Schnabel ENGINEERING
T 303.651.1468 / F 303.651.1469
600 S. Airport Road, Suite A-205 / Longmont, CO 80503 schnabel-eng.com

TECHNICAL MEMORANDUM

TO:	Lynn Mayer Shults	**DATE:**	July 18, 2025
COMPANY:	L.G. Everist, Mountain Division	**SUBJECT:**	Heins Property Groundwater Model Revision 1
ADDRESS:	7321 E. 88th Ave., Suite 200, Henderson, CO 80640	**PROJECT NAME/NO.:**	L.G. Everist Heins Property 20C26026.06
FROM:	Sampson Ash, PG Victor deWolfe, PE, PG	**CC:**	Susan Rainey, PE

INTRODUCTION

This memorandum discusses the groundwater impact analysis at the proposed Heins Property mine site. The purpose of the analysis is to provide information related to the potential impacts to the groundwater table in the vicinity of the site. This includes mounding upgradient and shadowing downgradient of the proposed slurry walls at the site. The site is located approximately three miles north of the town of Fort Lupton, Colorado. The mine plan for the site consists of two main mining areas (North and South) divided by the Meadow Island Ditch and, when constructed, the relocated east branch of the Lupton Bottom Ditch. There is a possible third or West cell. Slurry walls will be constructed around the perimeter of each of the planned cells to cut off groundwater, as shown on **Figure 1**. A standard offset of 200 feet from the river, and 15 feet from property lines, rights-of-way or utilities were used for the proposed slurry wall alignments.

Groundwater modeling was conducted to evaluate the impact of the proposed slurry walls on groundwater levels. The objectives of the groundwater modeling are to:

1. Approximate the existing hydrogeologic conditions pre-slurry wall using available data.
2. Simulate the hydrogeologic effects of the slurry walls by predicting potential groundwater mounding upgradient of the property and shadowing downgradient.

To satisfy these objectives, five steady-state (equilibrated) groundwater models were constructed for:

1. Pre-slurry wall conditions
2. Post-slurry wall construction conditions

This modeling memorandum presents the geologic setting; a general site conceptual model of the aquifer system; the groundwater modeling software used; construction of the model; calibration of the model in terms of target residuals and mass balance; and finally, a discussion of the predictive simulations and conclusions. The groundwater modeling was conducted in general conformance with ASTM standards for groundwater modeling.

GEOLOGIC SETTING

Geotechnical Investigations

The general subsurface lithology at the Heins Property consists of one to two feet of overburden at the surface, underlain by alluvial sand and gravel deposits ranging between 21.5 and 45.5 feet thick, followed by weathered Laramie Formation bedrock measuring about two feet thick, and finally less weathered Laramie Formation bedrock. The bedrock consisted of claystone, shale, and fine-grained cemented sandstone which are fine-grained rock types and therefore have a low hydraulic conductivity. The total depth to bedrock for the site was estimated to vary from about 23.5 to 47.5 feet deep or elevations 4812 to 4848 feet, respectively. The groundwater depths on the property range between 0.2 to 10 feet below ground surface or between elevations 4853 to 4869 feet, and the aquifer had a saturated thickness ranging between 16 to 30 feet.

Subsurface lithology data was obtained from the geotechnical investigation on the property, consisting of 26 borings, performed by Schnabel Engineering between September 23, and October 10, 2024. These boring locations are shown on **Figure 1**. The information from this investigation was used along with existing data from other projects in the domain to create the bedrock contours used in the groundwater model.

Site Conceptual Model

The site conceptual model of the South Platte Alluvial Aquifer as shown in **Diagram 1** below consists of two layers, the unconfined sand and gravel of the South Platte Alluvial Aquifer and the Laramie Formation. The overburden was removed from the model for simplification. Even though this material has a lower hydraulic conductivity it is insignificant in the contribution of the model. The highly conductive Alluvial Aquifer has an estimated hydraulic conductivity of 500 ft/day (0.17 cm/sec) (CDWR, 2024) and is bounded on the bottom by the fine-grained rock of the Laramie Formation. The Laramie Formation has an average hydraulic conductivity of 3.2×10^{-3} ft/day (1.2×10^{-6} cm/sec) as determined by packer testing during the geotechnical investigation. The rocks that comprise the Laramie Formation have a low hydraulic conductivity. In the model it acts as a no-flow boundary due to the orders of magnitude of difference in hydraulic conductivity between the two layers.

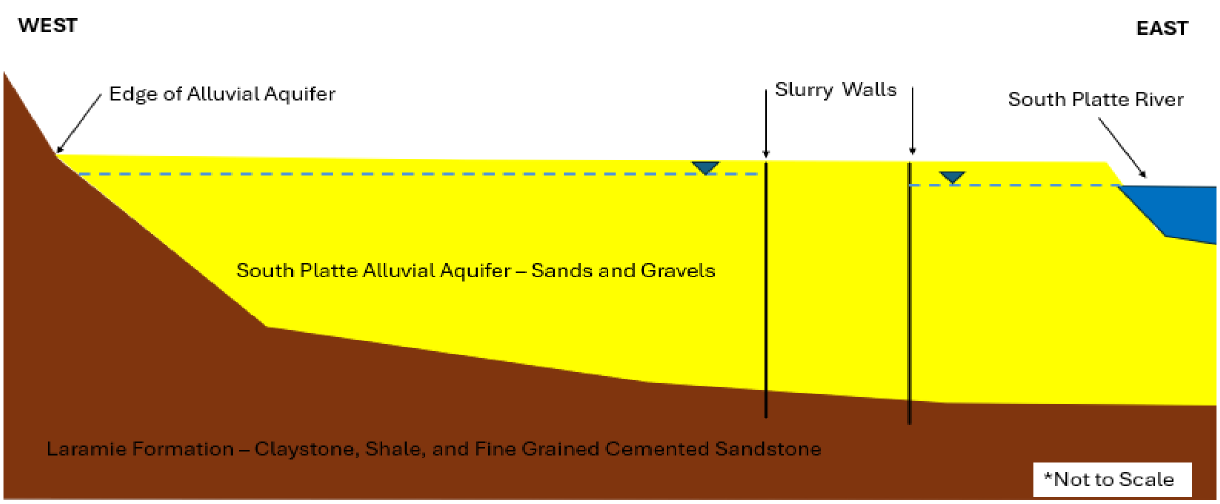

Diagram 1 – Site Conceptual Model

The primary sources of inflows into the alluvial aquifer are:

1. Subsurface inflow from the upgradient end of the aquifer and tributary valleys
2. Infiltration of precipitation and irrigation
3. Seepage from unlined ditches or reservoirs (depending on time of year)

The primary sink or area of outflow from the alluvial aquifer is the South Platte River because it is a gaining stream. However, water outflow from the aquifer also includes:

1. Seepage into unlined reservoirs or mines
2. Seepage into unlined ditches (depending on time of year)
3. Well withdraws
4. Subsurface outflow at the downgradient end of the aquifer

The model domain encompasses the South Platte River alluvial floodplain between Weld County Road 14 in the south and Weld County Road 24 in the north. The domain is set between the confluences of Big Dry Creek and Little Dry Creek within the South Platte River valley (**Figure 2**). The western boundary is set at the extent of the Alluvial Aquifer which is correlated to Elevation 4900 feet**.** The South Platte River is the primary surface discharge for groundwater in the area and is set as the eastern boundary of the model. The ditches and unlined ponds are drains in the model domain that can add or remove water to the aquifer depending on the head differences. Drains with outflow, for example, Little Dry Creek, return outflows to the South Platte River by surface flow and/or seepage into the aquifer.

