GILCREST AREA ALLUVIAL GROUNDWATER MODEL

POTENTIAL IMPACTS OF PROPOSED GRAVEL MINING

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1.0 INTRODUCTION

The Monarch DENM Gravel Mine (the Site) is located west of Colorado State Highway 85 with Weld County Road 40.5 to the south and is bounded by the South Platte River to the west and north. More specifically, the Site is comprised of portions of Section 18, Section 19, and Section 30, Township 4 North, Range 66 West of the 6th Principal Meridian.

The Site is permitted through the Colorado Division of Reclamation, Mining, and Safety as a construction aggregate material mine. The approved mine plan calls for four (4) soil bentonite slurry wall (slurry wall) lined cells that will encompass most of the Site excluding approximately 15 acres along the eastern side of the Site along Highway 60 which will be wet mined and backfilled with wash fines and waste material. Currently, the Site is utilized for pivot irrigated and dry land farming.

A groundwater model was prepared for Monarch Mountain Minerals and Aggregates' (MMMA) Monarch DENM Gravel Mine Site to investigate the impacts of the final construction of slurry walls at the Site on the surrounding alluvial aquifer. This report details the model inputs and construction, the findings of the model and recommendations to mitigate alluvial aquifer impacts.

2.0 AREA GEOLOGY

The Site is located approximately 25 miles east of the eastern flank of the Rocky Mountain Front Range. Younger sedimentary strata dip eastward off the Pre-Cambrian igneous and metamorphic rocks that form the core of the Front Range into the Denver Structural Basin. The Denver Basin is an asymmetrical downwarp of sedimentary strata with a steeply dipping west limb and a gently dipping east limb.

Bedrock does not crop out at the Site, however regional geologic mapping of the area (Colton, 1978) indicates the near surface bedrock at the Site is most likely the Laramie Formation. Colton (1978) describes the Laramie Formation as mostly claystone, shale, sandy shale, and lenticular sandstone (refer Figure 1). The regional mapping indicates the bedrock is overlain by the Broadway Alluvium. Colton (1978) describes these alluvial deposits as sand and gravel deposited by the South Platte River and its tributaries. The regional geology map is depicted in Figure 1.

Civil Resources analyzed and mapped bedrock from 177 well logs from the Division of Water Resources as well as 27 borings that were drilled at the site by the operator. As shown on Figure 1, bedrock in the area generally slopes to the northeast following the route of the South Platte River. Approximately one and a half (1.5) miles southeast of the South Platte River the bedrock drops in elevation dramatically from an elevation of 4,697 feet in the southeast corner of the Site to an elevation of 4,664 feet around the Town of Gilcrest. On the southeastern side of Highway 85 the bedrock rises to an elevation of 4,719 feet on the southeast side of Highway 85. Bedrock elevation contours are depicted in Figure 1.

3.0 SITE GEOLOGY

A total of twenty-seven (27) borings were drilled to bedrock at the Monarch DENM Site. Depth to bedrock ranged from 13 feet in H-13 on the lower terrace approximately 800 feet west of the site boundary to 58 feet in H-02 in the northeast corner of the Site. The bedrock encountered at the Site consisted of wet brown weathered claystone in the first 6 inches to 1 foot which transitioned in to moist to dry, olive to grey claystone with further depth. The claystone had a high plasticity and minimal fracturing. The bedrock unit was not sampled. Borehole locations and depth to bedrock are included in Figure 1.

The alluvial aquifer at the Site consists mainly of gravelly sand which grades to sandy gravel, usually becoming more gravelly with depth. Aggregate unit thickness varied from 11 feet in H-13 west of the Site to 57 feet in H-02 in the northeastern side of the Site.

4.0 EXISTING GROUNDWATER CONDITIONS

Groundwater was measured in seven (7) piezometers, and typically occurs at depths usually ranging from 4.6' to 29.3' feet below surface with shallower groundwater to the north and west of the Site. The prevailing groundwater flow direction at the Site is to the northwest reflecting the Site topography. Groundwater in the area is tributary to the South Platte River located west of the site. Depth to groundwater is shallower, as little as 5 feet, underlying the Town of Gilcrest likely due to the deep bedrock and low topography relative to the surrounding area. Locally the groundwater levels and flow directions are influenced by:

- The South Platte River is northwest of the Site. For most of the year, the river likely acts as a drainage way, or gaining river reach, maintaining groundwater levels at elevations greater than water elevations in the river. In shorter periods of high runoff, usually in the spring, river water levels will locally recharge the groundwater table.

