FINAL REPORT

Evaluation of Mirasol Springs Proposed Well Application

Prepared for:

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APRIL 2023

Executive Summary

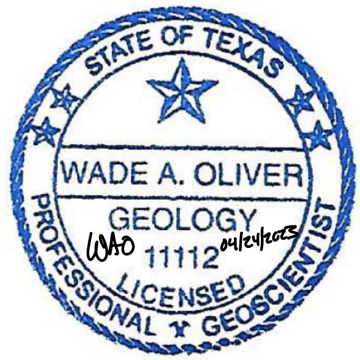
Clancy Utility Holdings, LLC has applied to produce groundwater for its Mirasol Springs development from Travis and Hays counties in portions of the Southwestern Travis County Groundwater Conservation District (SWTCGCD) and Hays Trinity GCD (HTGCD). INTERA has been asked by these Districts to evaluate the expected impacts of the proposed groundwater production on local water levels and springs. The proposed Mirasol Springs production wells may produce up to 28.3 acre-feet per year from Travis County (from one well) and 56.7 acre-feet per year from Hays County (from four wells), a total of 85 acre-feet per year. INTERA investigated the geology and hydrogeology of the area and developed a conceptual model of the study area based on the information provided by the Districts, the Bureau of Economic Geology (BEG), Tarver Geologic Services, and the groundwater availability model (GAM) for the Hill Country portion of the Trinity Aquifer. Based on this conceptual model, INTERA developed a three-dimensional groundwater model to evaluate the potential impacts of the development. The model simulates steady-state flow in the Cow Creek Limestone and Hensell Sand as well as flow from local springs and seeps along the Pedernales River.

INTERA performed model runs assuming average rainfall conditions and runs assuming drought conditions. The springflow and water level impacts of the proposed Mirasol wells were assessed in all rainfall scenarios. During average rainfall conditions, the model indicates a maximum of 3.5 feet of additional drawdown as a result of the proposed pumping. This corresponds to a 3% reduction in flow from springs and seeps along the Pedernales River, a 3% flow reduction at Hamilton Springs and an 8% flow reduction at Roy Creek. When there is no applied recharge, the model indicates a maximum of 7.4 feet of additional drawdown as a result of the proposed pumping. This corresponds to an 8% reduction in flow from springs and seeps along the Pedernales River. Hamilton Springs does not have any baseline flow until recharge reaches at least 40% of average conditions.

Generally, impacts to springsheds are comparable for the cases between 20% and 80% of average recharge. When recharge is reduced from 20% to 0%, baseline flow at Roy Creek is greatly reduced (~80% reduction), causing volumetric impacts of pumping to increase at other springsheds and seeps. When recharge is increased from 80% to 100%, a greater proportion of Mirasol pumping is sourced from the “Other Springs/Seeps” category, representing ephemeral springs which are active during periods of increased rainfall. Impacts to water levels due to Mirasol pumping increase as recharge decreases at all proposed well sites.

PROFESSIONAL GEOSCIENTIST SEAL

The work presented here was overseen by Wade Oliver, a licensed Professional Geoscientist in the State of Texas (#11112).



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Wade A. Oliver, Licensed Professional Geoscientist (TX #11112)

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Acronyms and Abbreviations

afy	acre-feet per year
fasl	feet above sea level
ft	foot/feet
INTERA	INTERA Incorporated
µg/L	micrograms per liter

1.0 STUDY AREA

The study area focuses on the proposed Mirasol Springs development in northern Hays County and western Travis County (**Figure 1**) and the immediate surrounding area. The development is set on a 1,401-acre property, 169 acres in Travis County and 1,232 in Hays County. Here, the Upper, Middle, and Lower Trinity aquifers outcrop close to the Pedernales River, which bounds the development on the northwest side. There are many springs in the area which flow into tributaries, a majority of which are sourced by the Middle Trinity Aquifer.

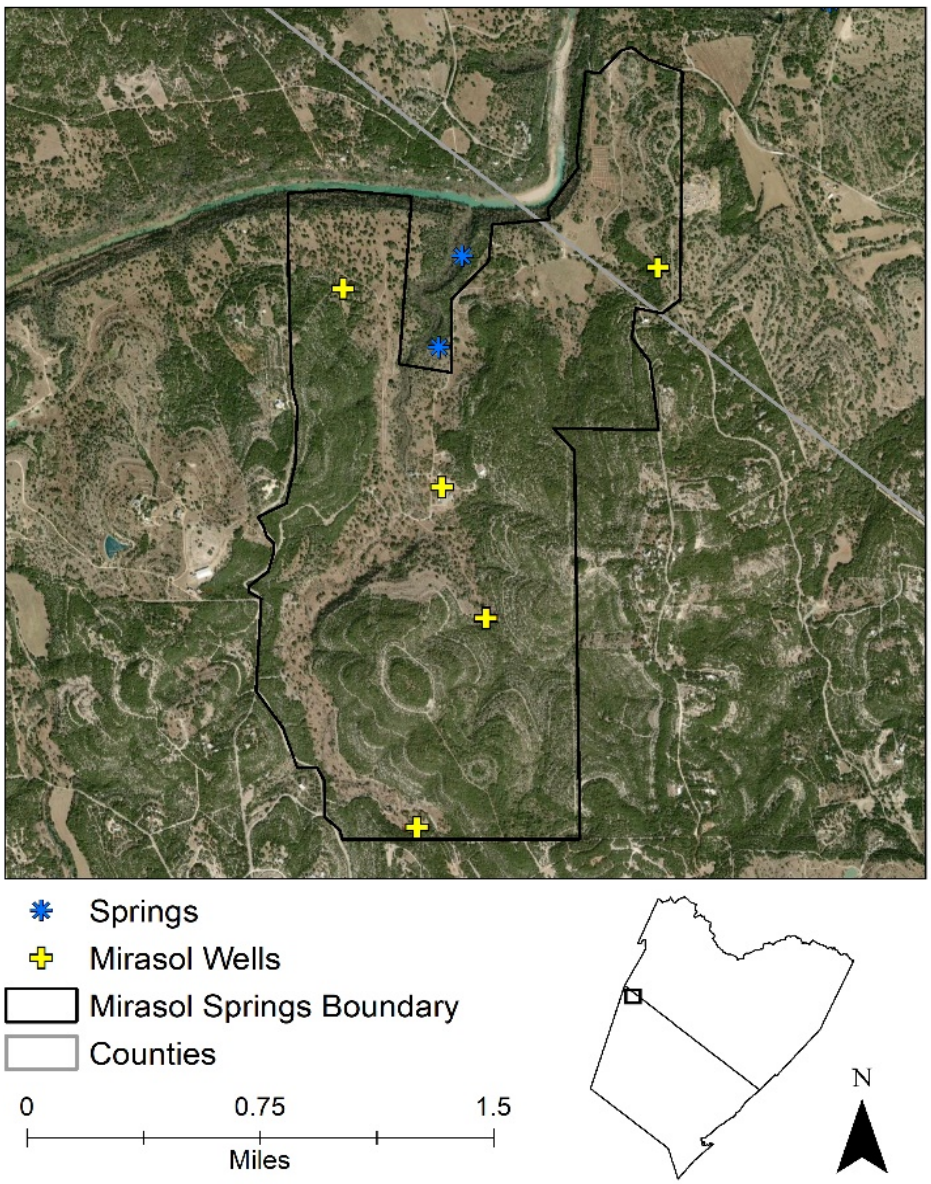

Figure 1. Study Area focusing on Mirasol Springs Development.

1.1 GEOLOGY

The rocks that comprise the Trinity Aquifer in this area were deposited during the early to middle Cretaceous and lie atop older Paleozoic units (**Figure 2**). Units in the study area dip to the east, consistent with the regional eastward to northeastward dip of the Trinity (Toll et al., 2018; Hunt et al., 2020). The landscape in the study area is incised by the Pedernales River and smaller tributaries. Units of the Upper and Middle Trinity can be seen in creek-bed exposures and hillsides. Karst features, solutioned fractures and bedding planes are prevalent within the valleys and are often associated with springs and seeps.

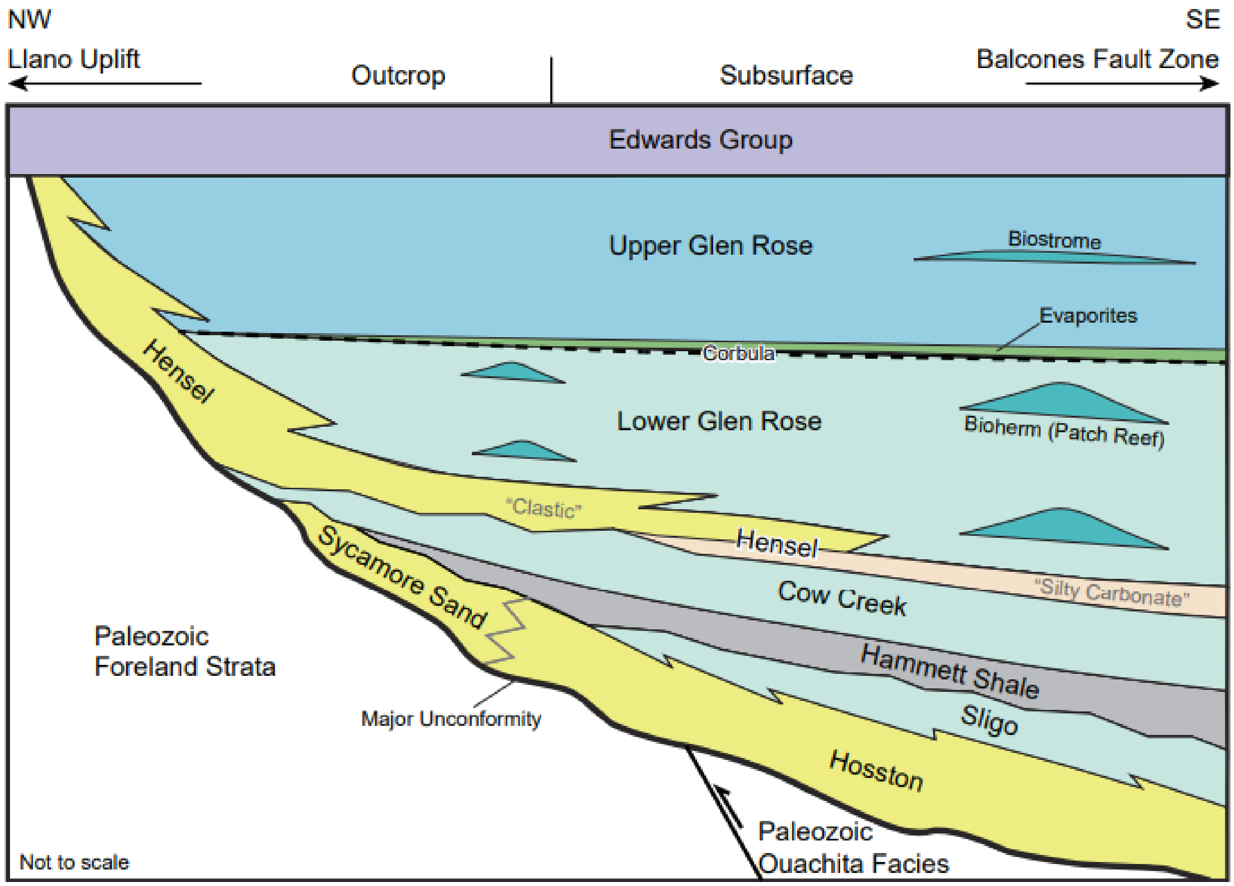

Figure 2. Regional stratigraphy (Hunt, et al. 2020)

The Lower Trinity in our study area unconformably overlies the Pre-Cretaceous units, starting with the Sycamore Sand (Toll et al., 2018). The Sycamore (known as the Hosston Formation in the subsurface) is a well-cemented conglomerate which thickens to the east from about 100 to 200 feet in the study area (Hunt et al., 2020). The Sycamore is directly overlain by the Hammett Shale. The Hammett Shale is a mixture of silt, clay, and carbonates which shares a transitional boundary with the overlying Cow Creek. It is a well-known aquitard in the region and serves as a vertical barrier to flow in our model area.

The Middle Trinity Aquifer in our study area begins with the Cow Creek Limestone at its base. It is the lowermost water-bearing unit and the only fully saturated layer in our model area (**Figure 3**). The Cow Creek Formation is a generally fine-grained silty dolomite at its base that transitions into calcarenite and coquinite at the top (Toll et al., 2018; Hunt et al., 2020). The Cow Creek is karstic and contains high secondary porosity and permeability. This unit is unconformably overlain by the Hensell Sand, a mixture of sand, silt, clay, and conglomerate which is mostly friable except where it is calcareous (Stoeser et al., 2005). In our model area, it is an intermittently saturated unit when recharge is available. The Lower Glen Rose overlies the Hensell, and in this region is a karstic limestone with high secondary porosity.

The Upper Glen Rose Limestone comprises the Upper Trinity Aquifer. The unit is a low-permeability, calcareous limestone which is known to impede recharge to the underlying units (Hunt, 2022). It is exposed at the surface in the upper watersheds of the study area and is the uppermost stratigraphic unit present.