The topography slopes gently down from south to north along the valley. The project area exhibits widespread aggregate mining where slurry walls and/or clay liners (low permeable barriers) have been installed. These low permeability features act as hydraulic barriers and redirect groundwater flow, creating mounding on the upgradient sides and shadows on the downgradient sides. Land use in the area consists of mining and agricultural uses.

ANALYSIS APPROACH – STEADY-STATE GROUNDWATER MODELING

Overview

The Heins groundwater model was developed using a combination Geographic Information System (GIS) database and GIS data analysis techniques (ESRI, 2024) as well as Leapfrog geologic modeling to create model layers (Leapfrog Geo, 2024). That data was then imported into the software Groundwater Vistas Version 7.0 (Rumbaugh & Rumbaugh, 2015), a graphical user interface for MODFLOW.

Groundwater Modeling Software

The MODFLOW-2005 computer code was used to simulate groundwater flow by solving the 3-dimensional groundwater flow equation using a finite-difference method where the model domain is subdivided into a grid of cells, and the hydraulic head is calculated at the centroid of each cell (Harbaugh, 2005). Groundwater flows into and out of the model via head-dependent flux boundaries. These flows are calculated in the same manner for each simulation. Pre- and post-processing of MODFLOW-2005 files were completed using Groundwater Vistas. Groundwater Vistas is a graphical user interface that facilitates model construction, runs MODFLOW, data analysis and data presentation. It summarizes results as contours, shaded contours, velocity vectors and detailed mass balance analyses. This section discusses the modeling assumptions, limitations, solution techniques, and the way that they affect the models.

When analyzing the groundwater flows in the model, as implemented, MODFLOW-2005 simulates the system as an unconfined aquifer with one value of hydraulic conductivity. One limitation is that cells can go “dry” or “flood”. If the calculated head is above the top of the aquifer (ground surface) at any model cell, then that cell is flooded and will be treated as if the aquifer is confined (i.e., the saturated thickness will equal the top-elevation minus the bottom-elevation). If the calculated head falls below the bottom of the aquifer, that cell is dry and will be assigned a zero value for hydraulic conductivity.

The preconditioned conjugate-gradient with Newton (PCGN) solver package of MODFLOW-2005 was used to solve the groundwater flow equations for the model. It combines the efficiency of the conjugate gradient method with Newton-Raphson iteration to handle nonlinearities commonly found in unconfined aquifers and head-dependent boundary conditions. The solver uses preconditioning techniques to improve convergence speed and stability, making it well-suited for large, complex, and nonlinear models where traditional solvers like PCG or SOR may struggle.

This package defines the number of outer and inner solver iterations, as well as criteria for both maximum head and residual change between iterations before allowing convergence. Tolerances for the maximum change in head and flow residual between iterations were specified as $1x10^{-3}$ feet and 100 cubic feet per day (cfd), respectively. These tolerances result in a mass balance of less than 0.001%, indicting model convergence and solution accuracy. Steady-state conditions were simulated because the maximum water level rise is of principal interest and the time required to reach steady state is not of concern.

Model Geometry and Spatial Discretization

The model was constructed by importing shapefiles made in GIS representing aquifer parameters and boundary conditions into Groundwater Vistas. The model domain is a rectangular area 12,760 feet wide by 23,120 feet long (**Figure 2**). The domain was divided into a grid of cells measuring 10 feet on each side. Active cells contain values representing the following parameters:

1. The elevation of the top of the aquifer
2. The elevation of the bottom of the aquifer
3. The hydraulic conductivity of the aquifer
4. The recharge applied to the cell
5. The initial groundwater head within the aquifer
6. The boundary conditions for the model

Layer Construction

The maximum top of the alluvial aquifer is represented by the topography of the ground surface. Topographic data used for this model input are from a 1-meter digital elevation model (DEM) obtained from the Colorado Hazard Mapping & Risk Map Portal (CWCB, 2024).

The bottom of the aquifer and model is the low permeability Laramie Formation bedrock. Therefore, the model contains an elevation map of the bedrock surface. To create this surface, bedrock elevation data was obtained from the geotechnical investigation described previously in this memo, data from previous projects done for L.G Everist in the area, and publicly available data from Colorado's Decision Support Systems (CDWR, 2024). The bedrock elevations were contoured in AutoCAD. Overall, the spatial reliability of the bedrock data is considered good and deemed appropriate for the scope of this groundwater model.

The DEM and the resulting bedrock elevation contour map were imported into Leapfrog to create the top and bottom of the alluvial aquifer. Due to the 10x10 foot grid size used, the topographic and rock elevation data were averaged within that area resulting in some variation between model elevations and contoured ground/rock elevations.

Aquifer Properties

The horizontal hydraulic conductivity (Kx and Ky) of the alluvial aquifer used in the model was input between the range of 500 feet per day (fpd), and areas with known wash fine fill had an input of approximately 50 fpd. This value is based on average values from the Colorado Decision Support Systems GIS map and our experience in the area. We assumed an anisotropy ratio of 0.5 (Kv/Kr), meaning that the value in the vertical direction (Kv) is half the value in the radial direction (Kr).

A groundwater elevation contour map for the alluvial aquifer provided the starting heads for the finite difference solution and was used to define general head boundary values. This surface was developed using the groundwater level data collected from monitoring wells in the area. This consists of wells owned by LG Everist on-site and off-site.

Boundary Conditions

The boundary conditions listed below define the sources and sinks for the water budget of the model. The system is assumed to be in equilibrium under pre-slurry wall conditions. The model domain is inactive outside of the defined boundary conditions. These boundaries are shown on **Figure 2**.

Exterior Boundary Conditions

The exterior or the outer boundary conditions used for the model include three general head boundaries, two no-flow boundaries, and the river boundary:

General Head Boundaries

1. Subsurface inflow from the upgradient portion of the alluvial aquifer (Southern Boundary).
2. Subsurface outflow from the downgradient portion of the alluvial aquifer (Northern Boundary).
3. Subsurface inflow from the tributary valley of Little Dry Creek (Part of the Western Boundary).