- The Farmers Independent Ditch (FIDCO) passes southeast of the Site under the intersection of Weld County Road 42 and Weld County Road 29. North of Weld County Road 36, the ditch joins with a wetland drain which likely provides water year-round. During the irrigation season, the ditch diverts water from the South Platte River as well raising the water level of the ditch.

- The Western Mutual Ditch (Western) traverses the southeast corner of the Site and bisects Cell 1 and 2. The ditch flows most of the year based on diversion records for the ditch headgate located southwest of Platteville.

- The Evans #2 Ditch passes southeast of the Town of Gilcrest on the eastern side of Highway 85. The ditch did not have discharge during the months of November and December but did have flow during the remainder of the year.

- The Platte Valley Ditch branches off from the Evans #2 Ditch south of the Town of Gilcrest. The Platte Valley Ditch does not have a stream gage, so it was assumed that it was flowing at the same time as the Evans #2 Ditch.

- There are two unnamed sloughs approximately 500 feet to the west and another a ½ a mile to the northeast of the Site, respectively. These sloughs receive groundwater flowing out from the higher terrace and act as drains transporting water to the river.

- There are multiple recharge ponds in the area of interest which provide groundwater recharge (refer Figure 2).

- Irrigation: The Site is located in an area of irrigated cropland. Applied irrigation that is not lost to evaporation and transpiration recharges the groundwater.

- Alluvial wells: Other than the seven monitoring wells drilled at the Site for monitoring groundwater levels, there are also eight pumping wells permitted within 600 feet of the mine property.

Wells within 600 feet of the permit boundary (not owned by the site property owner) are discussed below:

- Carrol Sorrell Well 12462-R-R: This well is northeast of the plant area and is cross-gradient from the site. It is not expected to see a rise or fall due to the mine.

- Richard Karbowski Well 216684—8: This well is located between the north Freshwater Pond and the Siltation Pond. During mining of the North Freshwater Pond and Siltation Pond this well may see some drawdown due to the dewatering process. A monitoring well was installed approximately 250 feet to the west in order to monitor the effects of dewatering on the Karbowski well.

- Red Tierra Equities LLC Well 13689-R-R: This well is approximately 350 feet east of the Siltation Pond and may see some drawdown during dewatering of the Siltation Pond.

- United Water and Sanitation District Well 14028-R: This well is located approximately 365' southeast of the southern Fresh Water Pond. This well is upgradient from the unlined Fresh Water Pond and may see some drawdown during dewatering operations.

- Gerald Moran Well 187426—A: This well is located approximately 220 feet southeast and upgradient from the slurry wall lined Cell 2 and north of the Western Mutual Ditch. This well may see a groundwater mounding effect from the Cell 2 slurry wall on the order of a couple feet.

- Allan Frank Well 206387-: This well is located approximately 520' south west of the slurry wall lined Cell 1. The well is cross-gradient from Cell 2 and it is not anticipated to see changes in groundwater table.

- Janice Frank Well 14042-R: This well is located approximately 520' south west of the slurry wall lined Cell 1. The well is cross-gradient from Cell 2 and it is not anticipated to see changes in groundwater table.

- Ben Gutfelder Well 1874250-: This well is located approximately 275 feet northwest and downgradient from Cell 2. The well may see a groundwater shadow effect from the Cell 2 slurry wall on the order of a couple of feet. The groundwater shadow effect will likely be mitigated by the wells proximity to the South Platte River.

5.0 GROUNDWATER MODEL

The MODFLOW program utilizes a finite-difference mathematical model to simulate groundwater flow and was developed by the United States Geological Survey (USGS). Groundwater Modeling System (GMS V 10.4.10) provided the graphical user interface for entering and reviewing the MODLFOW data. The model has a total area of approximately 42 square miles, extending from the South Platte River to the west, the Town of Platteville to the south, the Evans #2 Ditch to the east and the Town of La Salle to the north (refer to Figure 1). The grid size was set at 200 feet by 200 feet squares.

