of moderate to high aquifer recharge potential as shown in **Figure 3**.

As shown in **Figure 3**, the area near the City has been defined by the SJRWMD as a zone of medium (moderate) to high recharge in its vector digital data titled "UFA Groundwater Recharge (2015)".

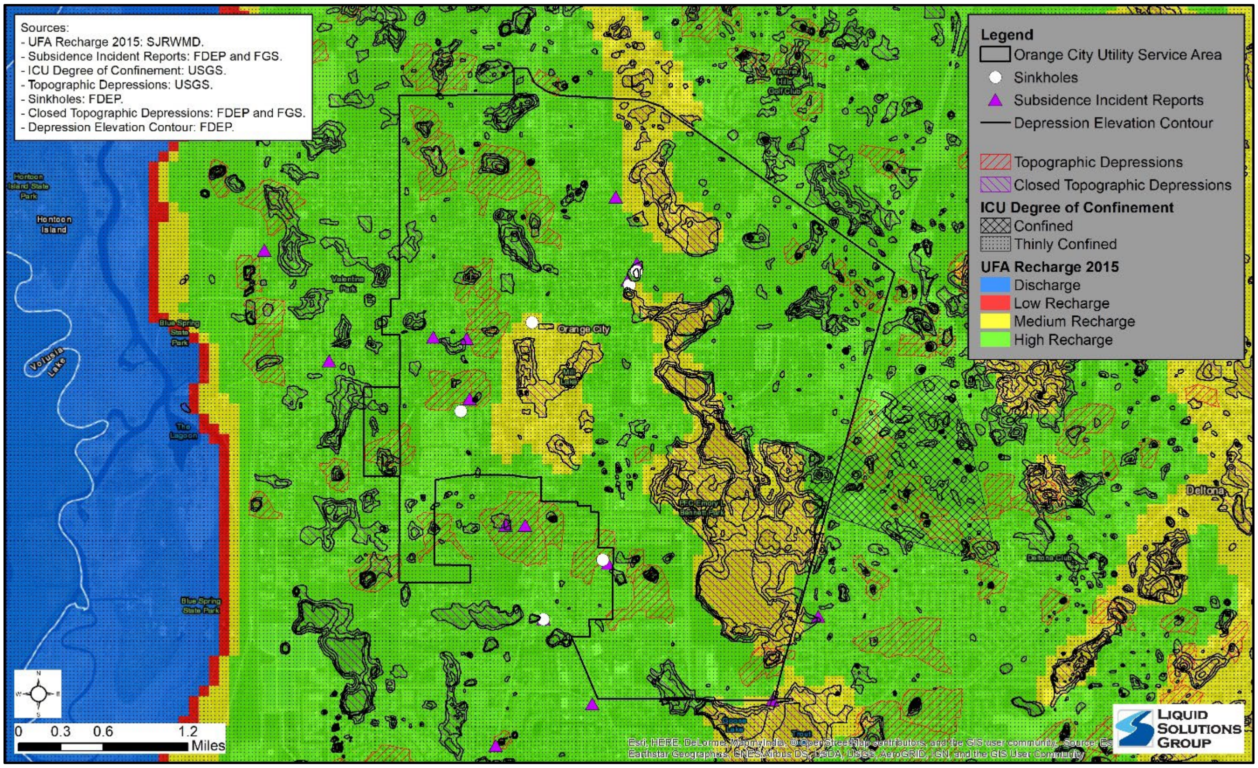


Figure 3. Aquifer Recharge Potential and Hydrogeologic Characteristics near the City.

According to the SJRWMD (Boniol and Mouyard, 2016): *"High to moderate UFA recharge occurs in areas of central SJRWMD where the UFA is thinly confined (ICU thickness of 20 to 50 feet) or semi-confined (ICU thickness of 50 to 100 feet). Relatively higher recharge rates occur where the integrity of the ICU has been compromised by sinkholes and solution pipes…The UFA limestones are typically not exposed at land surface in the high and moderate recharge areas in central SJRWMD, but their near surface presence is indicated by karst terrain that results as the overlying siliciclastic sediments settle into the irregular and highly soluble limestone rocks. The dissolution of the UFA limestones and the occurrence of closed surface drainage basins with internal drainage result in the development of closed depressions, sinkholes, caves, and other karst features."*

As shown in **Figure 3**, the City is located in a region characterized by numerous sinkholes, and closed topographic depressions. Furthermore, the USGS describes the ICU degree of confinement within and around the City as "Thinly Confined" (Williams and Dixon, 2015). These hydrogeologic features and descriptions match the characteristics described by Boniol and Mouyard (2016) for areas with high to moderate UFA recharge potential.

Another indication of the high aquifer recharge potential that exists within the City is the inclusion of the City's utility service area in the determination of FDEP's Blue Spring Priority Focus Area (PFA) (See **Figure 4**). According to the FDEP (2017): *"The areas to be considered in the PFA delineation are those with the highest recharge to the aquifer. These could occur as diffuse infiltration through permeable geological material as well as focused recharge to sinkholes that breach confining layers".*

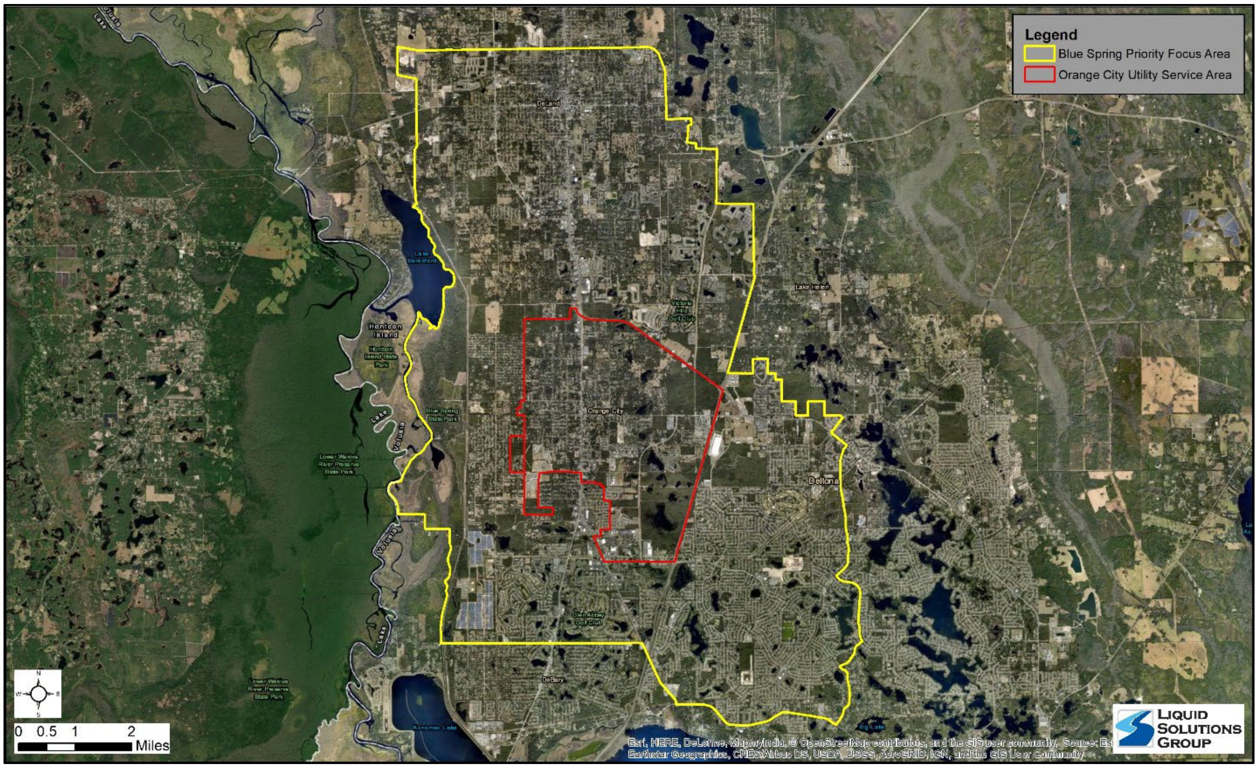


Figure 4. City's Utility Service Area and Blue Spring PFA.

Finally, water balance results performed within the City's utility service area, using the steady-state version of the CSM (i.e., average 2005 to 2018 conditions), shows that, currently, the CSM simulates an UFA recharge rate of approximately 2 inches/year in this region. However, according to the SJRWMD (Boniol and Mouyard, 2016) a UFA recharge rate of approximately 2 inches/year falls within a "low recharge" category. Areas of moderate to high recharge have recharge rates of 5 to 10 inches/year, and greater than 10 inches/year, respectively.

Based on the information described above, a review and modification of the CSM's simulated ICU K_V is warranted and highly important. The City and its vicinity are located within Blue Spring's Springshed. As such, and considering the future use of the CSM as a regulatory tool by the SJRWMD, it is crucial to adjust the CSM to simulate proper recharge rates to the UFA in this region.

<u>Drain Cells in the Surficial Aquifer System</u>

2. The simulation of wetlands, streams, and/or small lakes within the City, using drain cells appears inappropriate. As shown in **Figure 5**, almost the entire City's utility service area is covered with drain cells in the CSM Layer 1 (SAS). These cells remove simulated excess water in the SAS, when available. However, as described previously, the City is located in a region of moderate to high recharge with numerous closed topographic depressions, sinkholes, and thin confinement (see **Figure 3**).

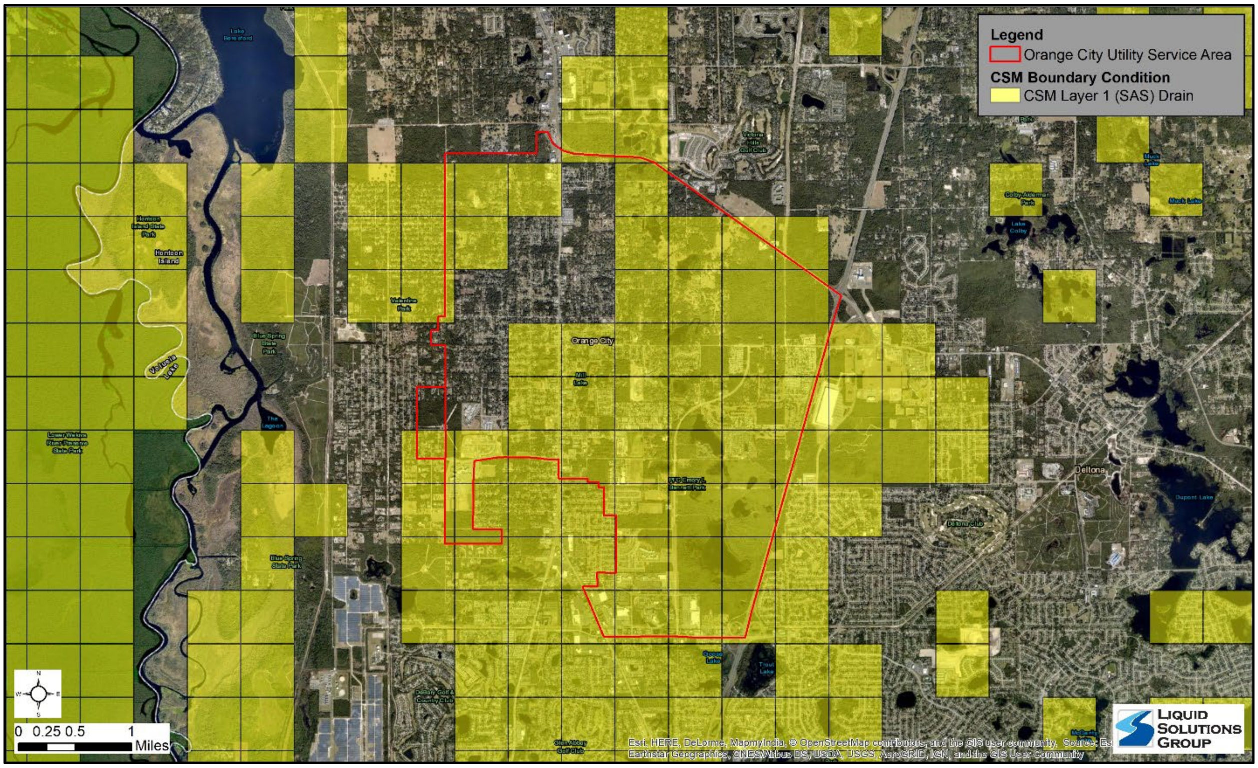


Figure 5. CSM's Drain Cells near the City.

According to the SJRWMD (Boniol and Mouyard, 2016): *"Closed depressions and sinkholes capture rainfall and surface water drainage and funnel it underground, providing a more direct pathway for the UFA recharge."* As such, removing excess water from the model, through the use of MODFLOW's Drain Package, does not seem an appropriate conceptualization of the SAS hydrogeological characteristics near the City. A more appropriate conceptualization of the SAS within the City would be the use of MODFLOW's Drain Return Package, which would allow water from the drains to recharge the UFA.

<u>Blue Spring Springshed</u>

3. The size and shape of the Blue Spring springshed simulated by the CSM differs from the springshed developed by the SJRWMD, and used by the FDEP for planning and regulatory purposes (e.g., Volusia Blue Spring Basin Management Action Plan). As shown in **Figure 6**, a reverse particle tracking analysis from Blue Spring, using the steady-state version of the CSM, shows that the source of the water to Blue Spring extends beyond Blue Spring's springshed as documented by the FDEP in the Volusia Blue Spring Basin Management Action Plan (FDEP, 2018).

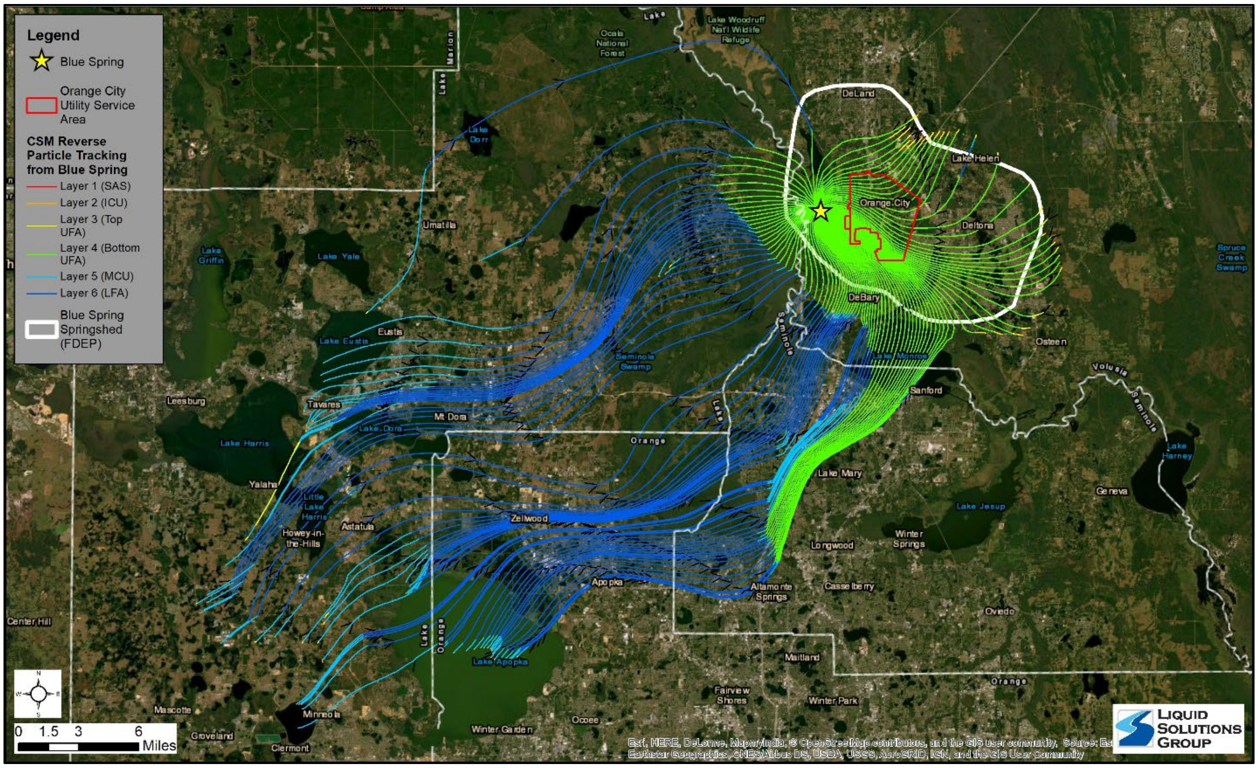


Figure 6. Reverse Particle Tracking from Blue Spring using the CSM.

According to the FDEP (2018), in reference to Blue Spring: *"The springshed area was defined by the St. Johns River Water Management District (SJRWMD) based on U.S. Geological Survey (USGS) potentiometric surface contour maps. Flow pathways were compared for multiple measurement dates to develop the contributing area that accounts for seasonal variation in flow direction."*

As shown in **Figure 6**, Blue Spring's contributing area simulated by the CSM extends to areas in west Orange County and Lake County. In fact, approximately 55% of the simulated contributing area appears to originate from Orange and Lake counties. Hence, a review of Blue Spring's simulated springshed is warranted.

Dry Cells in Upper Floridan Aquifer

4. Both the steady-state and transient versions of the CSM produce "dry" cells in the UFA (CSM's Layer 3 and Layer 4), in the vicinity of the City's utility service area and near Blue Spring. For reference, **Figure 7** shows the distribution of dry cells near the City and Blue Spring simulated by the CSM steady-state simulation in Layer 4. The presence and potential impact of these dry cells on groundwater flow simulated in the vicinity of the City's utility service area and Blue Spring should be investigated and mitigated.

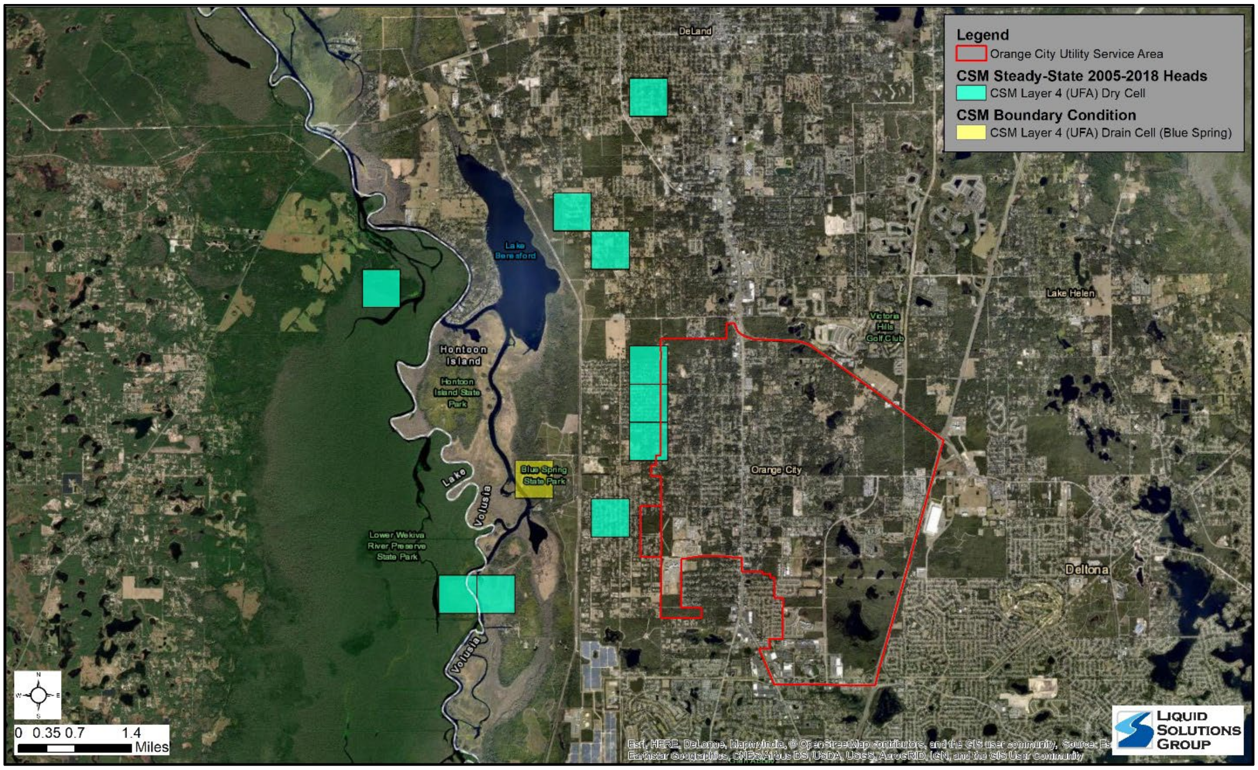


Figure 7. CSM's Simulated Dry Cells in the Layer 4 (Bottom UFA) near the City and Blue Spring.

Also for reference, additional dry cells were also detected throughout the CSM's active domain in all layers. For reference, **Figure 8** shows dry cells in CSM's Layer 4 for the full model domain.

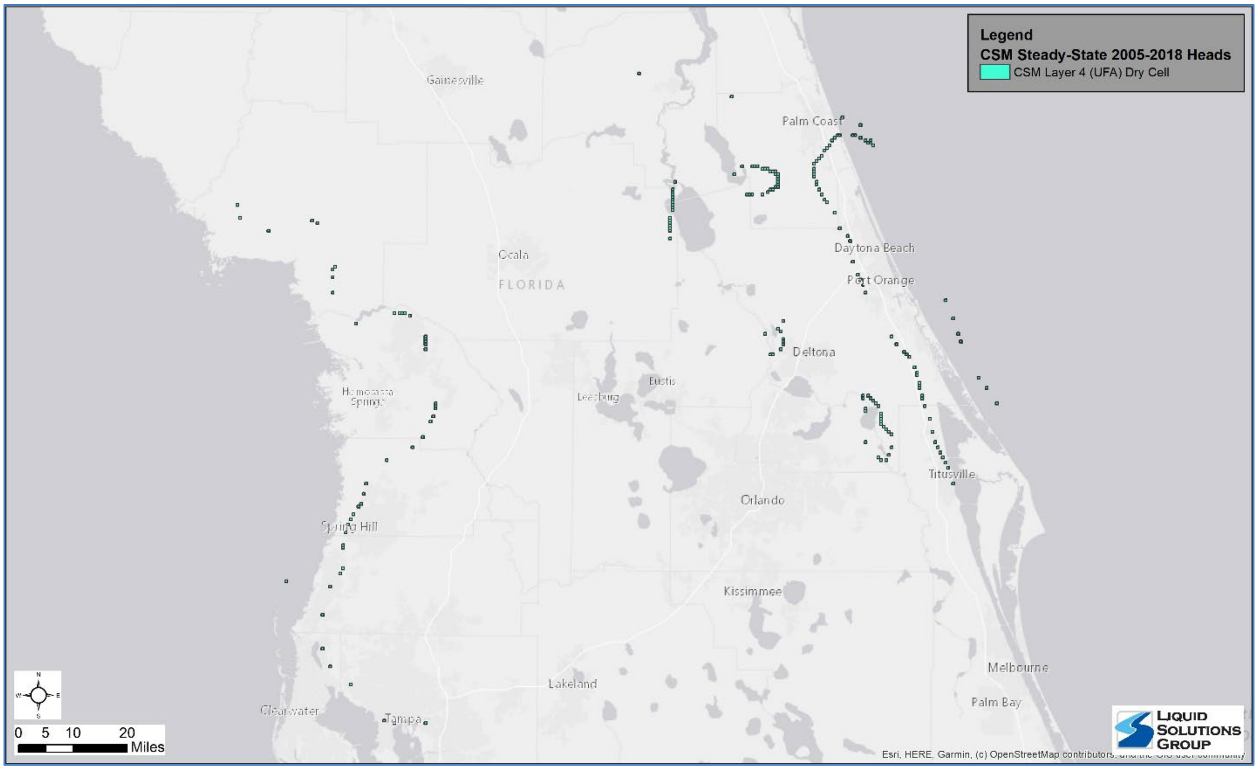


Figure 8. CSM's Simulated Dry Cells in the Layer 4 (Bottom UFA), Model-Wide.