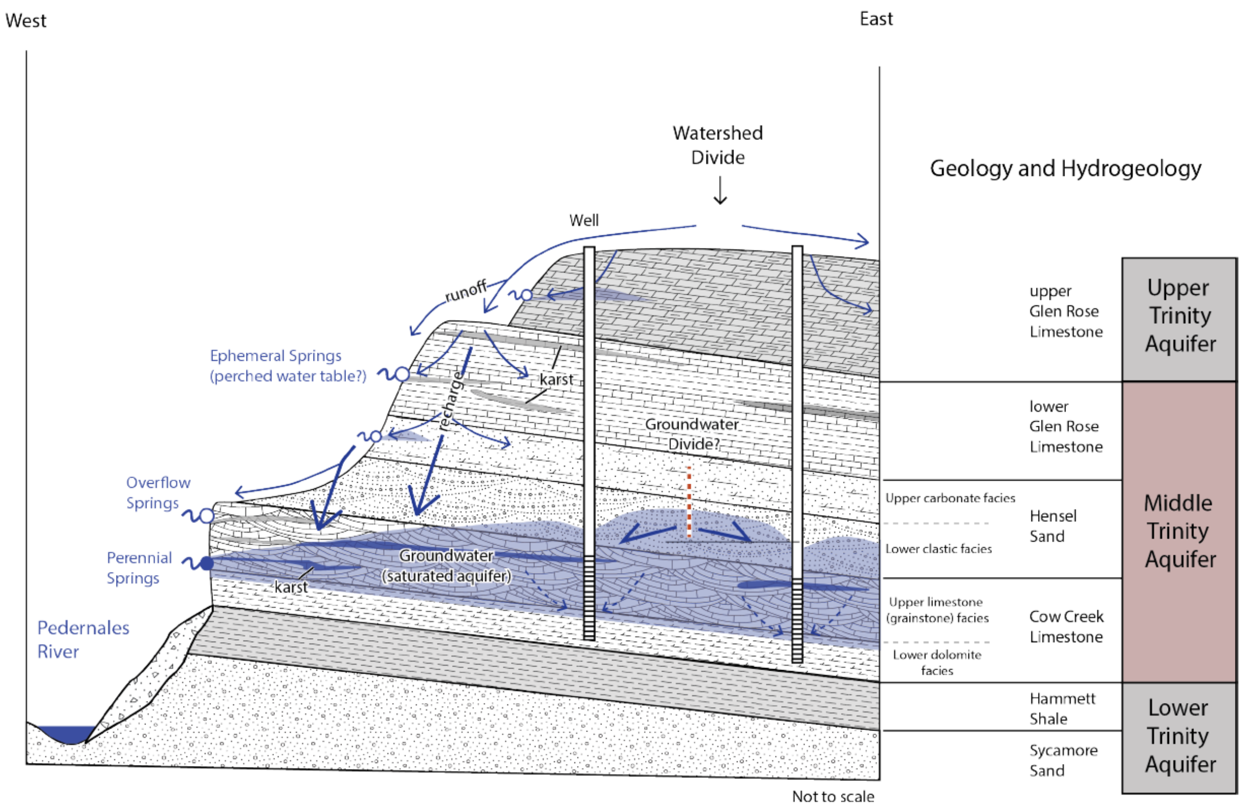

Figure 3. Conceptual hydrogeologic framework (Hunt, 2022)

1.2 HYDROGEOLOGY

Though the Middle Trinity Aquifer demonstrates a northeastward regional head gradient, the geologic framework in our study area is such that local surface watersheds generate localized northwestward head gradients that feed springs and seeps along the Pedernales River and its tributaries (Hunt, 2022). The primary recharge area for these springs are the respective watersheds where the Middle Trinity outcrops beneath the Upper Glen Rose Limestone (**Figure 4**). Groundwater divides are likely spatially dynamic, meaning they could shift in response to pumping and recharge rates. Ephemeral springs and perched water tables are noted in this region given the geology of the Glen Rose Units. Data from Hunt (2022) provided to INTERA included streamflow measurements that correspond to various springs in the study area. Hamilton Pool, Roy Springs, and Pogue Springs are included in the model area, though Hamilton Pool is the only location that has a complete year of corresponding data (**Figure 5**). INTERA does not have flow measurements from seeps along the Pedernales river although it is assumed that seeps exist along the length of river in the study area where the Upper and Middle Trinity outcrop.

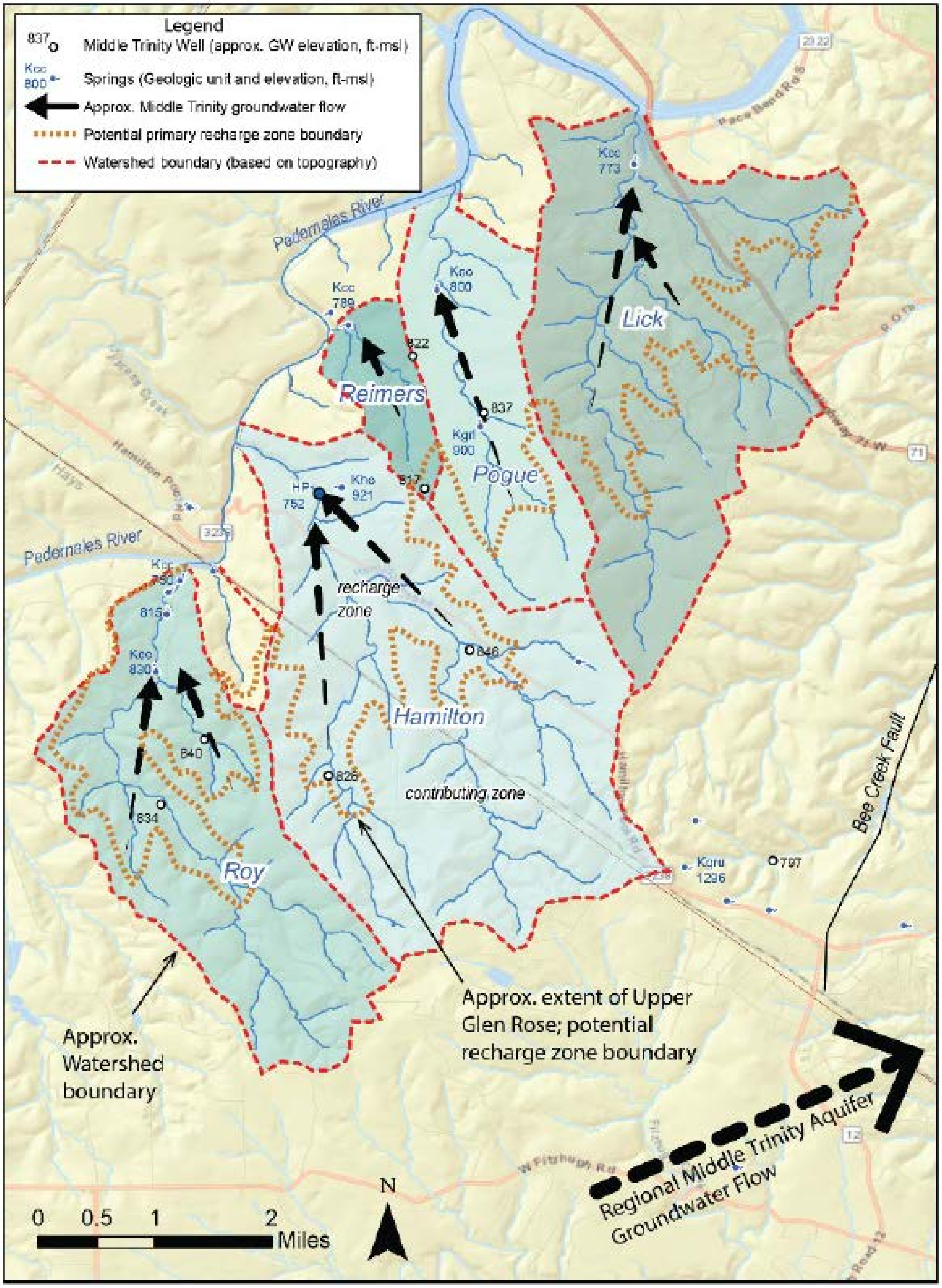

Figure 4. Conceptual Model of Watershed boundaries from (Hunt, 2022)

1.3 RAINFALL

According to the PRISM (2022) 30-year normalized rainfall measurements, this region experiences an average of approximately 28-30 inches of rain per year. The BEG measured a total of 29.91 inches of rain during their one-year measurement period (April 2021 – April 2022). According to U.S. Drought Monitor, this area experienced moderate-to-severe drought conditions from January 2022 until the end of the collection period. The BEG collected and tabulated a year of rainfall data from various locations across their study area and provided this data in Microsoft Excel format used in Hunt (2022). **Figure 5** details the rainfall data overlain with the various spring flow measurements in the study area. Though nearly average rainfall was observed through a 12-month period, it fell mostly in the first half of the collection period. Note that regional springflow trends change with precipitation, as the months with higher total rainfall show elevated spring flow measurements when compared with the months in drought conditions, which have generally lower spring flow. This data is consistent with the conceptual model for a mostly rainfall-dependent system of springs in this region.

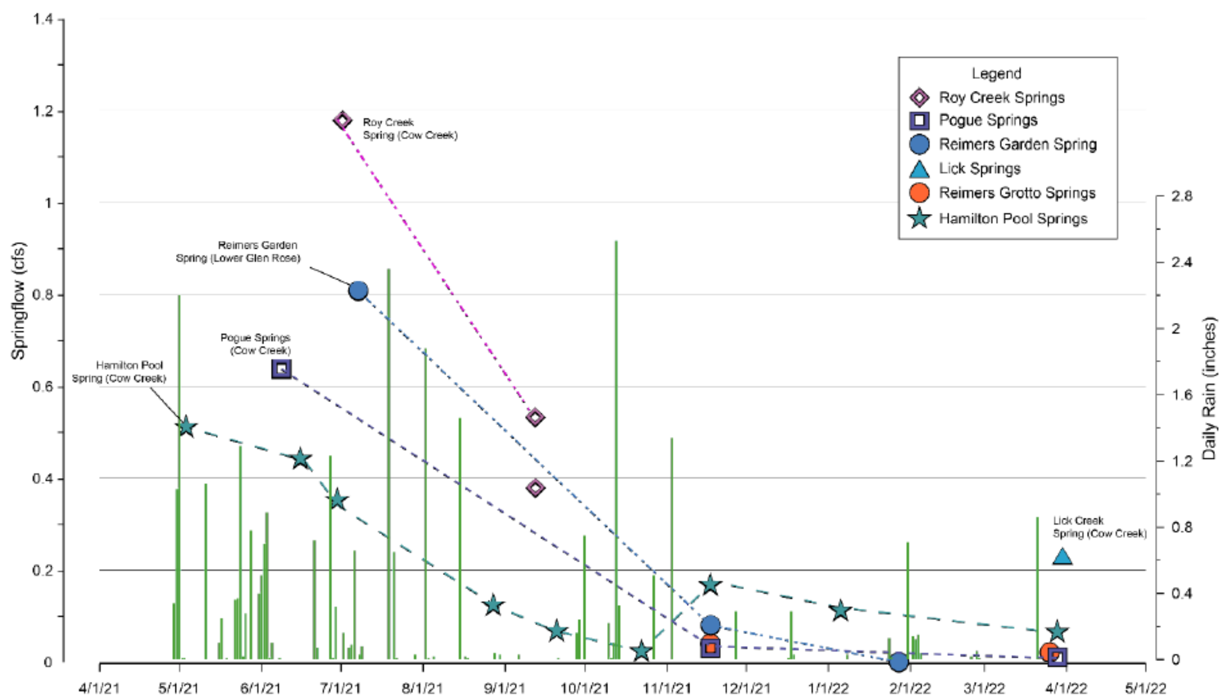

Figure 5. **BEG figure detailing rainfall data overlain with spring flow measurements in the study area.**

2.0 MODEL DESIGN

Designing a model involves determining the optimal way to match the characteristics of the conceptual model to the framework of the numerical model. This includes determination of model layering, structure, boundary conditions, temporal and spatial discretization, and other elements to represent the key components of the aquifer system. The aim is to develop a tool which can be used to generate a more well-informed answer to a given question.

This model is the synthesis of several datasets which provide us with an understanding of the hydrogeology in this region. It is designed and optimized to estimate the impact of the proposed Mirasol Springs production wells on springs and water levels in the Middle Trinity Aquifer. The accuracy of the results depends on the accuracy of the empirical data, as well as on the strength of the assumptions made about the gaps in the data. INTERA's goal was to develop a model that was simple enough to be developed timely and cost-effectively while still being an appropriate tool to evaluate the potential impacts. We believe this model produces realistic results consistent with the conceptual model.

2.1 NUMERICAL CODE AND PROCESSOR

For this project, INTERA used MODFLOW 6 developed by USGS (Langevin et al., 2017). This is the newest edition of the MODFLOW family of groundwater modeling codes that have been used by hydrogeologists for almost 40 years. We utilized a Python-based program called FloPy (Bakker et al., 2016) to build, run, and perform post-processing for the MODFLOW input and output files.

2.2 LAYERS AND MODEL GRID

The model uses a structured, finite difference grid bounded on the northwest by the Pedernales River (**Figure 6**). The model extends approximately 3.5 miles south from the river and 3 miles to the east, forming a square grid with individual cells that are 1/8th of a mile on each side. Each layer consists of 48 rows and 48 columns, totaling 2,304 model cells. The model's lateral extents are six miles by six miles and align with a selection of 1 square mile grid cells from the Trinity Hill Country GAM that encompasses the Mirasol Springs development (Jones et al., 2011). INTERA's model grid is a spatial refinement of these grid cells, though our layering structure is unique. The only structural data from the GAM used in the INTERA model grid are the bottom elevations of the Middle Trinity. INTERA extracted this data from the GAM and interpolated from the GAM cell centers to generate a smooth bottom-elevation surface across the model grid (**Figure 7**).