These edges of the aquifer were chosen to be modeled by the MODFLOW General-Head boundary package to allow groundwater to flow into and out of the model and to permit groundwater elevations to change at the boundaries in response to aggregate mining.

No-Flow Boundaries

1. The edge of the South Platte Alluvial Aquifer (Part of the Western Boundary).
2. The contact between the South Platte Alluvial Aquifer and Laramie Formation (Bottom Boundary).

The base and most of the western side of the model are simulated using the no-flow boundary (inactive cells) to represent the contact between the low-conductive Laramie Formation and the alluvial aquifer.

River Boundary

1. The South Platte River (Eastern Boundary). The elevations of the river were determined using river gauges near the site to estimate starting and ending elevation.

The South Platte River was simulated using the MODFLOW River package, which contributes water to or releases water from the aquifer at adjacent cells as determined by the hydraulic gradient between the aquifer and the river and as a function of streambed conductance. The unlined reservoirs or ponds within the model domain were also modeled as river boundaries.

Interior Boundary Conditions

Interior boundaries or inner boundaries included 6 drains, 8 no-flow boundaries, and 11 constant head boundaries:

Drains

The ditches, unlined ponds, intermittent stream (Little Dry Creek), and the drain at the Zadel Pit within the model were simulated using the MODFLOW Drain Package which removes water from the adjacent cells as determined by the hydraulic gradient between the aquifer and the ditches and stream as a function of drain conductance.

No-Flow Boundaries

Aggregate mines that have installed slurry walls and/or clay slope liners around their properties were simulated using the no-flow boundary (inactive cells) as their contributions to the aquifer are negligible.

CALIBRATION

Calibration Process

Model Calibration is an iterative process of adjusting model parameters (aquifer properties) and boundary conditions to obtain a reasonable match between field measurements and model-computed values. Calibration was conducted for the steady-state models, which is assumed to represent conditions observed during the months of August 2024 and March 2025. August 2024 was used to calibrate flows from the Lupton Bottom West Branch Ditch and measured piezometric heads while the March 2025 calibration was used to calibrate the model to piezometric heads recorded after the installation of the Zadel Pit Drain.

The calibration targets for the two different models include the measured groundwater elevations observed in 34 monitoring wells (**Figure 2)** measured during the month of March 2025, and from 22 groundwater measurements taken during the geotechnical investigation described above.

The monitoring wells were the primary targets as they were recorded on specific dates, offering high reliability and spatial relevance; while the geotechnical borings and publicly available data were secondary targets as they included data outside the time frame of calibration, which while useful for broader context is considered less reliable due to potential inaccuracies and differences in aquifer conditions. The model was calibrated primarily to the project-specific data, with the secondary dataset used to support regional trends and assess model robustness.

Model calibration acceptability is subjective, but the following general guidelines for judging calibration sufficient for this model included:

- Overall calibration quality is determined through statistical comparison of model results with field measurements and observations. This model includes only water elevations.
- The primary statistic used in gauging and reporting "best fit" was the squared error of the measured and computed groundwater elevations.
- Calibration continued until the coefficient of determination (R^2) between the measured and observed groundwater elevations was within 10% of 1.

The goals of the predictive simulation targets are:

1. To show how field measured groundwater heads differ from those in the steady-state simulation.
2. To show how pre-slurry wall groundwater heads differ from those in the predictive simulations.

Calibration Results

The model is simple and homogeneous, containing heads that are well constrained by measured values for boundary conditions as well as a reasonable estimate of hydraulic conductivity. The calibration targets used for the pre-slurry wall condition steady state model illustrate that the input groundwater heads are generally within five feet of the measured values throughout the entire model. However, near the site where the mounding is expected the modeled heads are within two feet of the observed heads. Calibration plots for the two calibrated models show the residuals (Observed Head Values Vs. Modeled Head Values) for the site specific and publicly available data in **Figure 3**. The calibrated models both resulted in an R^2 value of 0.99 at the end of the calibration process. In **Figure 4** the groundwater elevation contours for the steady state calibrated model are shown. **Figure 5** shows the data in terms of groundwater depth below ground.

The mass balance reported by MODFLOW for the steady state pre-slurry wall model in March 2025 is as follows:

March 28, 2025

Inflows	= 1,214,888.2 cfd
<u>Outflows</u>	<u>= 1,222,461.4 cfd</u>
Difference	= - 7,573.2 cfd (-0.6%)

This illustrates that the initial steady-state model is accurately solved. Because the pre-slurry wall groundwater table represents data from measured groundwater levels, and the mass balance is accurate, this suggests the model is sufficiently calibrated to be used for predicting water levels after construction of the slurry walls.

PREDICTIVE SIMULATIONS

Using the steady state model for pre-slurry wall condition as the base model, predictive simulations were performed for groundwater mounding after the proposed slurry walls are constructed.

Predicted Unmitigated Groundwater Mounding

To understand the magnitude and extent of potential groundwater mounding upgradient of the Heins slurry walls, a steady state simulation including slurry walls was performed. The pre-slurry wall model was changed by inputting the Heins slurry walls as no-flow boundaries.

All other aquifer parameters and boundary conditions remained unchanged. Initial heads were the model simulated heads from the pre-slurry wall steady state model. The steady state model for the post-slurry wall conditions generally produced higher groundwater elevation heads than those produced for the pre-slurry wall steady state condition.

The groundwater elevations from the predictive simulation are shown in **Figure 6**. The difference between the pre- and post-slurry wall groundwater surfaces are the predicted mounding levels shown on **Figure 7**. For each of the predictive simulations, positive residuals are reported as values of groundwater mounding (warm colors) and negative values represent groundwater shadowing (cool colors). For this predictive simulation the magnitude of the maximum groundwater mounding is approximately 2.5 feet west of the Heins West and Zadel Pit.

For the Southern Slurry Wall Complex in this predictive simulation, the magnitude of groundwater mounding ranges from 1 foot on the southern side to maximum groundwater shadowing of 3 feet in the middle of the complex near Little Dry Creek on the north side.

The groundwater is closest to the surface on the west side of the Heins west cell as well as on the west side of the southern slurry wall complex as shown in **Figure 8**.

CHANGE IN DISCHARGE TO ACCRETION BOUNDARIES

The installation of slurry walls around the site can impact groundwater flow dynamics, resulting in changes to discharge at accretion boundaries. By reducing horizontal hydraulic connectivity of the aquifer, the slurry walls have modified the natural flow regime, limiting groundwater movement into and out of the enclosed area. As a result, discharge patterns at accretion boundaries have shifted, particularly along downgradient zones where the walls intersect historic flow paths. These changes were incorporated into the groundwater model by updating boundary conditions and representing the slurry walls as zones of low permeability or no-flow barriers. The model was subsequently recalibrated using observed groundwater levels and flow data to ensure it reflects post-construction conditions. A summary of the changes in flow at accretion boundaries is provided in **Table 1** below.