The following boundary conditions were applied to the model as presented in Figure 2:

- South Platte River to the northwest (River Package within MODFLOW);

- A constant head boundary to the south;

- A no flow boundary to the east to simulate the rise in bedrock east of Highway 85;

- A constant head boundary to the north;

- Claystone bedrock – acting as an aquiclude forming the bottom of the aquifer.

The shallow alluvial aquifer was modeled as a single aquifer (sand and small gravel), with zoned hydraulic conductivities based on historical well pumping tests, underlain by impervious claystone bedrock. The model parameters and boundary conditions, such as Site topography, bedrock elevations, and hydraulic conductivities are further discussed in the following sections.

5.1 *Regional Topography*

Surface topography was obtained from USGS digital quadrangle (the Milliken 7.5 minute quadrangle). The digital map was converted into a Civil 3d surface and imported to GMS and interpolated to the top elevations of the aquifer layer.

5.2 Bedrock Surface

The bedrock surface for the Site was obtained from borings completed by the Operator at the Site, borings completed by Civil Resources at the Section 20 Site, and 177 wells logs retrieved from the Colorado Division of Water Resources website. These points were entered into Civil 3d to create a surface and smoothed using natural neighbor interpolation with a 20-foot by 20-foot interval. The locations of the bedrock points are shown on Figure 1. Bedrock is exposed to the west of the South Platte River, indicating that the alluvial aquifer pinches out to the west. A feature line was used to map out the bedrock outcrop to bring the bedrock surface to meet the ground surface west of the river. Corrections were made to this surface to lower the bedrock in areas in order to maintain usable cells along the river corridor and bedrock is likely shallower than the model input in this region.

5.3 Hydraulic Conductivity

Hydraulic conductivity is a measure of the soils ability to transmit water within the aquifer. Some factors affecting hydraulic conductivity are: pore size distribution, grain size distribution, void ratio, roughness of mineral particles, and degree of soil saturation (Das, 1998). The alluvium, underlying the region, is generally a clean to silty sand and gravel, as described above with an approximate depth of 50 to 95 feet in the upper terrace and shallower than 10 feet along the South Platte River floodplain. Aquifer properties used in a previous study of the area performed by Bishop-Brogden Associates, Inc.(BBA) for the Town of Gilcrest were incorporated as this report utilized two long-term aquifer pumping tests in the vicinity of Gilcrest: the B4-66-11adc well 3 miles north of Gilcrest and the Lorenz Well approximately ½ mile to the east of Gilcrest.

- The B4-66-011adc well approximately 3 miles north of Gilcrest is the nearest controlled long-term aquifer pumping and showed a hydraulic conductivity of 1,270 ft/day.

- BBA performed an analysis of water level data from observation wells located near the Lorenz Well approximately ½ mile to the east of Gilcrest. Their analysis indicated a hydraulic conductivity of approximately 150 ft/day.

The hydraulic conductivity was set at the lower end of the ranges provided by BBA and were increased until the model heads converged. The model is sensitive to horizontal hydraulic conductivity and operates without errors in a narrow range of values at the high end of the ranges provided by BBA.

Horizontal hydraulic conductivity for the calibrated model range from a low of 65 ft/day for the hills to the east and a high of 805 ft/day underlying the Site. A map with the horizontal hydraulic conductivity values utilized in the model is shown on Figure 3.

5.4 Specific Yield

Specific yield for the aquifer was set at 20% which corresponds to the value determined by BBA and in support of numerous water court decrees.

5.5 Boundary Conditions

Boundary conditions were set based on geologic features on the east and west sides of the model. The constant head boundaries on the south and north sides were varied to match observed groundwater data sets.

- Boundary conditions in a groundwater model are one tool used to approximate existing conditions at the outer extent of the model. The boundary conditions are set sufficiently far away from the area of interest to allow the aquifer to respond to local stresses and are based on hydraulic, hydrogeologic, hydrologic, geological and geographical assumptions.

- The model extends 3.3 miles southwest where constant head nodes were placed approximately 14 feet below the ground surface to represent existing groundwater levels taken in the area.

- Another constant head boundary was placed approximately 3.7 miles northeast Site and constant head nodes were placed on the southeastern flank at water surface elevations approximately ten feet below the ground.

- To the southeast of the model surface topography and bedrock slope up in elevation creating a natural barrier to flow. The eastern limit of the alluvial aquifer was confirmed by researching the states database of permitted wells in the area and mapping where the permitted aquifer switches from the alluvial aquifer to a deep confined aquifer. The approximate location of the shallow and deep aquifer divide is approximately ¼ mile east the location of the Platte Valley Ditch.