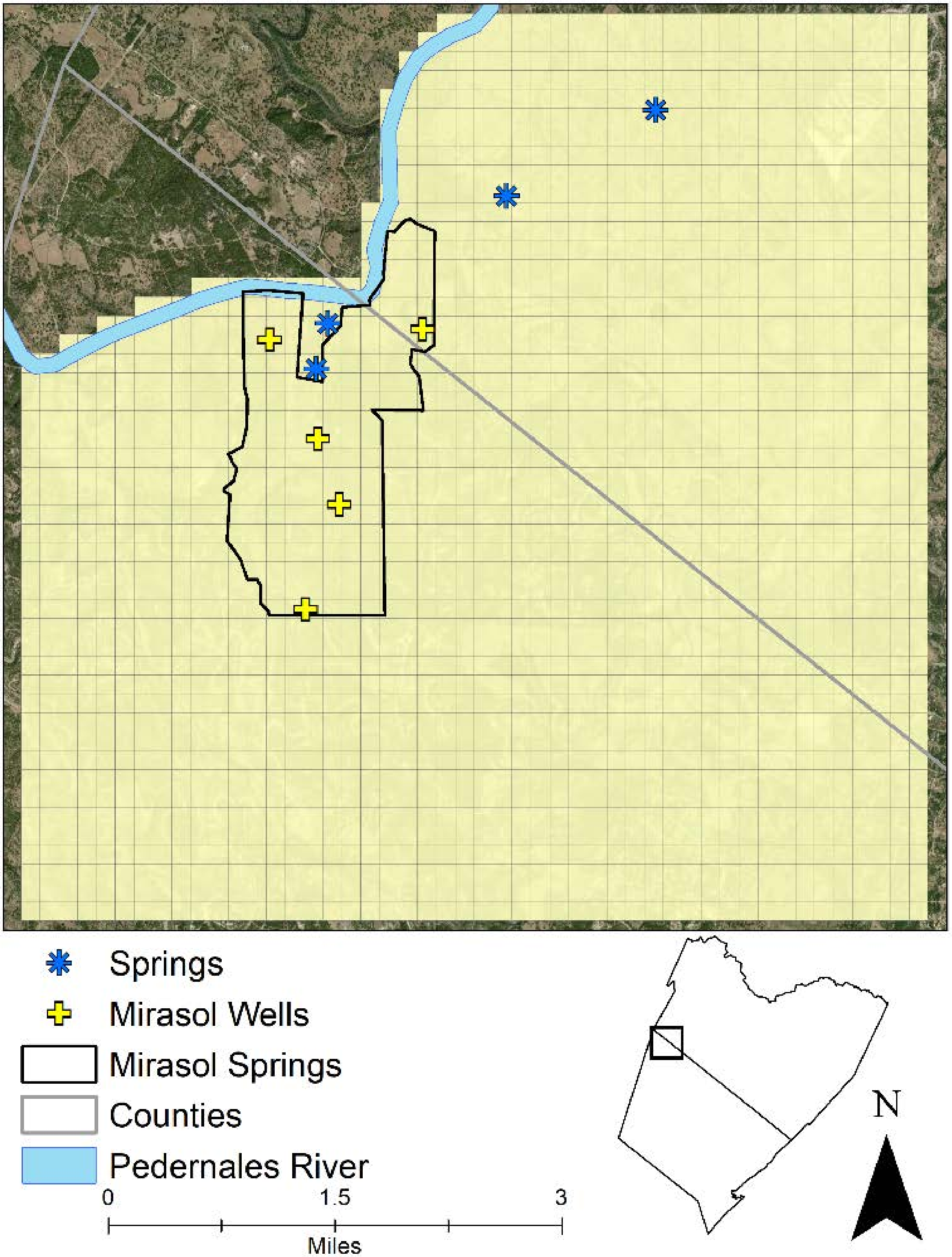

Figure 6. Active cells in the model grid.

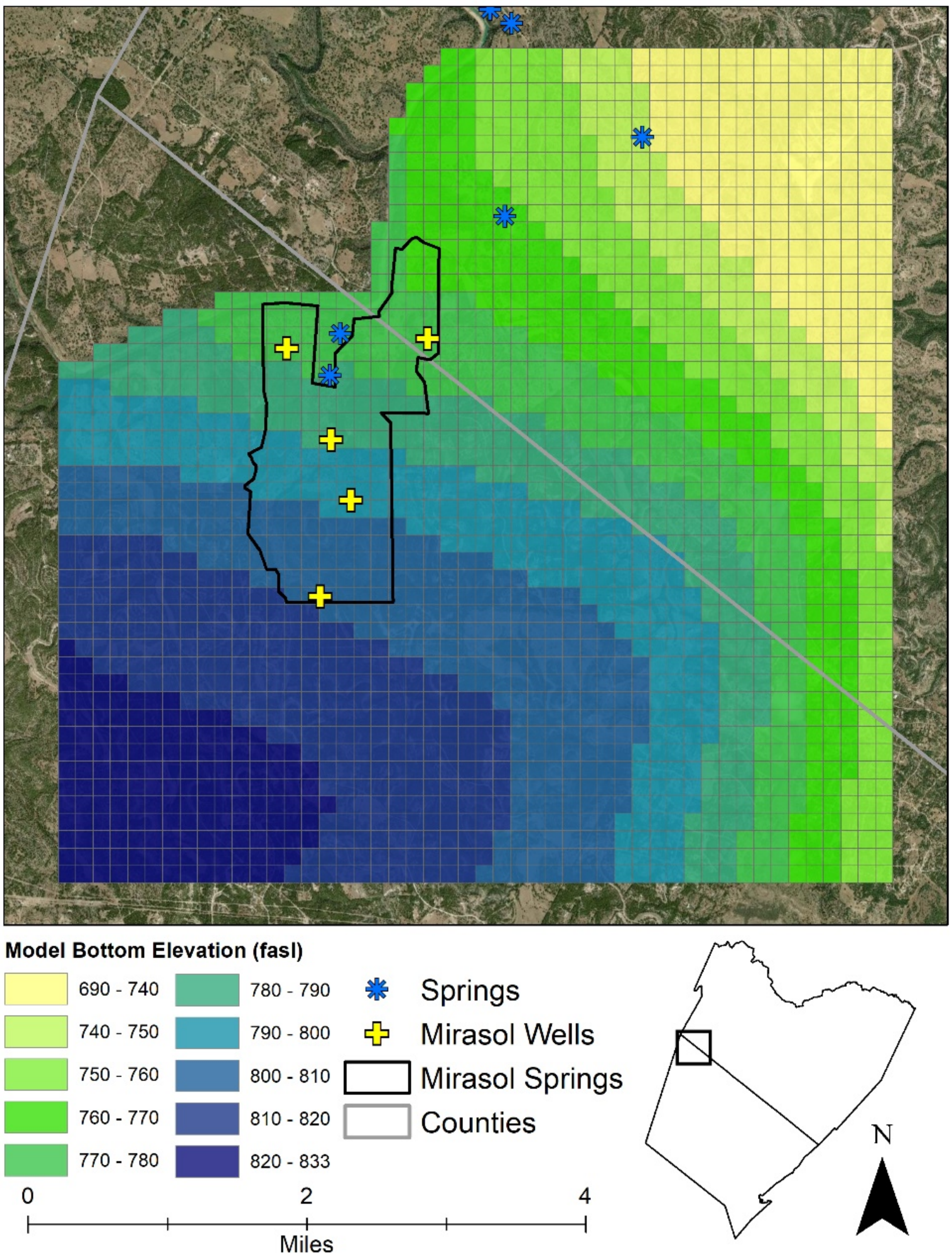

Figure 7. Model bottom elevations in feet above sea level.

The model is comprised of two layers, the thicknesses of which were informed by geologic logs collected by Tarver Geologic Services, LLC and submitted with Clancy Utility's permit application. The top layer (Layer 1) is 30 feet thick and represents the Hensell Sand. The bottom layer (Layer 2) is 100 feet thick and represents the Cow Creek Limestone. Layer thickness is constant throughout the model area. The bottom of the model is conceptually defined by the Hammett Shale, an aquitard that separates the Middle and Lower Trinity Aquifers. It serves as a vertical no-flow boundary for the base of the model. The Upper and Lower Glen Rose units are not simulated in the model, mainly because they are generally unsaturated within the model area (Hunt, 2022) and function either as a contributing area for runoff (Upper Glen Rose) or as vertical pass-through layer (Lower Glen Rose) to the underlying Hensell Sand and Cow Creek Limestone. USGS collects high-resolution land surface elevation data which can be used to create digital elevation models (DEMs). The Trinity Hill Country GAM (Jones et al., 2011) utilizes a DEM which INTERA used as a guiding tool for assigning drain elevations (discussed in Section 3.7) and establishing aquifer thicknesses.

2.3 STEADY-STATE APPROACH

Numerical models may simulate either transient or steady-state flow. In steady-state flow models, a single time step is provided to allow the model to fully equilibrate. A transient flow system, conversely, can be simulated over a finite series of time steps to represent a dynamic flow system with input variables that change through time. Transient systems are not meant to reach a static equilibrium. Models which utilize this type of system will ideally have a strong record of observed data against which the model may be calibrated.

INTERA has chosen a steady-state simulation to represent the flow system in the model. Due to the lack of long-term (greater than one year) springflow and rainfall data and sparse water level records in the area, it is difficult to justify changing input variables to capture volumetric stresses through time. It is also difficult to confidently establish a record of transient-state calibration targets given the short data record. Given data availability and the scope of this assessment, simulation and calibration to steady-state flow conditions is most appropriate. This method is supported by the karstic nature of the units in the area, which lends to a faster equilibration than a system dominated by units with less conductive aquifers.

2.4 MODEL PARAMETERS

Hydraulic conductivity was estimated using pump test data provided by Tarver Geologic Services, LLC and submitted with Clancy Utility's permit applications. The conductivity values for the pumping wells under review ranged from 5 feet/day to 35 feet/day. Storativity values ranged from 4.0E-4 to 0.04, though this value is not used in steady-state modeling. Constant values for hydraulic conductivity were set per layer. Model parameters were calibrated within the ranges of observed values and can be found in **Table 2**. Model calibration is discussed further in Section 3.9.

2.5 MODEL BOUNDARIES

MODFLOW models do not assume an infinite aquifer extent and require that spatial limits be defined for vertical and horizontal flow. The MODFLOW Discretization file is used to define cell dimensions and their designations as either Active (able to store, gain, and lose volume) or Inactive (not considered in flow calculations). We have designated certain cells on the model's lateral limits as General Head Boundaries (GHBs). These cells have a dynamic head value at the model's outer boundary and allow water to follow into or out of the model depending on the water level. In the model, GHBs are set along the outer boundaries of Layer 2 in all cells which are not adjacent to a drain or an inactive cell (**Figure 8**).

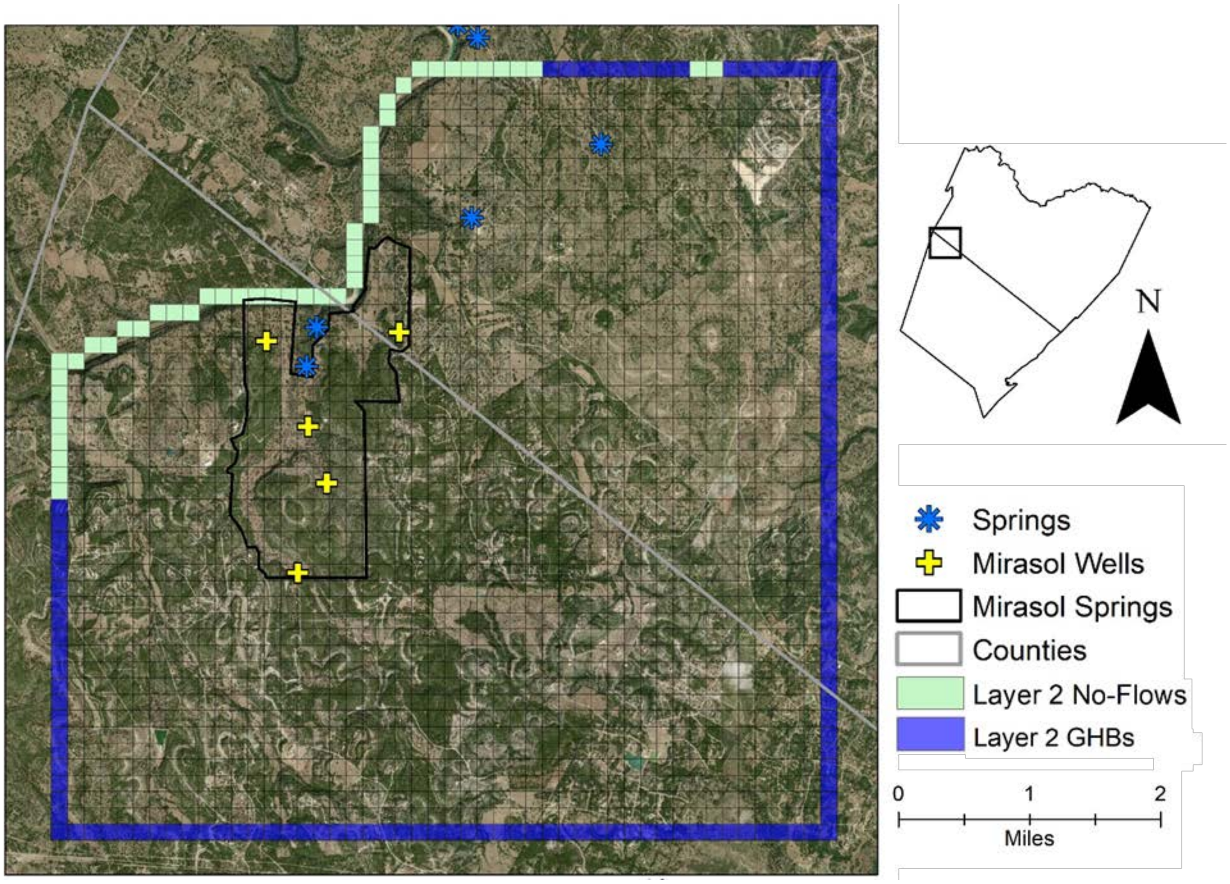

Figure 8. GHBs and no-flow boundaries in Layer 2. All boundaries in Layer 1 are no-flows.

Other boundary conditions may also be defined. Cells adjacent to inactive cells (or the model's lateral limits) that are not otherwise defined are considered "no-flow" boundary cells, which means water is not able to exit through the adjacent cell face (**Figure 8**). In the model, all boundary cells designated as drains in Layer 2 (Section 3.7) and all boundary cells in Layer 1 have no-flow boundaries on the edge of the model's active extent. These conditions represent Layer 1 as a conditionally saturated layer which serves only to recharge the fully saturated Layer 2 and store water only when recharge is large enough to saturate it.

2.6 RECHARGE (RCH) PACKAGE

Recharge is applied to the model using MODFLOW's Recharge (RCH) input file. Recharge, in this case, represents rainfall which is not lost to evapotranspiration or runoff. It is applied directly into a model layer as a vertical inflow. INTERA used the Parameter-elevation Regressions on Independent Slopes Model (PRISM) developed by Oregon State University and rainfall measurements collected by the BEG to determine a range of acceptable volumes which could be applied to each model cell designated for recharge.