References

Boniol, D., and Mouyard, K. 2016. Recharge to the Upper Floridan Aquifer in the St. Johns River Water Management District, Florida. Technical Fact Sheet SJ2016-FS1. St. Johns River Water Management District.

Florida Department of Environmental Protection. 2017. Priority Focus Area for Volusia Blue Spring. Division of Environmental Assessment and Restoration. August 2017.

Florida Department of Environmental Protection. 2018. Volusia Blue Spring Basin Management Action Plan. Division of Environmental Assessment and Restoration. Water Quality Restoration Program. Florida Department of Environmental Protection with Participation from the Volusia Blue Spring Stakeholders. June 2018.

Williams, L.J., and Dixon, J.F., 2015. Digital surfaces and thicknesses of selected hydrogeologic units of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Data Series 926, 24 p., http://dx.doi.org/10.3133/ds926.

APPENDIX C – COMMENTS RECEIVED FROM LIQUID SOLUTIONS GROUP, LLC AND ANDREYEV ENGINEERING, INC. (THROUGH VIKUS WATER) ON BEHALF OF THE VILLAGES

VIKUSWATER

November 13, 2023

St. John's River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: Technical Review Comments on the Central Springs Model for
Southern Marion County, Western Lake County, and Sumter County

To Whom it May Concern:

Vikus Water, on behalf of Village Center Community Development District, North Sumter County Utility Dependent District, Wildwood Utility Dependent District, Gibson Place Utility Company, LLC, Gibson Place Water Conservation Authority, LLC, Middleton Utility Company, LLC, Middleton Water Conservation Authority, LLC, Blue Goose Utility Company, LLC and Blue Goose Water Conservation Authority, LLC, jointly commissioned Liquid Solutions Group, LLC and Andreyev Engineering, Inc. to conduct a comprehensive review of the Central Springs Model, specifically focusing on southern Marion County, western Lake County and Sumter County. The primary objective of the review was to ensure the accuracy and reliability of the Central Springs Model (CSM), given its significant potential for influence on water resource management decisions in the region. Please consider this submittal as the above-mentioned stakeholders' formal review comments on the proposed CSM.

Enclosed with this letter, please find the attached reports prepared by Liquid Solutions Group, LLC and Andreyev Engineering, Inc. Upon review of their reports, it has become apparent that the current state of the model necessitates significant modifications for it to be effectively utilized in the referenced region. The following summarizes the stakeholders' primary concerns with the CSM as proposed:

- CSM utilizes erroneous historical pumping data for the region
- CSM has production wells located in incorrect aquifer layers in the region
- CSM did not utilize available aquifer performance testing (APT) data
- CSM is not accurately calibrated for the UFA and LFA in the region

Please advise of your intent to make the requested updates and corrections to the CSM. We appreciate your attention to this matter and look forward to the prospect of collaborative efforts in refining the model for the improved evaluation of water resources in the region.

Sincerely,

Trey Arnett

Trey Arnett, P.E.

cc: SWFWMD
Bruce Brown / The Villages Community Development Districts
Robert Chandler, IV / The Villages Development Company

352-753-4747 • 1038 Lake Sumter Landing, The Villages, FL 32162

Liquid Solutions Group

Technical Memorandum

To: Vikus Water
Date: November 13, 2023

From: Rob Denis, P.E., BC.WRE
Tim Desmarais, P.E., BC.WRE
Reference: CSM Review

Subject: Comments on the Central Springs Model Released on October 4, 2023

Background Information

On October 4, 2023, the St. Johns River Water Management District (SJRWMD), and the Southwest Florida Water Management District (SWFWMD), herein referred as the "Districts" released the Central Springs Model (CSM) for stakeholder review. The CSM is a complex, regional groundwater model that encompasses a large area of the state and draws upon elements of several other surface water and groundwater models. We appreciate the Districts' efforts to continue to work to improve the tools available for stakeholders to use.

On behalf of Vikus Water, Liquid Solutions Group, LLC (LSG) has reviewed the CSM, with a focus in southern Marion, western Lake and Sumter Counties, in the area generally known as The Villages. Based on this review, LSG has developed comments on the CSM for consideration by the Districts, and the CSM Technical Team. In summary, we request that the Districts perform the following actions:

- Review and modify the simulated layer used for several wells as described herein
  - Due to the number of layer mismatches, evaluate the methodology used to assign layers in the WEL file.
  - Provide additional documentation on the process used to assign layers in the WEL file since the report did not contain any details on this process.
- Review and update historic water use data in the CSM and update as necessary for accuracy.
- Consider the use of aquifer performance test (APT) data in the calibration process.
  - Include additional information on the development of the model parameters in the CSM.
  - Add a discussion regarding the significant localized parameter changes in the model that are coincident with observation wells.

Detailed information related to these comments is provided in more detail below.

Technical Review

The Villages development encompasses numerous Water Use Permits (WUPs) with the SWFWMD and Consumptive Use Permits (CUPs) with the SJRWMD, whose withdrawals have been included in the CSM. The locations and Steady-State (SS) model flow rates (Average of 2005-2018 conditions) are summarized in **Figure 1**.

Comment 1: Production well layer characterizations should be corrected

The representation of production wells within The Villages was checked for both spatial location (row and column) and depth (layer).

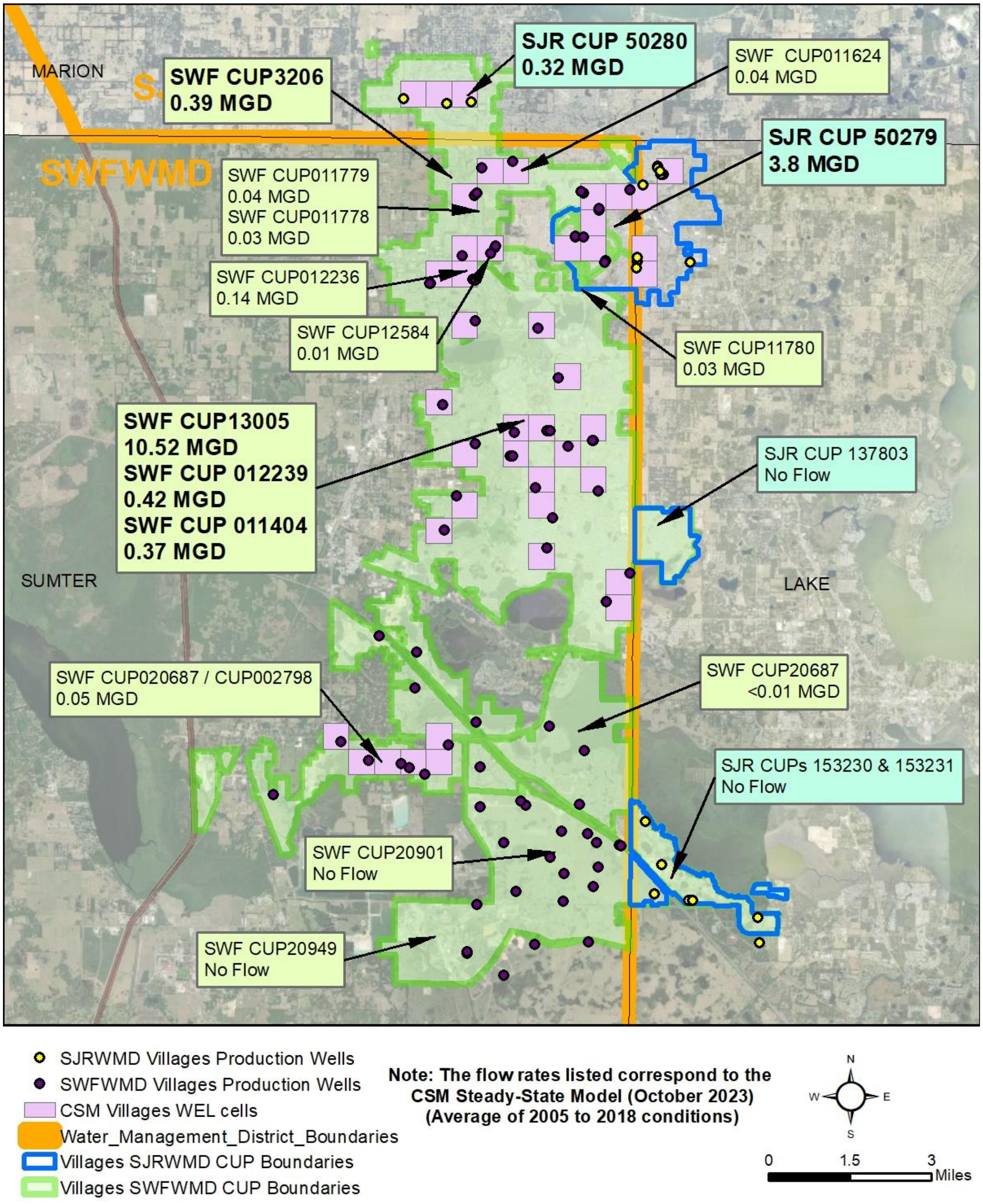
As shown in **Figure 1**, there is excellent correspondence between the model cells and the locations of the production wells. Some more recently permitted wells are not included in the model, which is to be expected given the period of record (2005 to 2018).

Table A-1 in **Appendix A** compares the well casing and total depths to the model layer elevations and layer assignments used in the CSM model for the production wells within The Villages in SWFWMD. Most of the wells were assigned to the correct model layer, but the errors and minor corrections are summarized in **Table 1**.

Table 1. Production Well Model Layer Issues - SWFWMD Production Wells

Permit Number	Station ID	Casing Depth (ft)	Total Depth (ft)	Layer 4 Bottom (ft NAVD)	Layer 5 Bottom (ft NAVD)	Layer 6 Bottom (ft NAVD)	CSM Model Layers	Correct Layer	CSM SS Flow Rate (mgd)
Incorrect Aquifer Assignment									
3206	25	602	1000	-268	-500	-1536	3&4	6	0.285
12239	1	630	1006	-285	-522	-1504	4	6	0.076
12239	2	633	1000	-283	-517	-1515	3	6	0.114
12239	3	595	890	-297	-531	-1481	3	6	0.098
12239	6	550	800	-289	-521	-1505	3	6	0.125
12239	13	597	983	-285	-515	-1470	3	6	0.018
20687	25	600	900	-295	-523	-1410	3&4	6	0
Minor Well Split Corrections									
3206	8	146	601	-268	-500	-1536	4	4&5	<0.0001
11404	8	238	452	-248	-477	-1545	4	4&5	0.012
11404	9	240	450	-248	-477	-1545	4	4&5	0.001
11624	1	250	430	-256	-486	-1517	4	4&5	0.042

Figure 1. Representation of the wells located within The Villages in the CSM Model



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

LIQUID SOLUTIONS GROUP

Table A-2 in **Appendix A** compares the well casing and total depths to the model layer elevations and layer assignments used in the CSM model for the production wells within The Villages in SJRWMD. The flow for the SJRWMD wells were either split evenly between layers 3 & 4 (Upper Floridan Aquifer, or UFA) or assigned to Layer 6 (Lower Floridan Aquifer, or LFA). **Table 2** summarizes the errors and minor corrections with the layer assignments in the CSM. Most of the UFA wells should technically be assigned to only Layer 4. Though this is not likely to make a significant difference to the model, it could be important for more localized analyses.

Table 2. Production Well Model Layer Issues - SJRWMD Production Wells

Permit Number	Station ID	Casing Depth (ft)	Total Depth (ft)	Layer 4 Bottom	Layer 5 Bottom	Layer 6 Bottom	CSM Model Layers	Correct Layer	CSM SS Flow Rate (mgd)
				(ft NAVD)					
Incorrect Aquifer Assignment									
50280	23222	540	750	-279	-504	-1508	3&4	6	0.042
Minor Well Split Correction									
50279	454722	135	315	-268	-500	-1536	3&4	4	0.094
50279	922	118	266	-248	-477	-1545	3&4	4	1.218
50279	923	131	304	-248	-477	-1545	3&4	4	0.987
50279	924	128	310	-266	-495	-1541	3&4	4	0.407
50279	925	190	700	-236	-464	-1536	6	4,5 & 6	0
50279	926	110	310	-236	-464	-1536	3&4	4	1.064
50279	927	180	330	-256	-486	-1542	3&4	4	0.031
50279	928	140	266	-258	-486	-1546	3&4	4	0

Given the number of layer discrepancies, we'd request that the Districts evaluate the methodology used to assign layers in the WEL file, document the process in the model report and make the indicated corrections.

Comment 2: Historical water use should be corrected

The modeled flow rates for the production wells within The Villages was compared to values obtained from each District's respective database, and was supplemented by data maintained by Vikus Water for the various permitted entities within The Villages or 'raw' data provided to the District (e.g., SJRWMD EN50 forms). **Appendix B** contains graphs of the transient water use data compared to the data from the databases.

Figure 2 shows the total monthly pumping from all of the SWFWMD production wells, which is nearly an identical match with the database beginning in May 2012. Prior to this period, the database values are consistently higher than the values used in the CSM model. Also of note is that the CSM WEL file has four months where the combined flow rate is nearly zero.

Most of the early period discrepancy with the SWFWMD production well data can be attributed to WUP 13005 and the former WUPs that it absorbed in 2007 (WUPs 11404, 12236, and 12239). As shown in **Figure 3**, there is a good match with the data after May 2012, but prior to that, the CSM values are significantly and consistently lower than the database values. The comparison for the SJRWMD production wells yielded a very close match for the entire simulation, when aggregated to the permit level.

Figure 2. Combined SWFWMD Monthly Pumping Comparison

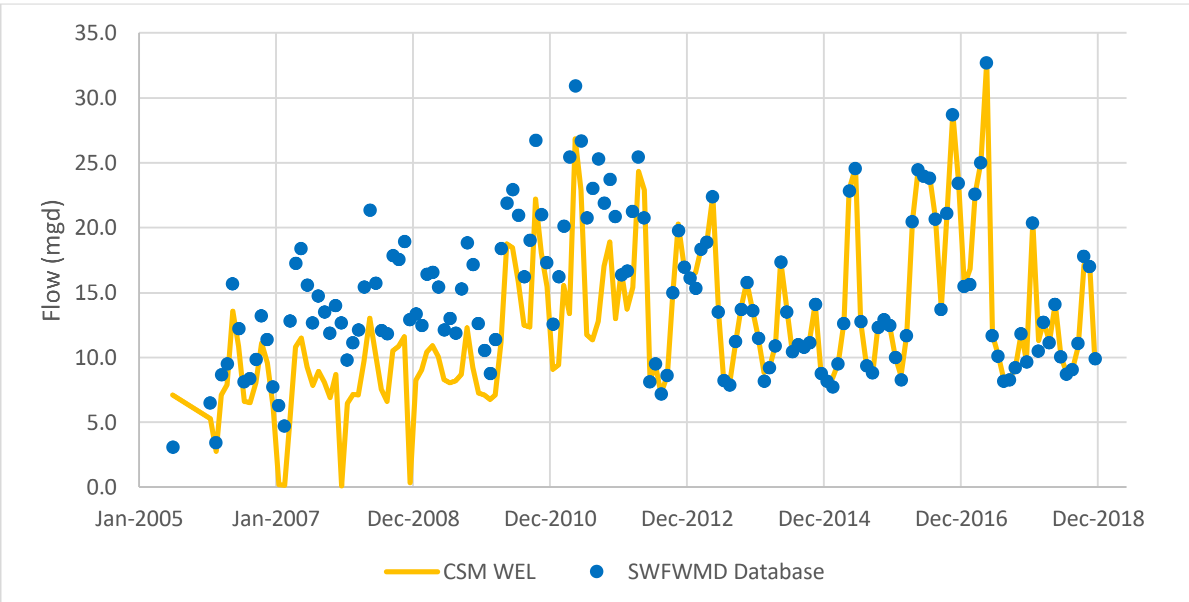


Figure 3. SWFWMD WUPs 13305, 11404, 12236, 12339 Combined Monthly Pumping Comparison

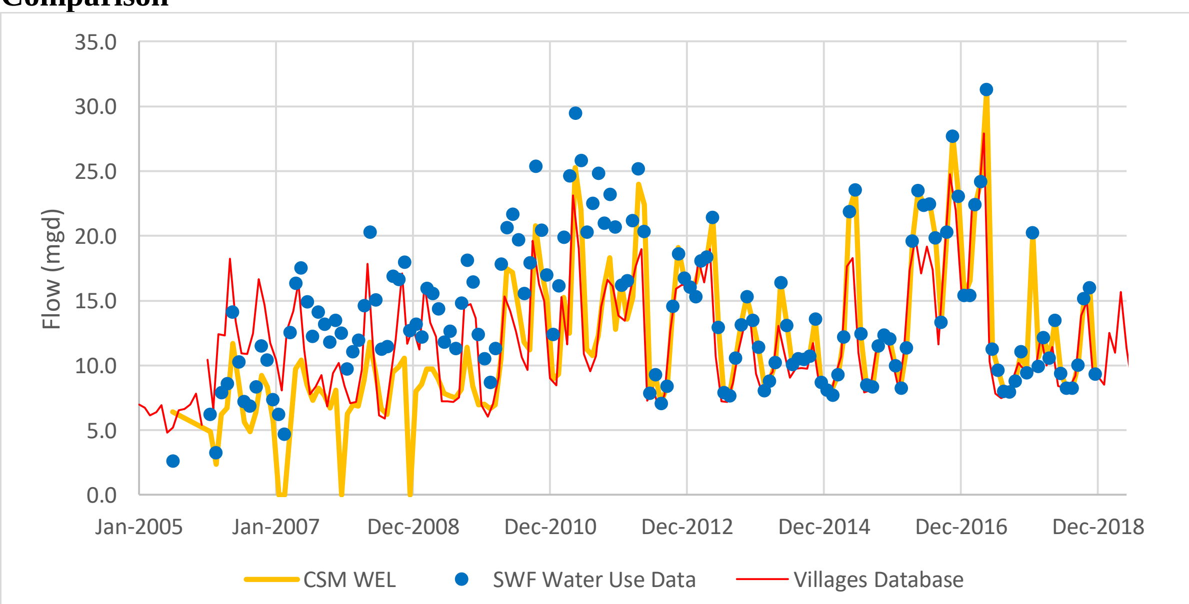


Table 3 provides an overall summary of the well comparison, using the SS model pumping rates, along with a description of the issues (refer to individual permit graphs in **Appendix B**).

Table 3. CSM SS Pumping Comparison

District	CUP/WUP Permit	CSM SS Model	Database Avg. 2005-2018	Comment
SWFWMD	2798	0.05	0.03	Matches from 2016 to 2018. No earlier data found
SWFWMD	3206	0.39	0.39	Match
SWFWMD	11404	0.37	0.25	Does not match due to combining with 13005
SWFWMD	11624	0.04	0.04	Match
SWFWMD	11778	0.03	0.03	Match
SWFWMD	11779	0.04	0	No data found
SWFWMD	11780	0.03	0	No data found
SWFWMD	12236	0.14	0.16	Minor mismatch due to combining with 13005
SWFWMD	12239	0.42	0.49	Minor mismatch due to combining with 13005
SWFWMD	12584	0.01	0.01	Data matches approx. 50% of the time. Low flow.
SWFWMD	13005	10.52	12.57	Mismatch before 2012
SWFWMD	20687	0.01	0.01	Minor mismatch. Low flow.
SJRWMD	50280	0.32	0.32	Match
SJRWMD	50279	3.80	3.60	Match
	Total	**16.15**	**17.91**	

Overall, the steady-state pumping rate for The Villages is approximately 10% too low, and this may have negatively influenced the calibration process. We request that the Districts review the data for the permits listed in Table 3 and evaluate the effect on the calibrated parameters in this area in conjunction with Comment 3 below.

Comment 3: Aquifer performance test data should be used to develop simulated hydrogeologic parameters

Based on information from the CSM model team, APT data were not used in the calibration process to help develop hydrogeologic parameters. While we understand that APTs may have limitations, the use of other groundwater model data also has limitations. We think that the decision to forgo use of APT data, upon which hundreds of thousands of dollars from State and utility funds have been expended, should be further documented and justified. Given the use of PEST, both information from other groundwater models and actual data could have been readily incorporated into the calibration. Furthermore, as shown in **Figures 4 and 5**, the

CSM contains highly localized parameter adjustments that coincide with observation wells and appear to be solely based on matching water levels at that point. If such localized adjustments are going to be in the CSM, they should be based on available data collected in the area.

Figure 4 shows a comparison between the UFA Transmissivity of the CSM model (Layers 3 and 4) relative the locations of Aquifer Performance Test (APT) data. In The Villages vicinity, there is significantly more variability in the UFA transmissivity values in the CSM compared to the range of values in the APT data. Several bull's eyes are evident in the central-south portion of the area of interest, which suggests that the calibration process may have made significant changes from the initial values in this area.

Figure 5 shows a comparison between the LFA Transmissivity of the CSM model (Layers 3 and 4) relative the locations of Aquifer Performance Test (APT) data. Similar to the UFA, there are considerable differences between the CSM and the APT values.

Tables 4 and 5 provide a tabular summary of the comparison between the CSM transmissivities and the APT values for the UFA and LFA, respectively.

We request that the Districts utilize the APT data to locally constrain the hydraulic parameters (e.g., set limits on the pilot points that are close to the APT locations). We understand the limitations of APT data, but this uncertainty (like the uncertainty of information from other groundwater models) can easily be addressed through the use of PEST.