Table 1 – Change in Discharge to Accretion Boundaries

Name	Discharge into Accretion Boundaries without Recharge from Lupton Bottom (CFD)		Difference (CFD)	Difference (CFS)	Difference (GPM)
	Prior to Construction	After Construction			
South Platte	243,407.9	231,189.7	-12,218.2	-0.1	-63.5
Little Dry Creek	199258.9	55169.3	-144,089.6	-1.7	-748.5
Lupton Bottom Ditch West Branch	0.00	0.00	0.0	0.0	0.0
Lupton Bottom Ditch East Branch	89,028.5	148,144.0	59,115.5	0.7	307.1
Meadow Ditch	0.00	153,656.0	153,656.0	1.8	798.2
Coal Ridge	0.00	1,806.9	1,806.8	0.0	9.4
Unlined Pits	393,839.4	293,221.9	-100,617.5	-1.2	-522.7
Alluvial Underflow (Groundwater Flow)	153,275.1	121,267.2	-32,007.9	-0.4	-166.3
Totals	1,078,809.8	883,187.8	58,270.5	0.67	302.70

As shown, there is a small increase of about 300 gpm in the discharge to accretion boundaries with Heins slurry walls installed. The results illustrate that construction of the proposed slurry walls has a negligible impact on groundwater accretion to the South Platte River. Additionally, the outflows reported for Little Dry Creek flow into the South Platte River outside (downstream) of the model domain.

CONCLUSIONS

This groundwater impact analysis was performed to evaluate the mounding and shadowing effect the construction of slurry walls has on the local groundwater table. The model accurately replicated the conditions of the South Platte River alluvial aquifer based on data available from recent geotechnical investigations. Model construction was facilitated by using an extensive GIS to inventory, analyze, and present the data.

The steady-state models reasonably simulated the equilibrated hydrogeologic changes caused by construction of the slurry walls. The predictive simulation during irrigation season showed that the magnitude of the maximum groundwater mounding and shadowing for proposed slurry walls can cause mounding as high as about 2.5 feet, and a minimum depth to groundwater of about 0.5 feet, before a drain is installed. The simulation also indicates that the maximum shadowing effect caused by the construction of the slurry walls is almost three feet and is located along Little Dry Creek in the middle of the Fort Lupton Pits.

The groundwater flow pathways for return flows to the river have been lengthened due to slurry wall installation, the differences between flow paths can be compared in **Figure 4** and **Figure 6**. These lengthened flow paths can increase the timing it takes for groundwater to return to the South Platte River. However, as the results show, the change in outflows to the South Platte River is negligible between pre- and post-slurry wall conditions.

RECOMMENDATIONS

The installation of the Heins North and Heins South cells on the eastern side of the property have minimal effect on the surrounding groundwater. No drain installation is recommended for these areas at this time. The site wells will be monitored approximately monthly. If the depth to groundwater, following the construction of the slurry wall(s) in any exterior well approaches three feet below ground surface, we recognize that a drain may need to be installed.

The Heins West cell of the Northern Heins complex as well as the Southern complex have shown to cause a considerable amount of mounding. To mitigate potential groundwater mounding caused by the reduced flow through the slurry walls, a subsurface drain may be required. If groundwater levels rise to approximately three feet below the ground surface near the exterior of the slurry wall, the drain will be necessary to maintain hydraulic gradients, prevent excessive buildup, and ensure continued groundwater movement. The drain would help relieve pressure, reduce the risk of seepage or surface expression of groundwater, and maintain the effectiveness of the overall groundwater control system.

LIMITATIONS

These are steady-state models and cannot be used to evaluate groundwater return flow timing. The results of the groundwater modeling and conclusions drawn from them represent approximations and are based on the best available data and engineering judgement. Conservative assumptions were made during the calibration process so that groundwater mounding was not under-predicted. Given the unknown heterogeneity of the aquifer in the field and variations in ground surface from the topographic data used, the groundwater mounding and/or drainage mitigation may deviate from the model simulation. There is a possibility that mounding may be higher than predicted, although the conservative assumptions of this work make the deviation toward a lower mound in the field a more likely possibility.

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Friday, June 13, 2025 02:32 PM

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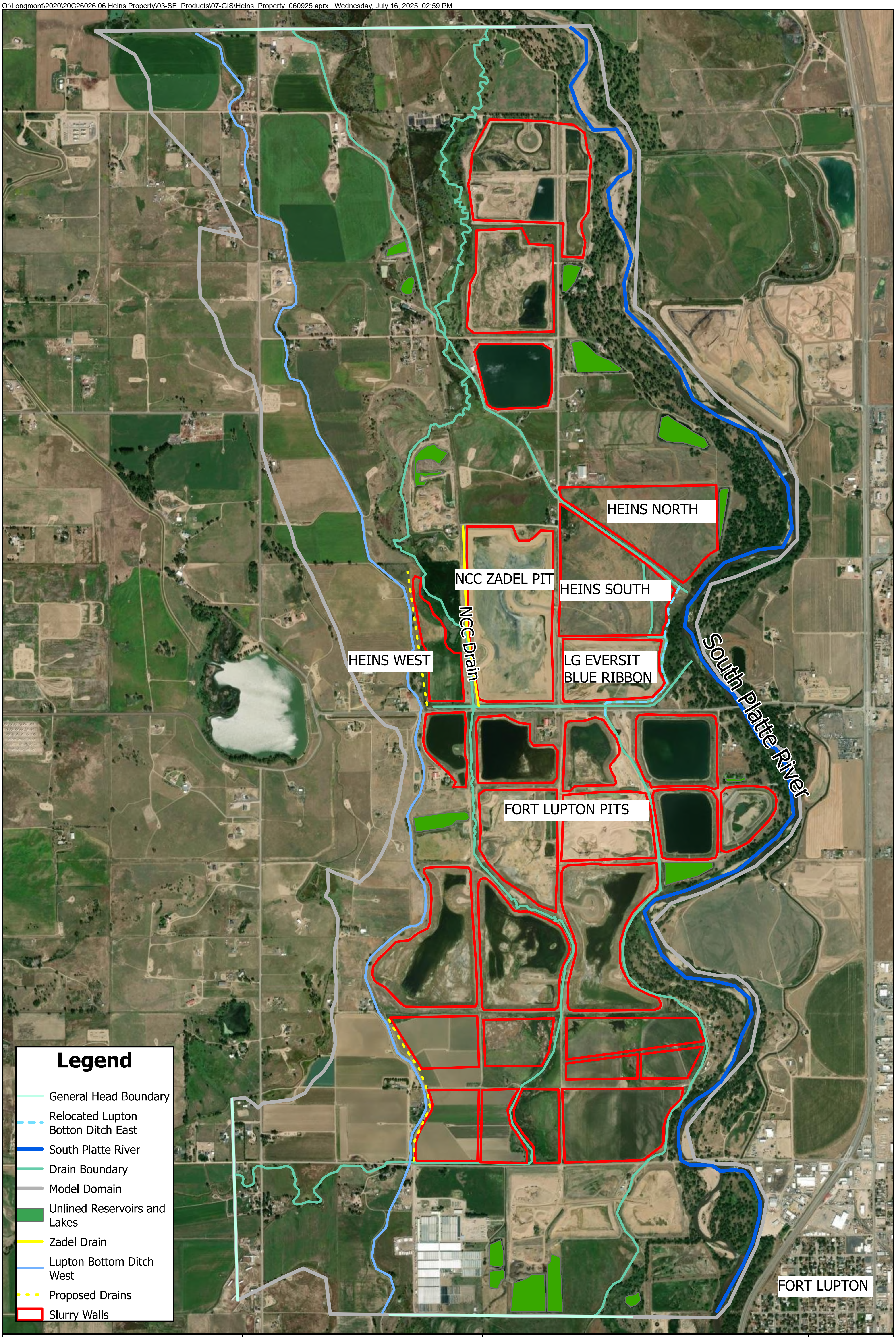