To represent this, we used the Geologic Atlas of Texas (GAT; Stoeser et al., 2005) to determine the areas in which units beneath the Glen Rose outcrop in the model area (**Figure 9**). As mentioned, the Upper Glen Rose outcrops in most of the model area and serves as a barrier to recharge. Cells where the Upper Glen Rose was the only outcropping unit received no recharge. If the Cow Creek Limestone outcrops in a cell, recharge was applied to the Cow Creek. For cells where the Lower Glen Rose or Hensell outcrop, recharge was applied to the Hensell (Layer 1). The Lower Glen Rose is assumed to have a high vertical hydraulic conductivity due to its high secondary porosity, so recharge is conceptualized as passing through the unit to the underlying Hensell.

The model cells designated to receive recharge were assigned a volume of 2.99 inches of rain per year, or approximately 10% of the observed average annual rainfall in this region (PRISM, 2022). It is important to note that the recharge applied to the model represents average rainfall conditions, not the pattern of high rainfall and then drought which were observed over the one-year collection period. In order to simulate the impact of the proposed Mirasol wells on springsheds during below average recharge conditions, five additional model runs were performed representing 80%, 60%, 40%, 20% and 0% of average recharge conditions.

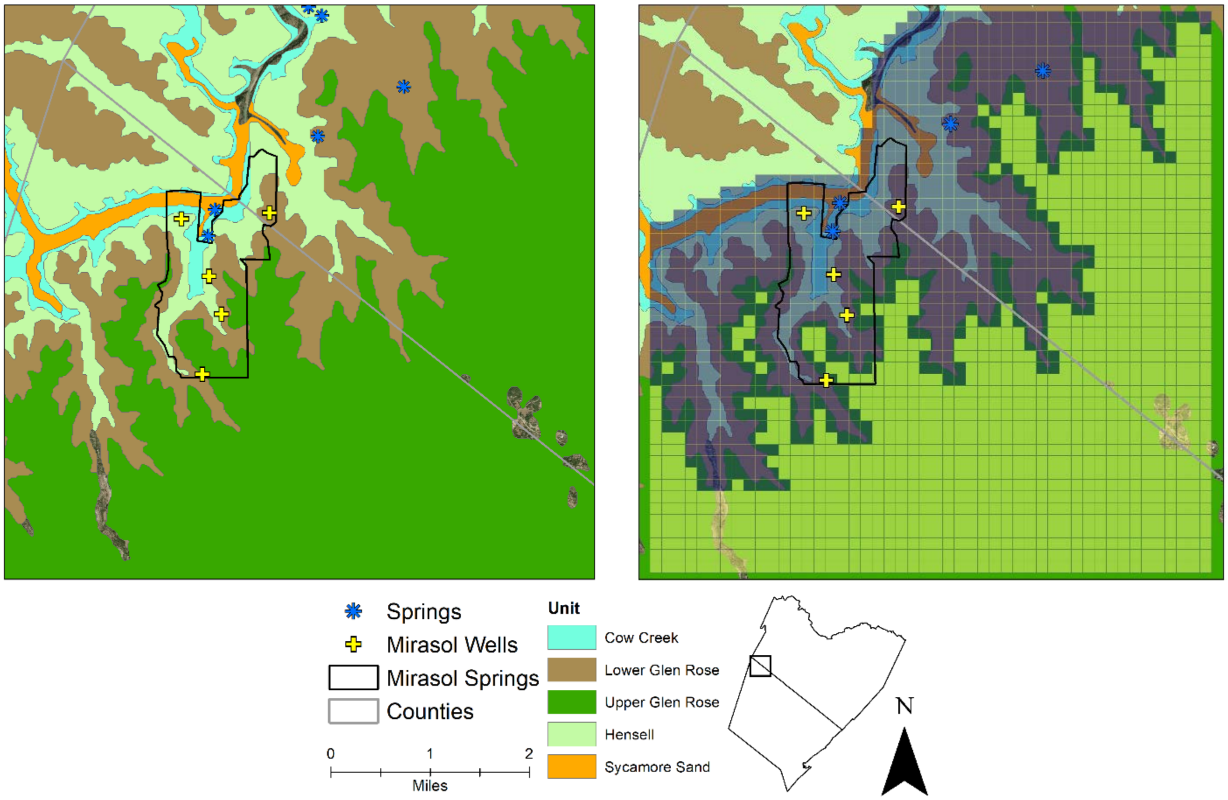

Figure 9. Texas GAT in our study area. Cells with recharge applied are shaded in blue.

2.7 DRAIN (DRN) PACKAGE

Springs, seeps, and river cells are represented in the model using the MODFLWOW Drain (DRN) package. In MODFLOW, drains are defined at a particular cell and a certain elevation. If the hydraulic head in the cell exceeds the drain elevation, water discharges from the cell. In the model, if a cell has a drain elevation which intersects the Cow Creek, a drain is also set at the base of the Hensell in that cell. This replicates the unconfined conditions which dominate the aquifers in the study area.

Drain locations and elevations in INTERA's model were determined using the GAT and the DEM in the GAM (Jones et al., 2011). Drains are located at outcropping sections of the Hensell and the Cow Creek (**Figure 10**). The Cow Creek has a lower dolomite facies (Hunt, 2022) which impedes flow. Thus, drain elevations were set at the estimated contact between the top of the facies and the bottom of the more conductive limestone, which INTERA estimated to be 30 feet above the base of the layer. This allows elevated heads close to the Pedernales River, as seen in the observed head values in the area. Drain elevations were assigned as shown in **Table 1**.

Table 1. Drain elevation assignments based on outcropping layer and relative DEM elevation.

	Cow Creek Only	Cow Creek and Hensell	Hensell/Cow Creek and Glen Rose	Hensell Only
DEM > Bottom 1	DEM	DEM	DEM	DEM
DEM ≤ Bottom 1	DEM	DEM	DEM	Bottom 1
DEM ≤ Bottom 2 + 30 feet	Bottom 2 + 30 feet	Bottom 2 + 30 feet	Bottom 2 + 30 feet	Bottom 1

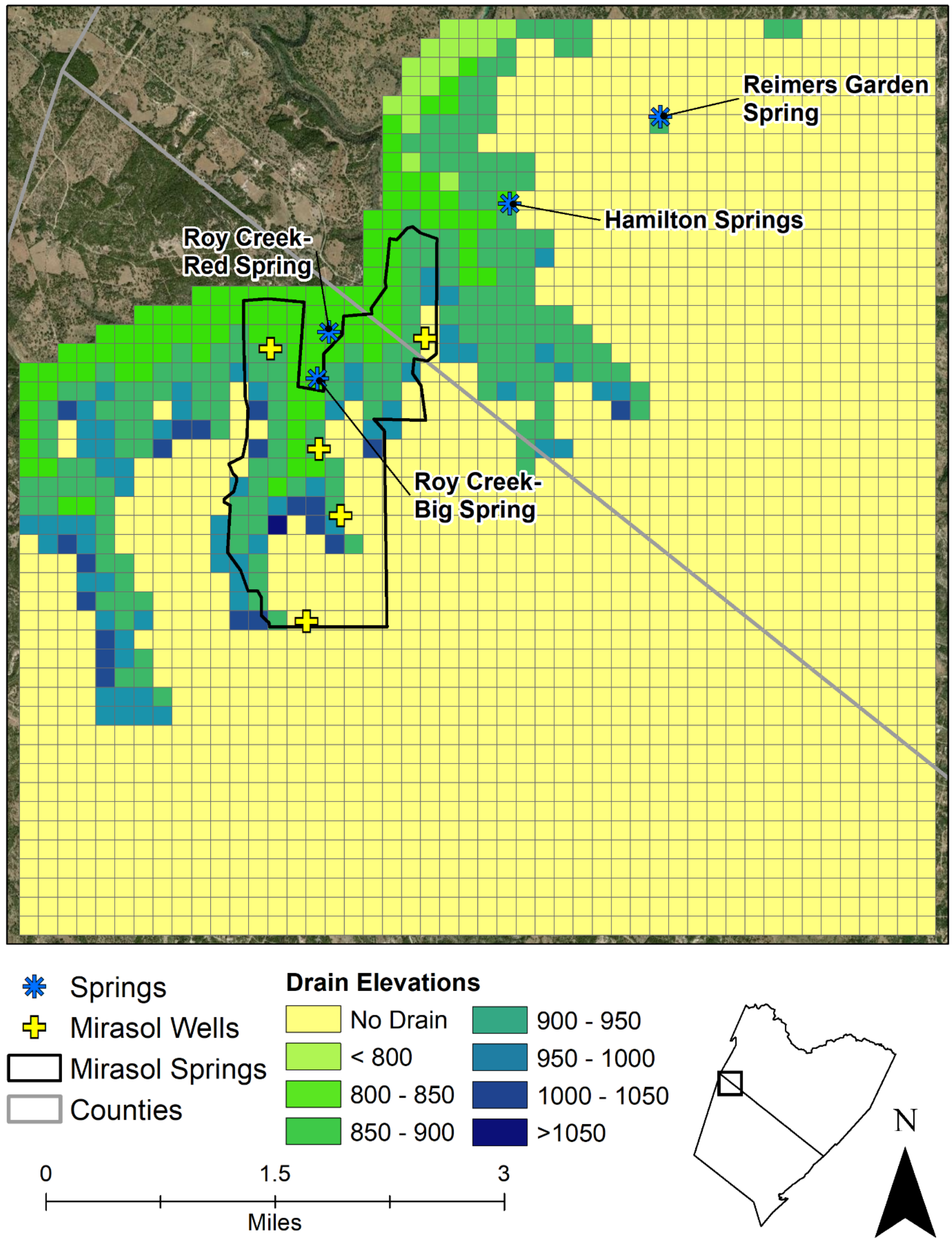
Reimers Garden Spring
Hamilton Springs
Roy Creek-Red Spring
Roy Creek-Big Spring
Springs
Mirasol Wells
Mirasol Springs
Counties
Drain Elevations
No Drain
< 800
800 - 850
850 - 900
900 - 950
950 - 1000
1000 - 1050
>1050
0
1.5
3
Miles
N

Figure 10. Drain elevations in model area.

Cells containing the Pedernales River (**Figure 6**) were assigned drain elevations at the top of the assumed dolomite facies. Cells containing one of the three marked springs that are not Hamilton Pool were assigned drain elevations equal to the DEM. Hamilton Pool was assigned a unique, calibrated drain elevation within the Cow Creek (44 feet above the bottom of the Cow Creek). Hamilton Pool's elevation is such that in the absence of recharge there is no estimated springflow, but when the calibrated recharge value is applied to the model the springflow matches the median observed flow rate provided in Hunt (2022).

2.8 WELL PACKAGE

Information about the locations and pumping rates of existing wells in Hays and Travis counties was provided by the Districts. These wells are represented in the model using the MODFLOW Well (WEL) package, which specifies the grid cell, model layer, and production rate of each well. The Districts provided the data on the existing production wells in Hays and Travis counties, including estimated production volumes from each well. According to this data, approximately 332 acre-feet per year (afy) of water is withdrawn from existing wells in the Middle Trinity in the model area.

The proposed Mirasol Springs production wells may produce up to 28.3 acre-feet per year from Travis County and 56.7 acre-feet per year from Hays County, a total of 85 acre-feet per year. For each recharge scenario, INTERA performed two model runs to evaluate the influence of the proposed Mirasol Springs wells, one run which included pumping from the proposed Mirasol Springs wells and a second run which did not. This allowed us to isolate and quantify the potential impact to water levels and springflows as a result of the proposed pumping. **Figure 11** shows the model cells with pumping in the model, including the proposed Mirasol production wells.

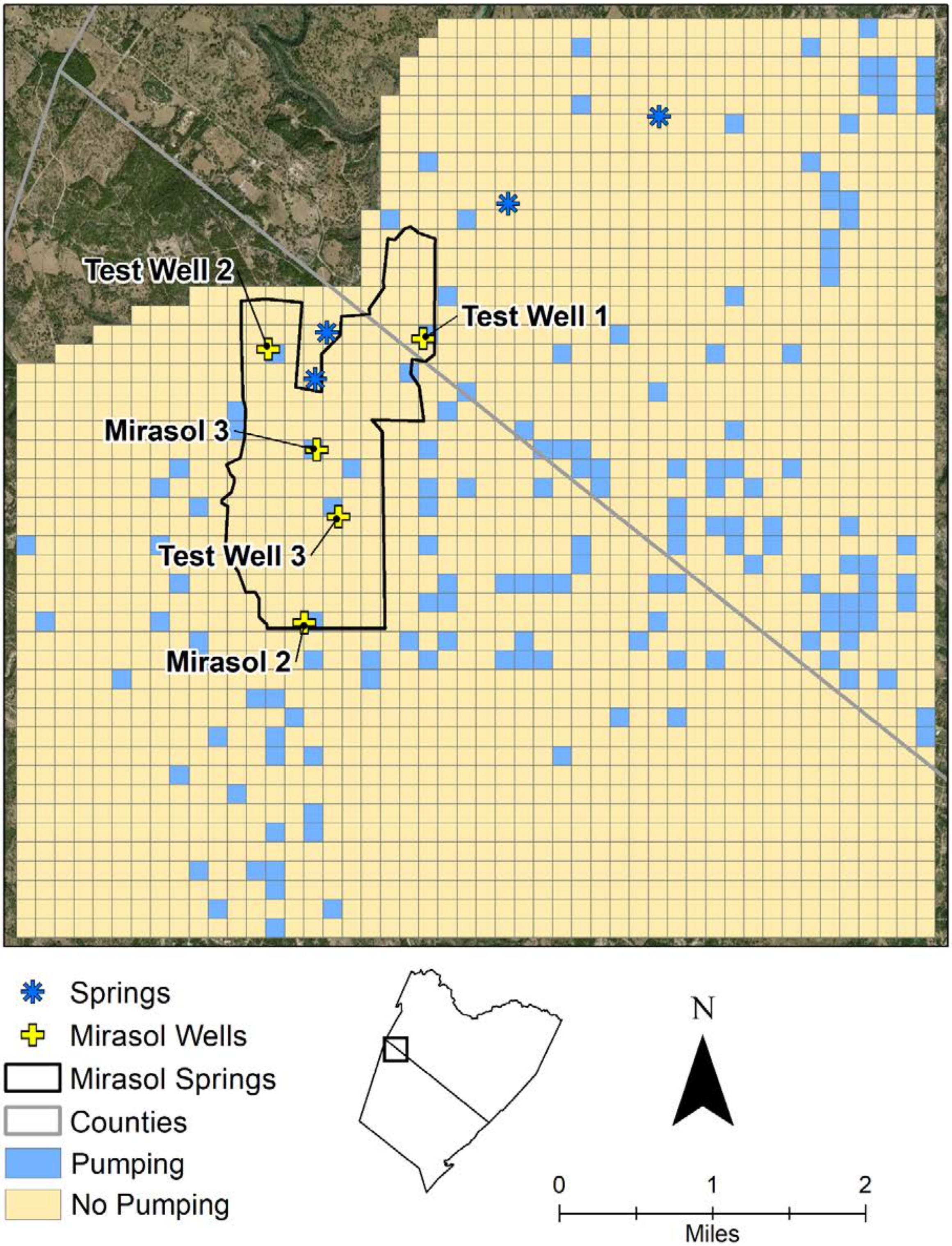

Figure 11. Cells where pumping is applied, including the proposed Mirasol Wells.