Figure 4. Upper Floridan Aquifer Transmissivity and APT Comparison

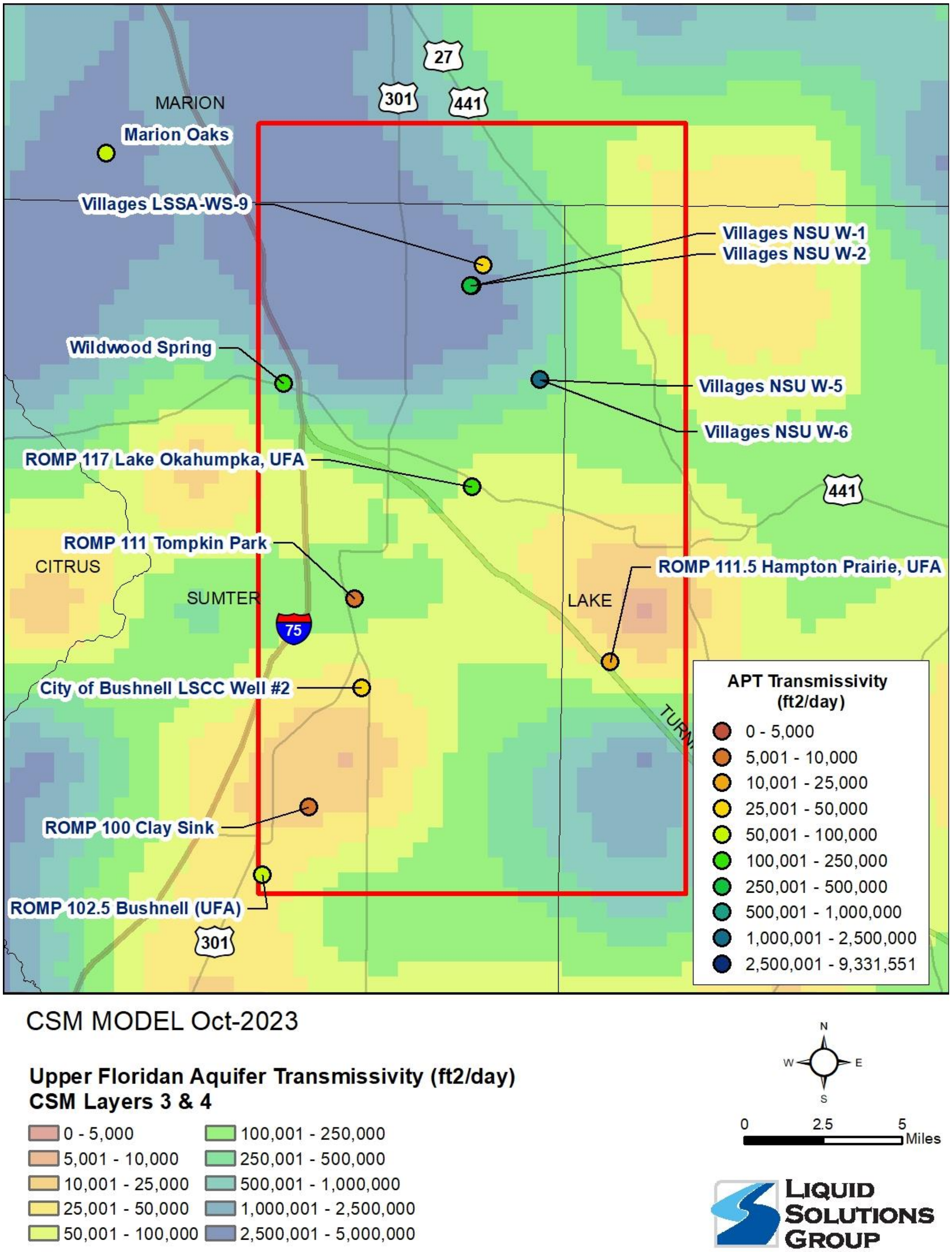


Figure 5. Lower Floridan Aquifer Transmissivity and APT Comparison

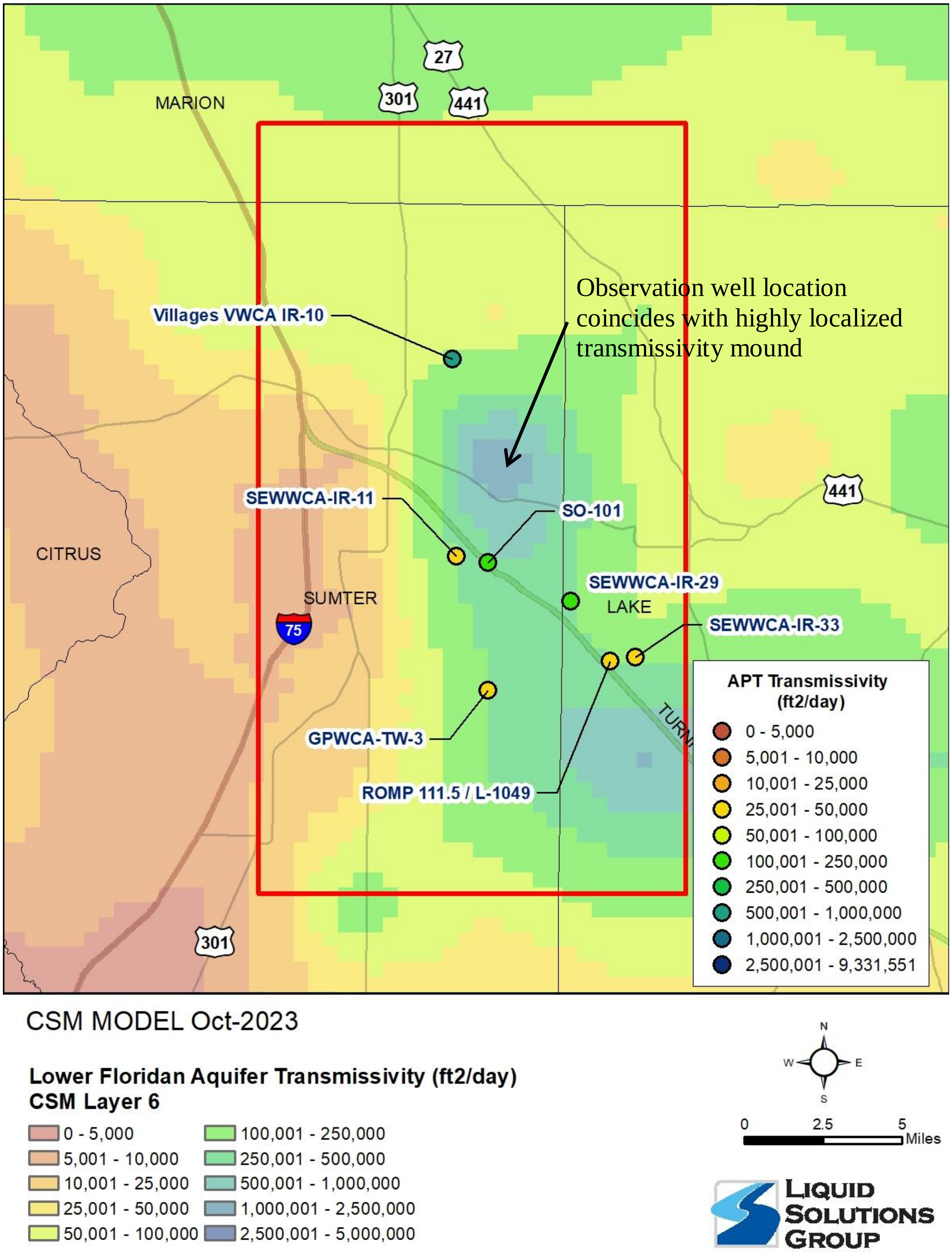


Table 4. UFA Transmissivity and APT Comparison

Site Name	APT Trans (ft2/day)	CSM L34 Trans	CSM:APT
Marion Oaks	53,475	3,875,038	72.5
LSSA-WS-9[1]	27,798	3,420,256	123.0
NSU W-1[1]	31,640	4,939,203	156.1
NSU W-1 [1]	184,404	4,939,203	26.8
NSU W-2 [1]	88,971	4,939,203	55.5
NSU W-2[1]	438,108	4,939,203	11.3
NSU W-6[1]	1,234,757	455,867	0.4
NSU W-6[1]	1,847,126	455,867	0.2
NSU W-5 [1]	1,076,203	455,867	0.4
Wildwood Spring	247,000	592,950	2.4
ROMP 117 Lake Okahumpka, UFA	103,000	85,794	0.8
ROMP 111 Tompkin Park	9,091	126,598	13.9
ROMP 111.5 Hampton Prairie, UFA	13,000	30,172	2.3
City of Bushnell LSCC Well #2	50,000	37,314	0.7
ROMP 100 Clay Sink	10,000	19,984	2.0
ROMP 102.5 Bushnell (UFA)	63,000	35,089	0.6
Min	9,091	19,984	2.2
Avg	342,348	1,834,226	5.4
Max	1,847,126	4,939,203	2.7

[1]Wells located within The Villages.

Table 5. LFA Transmissivity and APT Comparison

Site Name	APT Trans (ft2/day)	CSM L34 Trans	CSM:APT
VWCA IR-10[1]	53,475	3,875,038	72.5
SEWWCA-IR-11[1]	27,798	3,420,256	123.0
SO-101[1]	31,640	4,939,203	156.1
SEWWCA-IR-29[1]	184,404	4,939,203	26.8
SEWWCA-IR-33[1]	88,971	4,939,203	55.5
ROMP 111.5 / L-1049	438,108	4,939,203	11.3
GPWCA-TW-3[1]	1,234,757	455,867	0.4
Min	29,543	107,167	3.6
Avg	159,958	260,224	1.6
Max	604,024	453,811	0.8

[1]Wells located within The Villages.

Considering the issues identified during this short review period, the use of the current (October 2023) version of the CSM may not be appropriate for localized analyses such as WUP or CUP impact assessments. In this area, incorrect well layer assignments and issues with the water use data could have significantly influenced the calibrated parameter arrays. Not constraining the parameters through the use of the APT data can further compound the issues noted.

Appendix A – Layer Assignment Check

Table A-1. Layer Assignments for Production Wells within The Villages - SWFWMD

PERMIT	STN_ID	CASING	DEPTH	L1TOP	L1BOT	L2BOT	L3BOT	L4BOT	L5BOT	L6BOT	L7BOT	CSM Model Layers	Change
3206	8	146	601	63	42	32	22	-268	-500	-1536	-1594	4	L45
3206	9	105	240	63	45	35	25	-265	-496	-1541	-1593	4	
3206	16	110	200	75	26	16	6	-278	-510	-1518	-1597	4	
3206	25	602	1000	63	42	32	22	-268	-500	-1536	-1594	3	L6
11404	4	122	290	73	41	31	21	-267	-501	-1507	-1589	4	
11404	5	140	230	89	45	35	25	-257	-487	-1506	-1576	4	
11404	6	141	230	89	45	35	25	-257	-487	-1506	-1576	4	
11404	7	162	230	89	45	35	25	-257	-487	-1506	-1576	4	
11404	8	238	452	75	56	40	30	-248	-477	-1545	-1581	4	L45
11404	9	240	450	75	56	40	30	-248	-477	-1545	-1581	4	L45
11624	1	250	430	83	48	38	28	-256	-486	-1517	-1577	4	L45
11778	2	102	165	73	33	23	13	-276	-512	-1509	-1600	4	
11779	1	94	400	75	26	16	6	-278	-510	-1518	-1597	4	
11780	1	147	360	74	56	46	36	-252	-482	-1534	-1581	4	
11780	2	155	320	81	62	52	42	-241	-471	-1530	-1572	4	
12236	1	152	320	75	56	40	30	-248	-477	-1545	-1581	4	
12236	2	97	300	75	56	40	30	-248	-477	-1545	-1581	4	
12236	8	80	120	79	13	2	-8	-294	-527	-1483	-1630	4	
12239	1	630	1006	73	28	18	8	-285	-522	-1504	-1617	4	L6
12239	2	633	1000	60	18	8	-2	-283	-517	-1515	-1611	3	L6
12239	3	595	890	73	9	-3	-13	-297	-531	-1481	-1635	3	L6
12239	6	550	800	65	16	6	-4	-289	-521	-1505	-1618	3	L6
12239	13	597	983	90	25	11	1	-285	-515	-1470	-1618	3	L6
12584	1	132	172	73	41	31	21	-267	-501	-1507	-1589	4	

Table A-1. Layer Assignments for Production Wells within The Villages - SWFWMD

PERMIT	STN_ID	CASING	DEPTH	L1TOP	L1BOT	L2BOT	L3BOT	L4BOT	L5BOT	L6BOT	L7BOT	CSM Model Layers	Change
12584	2	80	300	73	41	31	21	-267	-501	-1507	-1589	4	
13005	1	600	1000	69	13	-7	-17	-307	-540	-1457	-1660	6	
13005	2	600	1000	66	27	6	-4	-307	-539	-1446	-1666	6	
13005	3	600	1000	75	1	-25	-35	-295	-517	-1442	-1641	6	
13005	4	600	1000	63	-3	-45	-55	-309	-520	-1477	-1649	6	
13005	5	600	1000	67	-1	-39	-49	-303	-511	-1465	-1646	6	
13005	12	600	1000	105	32	8	-2	-275	-502	-1438	-1616	6	
13005	13	600	1000	105	32	8	-2	-275	-502	-1438	-1616	6	
13005	15	97	300	71	31	21	11	-278	-514	-1503	-1605	4	
13005	16	152	327	71	31	21	11	-278	-514	-1503	-1605	4	
13005	17	200	310	84	14	1	-9	-292	-525	-1467	-1632	4	
13005	18	200	300	84	14	1	-9	-292	-525	-1467	-1632	4	
13005	19	139	280	110	49	37	27	-263	-492	-1462	-1589	4	
13005	20	135	280	110	49	37	27	-263	-492	-1462	-1589	4	
13005	31	633	1000	73	28	18	8	-285	-522	-1504	-1617	6	
13005	32	570	1080	66	21	11	1	-283	-521	-1491	-1619	6	
13005	33	595	890	73	9	-3	-13	-297	-531	-1481	-1635	6	
13005	34	595	1000	92	19	0	-10	-289	-518	-1459	-1627	6	
13005	35	600	1060	73	28	18	8	-285	-522	-1504	-1617	6	
13005	40	122	290	73	41	31	21	-267	-501	-1507	-1589	4	
13005	41	140	230	89	45	35	25	-257	-487	-1506	-1576	4	
13005	42	140	230	89	45	35	25	-257	-487	-1506	-1576	4	
13005	43	162	230	89	45	35	25	-257	-487	-1506	-1576	4	
13005	44	238	452	75	56	40	30	-248	-477	-1545	-1581	4	
13005	45	240	450	75	56	40	30	-248	-477	-1545	-1581	4	

Table A-1. Layer Assignments for Production Wells within The Villages - SWFWMD

PERMIT	STN_ID	CASING	DEPTH	L1TOP	L1BOT	L2BOT	L3BOT	L4BOT	L5BOT	L6BOT	L7BOT	CSM Model Layers	Change
13005	46	125	300	73	41	31	21	-267	-501	-1507	-1589	4	
13005	52	592	983	90	25	11	1	-285	-515	-1470	-1618	6	
13005	53	612	1000	96	29	4	-6	-286	-511	-1468	-1616	6	
13005	58	600	1000	84	14	1	-9	-292	-525	-1467	-1632	6	
13005	59	600	1000	110	49	37	27	-263	-492	-1462	-1589	6	
13005	60	600	1010	80	19	9	-1	-292	-528	-1459	-1641	6	
13005	61	600	1000	65	19	9	-1	-293	-532	-1473	-1643	6	
20687	11	597	900	77	57	47	37	-294	-507	-1379	-1645	6	
20687	13	596	990	81	51	41	31	-293	-496	-1387	-1645	6	
20687	15	596	960	61	24	14	4	-308	-521	-1412	-1670	6	
20687	17	598	960	82	28	18	8	-291	-479	-1413	-1646	6	
20687	19	595	960	85	52	42	32	-297	-482	-1407	-1656	6	
20687	21	596	960	70	11	1	-9	-304	-503	-1419	-1662	6	
20687	23	598	970	69	50	40	30	-294	-515	-1398	-1664	6	
20687	25	600	900	64	53	43	33	-295	-523	-1410	-1671	3&4	L6

Table A-2. Layer Assignments for Villages Production Wells - SJRWMD

PERMIT	STN_ID	CASING	DEPTH	L1TOP	L1BOT	L2BOT	L3BOT	L4BOT	L5BOT	L6BOT	L7BOT	CSM Model Layers	Change
50279	454722	135	315	73	49	33	23	-266	-495	-1541	-1593	3&4	L4 only
50279	922	118	266	91	68	34	24	-236	-464	-1536	-1572	3&4	L4 only
50279	923	131	304	91	68	34	24	-236	-464	-1536	-1572	3&4	L4 only
50279	924	128	310	76	59	38	28	-256	-486	-1542	-1587	3&4	L4 only
50279	925	190	700	92	63	28	18	-258	-486	-1546	-1591	6	L456
50279	926	110	310	73	49	33	23	-266	-495	-1541	-1593	3&4	L4 only
50279	927	180	330	70	51	28	18	-255	-484	-1555	-1590	3&4	L4 only
50279	928	140	266	91	68	34	24	-236	-464	-1536	-1572	3&4	L4 only
50280	23218	600	710	70	35	25	15	-281	-506	-1516	-1595	6	
50280	23221	600	710	80	49	39	29	-263	-489	-1507	-1580	6	
50280	23222	540	750	77	40	30	20	-279	-504	-1508	-1592	3	L6
50280	942	56	570	91	68	34	24	-236	-464	-1536	-1572	3&4	
50280	943	59	434	91	68	34	24	-236	-464	-1536	-1572	3&4	