- The South Platte River forms a natural hydrologic boundary to the west of the model. Model inputs for the MODFLOW river package are bottom elevation, head-stage and conductivity. The bed elevation was estimated using the USGS topographic quadrangle and Google Earth top of bed elevation and subtracting 6 feet to account for riverbed depth. Head-stage was taken from the South Platte River at Platteville, CO (PLAPLACO) monitoring station which was approximately 4' during the period of interest. See Appendix A for the PLAPLACO station discharge graph.

- River conductance is a model parameter in the river package which simulates the riverbed's ability to transfer water to the neighboring cell. The river conductance parameter is calculated by taking vertical hydraulic conductivity divided by bed thickness multiplied by river width. This value is then multiplied by GMS for the length of the river arc to which it is applied. Since the riverbed hydraulic conductivity is unknown for this reach of the South Platte River, it was necessary to calibrate this parameter to groundwater conditions at the Site. An initial conductance of 36 ft/day was determined from well test reports that occurred upstream of the Site north of Fort Lupton. Since the South Platte River acts as a drain throughout the reach, conductance values less than 150 ft/day caused unrealistic head values and flooded cells. Values higher than 160 ft/day cause head values to drop and dry cells through the area. The river conductance was modeled to increase from 150 ft/day where the river enters the model to 160 ft/day where the river exits the model. The rise in conductance was implemented to account for an increase in river width after the addition of the Saint Vrain River and groundwater inflows.

A summary of the boundary conditions is presented in Table 1 below.

Table 1: Boundary Conditions

Area	*Boundary*	*Notes*
North	Model extends 3.7 miles to the northeast	See Figure 1
West	South Platte River located approximately 4,000 feet west of Site	River bounds the western side of the model, see Figure 1
South	Model extends 3.3 miles to the southwest	Constant head nodes, see Figure 1
East	Steeper Slopes to a ridge, wells change from shallow to deep	See Figure 1

The model boundary conditions are shown on Figure 2

5.6 Internal Influences

Surface features and activities that affect the alluvial groundwater include:

- Ditches – There are four (4) ditches that traverse the interior of the model. These ditches were modeled in GMS as river nodes. As discussed in the South Platte River boundary condition above, the model inputs for the MODFLOW river package are: bottom elevation, head-stage, and conductance.

  The bed thickness for the ditches were all assumed to be 2 feet thick and to have a relatively low vertical hydraulic conductivity to limit seepage and were used as a calibration tool to match local groundwater elevations. Head stage was estimated from the FRMDITCO, WESDITCO, EVANS2CO river diversion monitoring stations(See Appendix A). The HB12-1278 Study of the South Platte River Alluvial Aquifer, performed by Colorado State University, states that calculated ditch seepage in the ranges from 10 to 50 percent, averaging at 23 percent. In the area of interest, ditch width ranges from approximately 10 feet wide to 30 feet wide. Assuming the 2-foot bed thickness and starting with 10 percent seepage, ditch conductance was set at 0.5 ft/day and was raised incrementally until known groundwater head elevations and gradient were reached. It was assumed that seepage from the ditches reduced over distance as water was consumed. See Figure 1 for inputted parameters.

  The Western Mutual Ditch was the main factor in affecting groundwater levels at the Monarch DENM Site and small changes in head elevation and conductance were used to calibrate the river input to reach observed head measurements throughout the Site.

- Drains – A series of drains were set at the base of three sloughs along the South Platte River. These drains were necessary to pull head elevations down to the slough elevation and not flood out the cells in the floodway. The drain inputs are bottom elevation and conductance. The bottom elevation was estimated from the USGS Quadrangle Map and were assumed to be at least 2 feet deep. The conductance input was set high enough to account for all water that was above the drain bottom to model the slough action of removing groundwater and setting groundwater head levels at the base of the terrace.

- Recharge – A number of upgradient recharge Sites were listed in the BBA report and were added to this model. The recharge values and location are located on Figure 2. It was assumed that pivot and flood irrigation contributed 0.001 feet per day to the groundwater table over the whole model area during irrigation season.