2.9 MODEL CALIBRATION

Calibration is the process of choosing model parameters which fit the conceptual model and produce results which match observed values, also called “targets”, within an acceptable margin of error. For this study, calibration targets included observed springflow measurements at Hamilton Pool and water-level data at 26 wells within the model area (**Figure 12**). The water-level data was sourced from Hunt (2022) and from the water availability study submitted by Tarver Geologic Services, LLC as part of the permit applications. INTERA obtained observed hydraulic conductivities for the Middle Trinity from Tarver’s study. All of the pumping wells in Tarver’s study (with the exception of Mirasol-1) were screened in the Cow Creek Limestone. The majority of the flow in the model is within the Cow Creek, so the calibration was mostly focused on this layer as the model did not appear to be as sensitive to changes in the parameters of the Hensell Sand. Horizontal hydraulic conductivity, vertical hydraulic conductivity, and recharge were modified within reasonable ranges during calibration. Calibrated model parameters are shown in **Table 2**.

The elevation of Hamilton Pool was also varied within an assumed range to better match the median observed springflow at the calibrated recharge volume. During calibration we noted that larger recharge volumes result in more springflow from the simulated Hamilton Pool spring, consistent with the conceptual model. As an additional check, we also eliminated recharge from the model to demonstrate that no springflow would occur at Hamilton Pool even though water is still flowing into and out of the model through the GHBs. The range of observed data over which the model error was calculated may be inflated by some outlier water-level data. To rectify this, we calculated the median absolute water level error for this dataset rather than the mean. The median absolute water-level error for this dataset is 9.9 feet.

Table 2. Calibrated model parameters.

Parameter	Layer 1 (Hensell Sand)	Layer 2 (Cow Creek Limestone)
Horizonal Conductivity	1 foot/day	11 feet/day
Vertical Conductivity	.01 foot/day	.1 foot/day

3.0 RESULTS

Results from the calibrated model which did not include pumping from the proposed Mirasol wells were compared to results which included pumping from these wells to analyze their potential impact. Water levels and Hamilton Pool springflow changes were monitored to assess impacts.

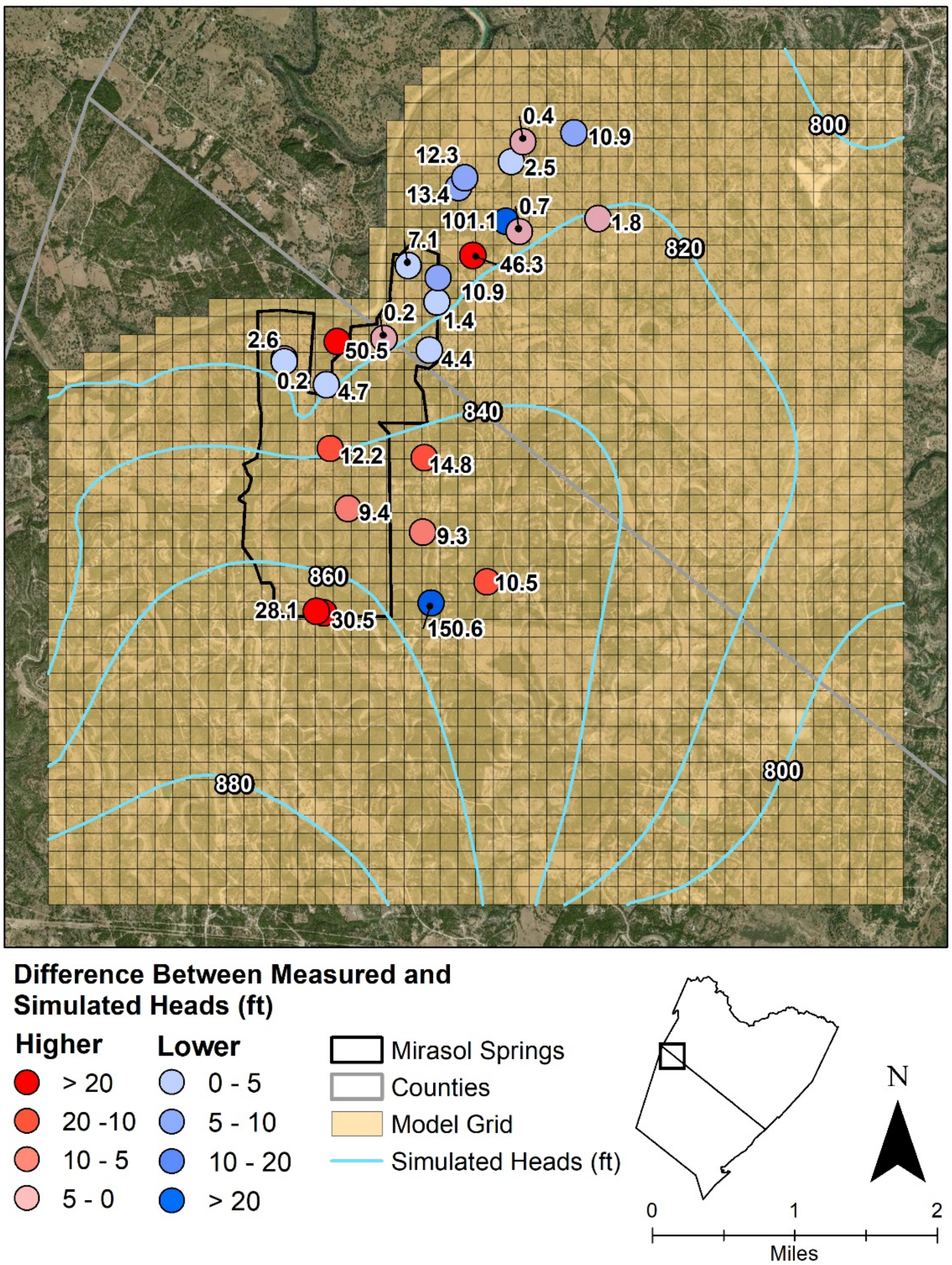

Figure 12. Simulated water levels and difference from observed values.

3.1 WATER LEVELS

Static water levels in the calibrated model are shown in **Figure 12**. The northeast regional flow pattern can be seen in the head contours, as can the influence of the Pedernales River and the local springs. Simulated water levels are generally higher than target values in the southern portion of the model area and lower than target values in the north. Simulated levels close to the Pedernales River and around Hamilton Pool generally show lower absolute error values than in the south. Note that some water levels were measured in October while some were measured in January. These months have different observed rainfall volumes, which is important in this system because it is conceptualized to be highly influenced by rainfall.

The simulated impacts of the proposed pumping from Mirasol Springs are calculated as the difference in water levels between the run with only existing pumping and a run with additional pumping associated with the Mirasol Springs permit applications. Water level difference contours at the pumping wells during average rainfall conditions (**Figure 13**) indicate a minimum drawdown of 1.8 feet at Test Well 2 and a maximum of 3.5 feet at Test Well 1, the single SWTCGCD well site. It is noteworthy that because of the size of the grid cells, actual impacts at the wellhead are likely to be greater because the water level difference in the cell represents an average over the 1/8th mile by 1/8th mile area.

Water level impacts at the wellheads increase as rainfall decreases. Maximum drawdown in the no-recharge case is measured to be approximately 7.4 feet. In the absence of recharge, any new production will have a greater impact on water levels as storage around the wellhead can only be replenished by regional flow. Maps of simulated additional drawdown due to Mirasol pumping during various recharge conditions can be found in **Appendix A**.

Table 3. Water Level Impacts.

	Test Well 2	Test Well 1	Mirasol 3	Test Well 3	Mirasol 2
0% Recharge	3.3	7.4	6.1	6.3	4.2
20% Recharge	2.3	5.5	4.0	4.6	3.5
40% Recharge	2.2	4.7	3.5	3.9	3.2
60% Recharge	2.1	4.3	3.1	3.5	2.9
80% Recharge	1.9	3.9	2.8	3.2	2.7
100% Recharge	1.8	3.5	2.1	2.4	2.3

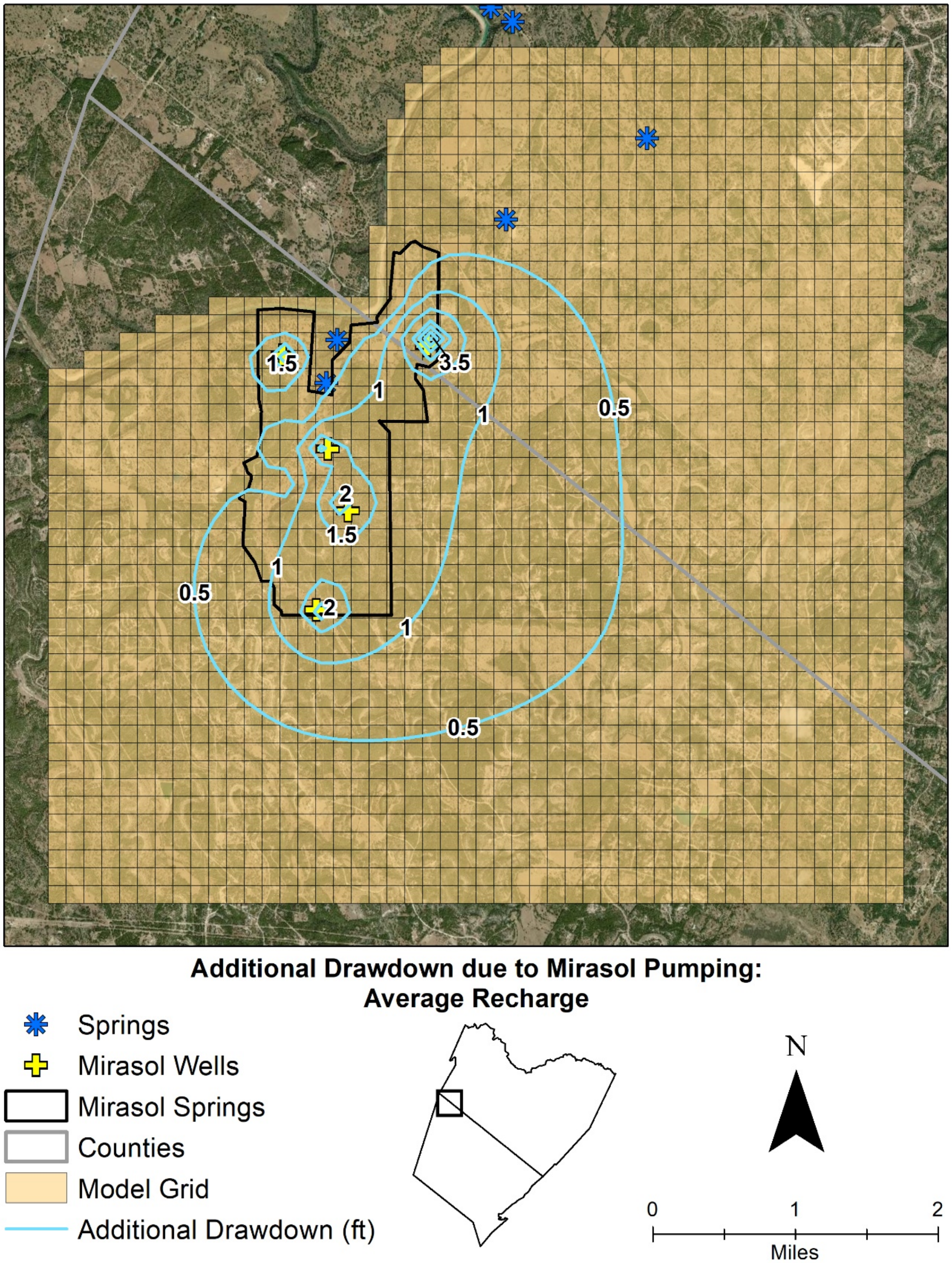

Figure 13. Additional drawdown from Mirasol Wells

3.2 SPRINGSHEDS

Springs and seeps account for 2,078 afy of water lost from the model, which is 48.7% of the entire model outflow. **Figure 14** shows the spatial distribution of springflow and river seeps from the model; the axes represent row and column numbers in the model. The model cell with the largest discharge (the lowest drain elevation) is located along the northern boundary. The two cells on the western model edge which show high discharge are in a local tributary to the Pedernales River where the Cow Creek and Sycamore Sand are exposed. It is not unreasonable that this location is draining water from the model, though the volume might be slightly inflated due to the cell proximity to the model boundary.

All the drain cells which represent the Pedernales River exhibit some outflow, in addition to the cells representing Hamilton and Roy Creek Springs. Hamilton Pool exhibits 94 afy of springflow, 5% more than the median observed springflow (Hunt, 2022). The Roy Creek Springs, including the seeps around them, exhibit a total of 244 afy of springflow.