Appendix B – Monthly Water Use Comparison

Figure B-1. SWFWMD WUP 2798 Historical Pumping Data

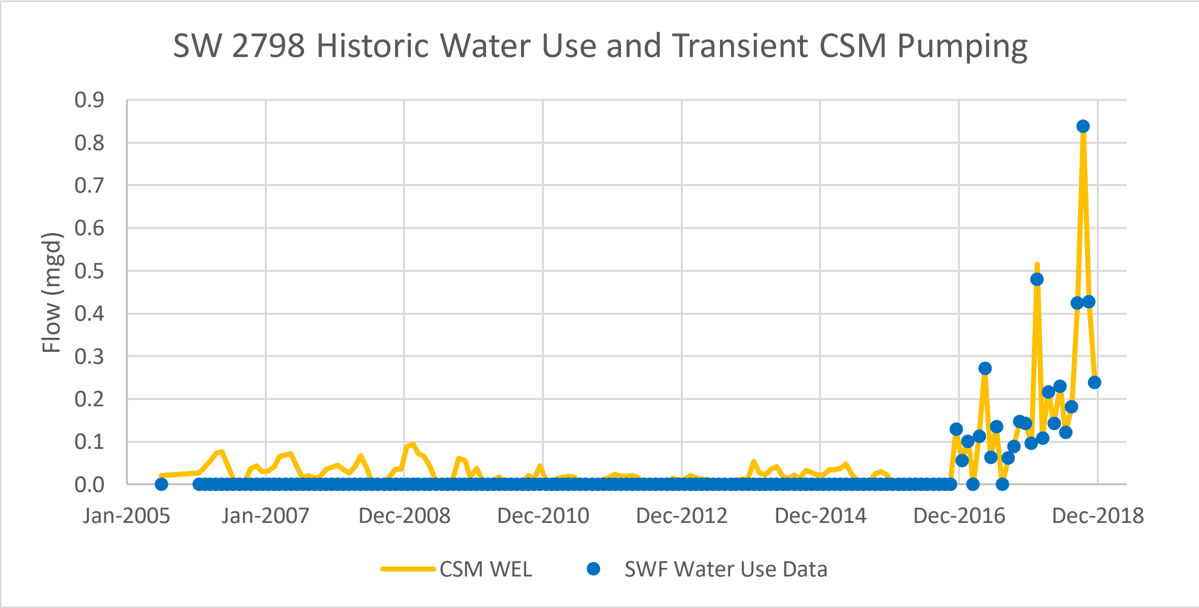


Figure B-2. SWFWMD WUP 32026 Historical Pumping Data

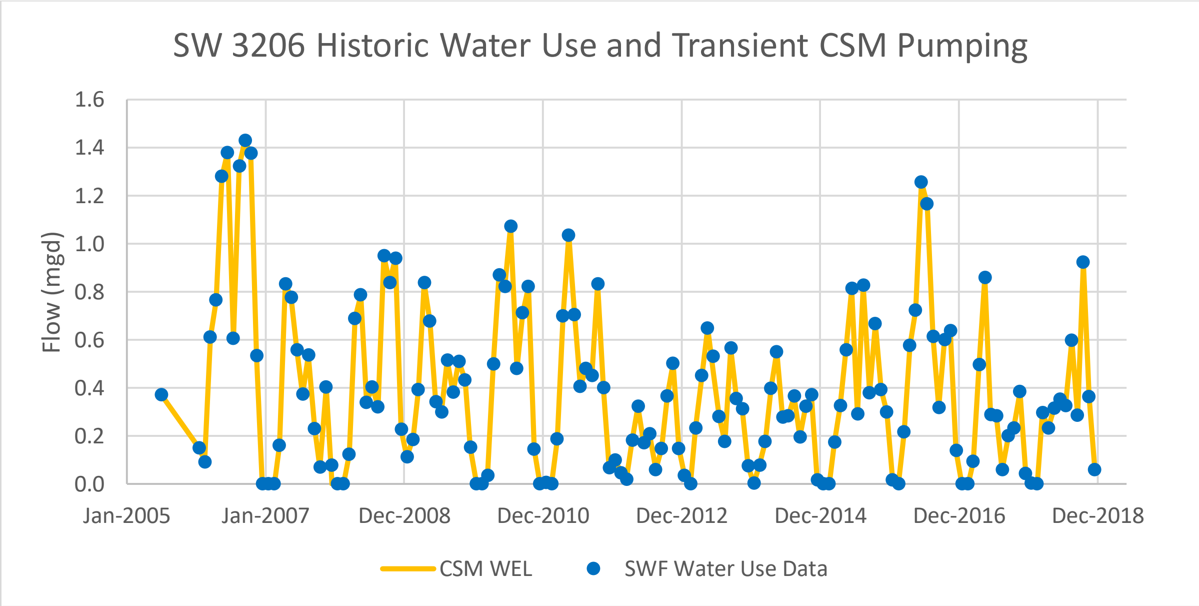


Figure B-3. SWFWMD WUP 11404 Historical Pumping Data

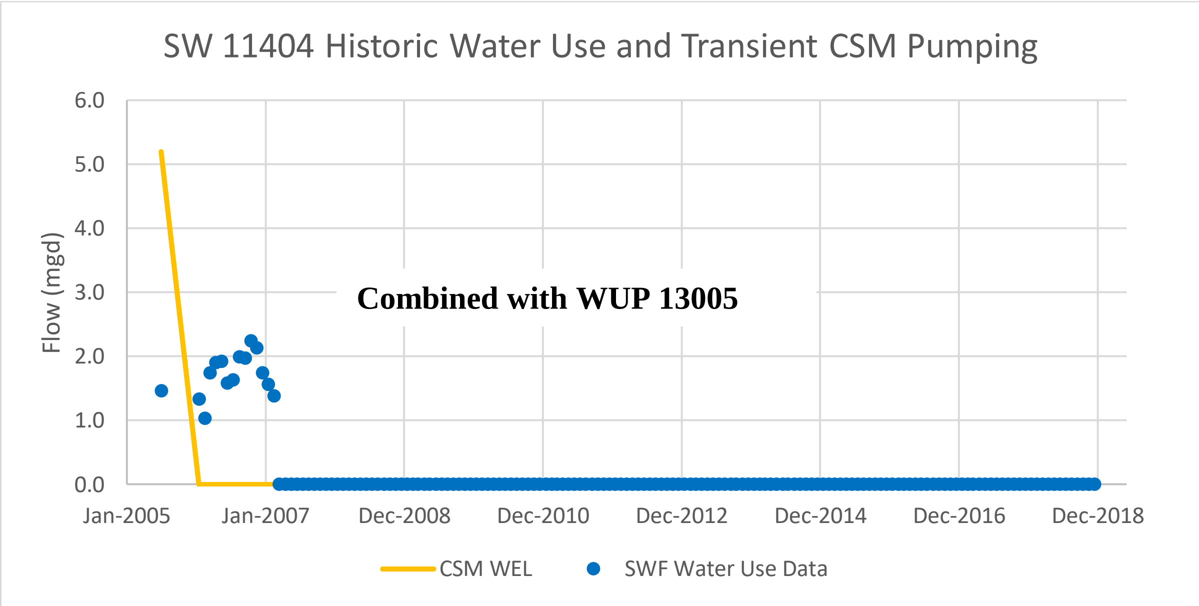


Figure B-4. SWFWMD WUP 11566 Historical Pumping Data

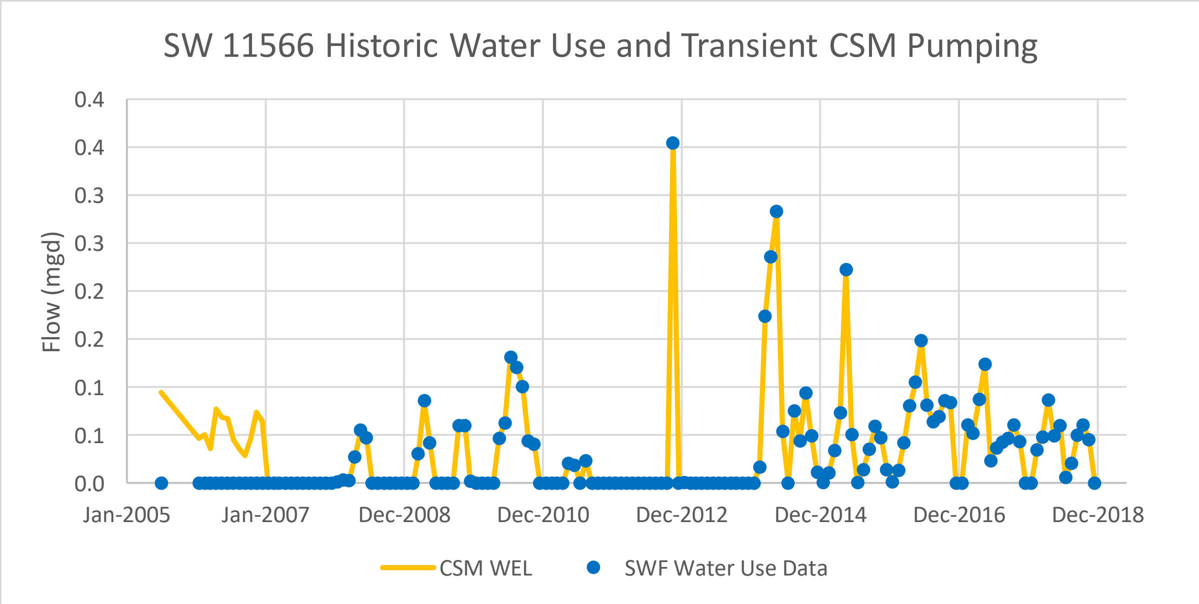


Figure B-5. SWFWMD WUP 11624 Historical Pumping Data

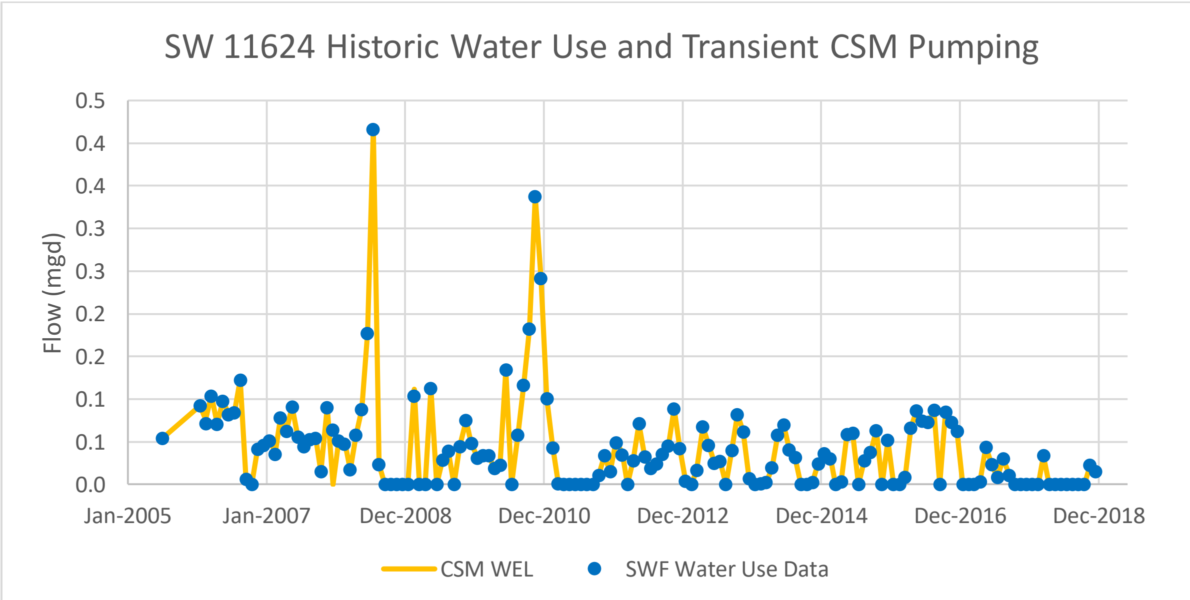


Figure B-6. SWFWMD WUP 11778 Historical Pumping Data

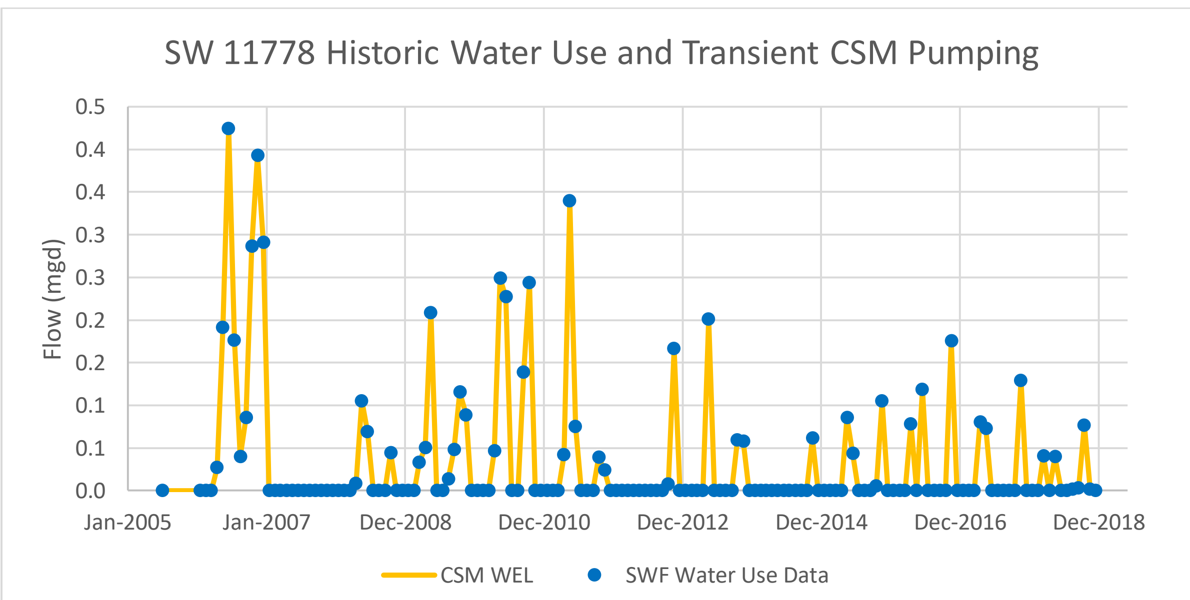


Figure B-7. SWFWMD WUP 11779 Historical Pumping Data

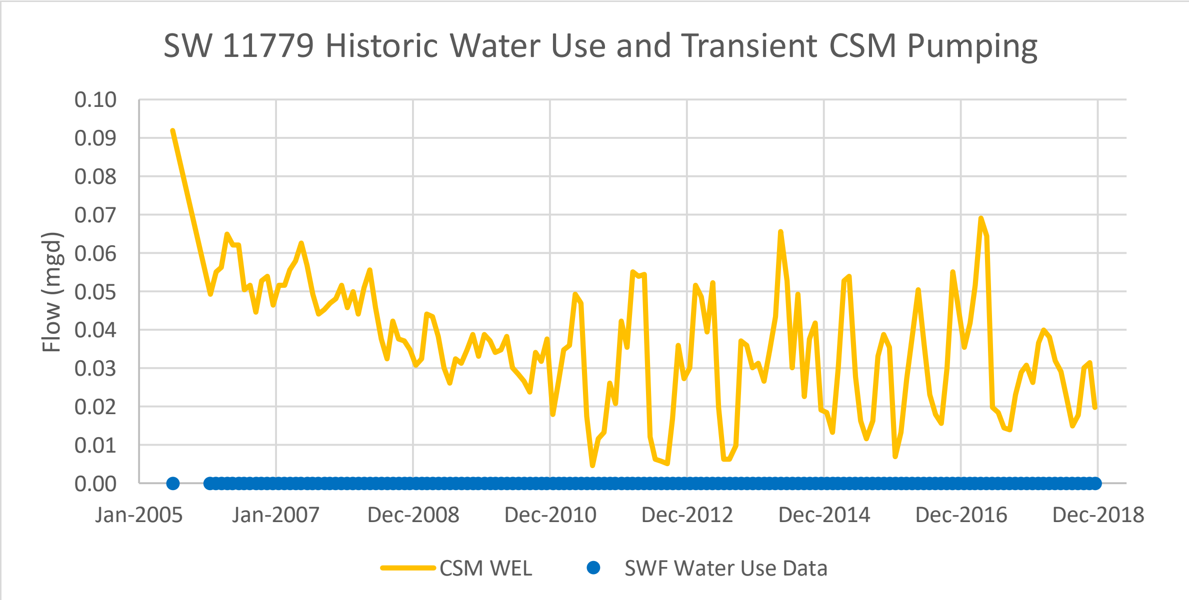


Figure B-8. SWFWMD WUP 11780 Historical Pumping Data

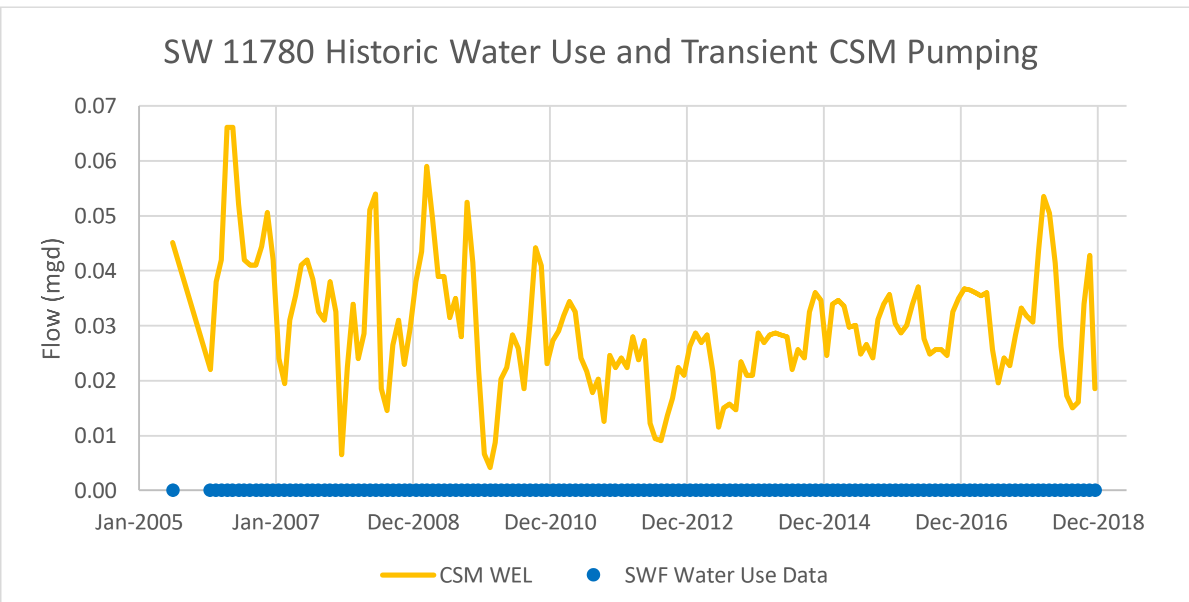


Figure B-9. SWFWMD WUP 12236 Historical Pumping Data

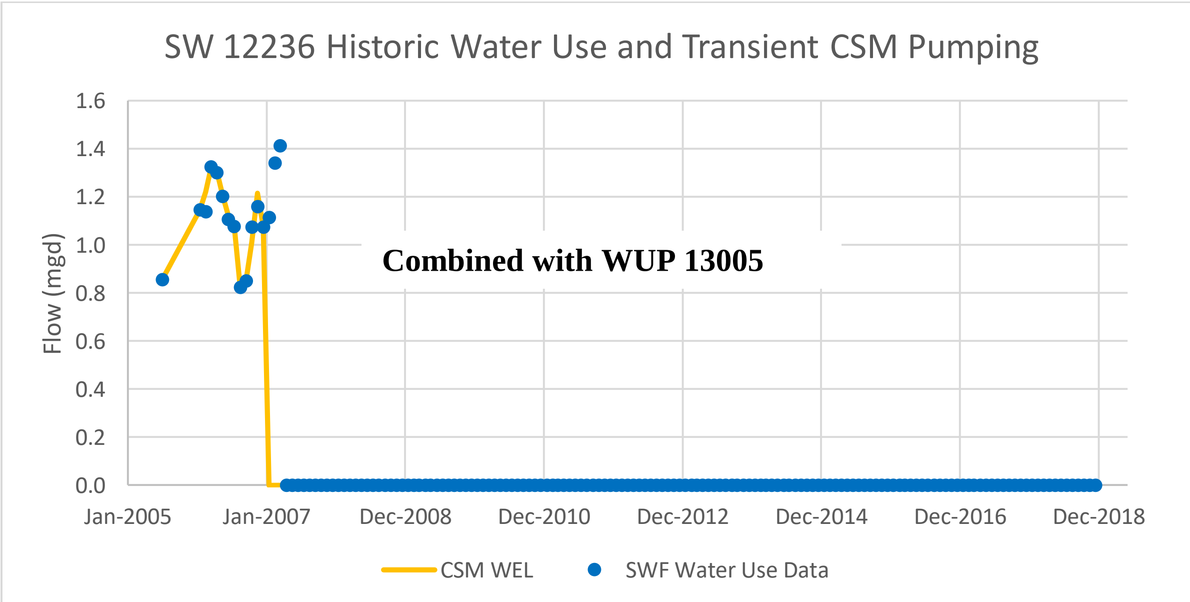


Figure B-10. SWFWMD WUP 12239 Historical Pumping Data

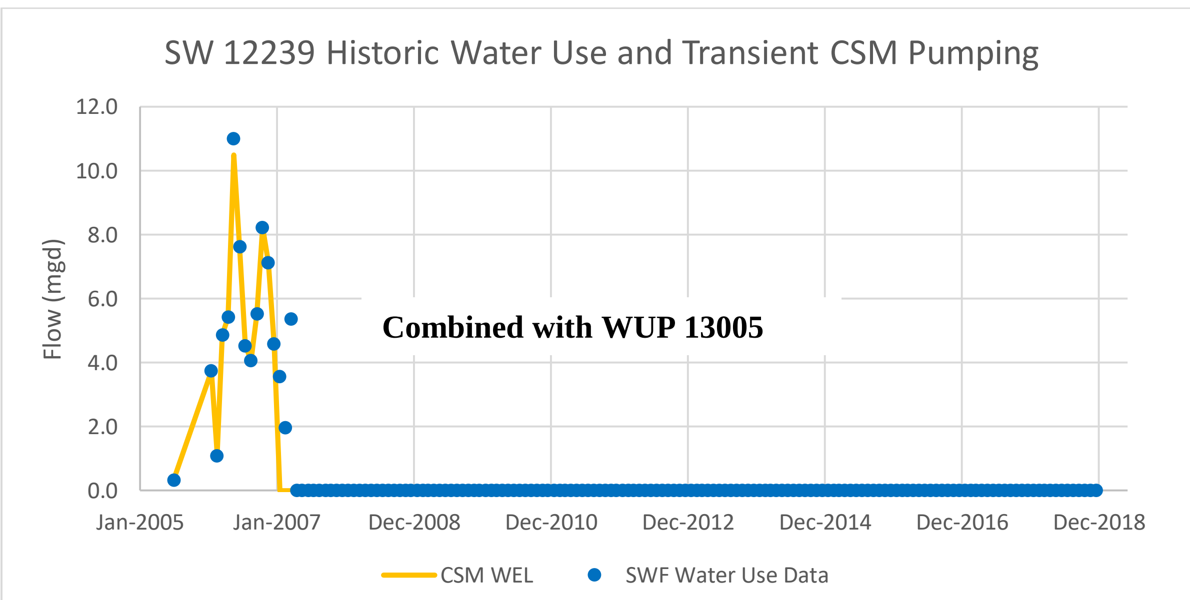


Figure B-11. SWFWMD WUP 12584 Historical Pumping Data

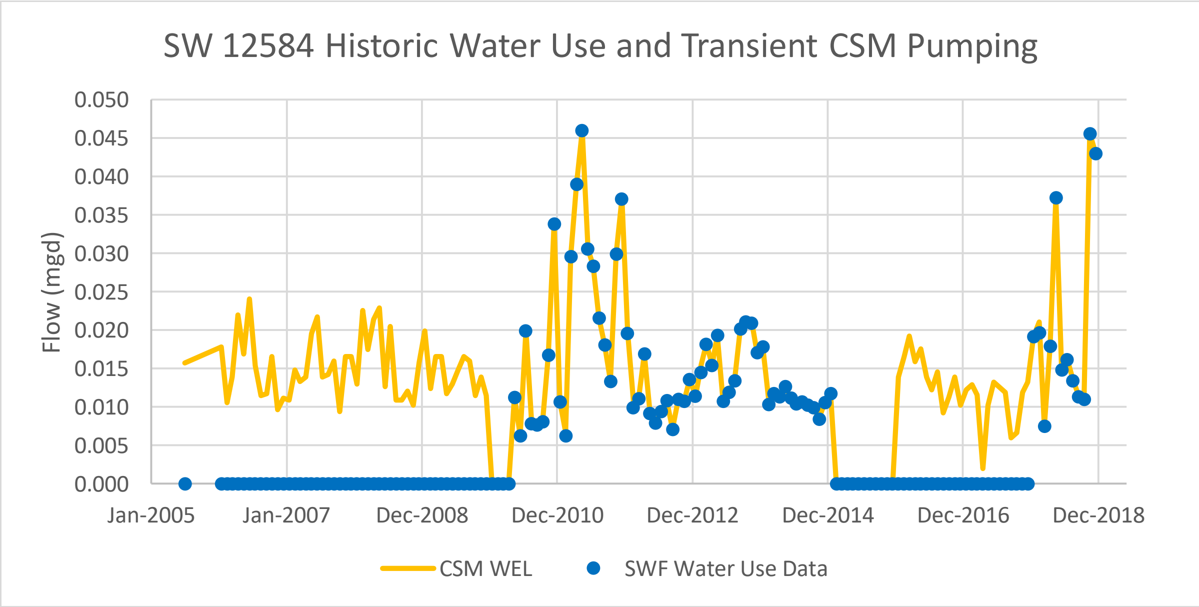


Figure B-12. SWFWMD WUP 13005 Historical Pumping Data

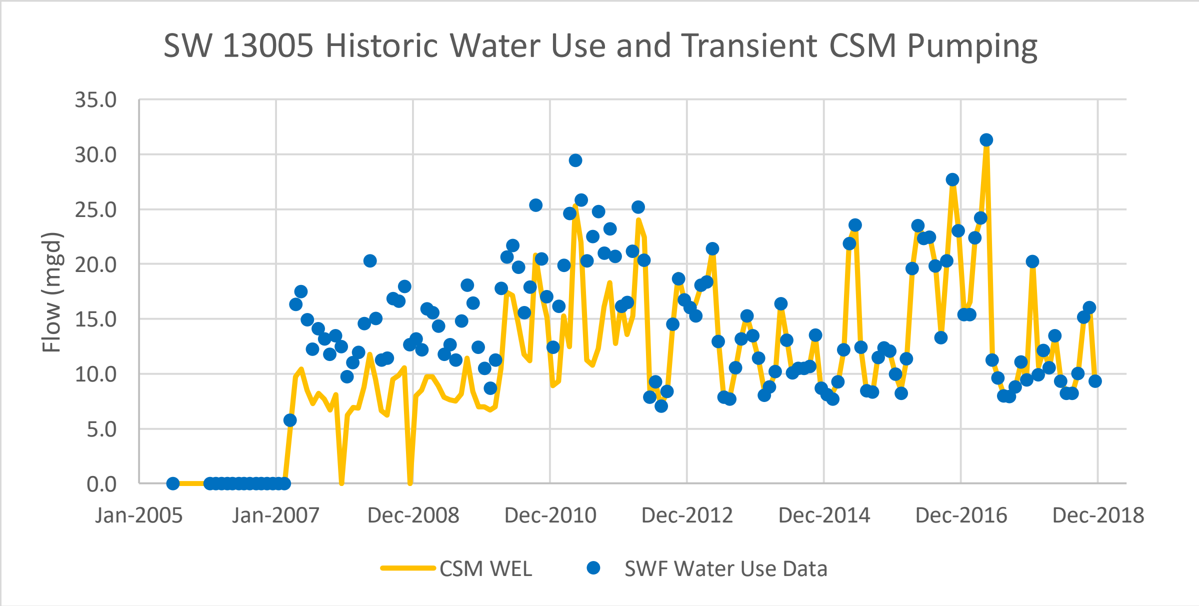


Figure B-13. SWFWMD WUP 20687 Historical Pumping Data

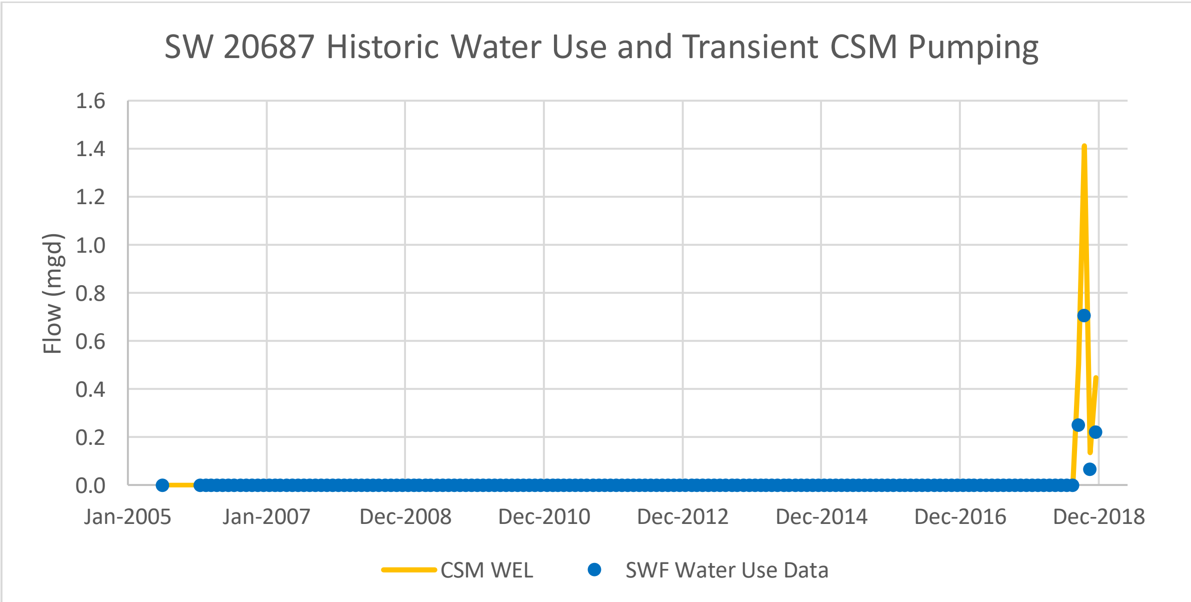


Figure B-14. SJRWMD CUP 50279 Historical Pumping Data

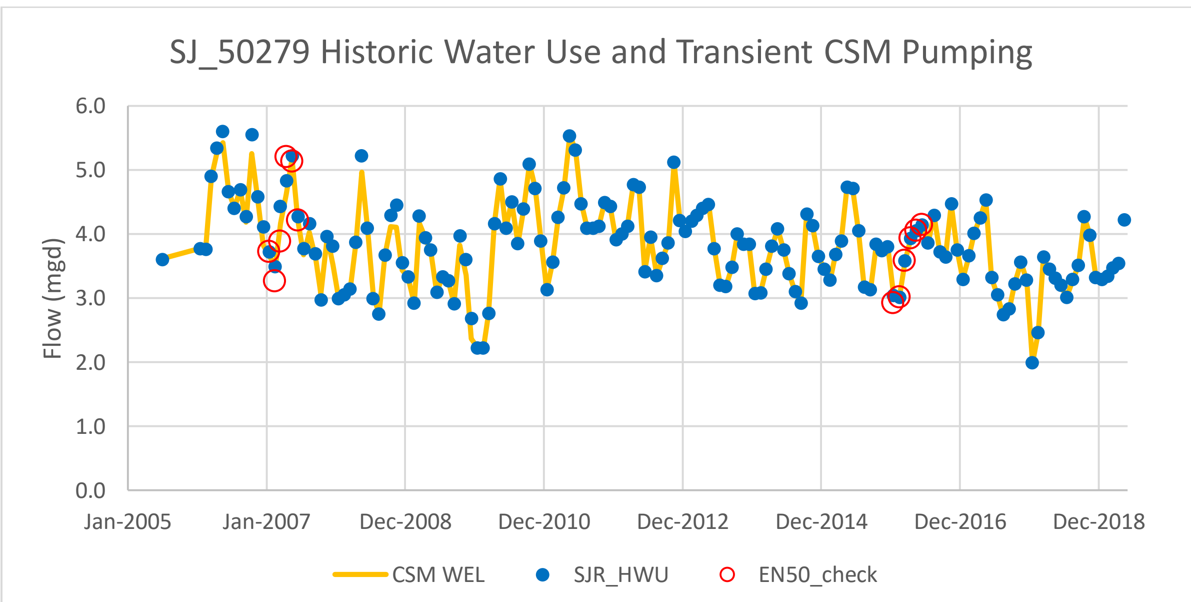
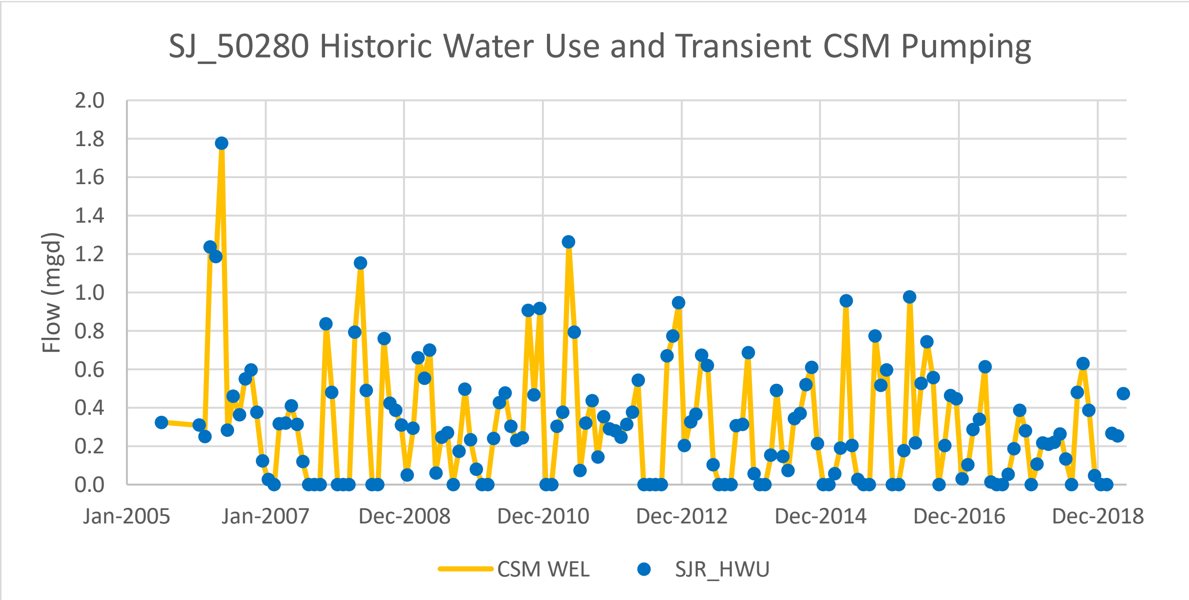


Figure B-15. SJRWMD CUP 50280 Historical Pumping Data



Andreyev Engineering, Inc.

ST. PETERSBURG OFFICE
3740 54th Avenue North
St. Petersburg, Florida 33714
727-527-5735

▼ Groundwater ▼ Environmental ▼ Geotechnical ▼ Construction Materials Testing

November 9, 2023
AEI Project No.: APGW-23-120

TO: **Vikus Water**
1038 Lake Sumter Landing
The Villages, Florida 32162

Attention: Trey Arnett, P.E.

SUBJECT: Review of Central Springs Model, Evaluation of Model Calibration Comparison to Real Data and Recommendations for WUP Permitting
The Villages, Sumter County, Florida

Dear Mr. Arnett:

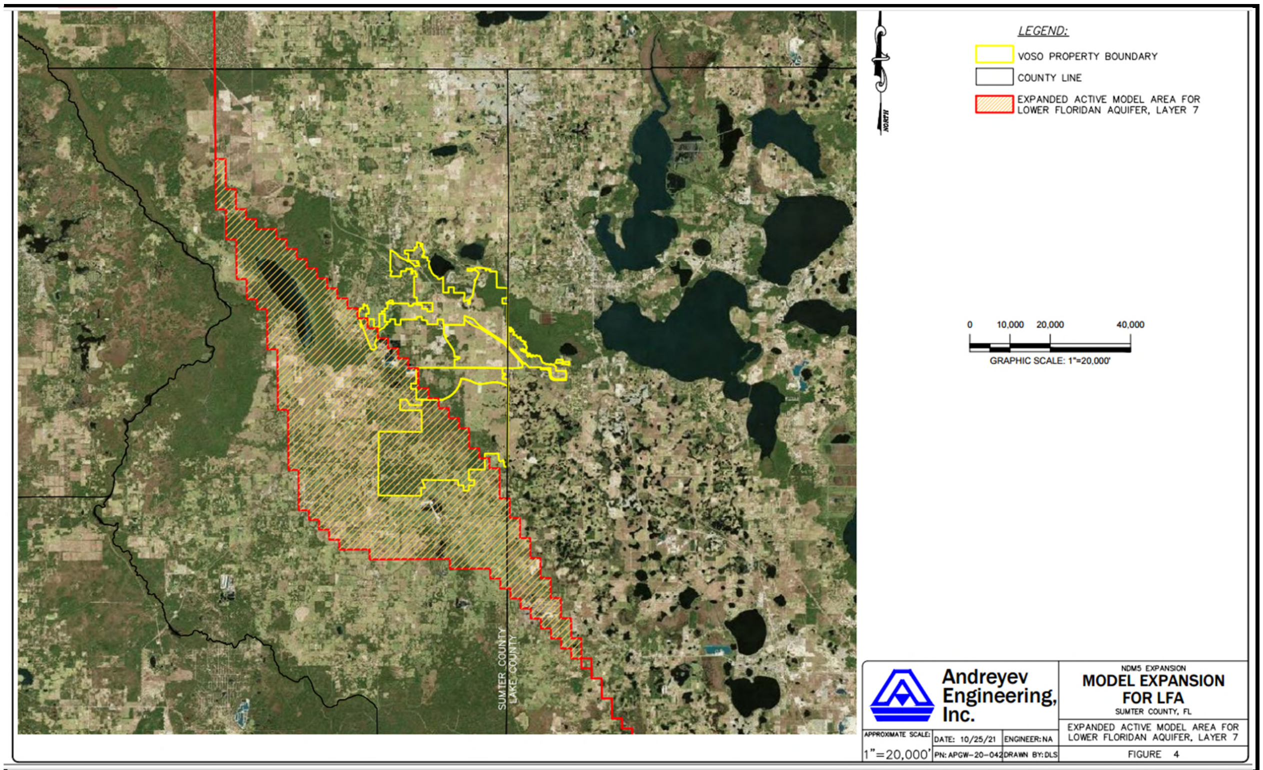