6.0 MODEL SIMULATIONS

Model simulations were completed to calibrate the model to reasonably represent the existing conditions and subsequently estimate the proposed change in hydrologic conditions.

6.1 Existing Conditions

Steady-state modeling of average baseline conditions of April through July were used to calibrate the system equilibrium to the measured water levels. Monthly water level readings and other reported data can be seen in Appendix A. The aquifer was modeled as consisting of alluvium from the existing ground surface to the top of bedrock. Civil Resources evaluated the claystone bedrock as an aquiclude, thereby forming the bottom of the model. The observed water levels used to calibrate the steady-state model are shown on Figure 1.

Calibration is the process of refining input parameters and boundary conditions, within reason, so the model reflects observed water levels. Parameters including: 1) hydraulic conductivity, 2) river conductance, 3) river head, 4) river bottom elevations, and 5) drain conductance were adjusted during calibration. The groundwater levels to the northeast were estimated from the level of the Lower Latham Reservoir. Groundwater levels to the southwest were estimated from monitoring wells in the area. The South Platte River, ditches and drain bottom elevations were estimated utilizing the USGS Quadrangle map and water surface elevations were estimated using stream gage head information from the DWR website(See Appendix A).

Figure 5 shows the modeled groundwater contours and Figure 5A shows the modeled groundwater contours zoomed in on the Site and the Section 20 Site. Table 2 below reports the steady-state modeled water levels and the measured water levels at the Site. Overall, the model matched the existing groundwater gradient to a good degree of accuracy and 6 out of the 7 Site monitoring wells were within 1.0 feet of observed with one well, PZ-09, which was modeled at 1.46 feet above the observed head elevation.

Groundwater levels for monitoring wells in the Town of Gilcrest were also utilized in calibration of the model. The BBA report contained well readings from multiple wells in the Town of Gilcrest measured in 2014. It was assumed that these readings were similar to current head elevations and four (4) monitoring wells were included to get a representative sample of the Town. Of the four(4) wells chosen, three (3) of them were within 0.5 feet of observed. BBA-EC, northeast of town on the eastern side of Highway 85 was 1.5 feet lower than the observed elevation head. The monitoring wells included in the BBA report were recorded in 1-foot intervals, which could account for the 1.5 feet difference. Table 2 below has the comparison between the measured and modeled groundwater levels at the Site. The head contours for the baseline condition are shown on Figure 4.

Table 2: Measured and Modeled Site Groundwater Levels

Well	Observed	Modeled	Difference	Cell (IJK)
PZ-01	4,712.93	4712.32	-0.61	146,111,1
PZ-04	4,712.60	4712.44	-0.16	136,119,1
PZ-09	4,723.90	4725.36	1.46	142,136,1
PZ-15	4,723.89	4724.4	0.51	153,136,1
PZ-20	4,737.52	4737.8	0.28	162,133,1
PZ-25	4,733.10	4733.1	0.00	162,115,1
PZ-27	4,741.33	4741.2	-0.13	148,122,1
BBA-MW4	4741	4740.3	-0.70	148,122,1
BBA-MW11	4737	4736.9	-0.10	148,122,1
BBA-MW17	4735	4734.4	-0.60	166,164,1
BBA-MW18	4738	4737.25	-0.75	148,122,1

6.2 Slurry Wall Installation Simulation

The Site is planned for a sequence of soil bentonite slurry wall lined cells encompassing the majority of the Site. The only area not planned to be slurry wall lined is the siltation and freshwater ponds along the eastern edge of the site parallel to Highway 60. The slurry walls will be constructed in stages starting in the south and progressing north. In order to model for the worst-case scenario with no mitigation, the model simulates the full buildout of all the sites slurry walls and filling in the siltation and freshwater ponds with waste material of a lower hydraulic conductivity. To make the slurry wall lined cells no flow areas, the horizontal hydraulic conductivity of these areas were set to zero (0) feet/day. The area where the Western Mutual Ditch runs through the Site remained at the 470 feet/day horizontal hydraulic conductivity. The horizontal hydraulic conductivity for the siltation and freshwater ponds was set to 75 feet/day to simulate filling the ponds with site overburden.