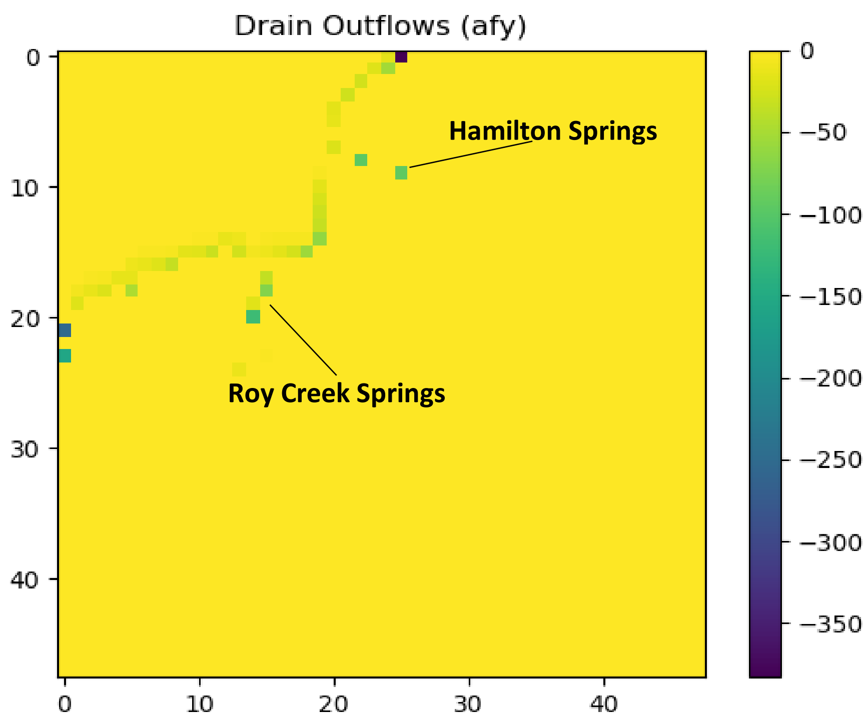

Figure 14. Spatial distribution of springs and seeps outflow in the calibrated model.

After the addition of the proposed Mirasol wells, there is a 3% reduction in the springflow observed at Hamilton Pool and an 8% reduction in the the springflow observed at Roy Creek. Including the various seeps along the Pedernales River, total springflow in the model was reduced by 68 afy. There was also an 8 afy increase in volume entering the model from the GHBs, and a 9 afy reduction in volume exiting the model through GHBs, indicating an influence on the regional head gradient. **Table 4** shows the estimated volumetric sources of the proposed pumping during average conditions of rainfall, and **Figure**

15 shows the spatial distribution of impacts to drain outflows as a result of the proposed pumping in average conditions of rainfall.

Table 4. Estimated volumetric impacts of the proposed Mirasol Production Wells during average conditions.

	Hamilton Springs	Roy Creek Springs/Seeps	Pedernales River Seeps	Other Springs/Seeps	GHB's (Regional Flow)
Baseline Total Flow (afy)	94	244	1151	589	-
Total Reduction in Flow (afy)	3	20	29	16	17
Percent reduction	3%	8%	3%	3%	-
Percent of Mirasol Pumping	3%	24%	34%	18%	20%

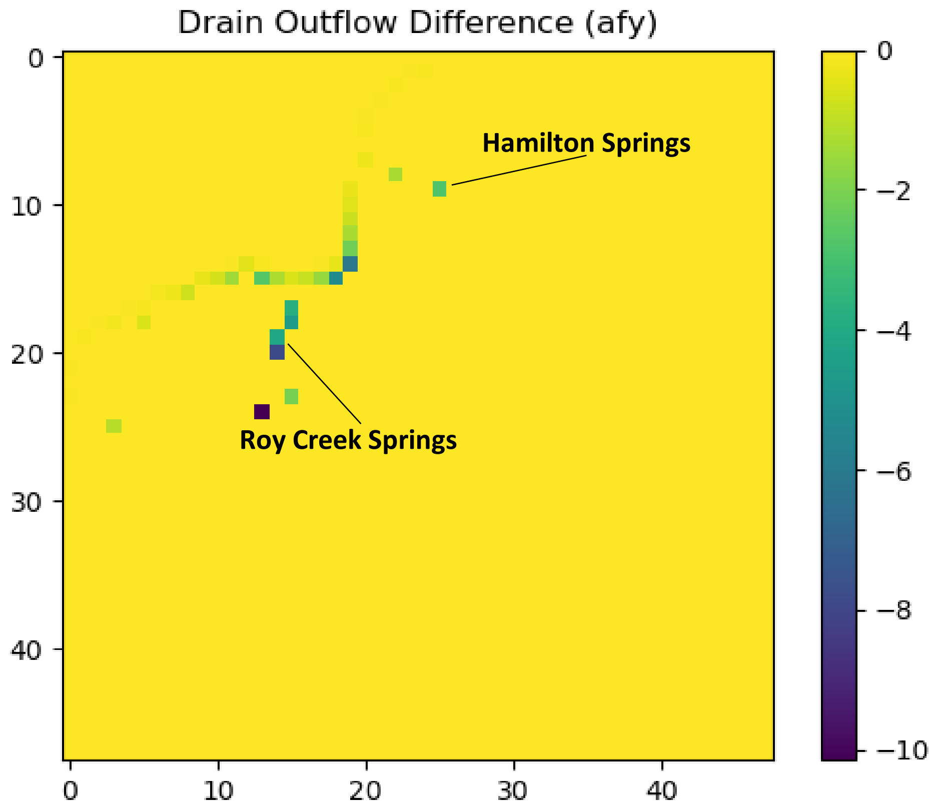

Figure 15. **Spatial distribution of the reduction of drain discharge (acre-feet per year) due to the proposed Mirasol production wells during average rainfall conditions.**

Several additional model runs were performed using recharge values less than the average rainfall, which simulate the impact of the Mirasol pumping wells during drought conditions. Recharge applied to the model for these runs totaled 10% (average conditions), 8%, 6%, 4%, 2%, and 0% of the observed average annual rainfall in this region (PRISM, 2022). As with the average recharge simulation, runs were performed with and without pumping from the proposed Mirasol wells to evaluate the incremental impact of their addition. Results from these additional runs are presented in **Figures 16-18**.

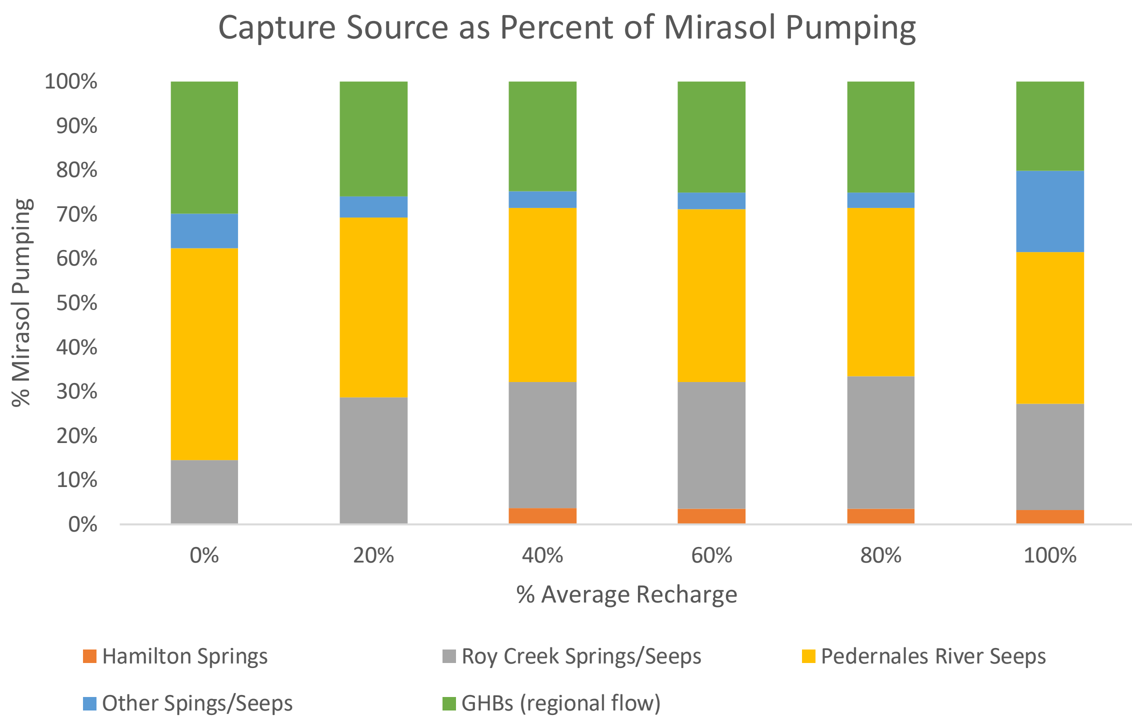

Figure 16. Flow volume reduced from each source or sink ("capture") expressed as a percent of Mirasol pumping for the range of recharge volumes analyzed.

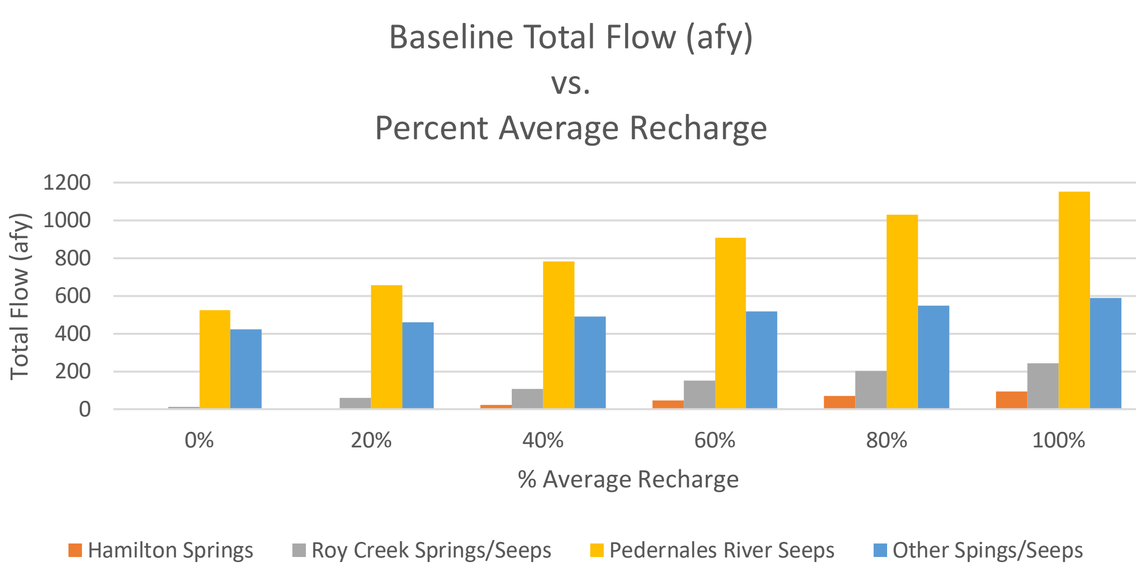

Figure 17. Flow volumes from each analyzed spring or seep before the addition of Mirasol Pumping for the range of recharge volumes analyzed.

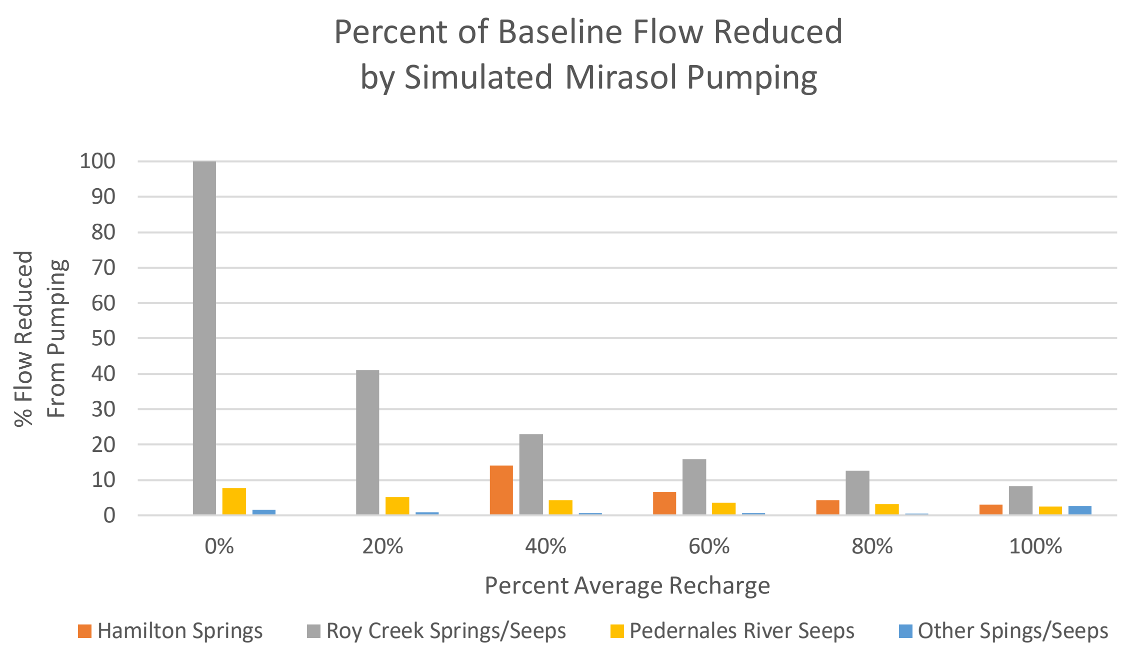

Figure 18. Percent of baseline flow reduced by simulated mirasol pumping in different recharge conditions.

Hamilton Springs doesn't appear in the **Figure 16** results for the 0 and 20% recharge cases because Hamilton Springs does not have any baseline flow until recharge reaches 40%. Roy Creek has 12 afy of baseline flow during the no-recharge case that is reduced completely when the Mirasol pumping is applied. In **Figure 16**, the Other Springs/Seeps category increases from 3% to 18% of Mirasol pumping for the 80% and 100% recharge cases, respectively. This can be attributed to an increase in the total number of active springs in the model as a result of this increase in recharge. The model structure has many drain cells (**Figure 10**) which are not active in low-recharge cases. From 80% to 100% of the average recharge, the hydraulic gradient rises to meet the threshold of activation for ephemeral springs and then is lowered below the threshold again once the Mirasol pumping is applied. **Figure 18** shows different percentages of baseline flow which are reduced as a result of simulated Mirasol Pumping. The baseline flow for Roy Creek Springs is relatively low in the 0% case (**Figure 16**) and the entire flow volume is captured by the simulated pumping (**Figure 18**). **Table 5** shows the total flow reduced from each source/sink attributed to simulated Mirasol pumping.