Per your request, Andreyev Engineering, Inc. (AEI) has completed a review of the Central Springs Model (CSM) that was recently released by the SJRWMD/SWFWMD for public review. This review was intended to primarily compare the CSM model to the recently expanded and re-calibrated NDM5 model in the southern portions of The Villages development. The expansion of the NDM5 model was limited to the lower Floridan aquifer (LFA) which was originally set to no-flow conditions in the southwestern areas of The Villages development (area of interest). This review report summarizes the calibrated parameters in the area of interest for both the recently expanded and recalibrated NDM5 model and the newly published CSM model and provides an evaluation of the data used to calibrate the new CSM model. In addition, this summary report provides our recommendations for the effectiveness of the model to be used for WUP/CUP permitting.

Expanded and Recalibrated Northern District Groundwater Flow Model (NDM5)

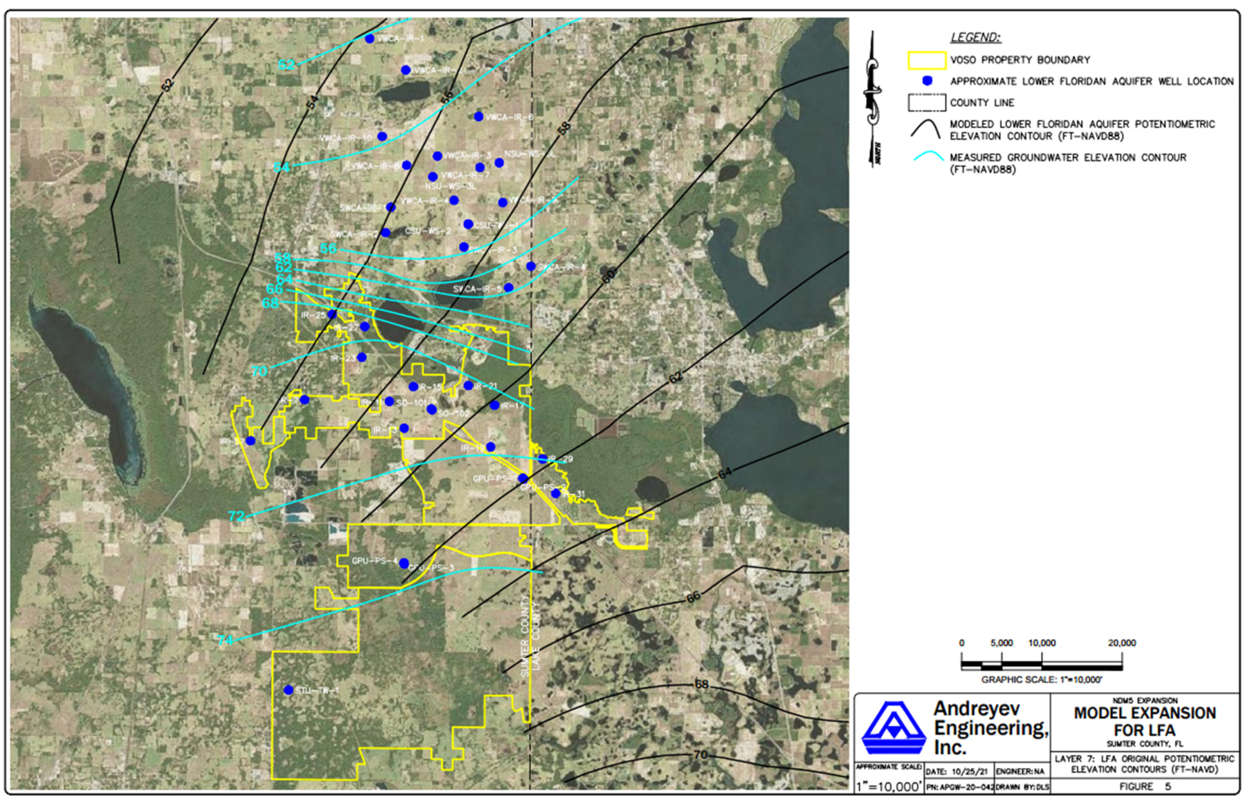
The original NDM5 model was regionally calibrated to the year 2010. Our review of the potentiometric surface elevations in the model and the site-specific levels measured at the test wells and production wells indicated that the potentiometric elevations of the LFA, Layer 7, in the model were significantly lower than the observed elevations, up to 10 feet lower, and AEI subsequently performed model expansion and recalibration. The active area of the LFA was expanded westwardly and the aquifer parameters for the LFA were recalibrated to match the observed potentiometric surface of the LFA. A detailed report was submitted to the SWFWMD for review and approval of the expanded model. The expanded model was utilized in support of The Villages water use permits which were subsequently accepted and approved by the SWFWMD.

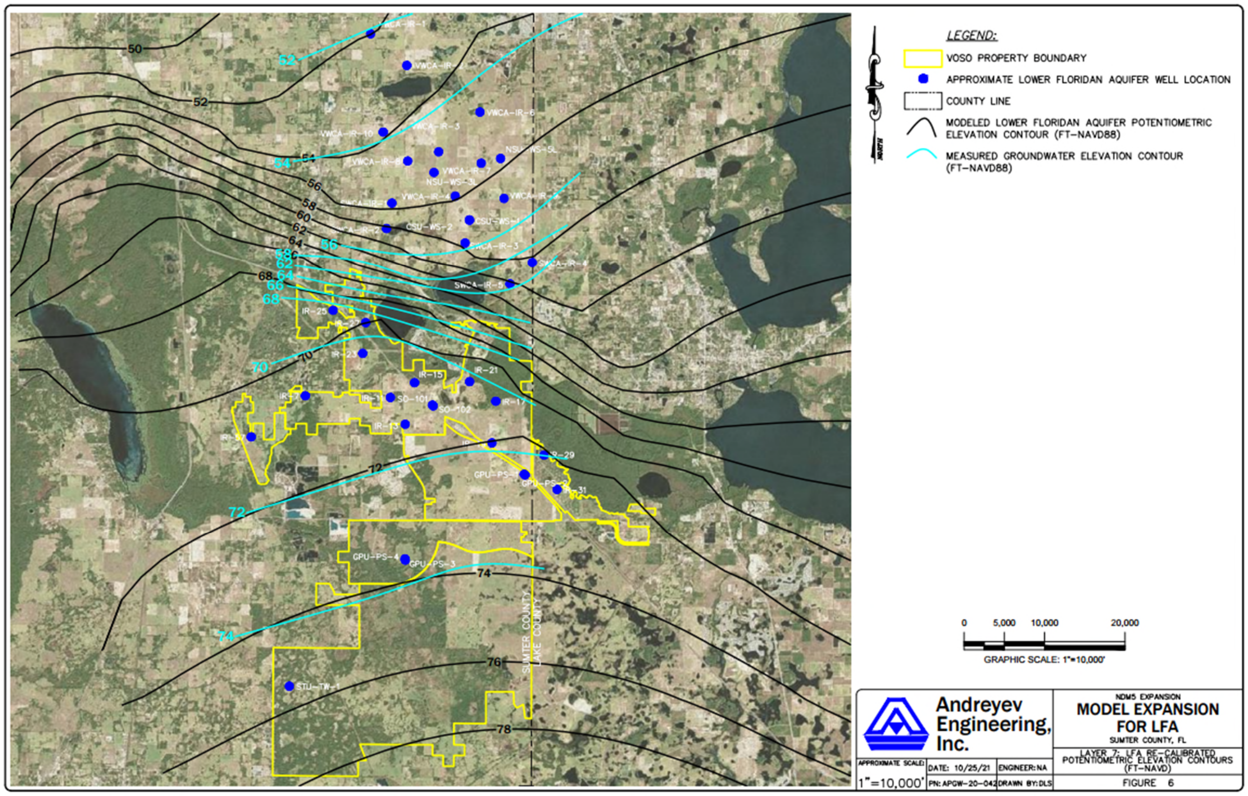
The following figure presents the westerly expansion of the LFA layer to include the future development areas of The Villages (area of interest). Prior to expansion of the model area, two lower Floridan test wells were installed in the western portion of development to test and verify that the LFA did exists and that it produced potable water sources.

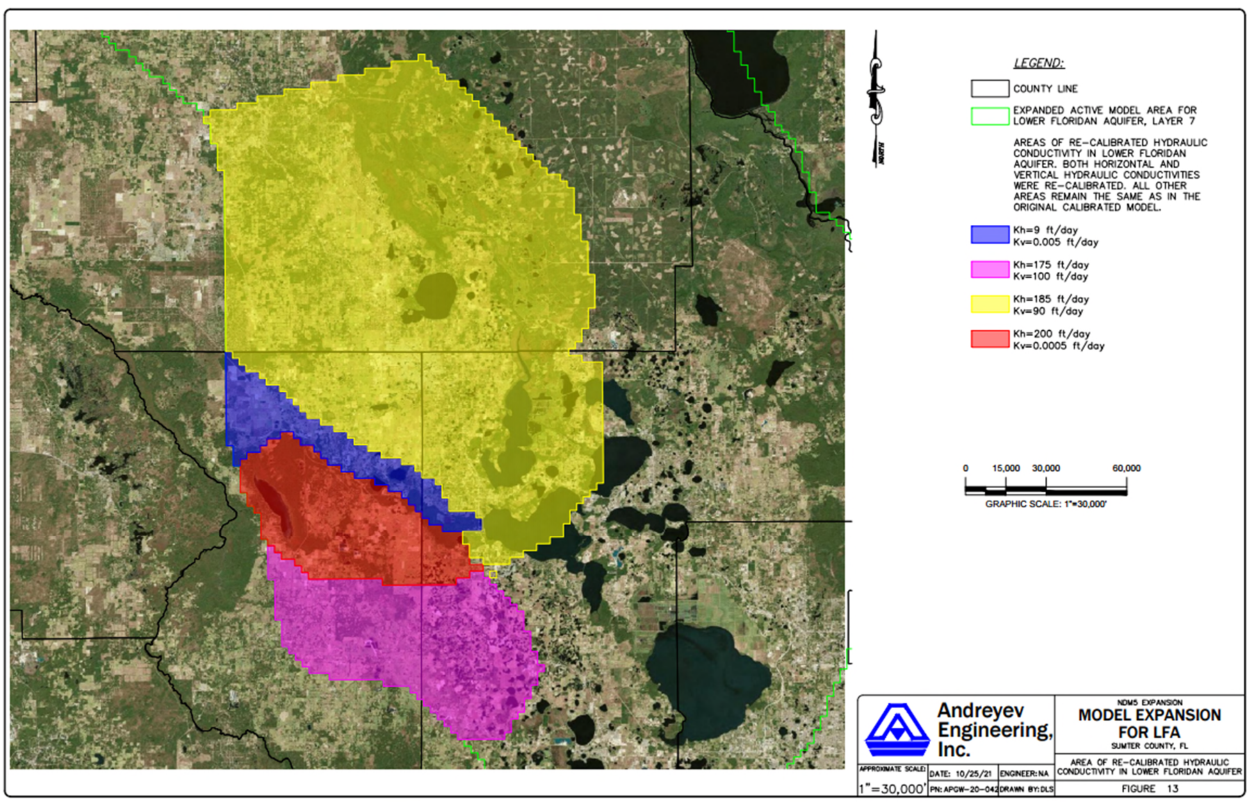
The Villages 352-751-2478
Clermont 352-241-0508
Sanford 407-330-7763



The following figures present the potentiometric elevation contours for the original NDM5 model and the expanded/recalibrated model as wells as the recalibrated horizontal and vertical permeability values for the region:




LEGEND:
VOSO PROPERTY BOUNDARY
APPROXIMATE LOWER FLORIDAN AQUIFER WELL LOCATION
COUNTY LINE
MODELED LOWER FLORIDAN AQUIFER POTENTIOMETRIC ELEVATION CONTOUR (FT-NAVD88)
MEASURED GROUNDWATER ELEVATION CONTOUR (FT-NAVD88)
0 5,000 10,000 20,000
GRAPHIC SCALE: 1"=10,000'
Andreyev Engineering, Inc.
NDM5 EXPANSION
MODEL EXPANSION FOR LFA
SUMTER COUNTY, FL
LAYER 7 LFA RE-CALIBRATED POTENTIOMETRIC ELEVATION CONTOURS (FT-NAVD)
APPROXIMATE SCALE: 1"=10,000'
DATE: 10/25/21
PN: APGW-20-042
ENGINEER: NA
DRAWN BY: DLS
FIGURE 6


LEGEND:
COUNTY LINE
EXPANDED ACTIVE MODEL AREA FOR LOWER FLORIDAN AQUIFER, LAYER 7
AREAS OF RE-CALIBRATED HYDRAULIC CONDUCTIVITY IN LOWER FLORIDAN AQUIFER. BOTH HORIZONTAL AND VERTICAL HYDRAULIC CONDUCTIVITIES WERE RE-CALIBRATED. ALL OTHER AREAS REMAIN THE SAME AS IN THE ORIGINAL CALIBRATED MODEL.
Kh=9 ft/day Kv=0.005 ft/day
Kh=175 ft/day Kv=100 ft/day
Kh=185 ft/day Kv=90 ft/day
Kh=200 ft/day Kv=0.0005 ft/day
0 15,000 30,000 60,000
GRAPHIC SCALE: 1"=30,000'
Andreyev Engineering, Inc.
NDM5 EXPANSION
MODEL EXPANSION FOR LFA
SUMTER COUNTY, FL
AREA OF RE-CALIBRATED HYDRAULIC CONDUCTIVITY IN LOWER FLORIDAN AQUIFER
APPROXIMATE SCALE: 1"=30,000'
DATE: 10/25/21
PN: APGW-20-042
ENGINEER: NA
DRAWN BY: DLS
FIGURE 13

3

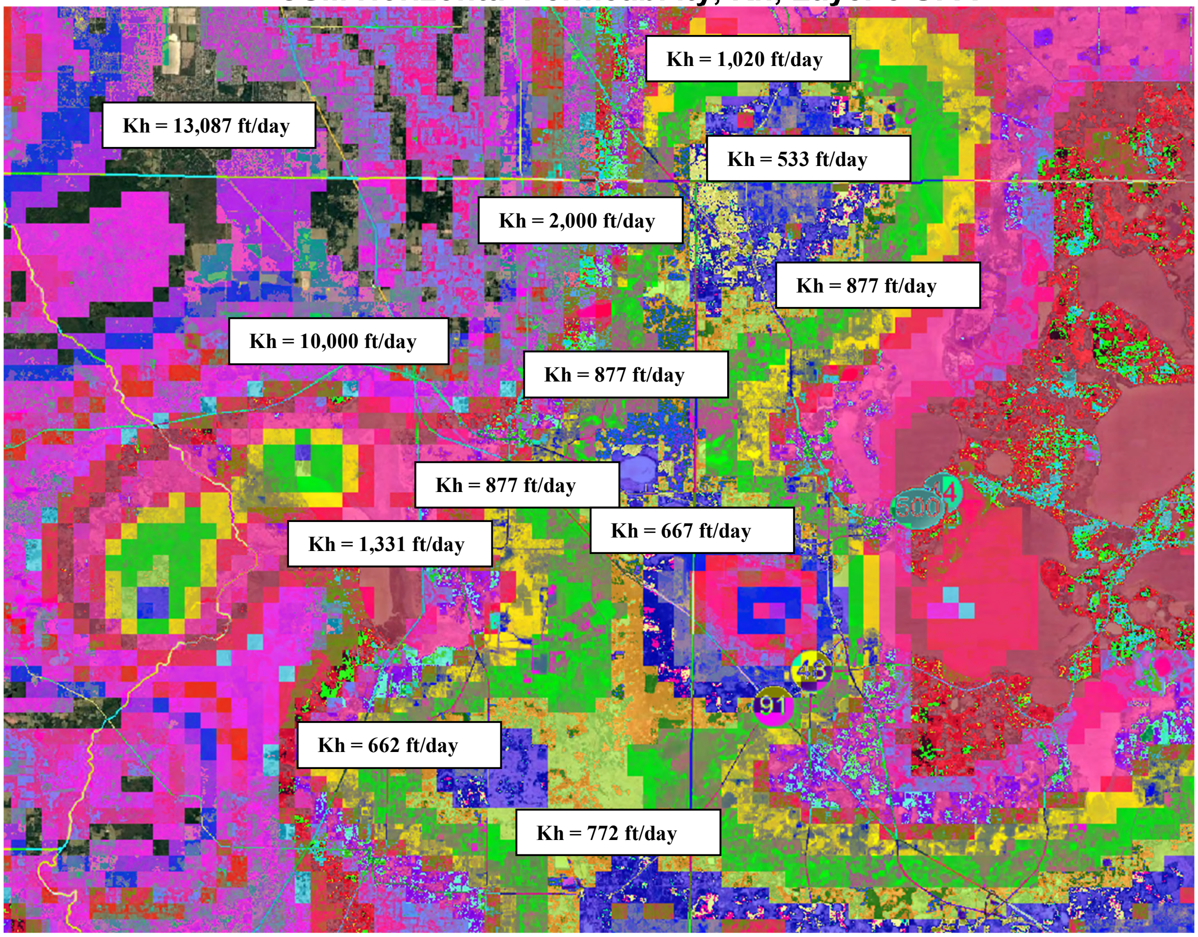
As can be observed on the figures above, the recalibrated aquifer parameters result in significant improvement to the model calibration in The Villages area. In the southern portion of the area of interest, the potentiometric surface of the LFA exists in artesian conditions and the potentiometric elevations occur at 6 to 12 feet higher than the potentiometric elevation of the upper Floridan aquifer (UFA).

Central Springs Model (CSM) Review and Evaluation

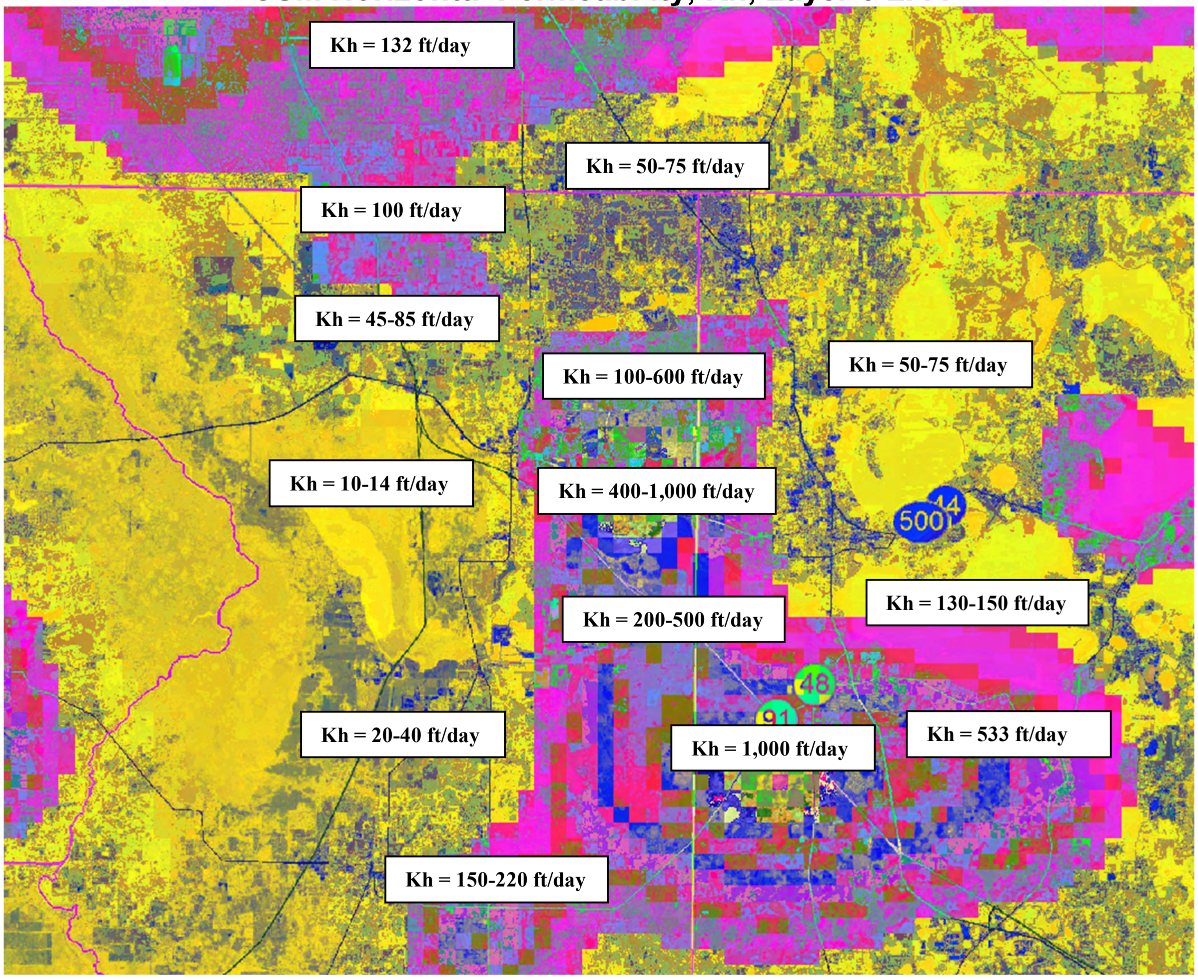
AEI has downloaded the CSM model, both transient and steady state versions. We have executed the models and reviewed both the model structure and the calibration. Then we extracted the model simulated potentiometric elevation contours for comparison with the expanded and recalibrated model described above. Several of the calibration target points were also downloaded from the interactive maps provided by the District and the resulting plots of observed and simulated data are included in **Appendix A**. The calibrated target points for the LFA appear to be very limited and are located far away from The Villages development areas. It appears that the well and pump test data submitted by The Villages over the past 20 years have not been used for model calibration. As a result, although the few calibration points in the far eastern portion were relatively well calibrated, they do not represent the conditions in the central and southwestern portions of The Villages development areas, the area of interest.

To compare the CSM calibrated horizontal and vertical permeabilities to the NDM5 expanded and recalibrated model for the area of interest, we have extracted the Kh values from Layers 3 and 6 (UFA & LFA) of the CSM model. The Kh values for LFA can be compared to the values on the figure above, page 3.

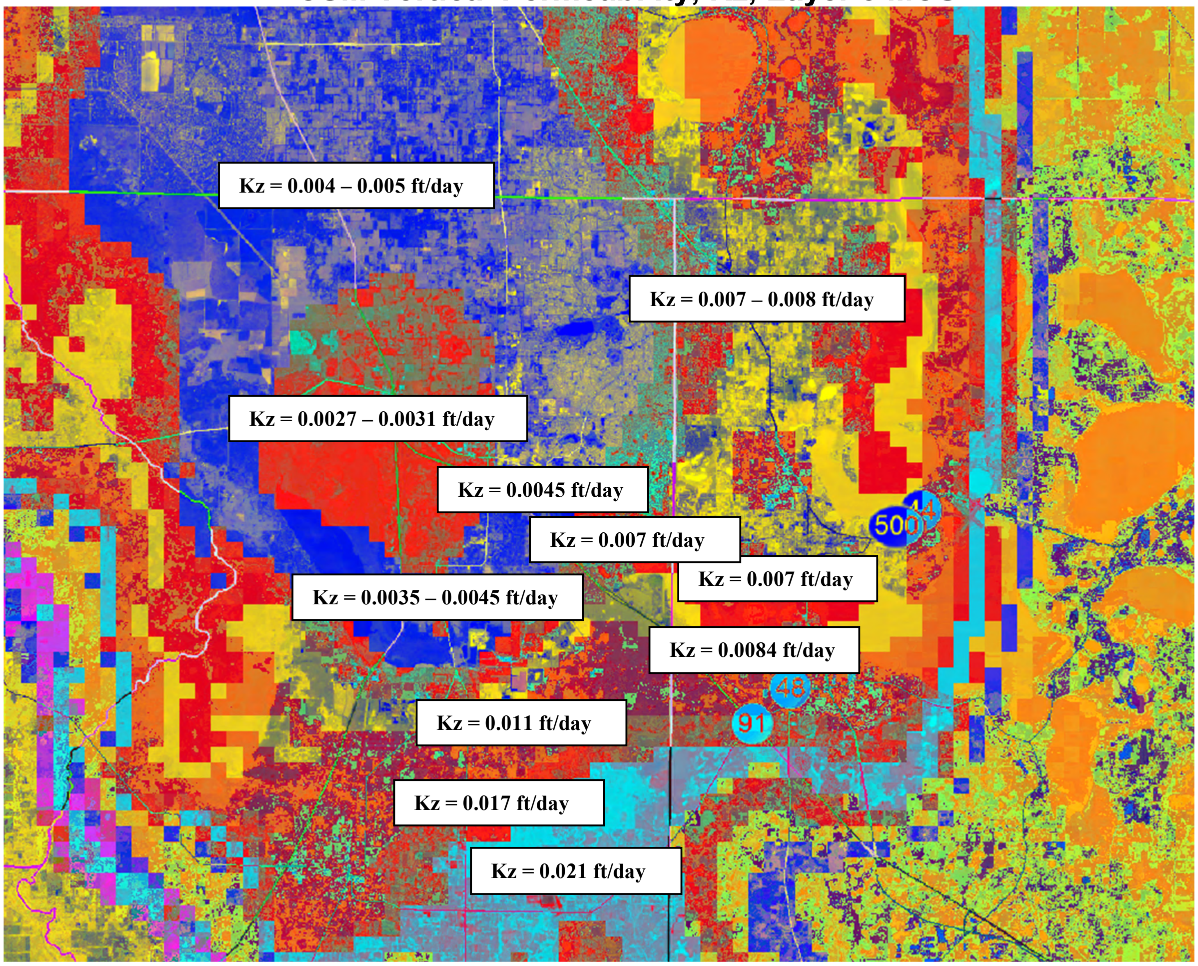
CSM Horizontal Permeability, Kh, Layer 3 UFA



CSM Horizontal Permeability, Kh, Layer 6 LFA



CSM Vertical Permeability, Kz, Layer 5 MCU



The data presented in the figures above indicate drastically different horizontal and vertical permeability values of the CSM model as compared to the recently expanded and recalibrated NDM5 model. The horizontal permeability values in the UFA, although extremely variable, appear to simulate the potentiometric surface reasonably well, except in the central-west area of The Villages. However, the horizontal permeability of Layer 6 (LFA) appears to be very low in the north and western portions of the area of interest and does not compare well with the recently recalibrated NDM5 model.

Perhaps the biggest difference between the two models, which is creating the large head difference in LFA, is the vertical permeability of Layer 5 (MCU), specifically in the southern area, and the observed anomalous region of extremely low horizontal permeability that occurs between the northern and southern areas. These were discussed in detail in our report for the expansion and recalibration of the NDM5 model. It is our opinion that the same aquifer characteristics need to be entered into the CSM model in order to achieve a reasonable calibration in the southern portion of The Villages development. For example, the vertical permeability between UFA and LFA in the red area (map on page 3) was calibrated at 0.0005 ft/day to achieve the high potentiometric elevations observed in wells drilled in this area. The LFA wells drilled in this area exhibit artesian conditions, with aquifer pressures rising 5 to 10 feet above ground surface. The CSM calibrated vertical permeability in this same area is 0.011 to 0.0035 ft/day (one to two orders of magnitude higher). Similarly, the horizontal permeability in the observed anomalous region was

9 feet/day as recalibrated in the NDM5 model, while in the CSM model it varies from 45 to 1,000 ft/day (again one to two orders of magnitude higher).

To provide visualization of the differences in potentiometric elevations between observed and simulated, we have plotted the CSM model simulated potentiometric elevation contours of the LFA in the area of interest and compared it to the recently measured elevations of the potentiometric surface at various LFA wells within The Villages development. The attached **Figures 1 and 2** present the results of measured potentiometric elevation contours versus simulated potentiometric elevations contours by the CSM model.

As can be seen, the CSM model calibrated potentiometric elevations for the lower Floridan aquifer are significantly off throughout the entirety of The Villages development, and most notably within the southern expansion (area of interest) of The Villages development, where the difference is as high as 8 feet. Review of the calibration target points used for LFA calibration indicate that none of the LFA test well data and potentiometric monitoring data submitted by The Villages was used for calibration. The very few target points used were located further east, which do not represent the conditions in the area of interest. It appears that the same data was used as the original calibration of the NDM5 model, which was also off by about the same amount of head difference. Based on the comparative data presented in this report, the CSM model is not adequately calibrated in the southern area of The Villages development. Everything south of Lake Deaton is significantly off and needs recalibration.

Based on the comparative data presented in this report and our review of the CSM model for potential WUP/CUP permitting, it is our recommendation that The Villages request the Water Management Districts (WMDs) to recalibrate the CSM model in the area of the existing and future Villages developments prior to using the model for permitting or water use planning in and around The Villages development. For this purpose, the District modelers shall collect all the Villages specific calibration target points data, aquifer performance test (APT) data and recalibrate the model accordingly. The current difference in the observed versus simulated potentiometric elevations of 4 to 12 feet in the UFA and LFA will result in erroneous prediction of withdrawal capacity and potential impacts to MFL springs and water bodies in the region.

If the WMDs are not willing to recalibrate the CSM model for the Villages area, then we recommend that The Villages continue to use the recently expanded and recalibrated NDM5 model for all future WUP/CUP permit modeling.

AEI appreciates the opportunity to participate in this project, and we trust that the information herein is sufficient for your purposes. If you have any questions or comments concerning the contents of this report, please do not hesitate to contact our office.

Sincerely,
ANDREYEV ENGINEERING, INC.

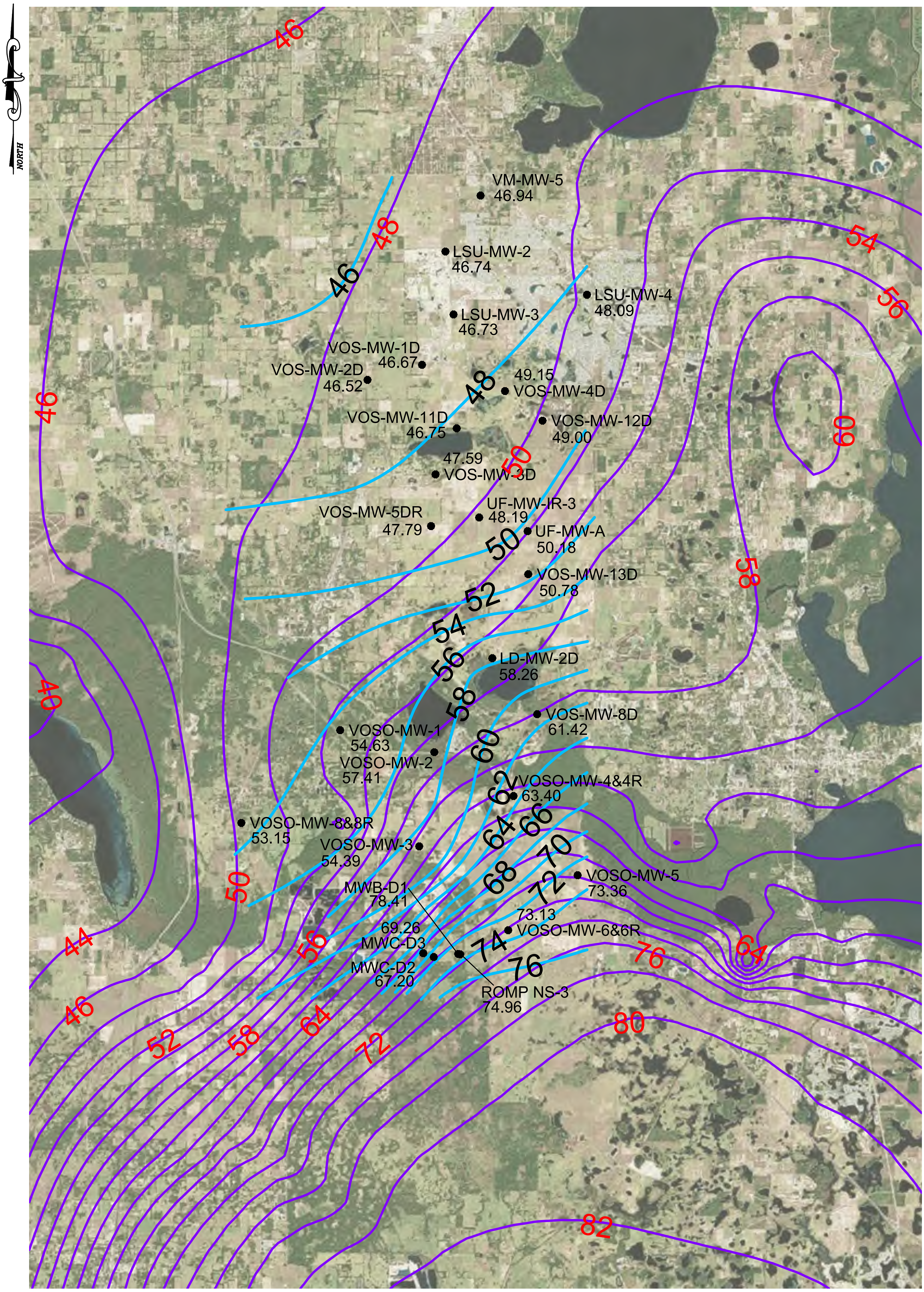
Jeffery E. Eller, P.E.
Vice President
Florida Registration No. 57434

This item has been digitally signed and sealed by Jeffery E. Eller, P.E. on November 9, 2023 using a digital signature. Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

Nicolas E. Andreyev, P.E.
President
Florida Registration No.: 35459

This item has been digitally signed and sealed by Nicolas E. Andreyev, P.E. on November 9, 2023 using a digital signature. Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

FIGURES



LEGEND:

MEASURED AVERAGE POTENTIOMETRIC SURFACE AT VILLAGES WELLS

CSM MODEL: CALIBRATED CONTOURS LAYER 3 UPPER FLORIDAN AQUIFER

0 1 2 4

GRAPHIC SCALE: 1"=2 Miles

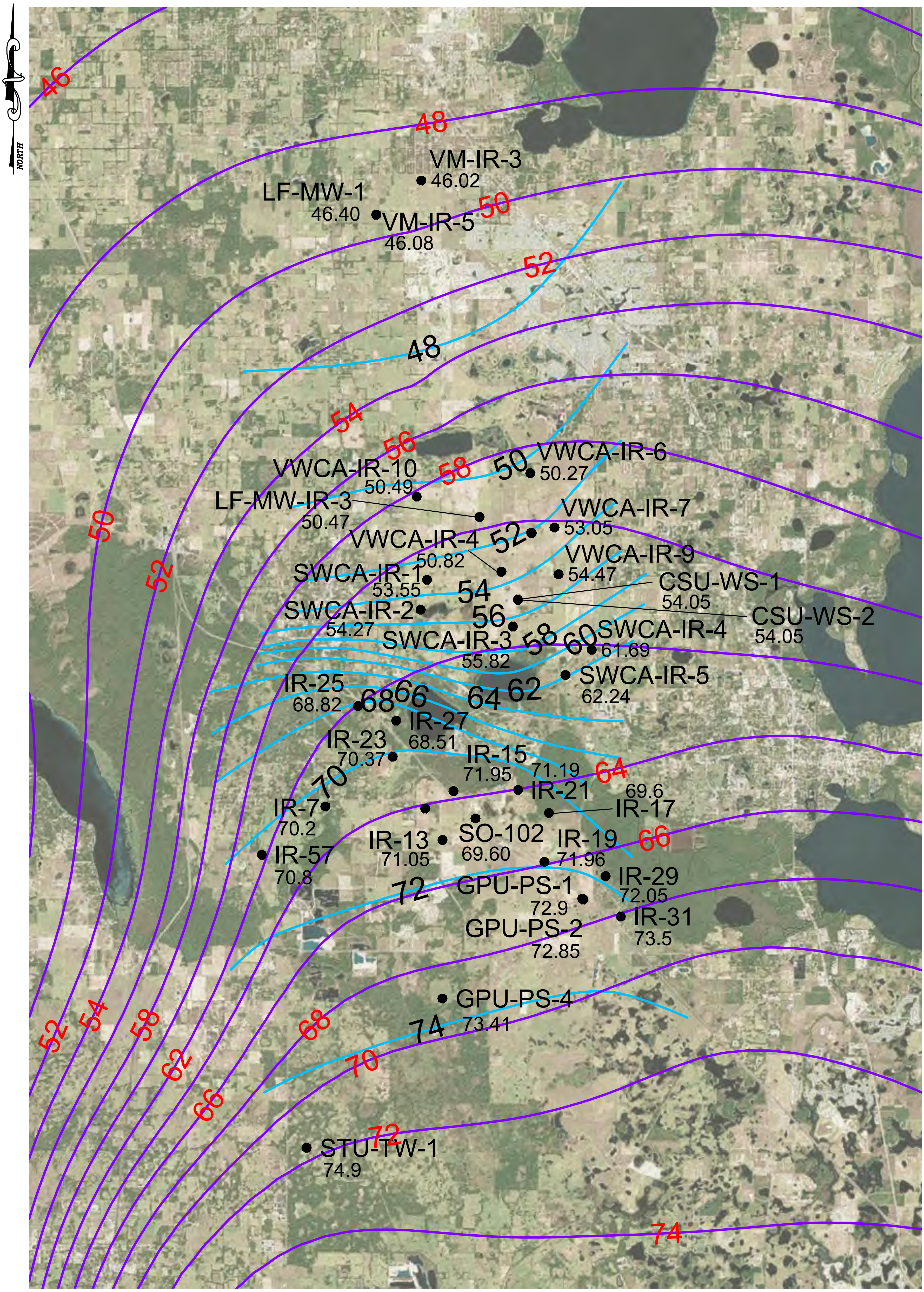
Andreyev Engineering, Inc.