N
0 1,500 3,000
Feet
SCALE: 1 in = 1,500 feet

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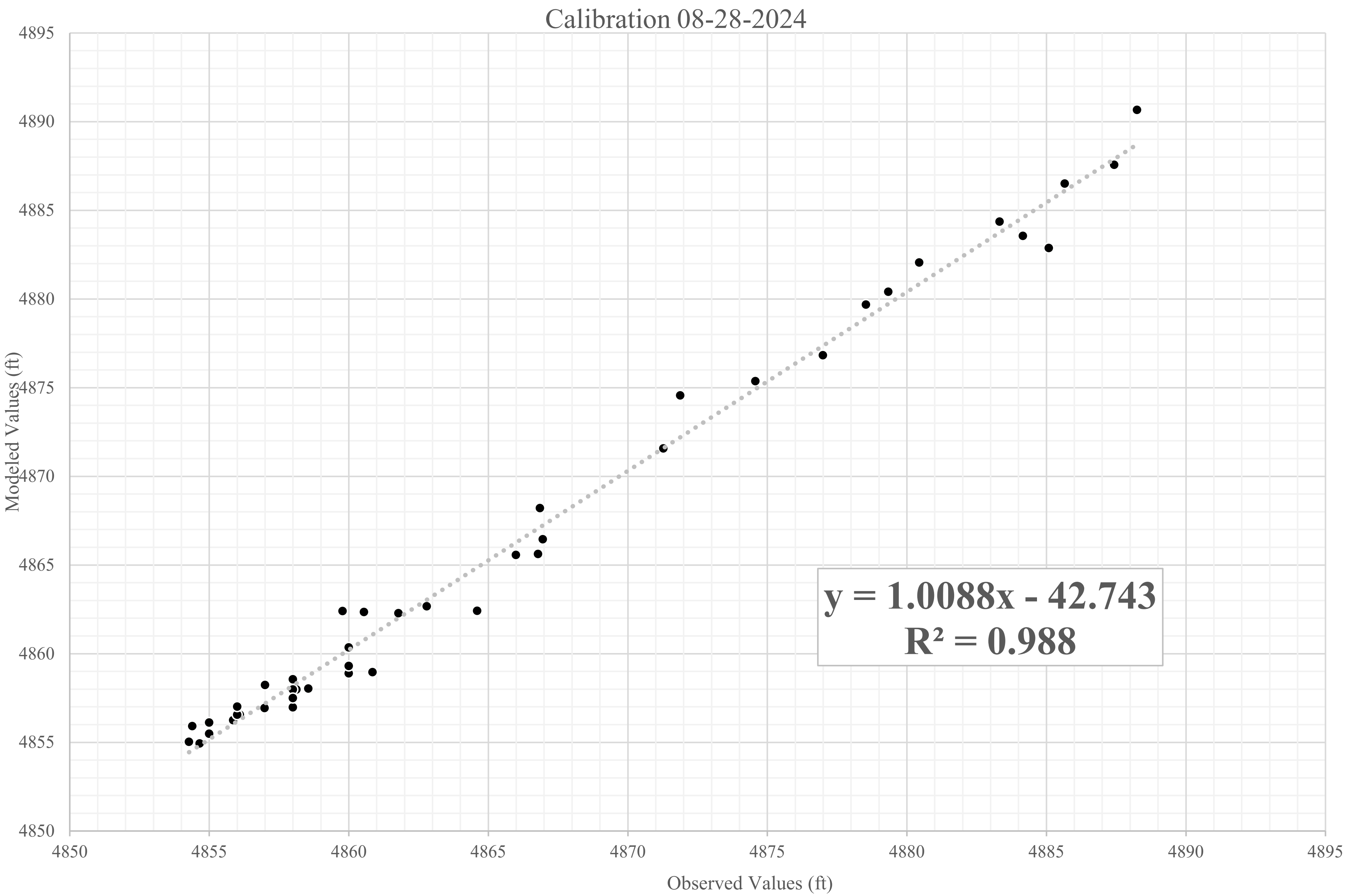
Heins Property Groundwater Model
Model Domain and Boundary Conditions

JOB NO: 20C26026.06 | DATE: 7/16/2025

FIGURE NO.
2



Note:

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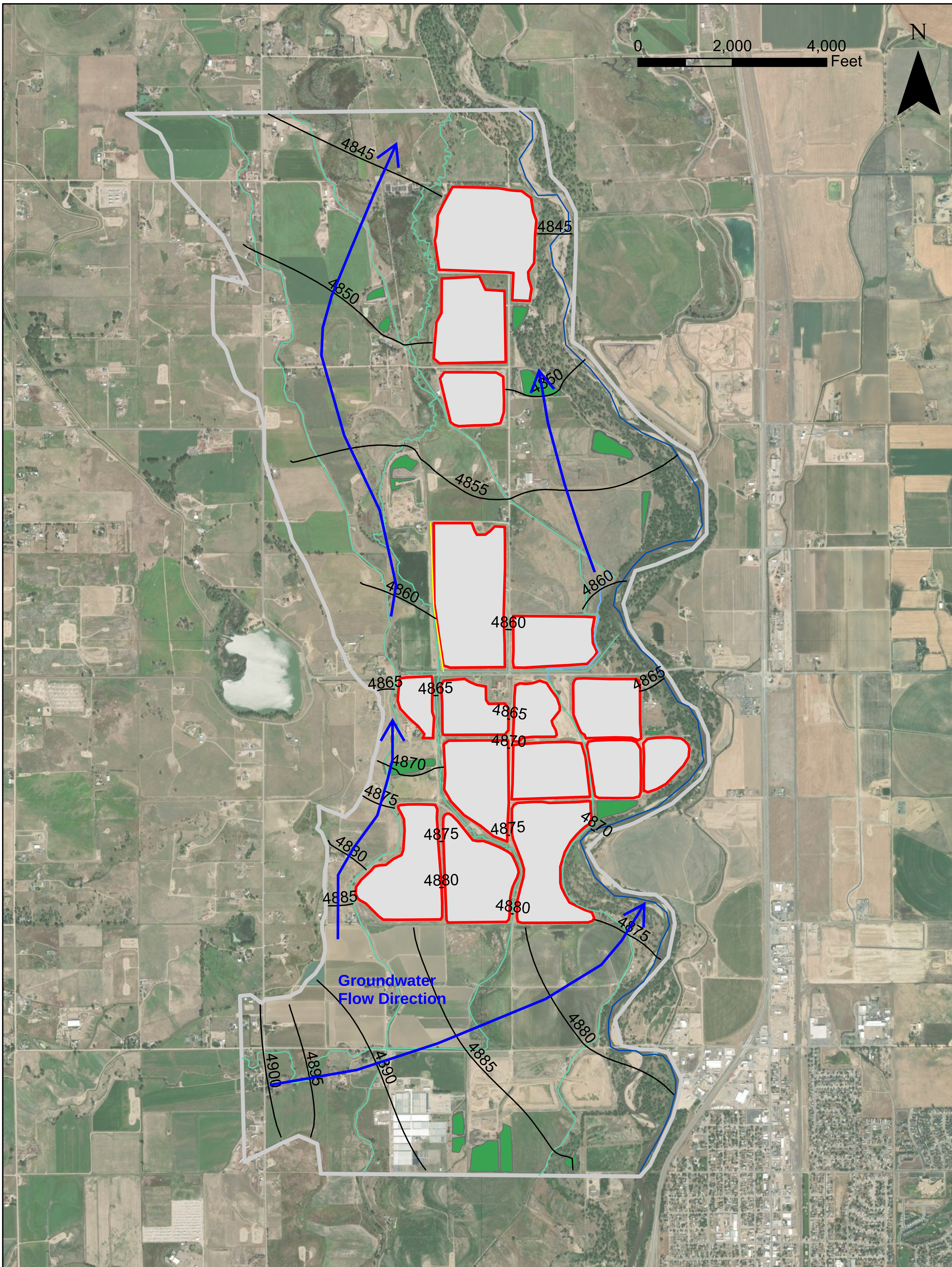
	JOB NO: 20C26026.06	DATE: 06/10/2024	



Legend

- Groundwater Elevation Contour (C.I. = 5ft)
- Lupton Ditch
- South Platte River
- Zadel Drain
- Ditch Drains
- Model Domain
- Slurry Walls
- Lakes

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HEINS PROPERTY GROUNDWATER MODEL
Existing Conditions Steady State Results

7/16/2025	PROJECT NO. 20C26026.06	FIGURE #4

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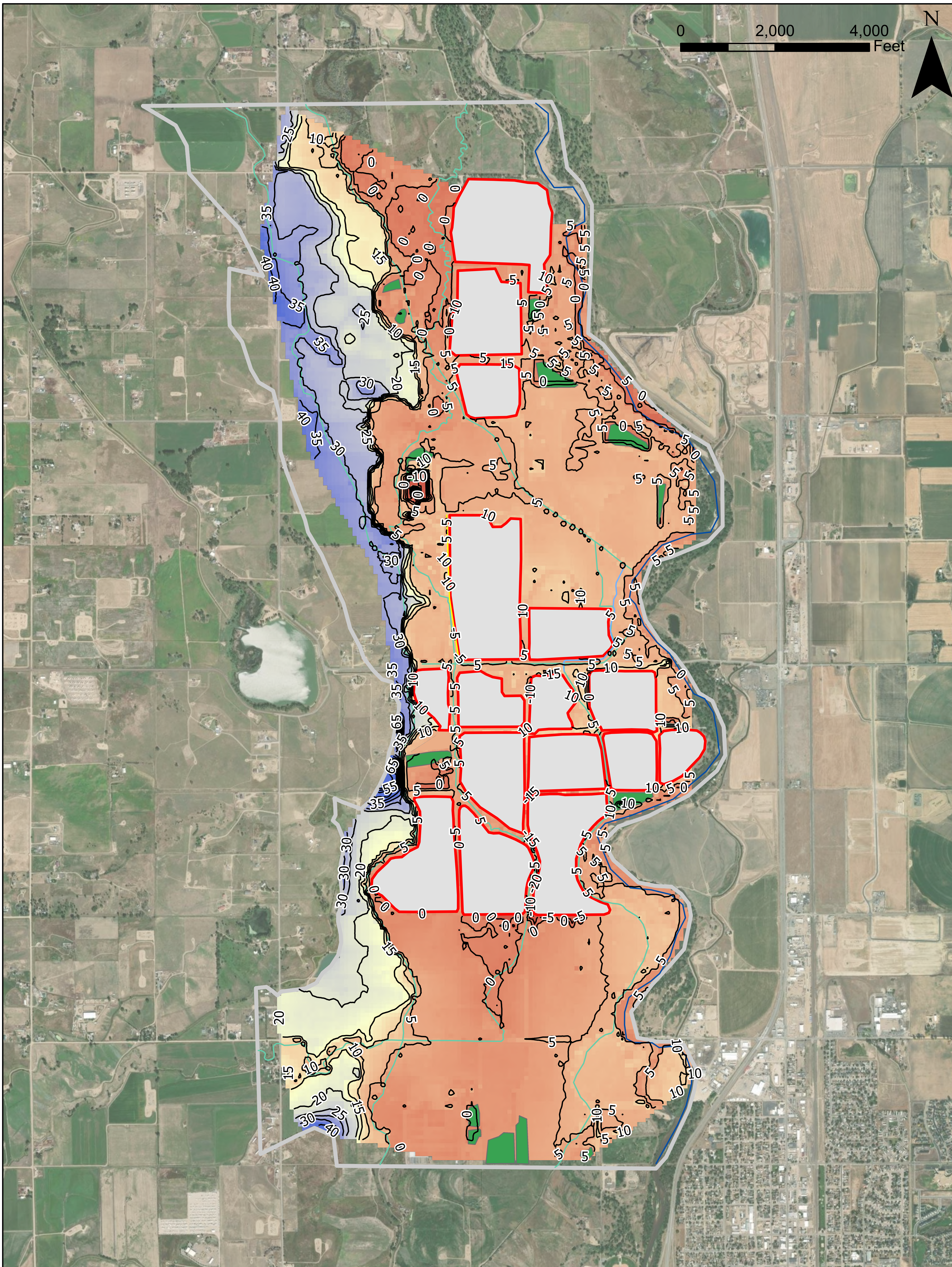