Table 5. Total flow reduction attributable to simulated Mirasol pumping (afy) for different percentages of average recharge.

	Hamilton Springs	Roy Creek Springs/Seeps	Pedernales River Seeps	Other Springs/Seeps	GHBs (regional flow)
0% Recharge	0	12	41	7	25
20% Recharge	0	24	35	4	22
40% Recharge	3	24	33	3	21
60% Recharge	3	24	33	3	21
80% Recharge	3	25	32	3	21
100% Recharge	3	20	29	16	17

4.0 MODEL LIMITATIONS AND FUTURE STEPS

This model is meant to estimate the potential impacts of the proposed Mirasol Springs wells on springflow and local water levels in the vicinity of the Mirasol Springs property. It is not meant for regional water planning or for evaluating other future permits in the study area without first updating the model. This study area is a complex system which has not been fully characterized.

Should the conceptual model change in the future as more hydrogeologic and structural data are collected, the numerical model should be updated. For example, the model could be updated to include additional layers of the Trinity Aquifer. Water levels, rainfall, layer thicknesses, hydraulic properties may be updated to reflect the latest data when it becomes available to better understand impacts of proposed pumping in the area. A longer data record may even allow for conversion to a transient model to reflect changing weather conditions and pumping rates in response to droughts.

5.0 CONCLUSION

This report documents the development of a three-dimensional groundwater flow model for the region surrounding the proposed Mirasol Springs development. The project was funded jointly by Southwestern Travis County GCD and by Hays Trinity GCD with the goal of determining the expected impact to springsheds and water levels of the Mirasol Springs Development. Clancy Utilities Holdings LLC has applied for permits for five production wells with production totaling 85 acre-feet per year between the two counties. The production will come entirely from the Middle Trinity, as all wells are screened in the Cow Creek Limestone.

Production was simulated in a steady-state flow system in six different recharge scenarios, representing a range of environmental conditions from average rainfall to drought. The impact of the proposed Mirasol Springs wells to water levels ranged from a minimum of 1.8 feet of additional drawdown at 'Test Well 2' during average rainfall conditions, and a maximum of 7.4 feet of additional drawdown at 'Test Well 1' during drought conditions. Generally, additional impacts to water levels increased as rainfall decreased. It's expected that local springflow will also decrease due to the proposed pumping. Volumetric impacts to the various springs and seeps in the area are comparable during all recharge scenarios. However, as the baseline flows for these springs/seeps are lower during drought conditions, the proportion of flow reduced by the Mirasol pumping is larger during drought conditions. Baseline flow at Hamilton Springs is eliminated in the 0 and 20% recharge scenarios. Baseline flow at Roy Creek Springs is significantly reduced in the no-recharge scenario so that the proposed pumping eliminates the remainder. As more geologic and hydrogeologic data about this area becomes available, updates to the model structure and input variables will become possible.

6.0 REFERENCES

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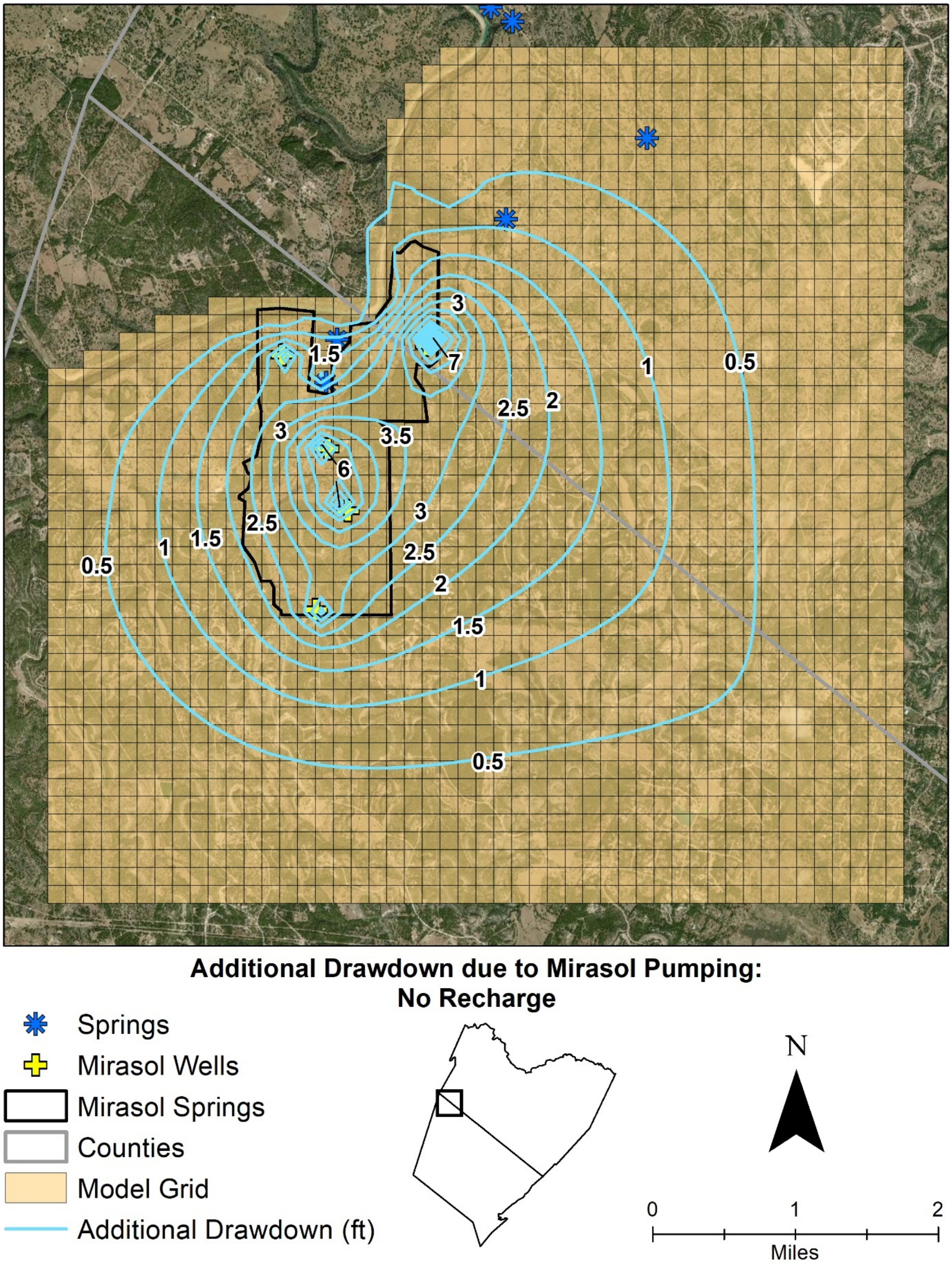
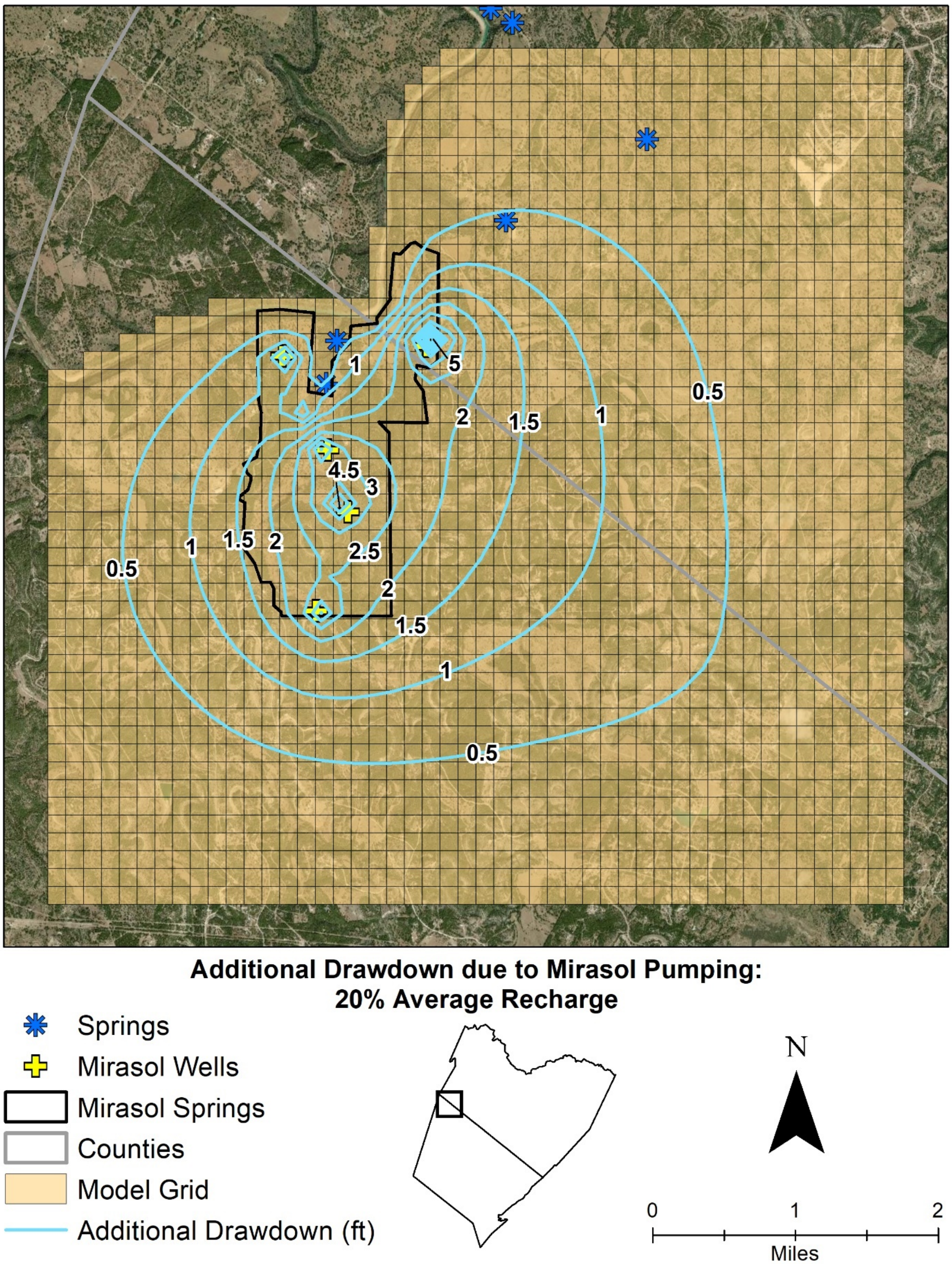
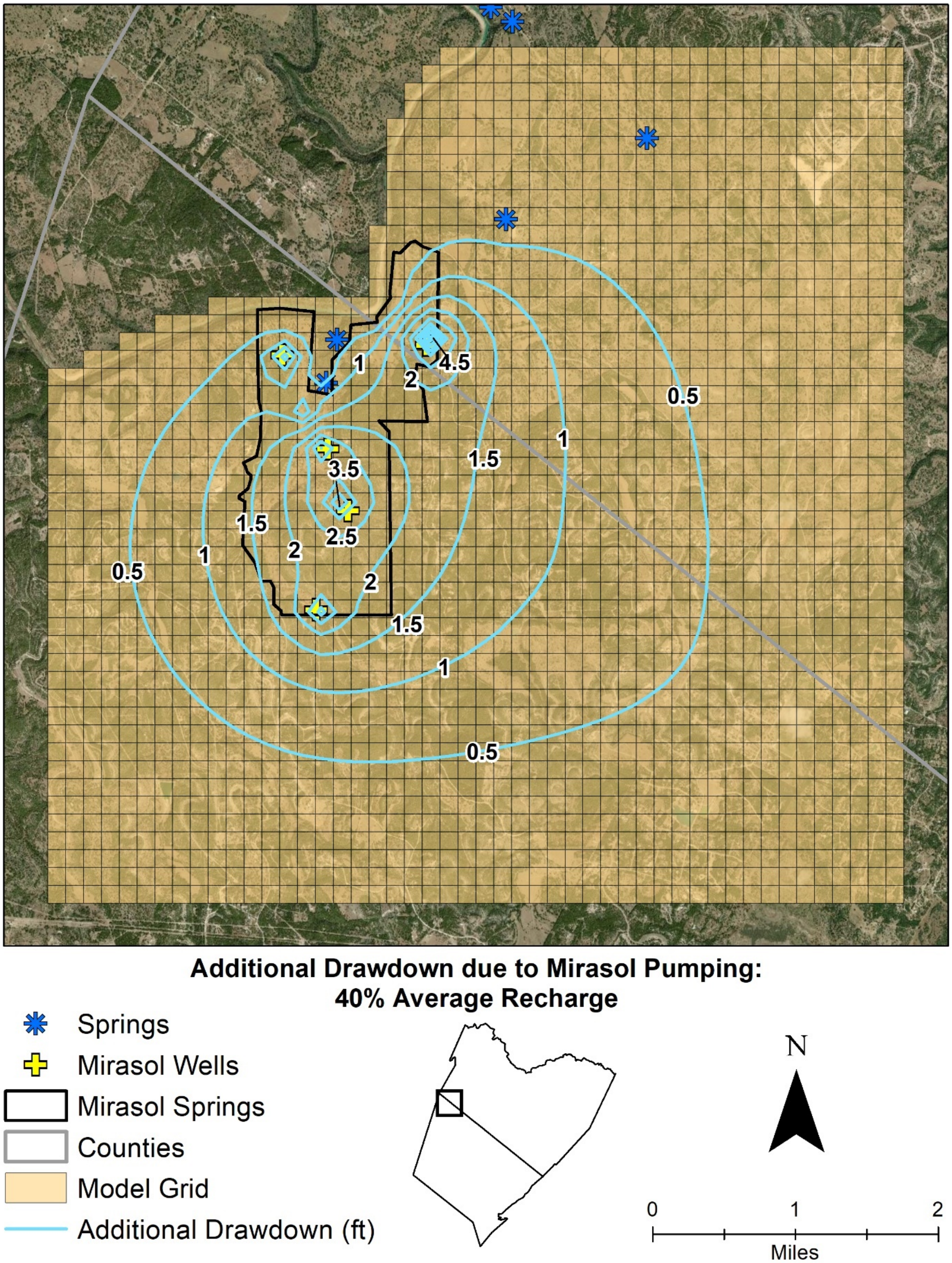
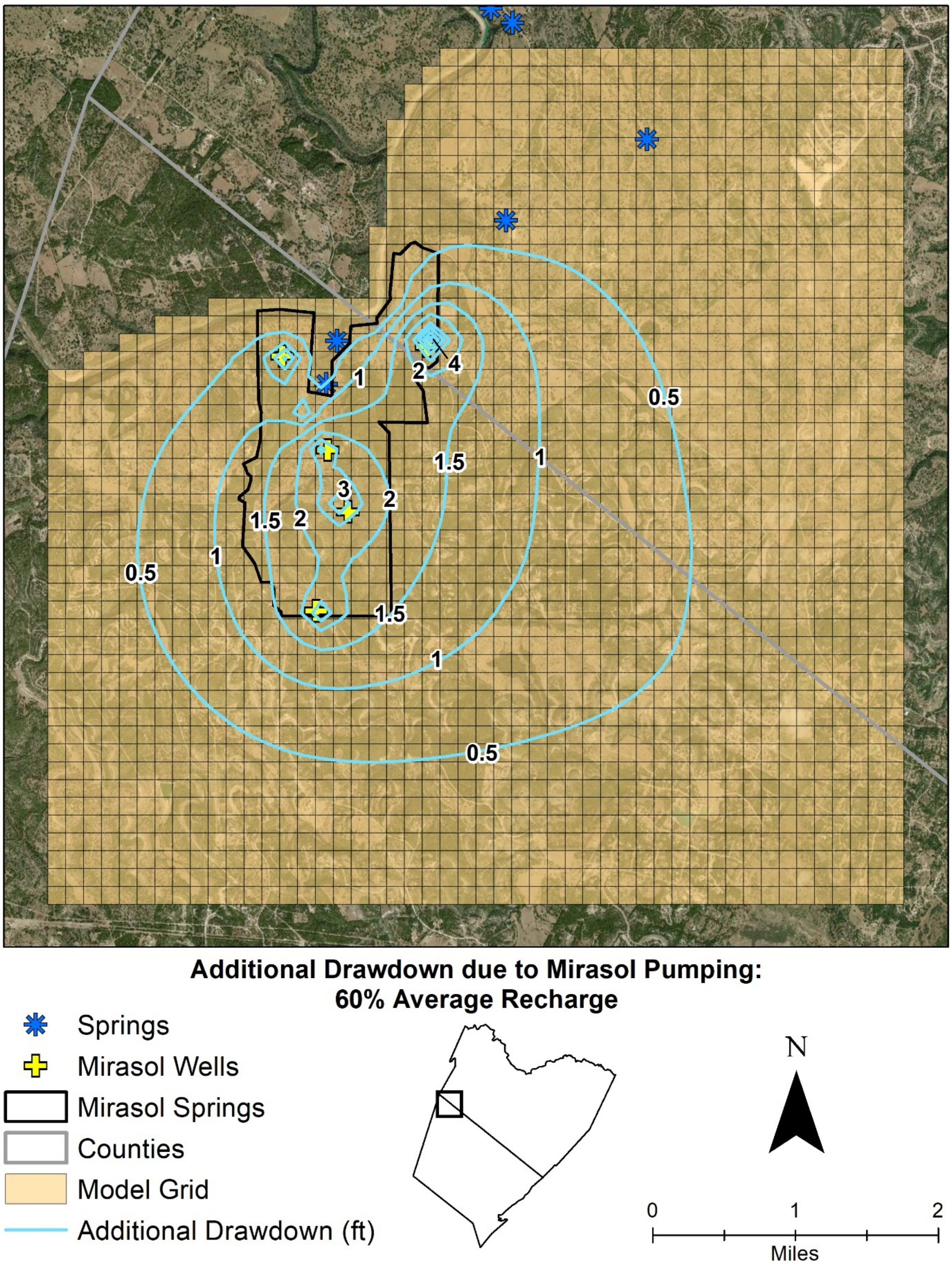
7.0 APPENDIX A