APPROXIMATE SCALE:	DATE: 10/30/23	ENGINEER: NA
1"=2 Miles	PN: APGW-23-120	DRAWN BY: DLS

CENTRAL SPRINGS MODEL CALIBRATION
THE VILLAGES, FL

CALIBRATED CONTOUR MAP

FIGURE 1



LEGEND:

MEASURED AVERAGE POTENTIOMETRIC SURFACE AT VILLAGES WELLS

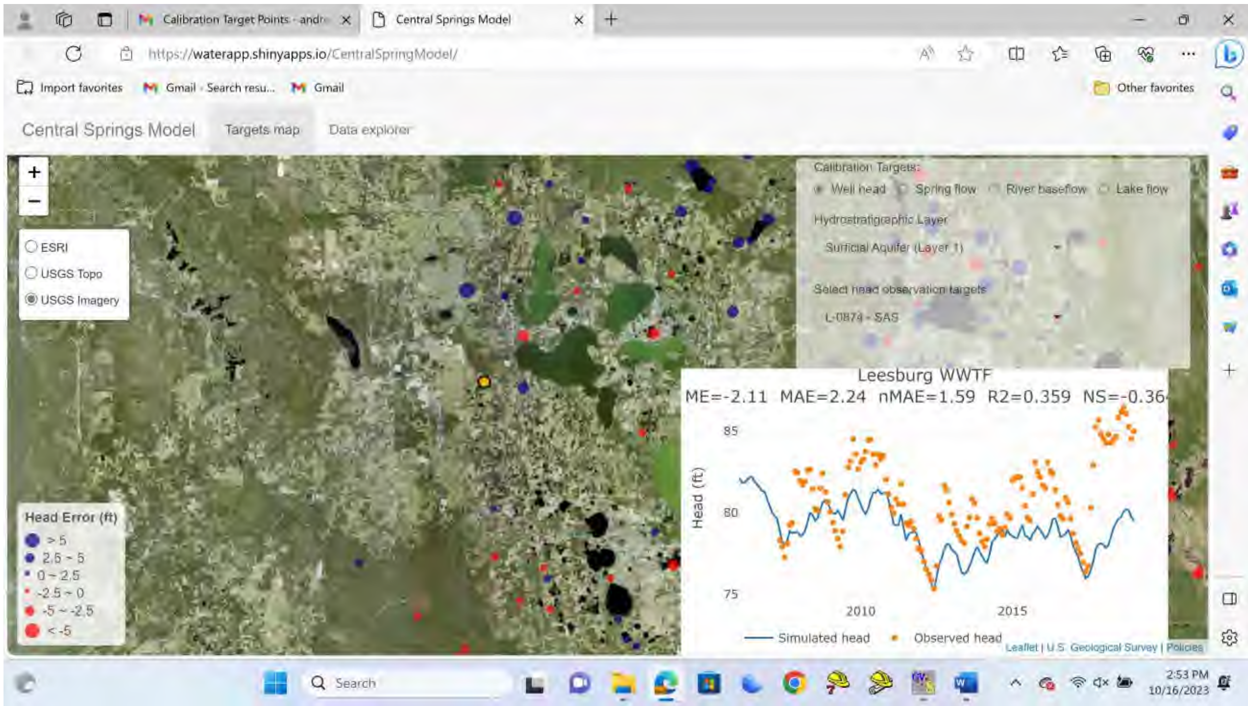
CSM MODEL: CALIBRATED CONTOURS LAYER 6 LOWER FLORIDAN AQUIFER

0 1 2 4

GRAPHIC SCALE: 1"=2 Miles

Andreyev Engineering, Inc.		CENTRAL SPRINGS MODEL CALIBRATION THE VILLAGES, FL
		CALIBRATED CONTOUR MAP
APPROXIMATE SCALE: 1"=2 Miles	DATE: 10/30/23 PN: APGW-23-120	ENGINEER: NA DRAWN BY: DLS	FIGURE 2

APPENDIX A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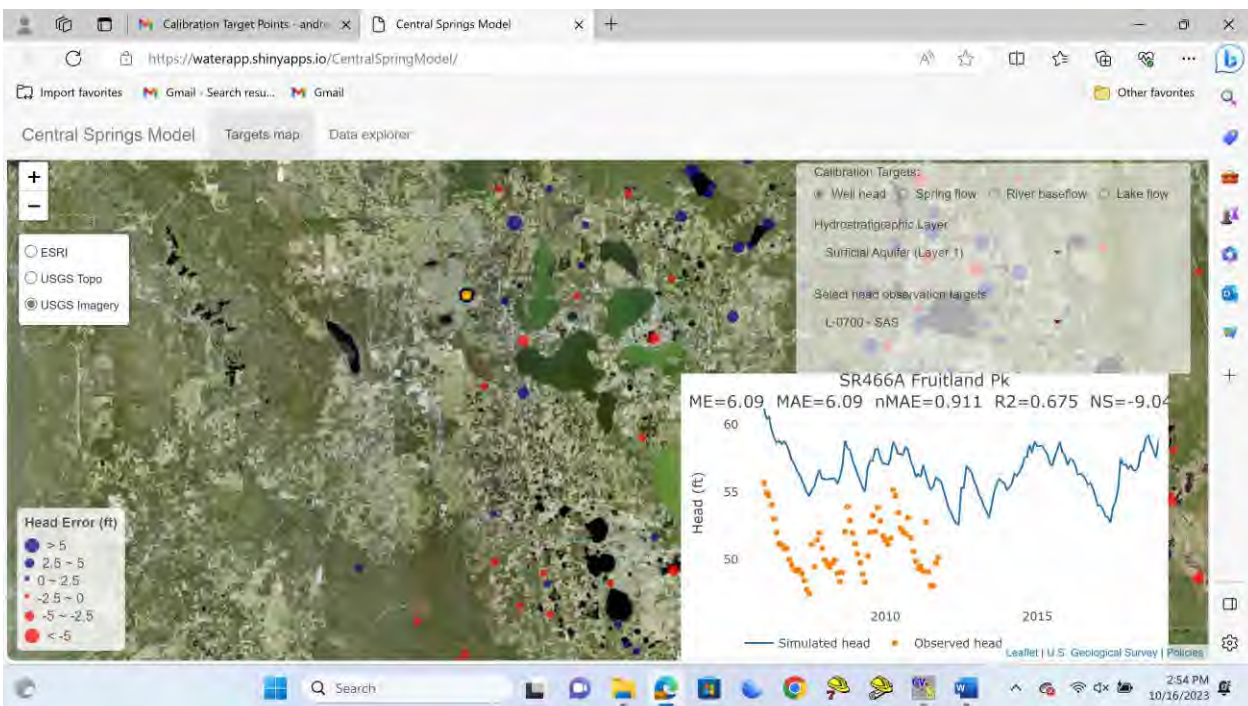
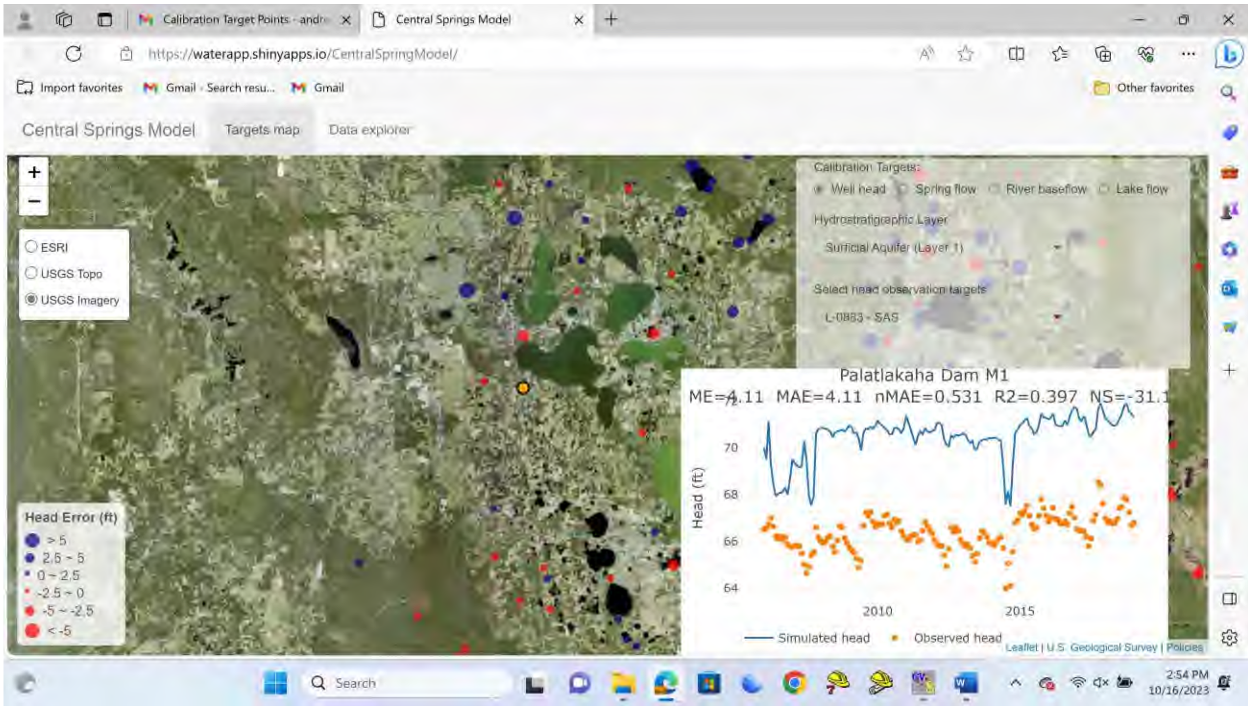
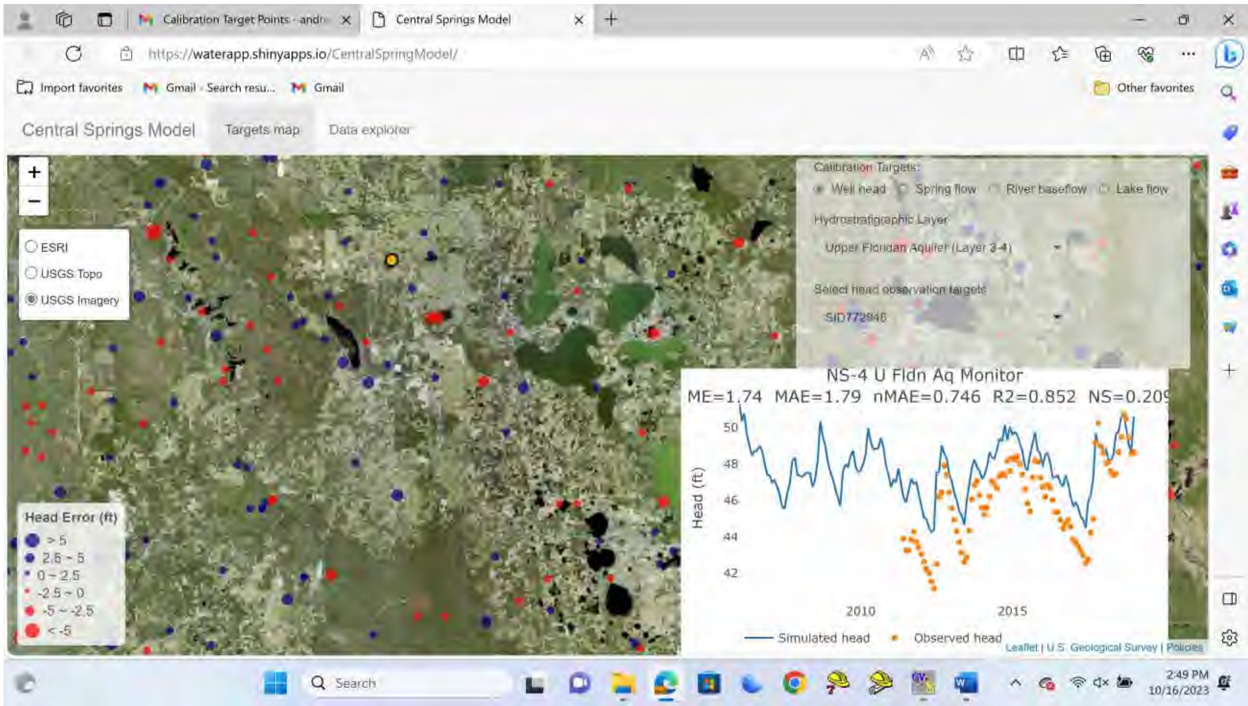
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
L-0874 - SAS
ESRI
USGS Topo
USGS Imagery
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leesburg WWTF
ME=-2.11 MAE=2.24 nMAE=1.59 R2=0.359 NS=-0.36
Head (ft)
85
80
75
2010
2015
Simulated head
Observed head


Central Springs Model
Targets map
Data explorer
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
L-0700 - SAS
ESRI
USGS Topo
USGS Imagery
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
SR466A Fruitland Pk
ME=6.09 MAE=6.09 nMAE=0.911 R2=0.675 NS=-9.04
Head (ft)
60
55
50
2010
2015
Simulated head
Observed head


Calibration Target Points - andr
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Surficial Aquifer (Layer 1)
Select head observation targets
L-0863 - SAS
Palatlakaha Dam M1
ME=4.11 MAE=4.11 nMAE=0.531 R2=0.397 NS=-31.1
Head (ft)
70
68
66
64
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
Search
2:54 PM
10/16/2023