Legend

- Depth to Groundwater (C.I. = 5ft)
- Lupton Ditch
- South Platte River
- Zadel Drain
- Ditch Drains
- Model Domain
- Slurry Walls
- Lakes

Depth to Groundwater (Feet)

69
0

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HEINS PROPERTY GROUNDWATER MODEL
Existing Conditions Depth to Groundwater

7/16/2025	PROJECT NO. 20C26026.06	FIGURE #5

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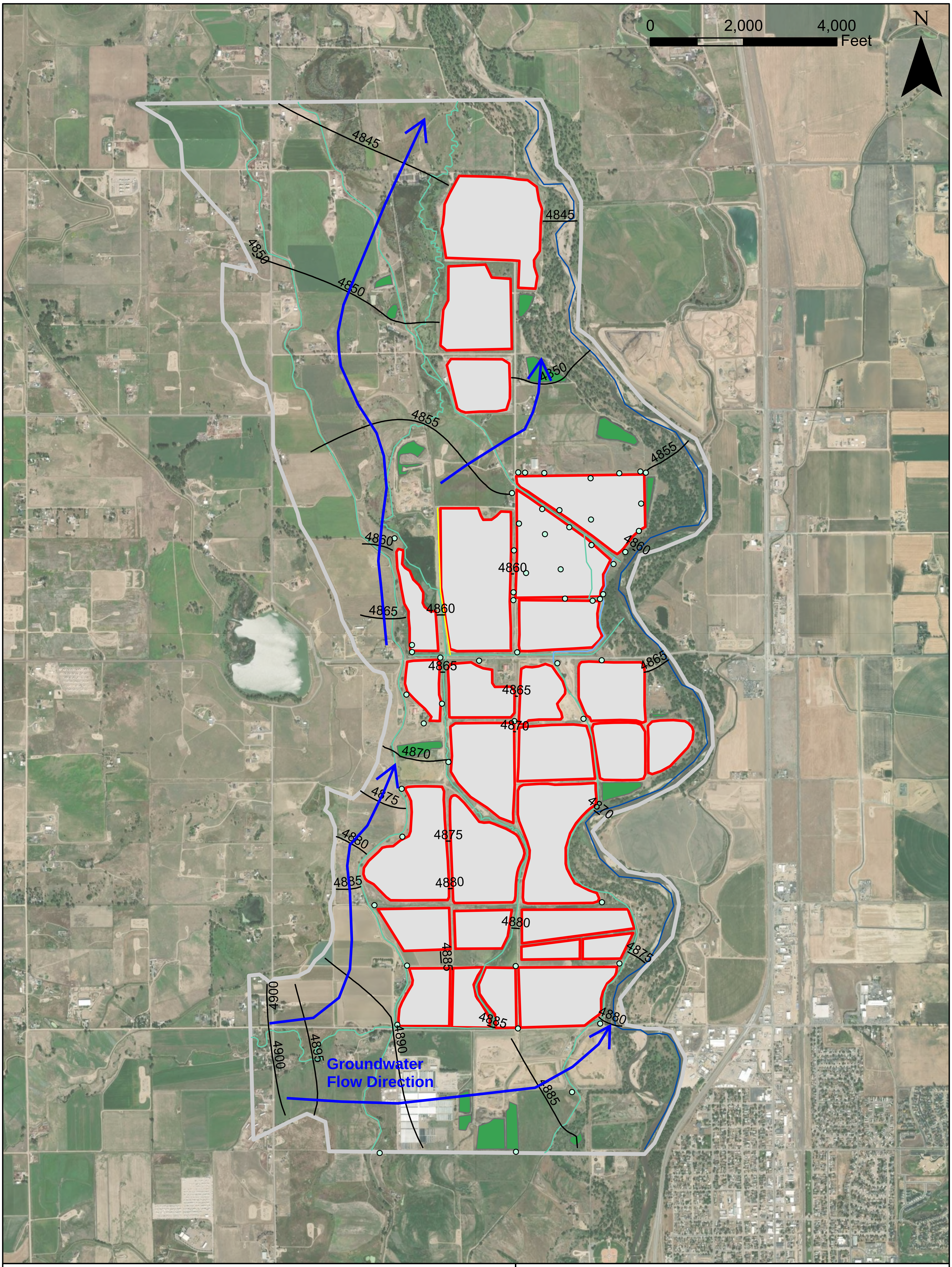

Legend

- Monitoring Wells
- Groundwater Elevation (C.I. = 5ft)
- Lupton Ditch
- South Platte River
- Zadel Drain
- Ditch Drains
- Model Domain
- Slurry Walls
- Lakes

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HEINS PROPERTY GROUNDWATER MODEL
Predictive Simulation Results