ESTIMATED ADDITIONAL DRAWDOWN DUE TO MIRASOL PUMPING WELLS

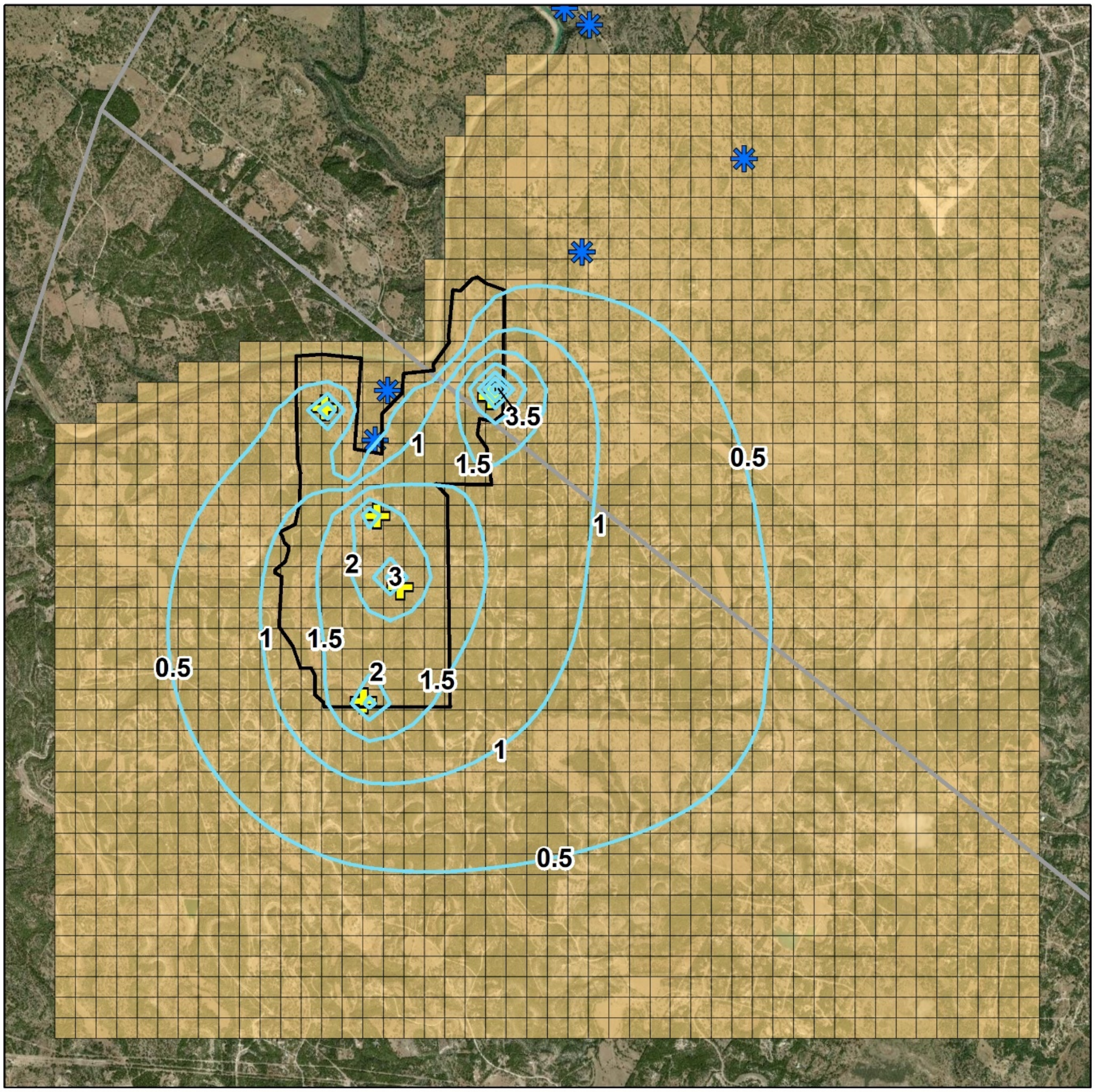

0.5
1
1.5
2
2.5
3
3.5
6
7
Additional Drawdown due to Mirasol Pumping:
No Recharge
Springs
Mirasol Wells
Mirasol Springs
Counties
Model Grid
Additional Drawdown (ft)
N
0
1
2
Miles


0.5
1
1.5
2
2.5
3
4.5
5
Additional Drawdown due to Mirasol Pumping:
20% Average Recharge
Springs
Mirasol Wells
Mirasol Springs
Counties
Model Grid
Additional Drawdown (ft)
N
0
1
2
Miles

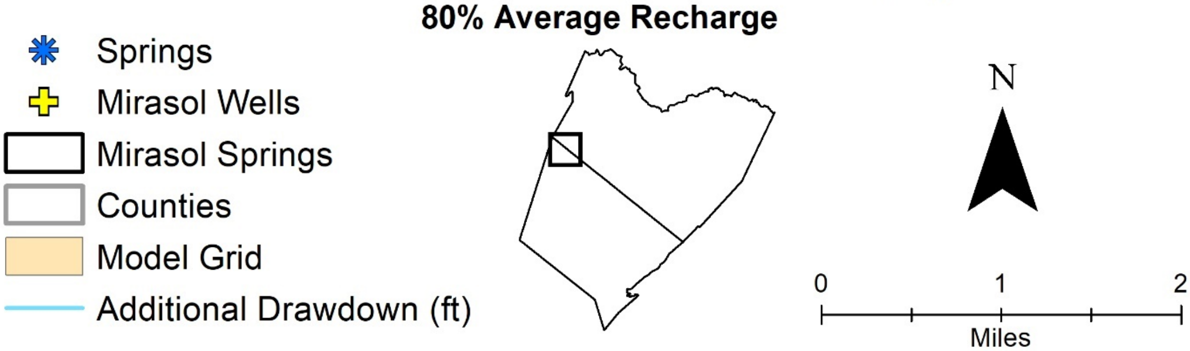

0.5
1
1.5
2
2.5
3.5
4.5
Additional Drawdown due to Mirasol Pumping:
40% Average Recharge
Springs
Mirasol Wells
Mirasol Springs
Counties
Model Grid
Additional Drawdown (ft)
N
0
1
2
Miles

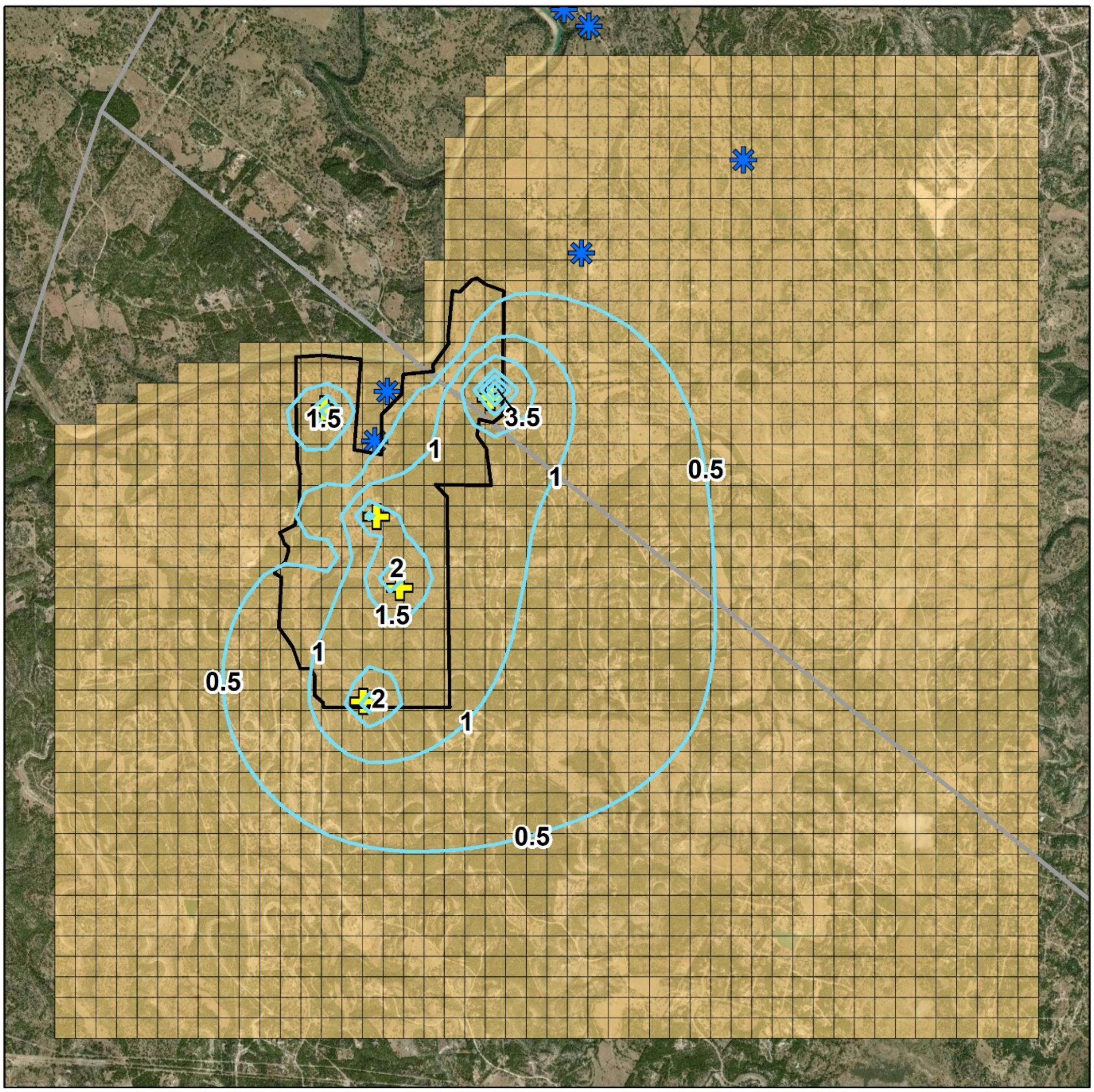


Additional Drawdown due to Mirasol Pumping: 60% Average Recharge



**Additional Drawdown due to Mirasol Pumping:
80% Average Recharge**





**Additional Drawdown due to Mirasol Pumping:
Average Recharge**