Central Springs Model
Targets map
Data explorer
https://waterapp.shinyapps.io/CentralSpringModel/
ESRI
USGS Topo
USGS Imagery
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID772946
NS-4 U Fldn Aq Monitor
ME=1.74 MAE=1.79 nMAE=0.746 R2=0.852 NS=0.20
Head (ft)
50
48
46
44
42
2010
2015
Simulated head
Observed head
Leaflet | U.S. Geological Survey | Policies
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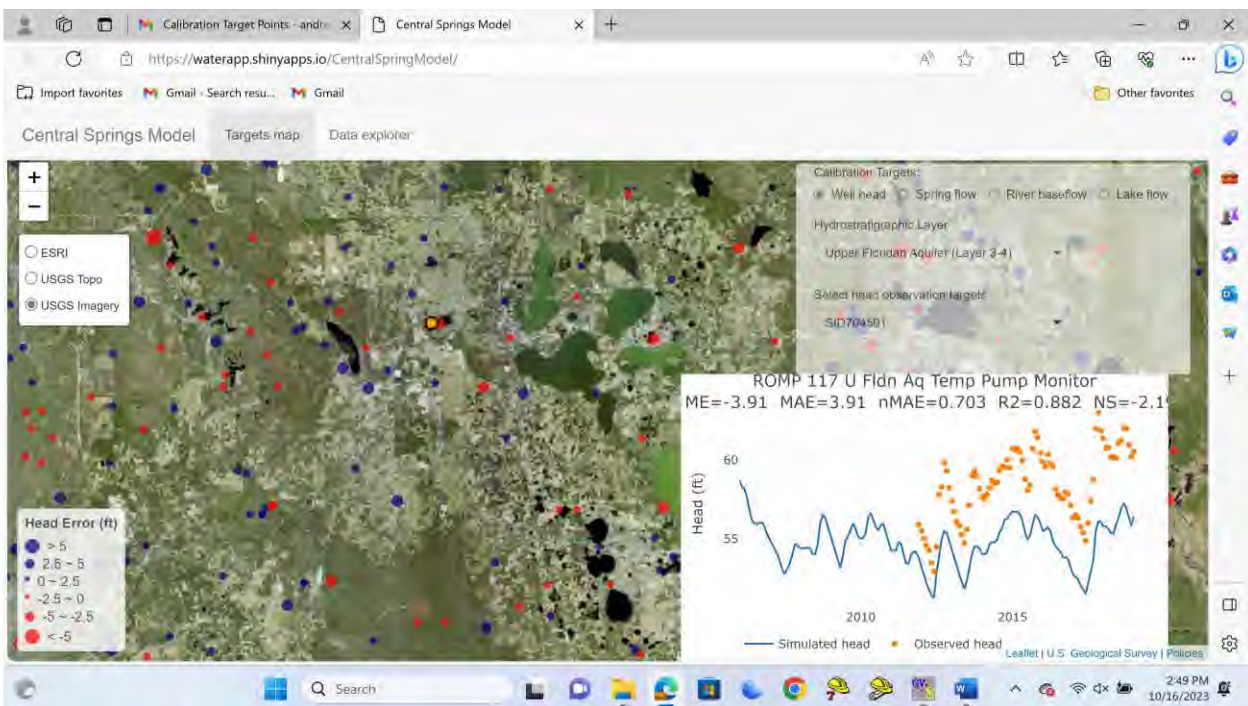
10/16/2023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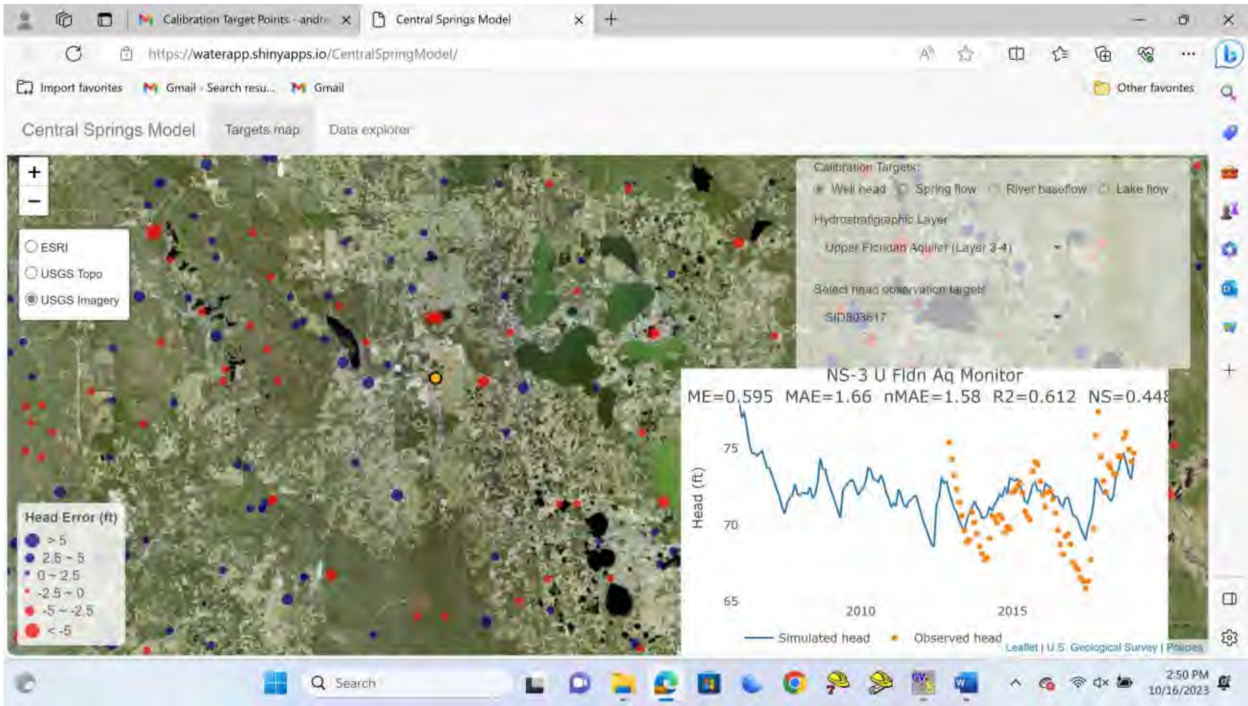
Targets map
Data explorer
https://waterapp.shinyapps.io/CentralSpringModel/
ESRI
USGS Topo
USGS Imagery
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID704501
ROMP 117 U Fldn Aq Temp Pump Monitor
ME=-3.91 MAE=3.91 nMAE=0.703 R2=0.882 NS=-2.1
Head (ft)
60
55
2010
2015
Simulated head
Observed head
Leaflet | U.S. Geological Survey | Policies
2:49 PM
10/16/2023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Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID803617
NS-3 U Fldn Aq Monitor
ME=0.595 MAE=1.66 nMAE=1.58 R2=0.612 NS=0.44
Head (ft)
75
70
65
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
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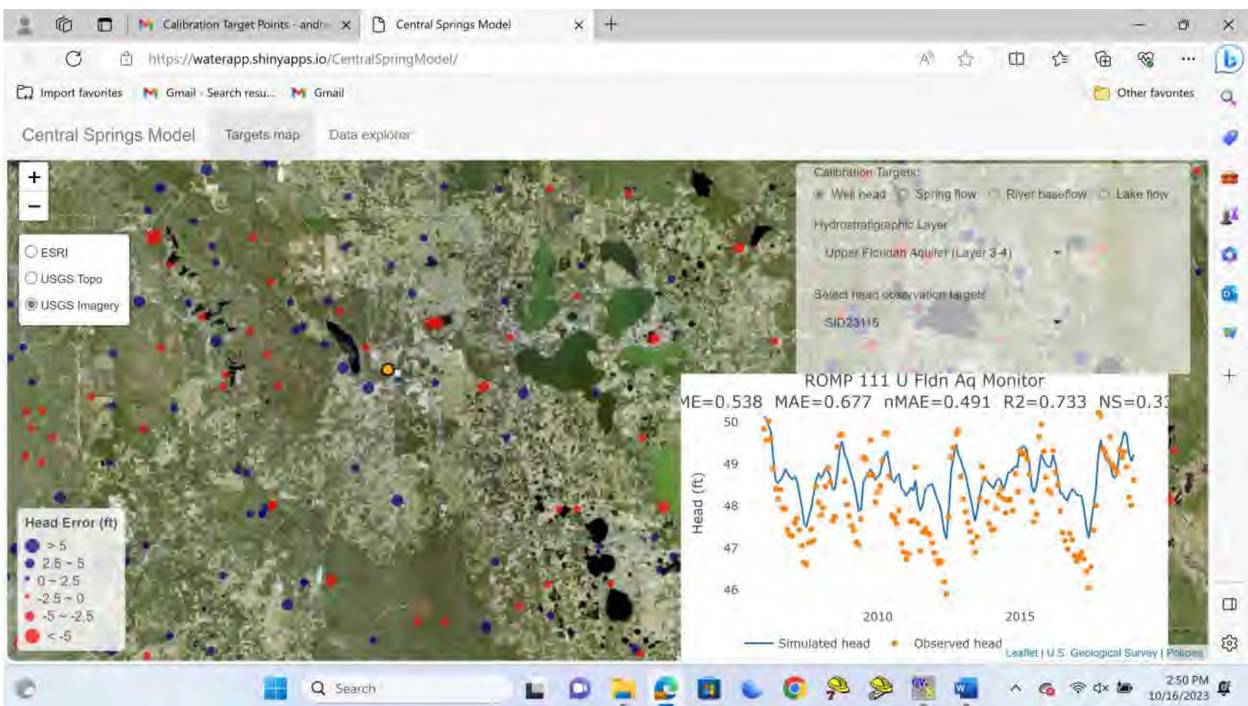
2:50 PM
10/16/2023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Central Springs Model
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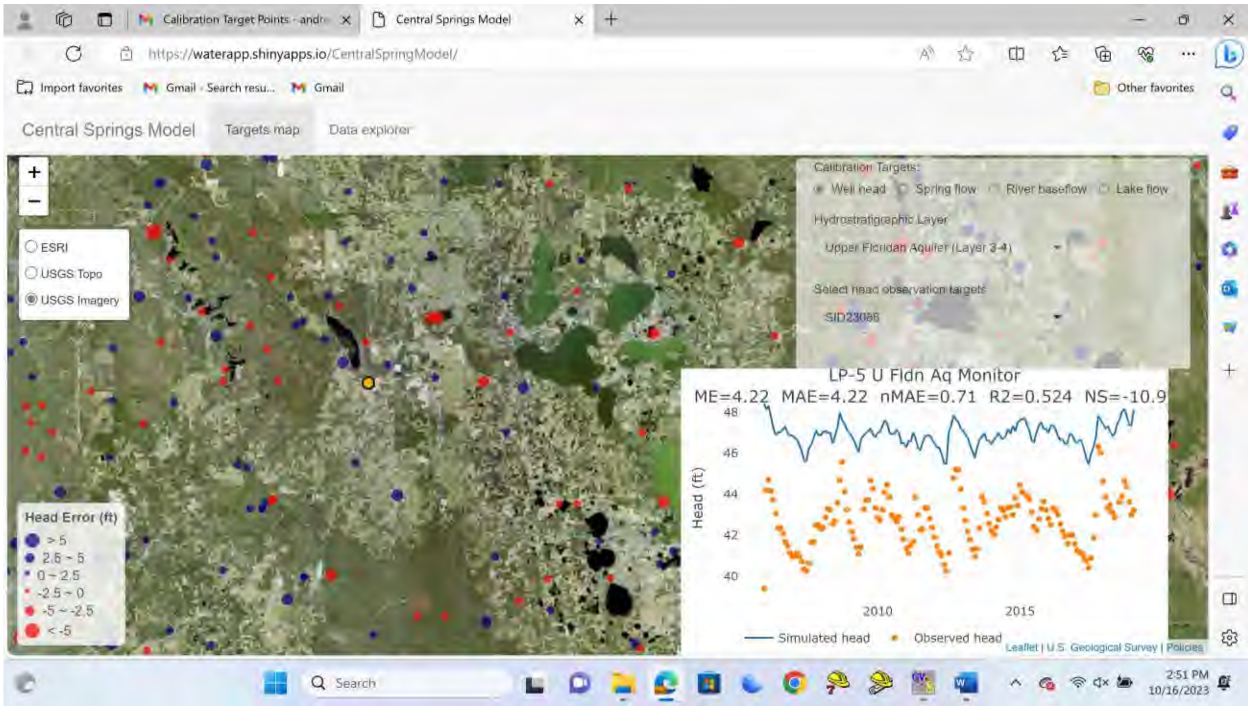
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID23115
ROMP 111 U Fldn Aq Monitor
ME=0.538 MAE=0.677 nMAE=0.491 R2=0.733 NS=0.3
Head (ft)
50
49
48
47
46
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
Search
2:50 PM
10/16/2023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USGS Topo
USGS Imagery
Calibration Targets:
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Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID23086
LP-5 U Fldn Aq Monitor
ME=4.22 MAE=4.22 nMAE=0.71 R2=0.524 NS=-10.9
Head (ft)
Simulated head
Observed head
Head Error (ft)
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0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
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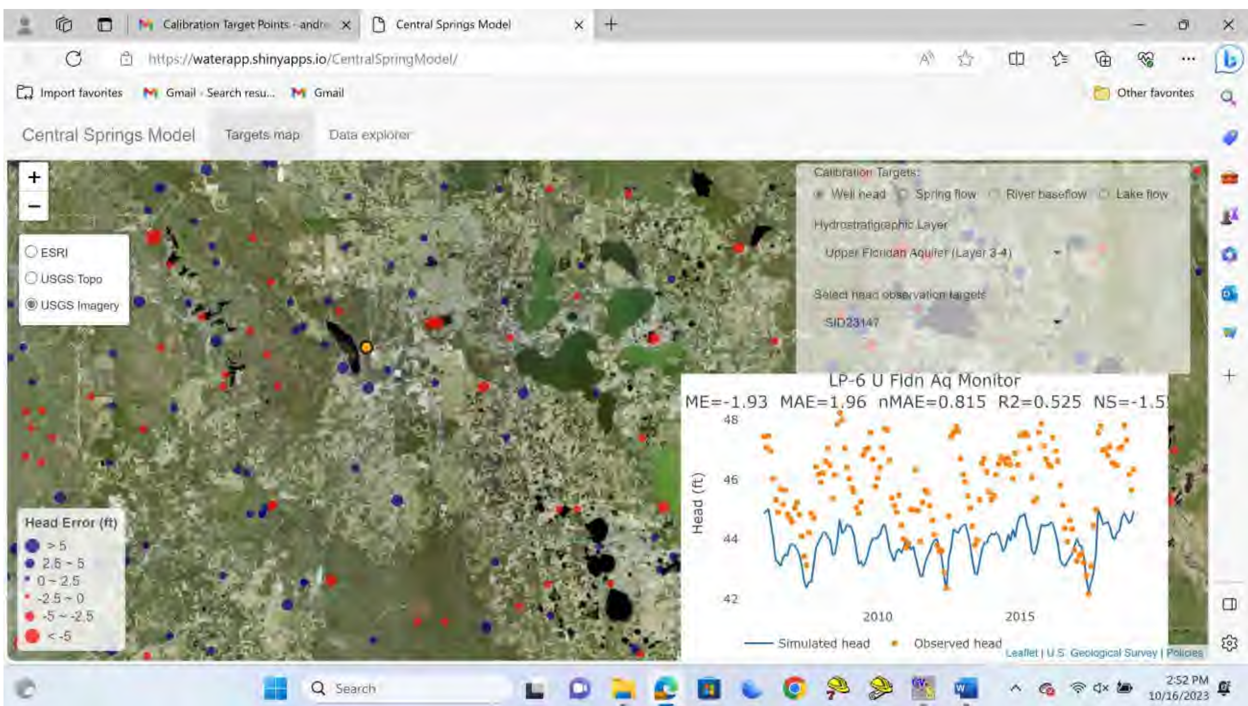
10/16/2023


Central Springs Model
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Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
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Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Upper Floridan Aquifer (Layer 3-4)
Select head observation targets
SID23147
LP-6 U Fldn Aq Monitor
ME=-1.93 MAE=1.96 nMAE=0.815 R2=0.525 NS=-1.5
Head (ft)
Simulated head
Observed head
Head Error (ft)
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-5 ~ -2.5
< -5
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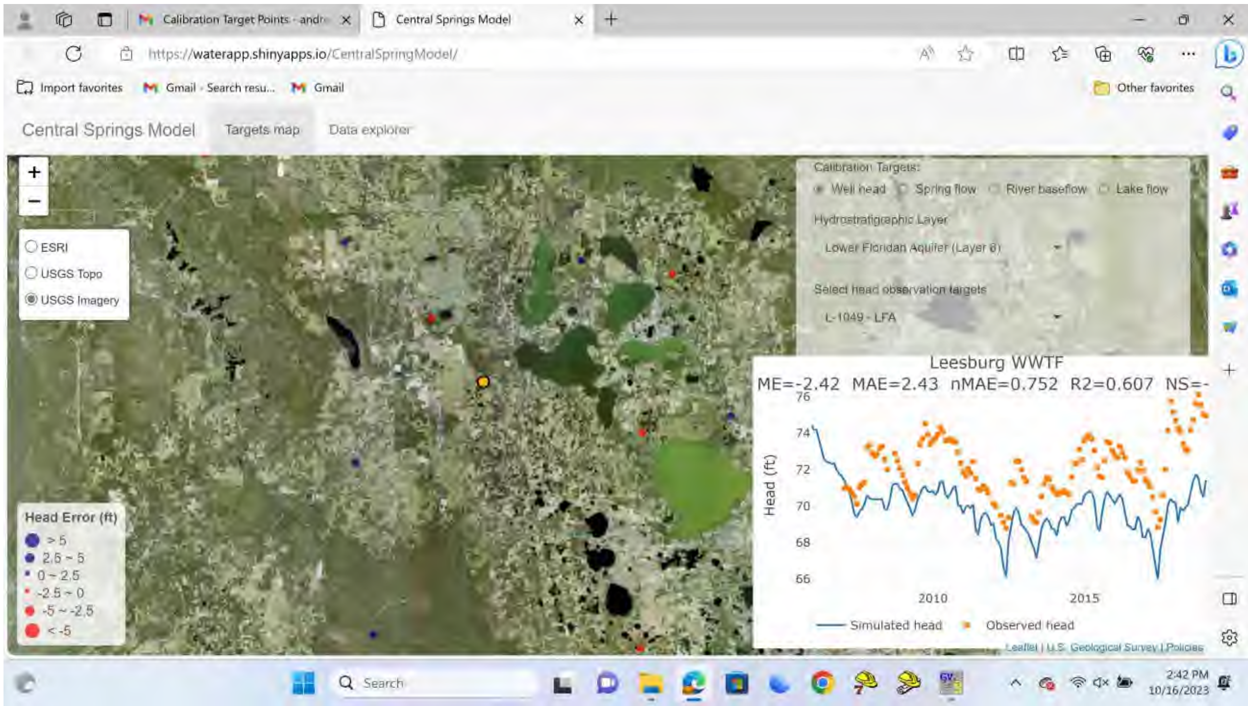
10/16/2023


Calibration Target Points - andr
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 8)
Select head observation targets
L-1049 - LFA
Leesburg WWTF
ME=-2.42 MAE=2.43 nMAE=0.752 R2=0.607 NS=-
Head (ft)
76
74
72
70
68
66
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
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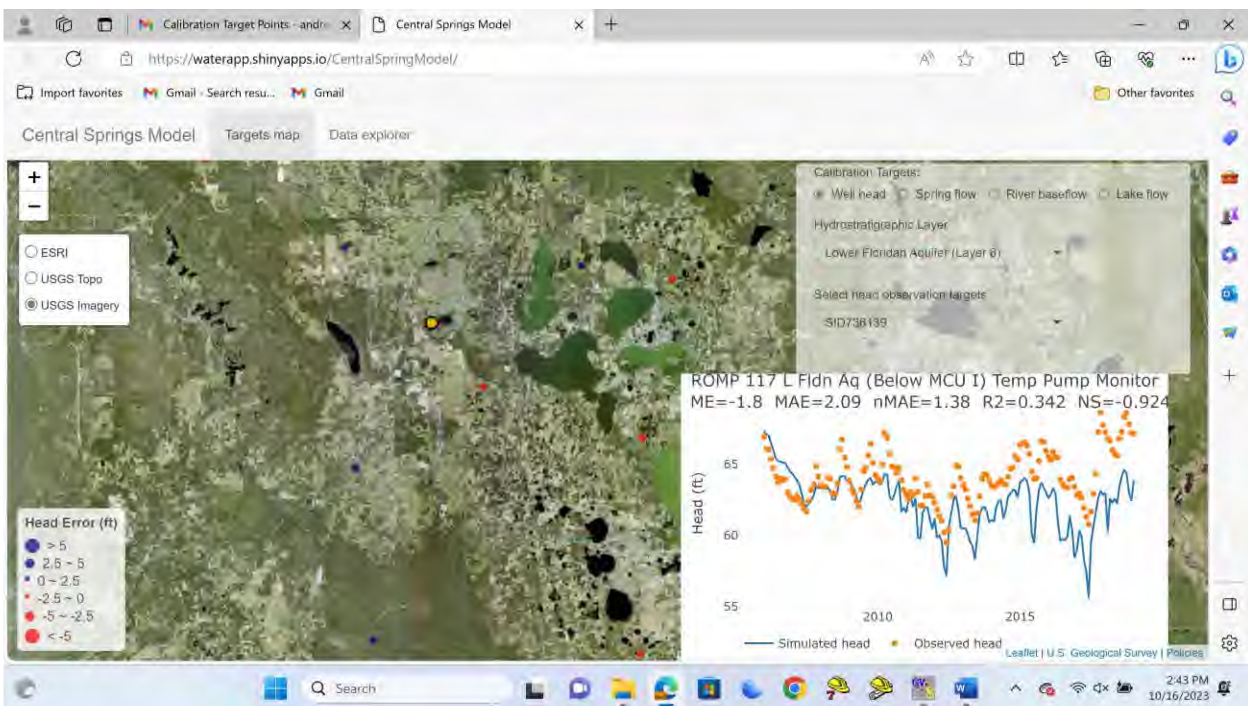
10/16/2023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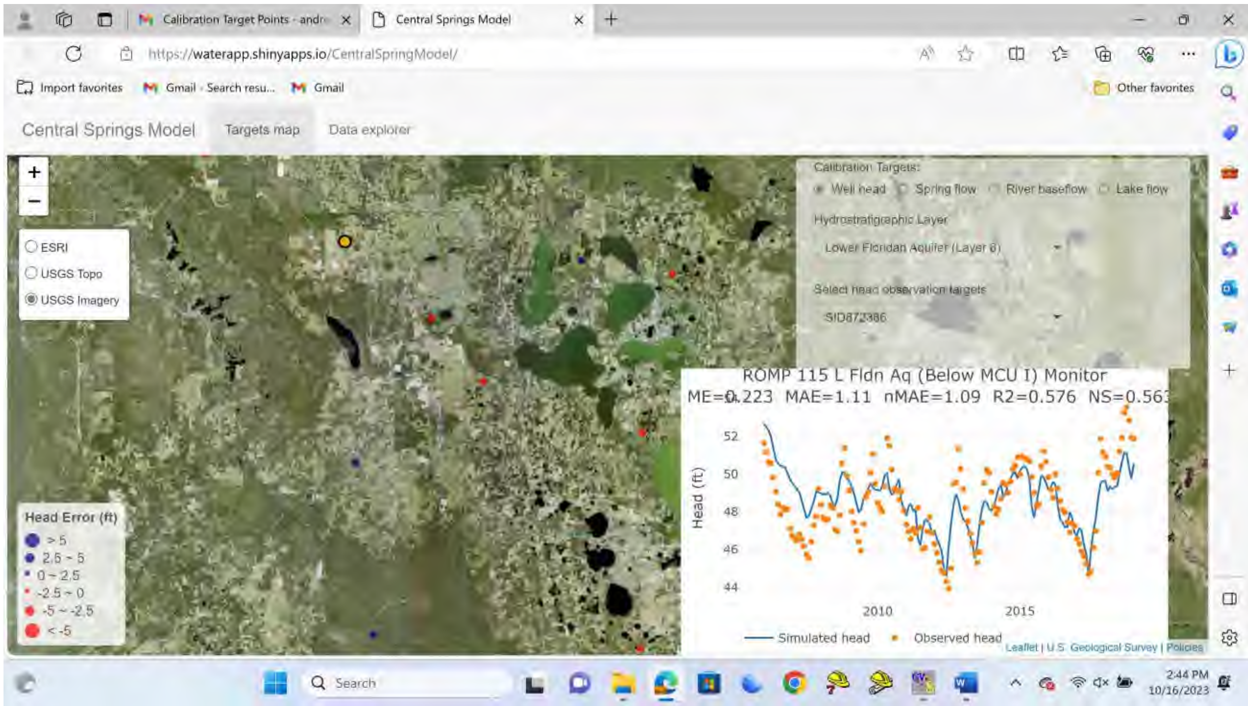
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 8)
Select head observation targets
SID738139
ROMP 117 L Fldn Aq (Below MCU I) Temp Pump Monitor
ME=-1.8 MAE=2.09 nMAE=1.38 R2=0.342 NS=-0.924
Head (ft)
65
60
55
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
Search
2:43 PM
10/16/2023


Calibration Target Points - andre
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
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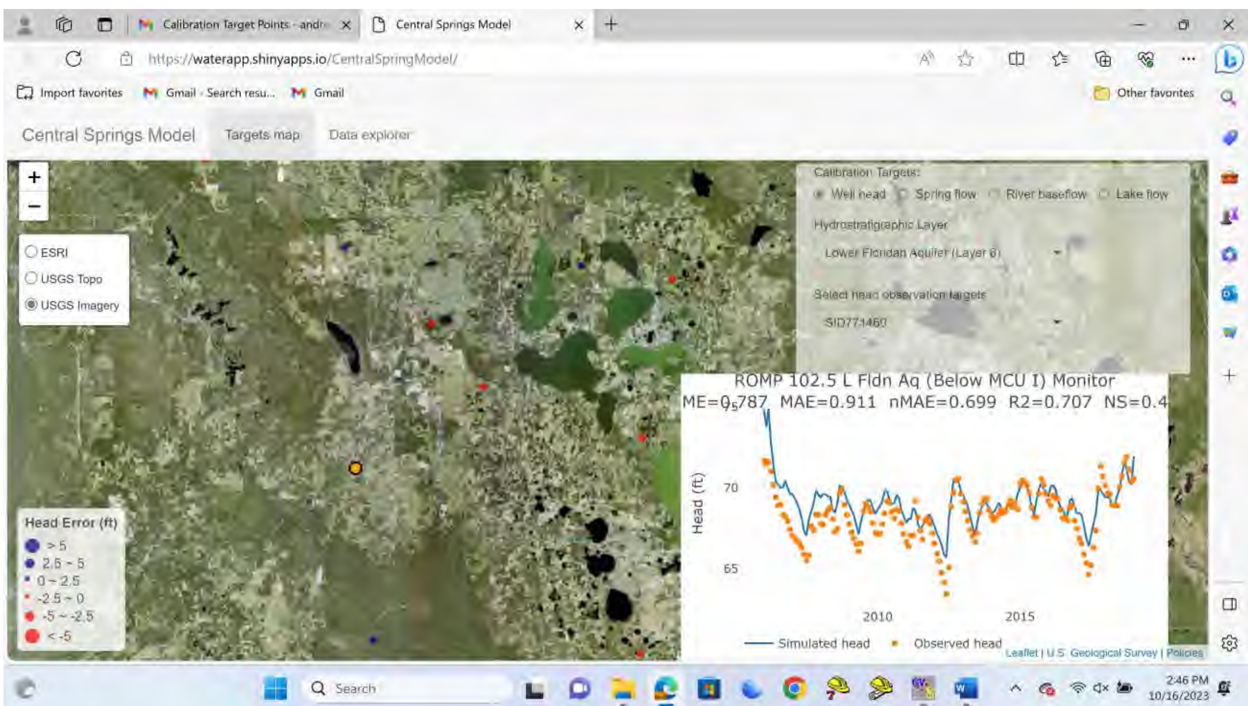
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
SID872386
ROMP 115 L Fldn Aq (Below MCU I) Monitor
MAE=1.11 nMAE=1.09 R2=0.576
Head (ft)
52
50
48
46
44
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
Search
2:44 PM
10/16/2023


Calibration Target Points - andre
Central Springs Model
https://waterapp.shinyapps.io/CentralSpringModel/
Import favorites
Gmail - Search resu...
Gmail
Other favorites
Central Springs Model
Targets map
Data explorer
ESRI
USGS Topo
USGS Imagery
Calibration Targets:
Well head
Spring flow
River baseflow
Lake flow
Hydrostratigraphic Layer
Lower Floridan Aquifer (Layer 6)
Select head observation targets
SID771460
ROMP 102.5 L Fldn Aq (Below MCU I) Monitor
MAE=0.911 nMAE=0.699 R2=0.707
Head (ft)
70
65
2010
2015
Simulated head
Observed head
Head Error (ft)
> 5
2.5 ~ 5
0 ~ 2.5
-2.5 ~ 0
-5 ~ -2.5
< -5
Leaflet | U.S. Geological Survey | Policies
Search
2:46 PM
10/16/2023