7/16/2025	PROJECT NO. 20C26026.06	FIGURE #6

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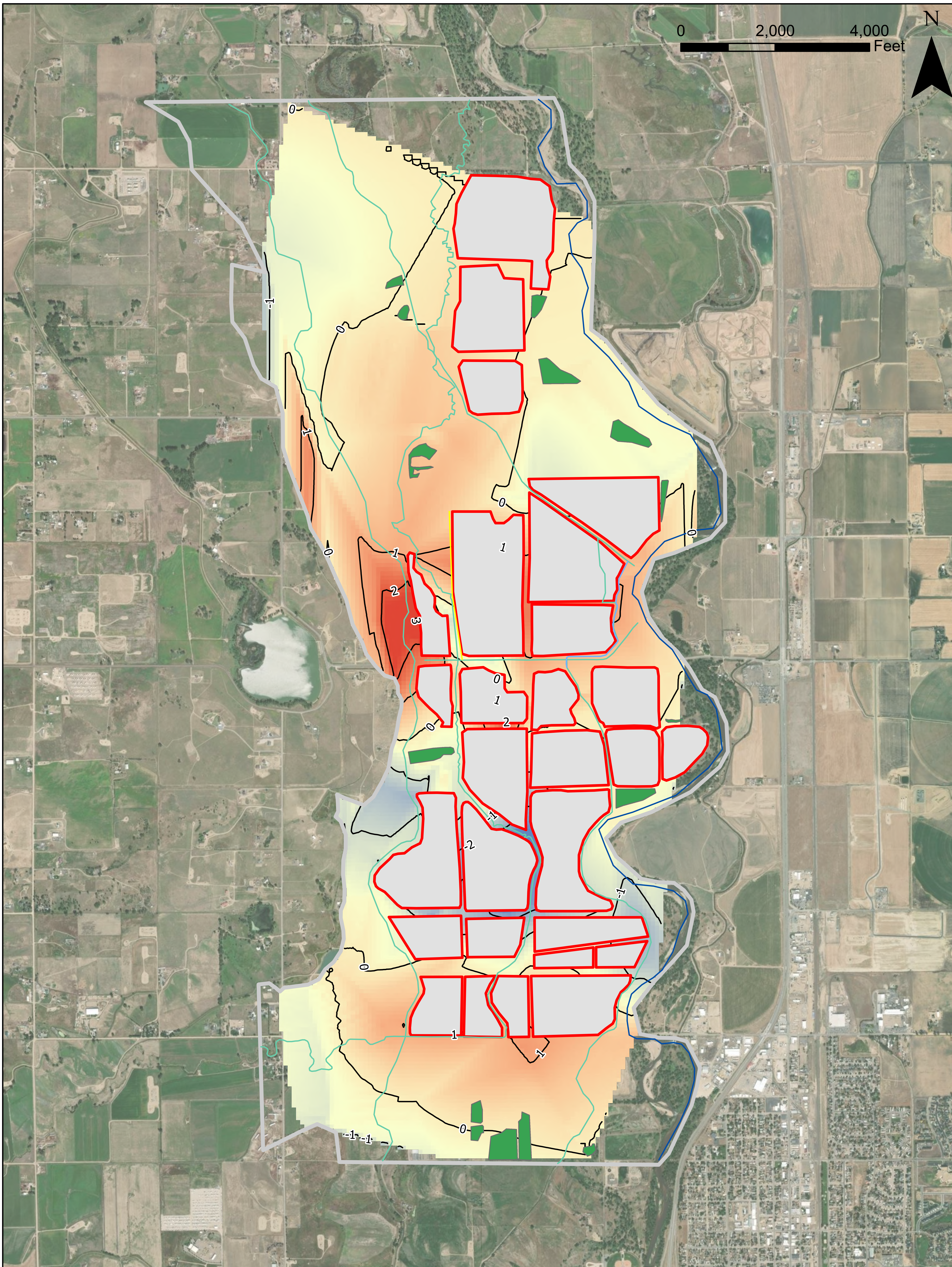

Legend

- Lupton Ditch
- South Platte River
- Zadel Drain
- Ditch Drains
- Model Domain
- Lakes
- Slurry Walls
- Change Contours (C.I. = 1ft)

Change from Existing Results (Feet)

3

-3

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HEINS PROPERTY GROUNDWATER MODEL
Predictive Simulation Change from Existing

7/16/2025	PROJECT NO. 20C26026.06	FIGURE #7

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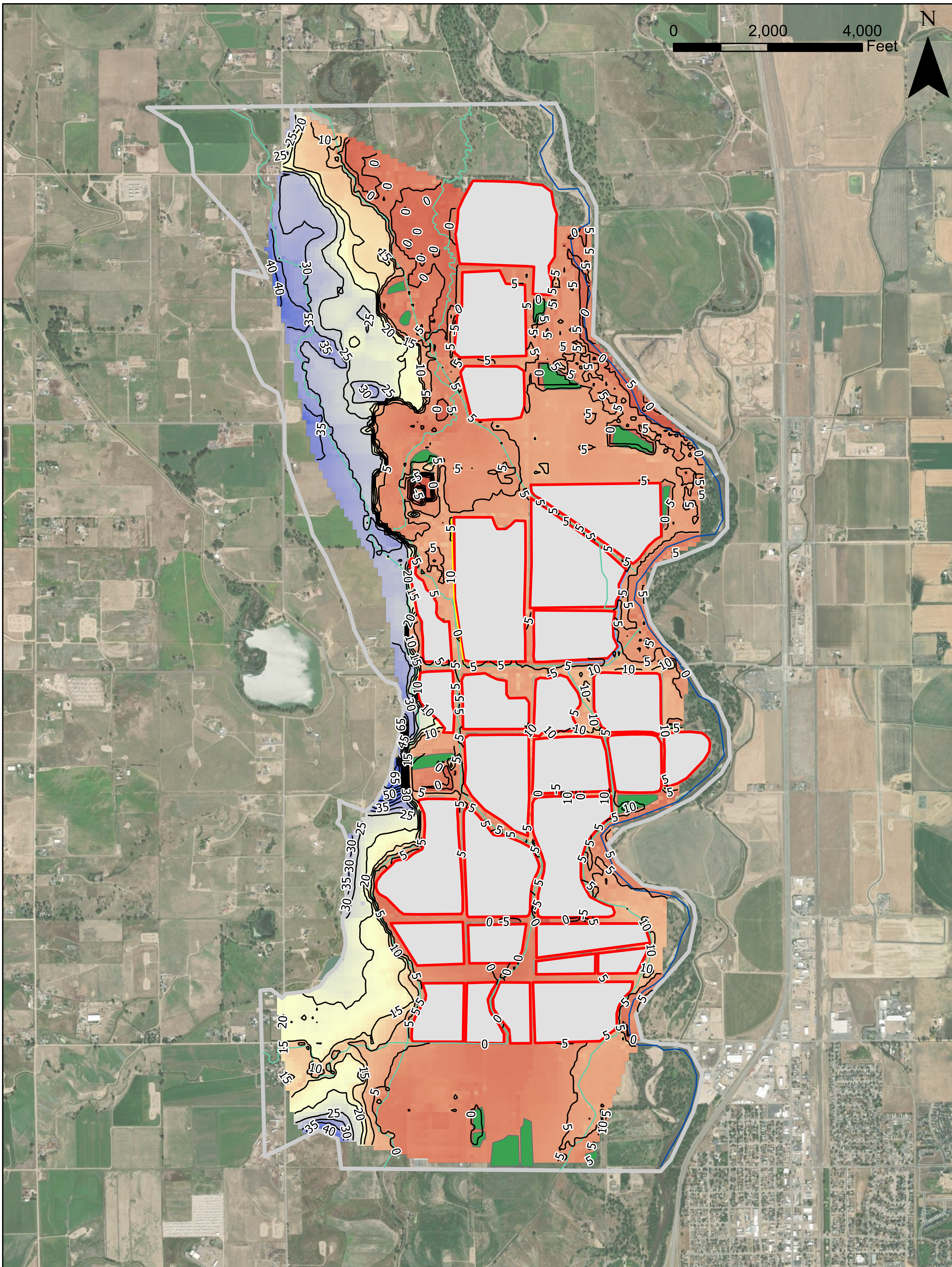

Legend

- Depth to Groundwater (C.I. = 5ft)
- Lupton Ditch
- South Platte River
- Zadel Drain
- Ditch Drains
- Model Domain
- Lakes
- Slurry Walls

Depth to Groundwater (Feet)
70
0

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HEINS PROPERTY GROUNDWATER MODEL
Predictive Simulation Depth to Groundwater

7/16/2025	PROJECT NO. 20C26026.06	FIGURE #8

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