The mounding and shadowing for the surrounding properties and wells is described in Table 3 below:

Table 3: Surrounding Property Groundwater Elevations – Site Slurry Walls

Location	Basement (y/n)	Baseline	After Slurry Wall Construction	Difference (FT Rise or Fall)	Groundwater Depth Below Surface	Surface Elevation (Google Earth)
Knutson Barn	n	4713.3	4713.7	0.4	13.3	4727
Karbowski Brave House	n	4725.4	4729.8	4.4	24.2	4754
Red Tierra House	n	4727.9	4732.0	4.1	28.0	4756
Sharp House	y	4738.3	4742.7	4.4	13.3	4760
Greybill House	y	4738.2	4743.8	5.6	13.2	4756
Poncelow House	n	4735.2	4740.7	5.5	24.3	4757
Moran House	y	4738.8	4744.5	5.7	19.5	4765
Doolittle House	y	4740.2	4745.6	5.4	20.4	4764
Maroney House	y	4741.8	4746.6	4.8	19.4	4766
Scott House	y	4742.3	4747.3	5.0	22.7	4766
Meining House	y	4744.1	4748.4	4.3	16.6	4770
Schmunk House	y	4741.8	4745.2	3.4	16.8	4765
Guevara House	y	4741.2	4743.6	2.4	20.4	4762
Frank House	y	4739.7	4741.2	1.5	13.8	4764
Gutfelder House	n	4728.3	4725.8	-2.5	29.2	4755
Gilcrest Valley HS	NA	4737.0	4738.2	1.2	7.8	4746

As noted in the table above, groundwater elevation impacts from the installation of the slurry walls will be highly spatially variable. The area east of Cell 2 is expected to see the most amount of mounding, up to 5.7 feet above baseline levels at the Moran property. Depth to groundwater in this area after construction of the slurry wall ranges from 18.4 to 20.5 feet below grade, so flooding is not anticipated to be an issue. Mounding decreases to the west of Cell 1 with the Schmunk house on the southwest corner of the Site potentially seeing 3.4 feet of mounding. Elevation from Google Earth for the Schmunk property is approximately 4765 feet, which would put the potential groundwater rise at approximately 16.8 feet below the surface.

Potential shadow effects from the slurry wall are present north of the Site (downgradient). There is one (1) well on the north side of the Site, between the site and the South Platte River, which will be in the groundwater shadow. The drop in groundwater elevation at this well was modeled at approximately 2.5 feet at full buildout of the site. The shadow effect is likely mitigated by the close proximity of the slough which is approximately two hundred (200) feet to the northwest and the proximity to the South Platte River. The modest shadow effect should have limited effect on the productivity of local alluvial wells.

The Town of Gilcrest is located between the Site and a rise in the bedrock elevation to the east which acts as a no flow boundary. It is anticipated that slurry wall construction will restrict flow to the west of Town causing elevated groundwater levels in Town as noted for "Gilcrest Valley HS" in the table above.

6.2.1 Red Tierra Equities, LLC Section 20 Site Impacts

In addition to the Monarch DENM Gravel Mine, the Red Tierra Equities, LLC (Red Tierra) Section 20 Gravel Mine has applied for a DRMS 112 Reclamation Permit on the east side of Highway 60. This site is comprised of eight (8) slurry wall lined cells and one (1) unlined cell at the northwest corner of the site. To simulate the eight (8) lined cells, the horizontal hydraulic conductivity in these areas was set to zero (0). The additional impacts from adding this site to the model are presented in Table 4 below and a layout of the site is shown on Figure 5 and 5A.

Table 4: Surrounding Property Groundwater Elevations – Both Sites

Location	Baseline	Full Buildout with Section 20	Difference
Knutson Barn	4713.3	4710.8	-2.50
Karbowski Brave House	4725.4	4731.4	6.00
Red Tierra House*	4727.9	NA	NA
Sharp House	4738.3	4750.8	12.50
Greybill House	4738.2	4749.9	11.70
Poncelow House	4735.2	4745.5	10.30
Moran House	4738.8	4749.3	10.50
Doolittle House	4740.2	4750.3	10.10
Maroney House	4741.8	4751.2	9.40
Scott House	4742.3	4751.8	9.50
Meining House	4744.1	4752.7	8.60
Schmunk House	4741.8	4747.5	5.70
Guevara House	4741.2	4745.6	4.40
Frank House	4739.7	4743.7	4.00
Gutfelder House	4728.3	4726.4	-1.90
Gilcrest Valley HS	4737.0	4742.5	5.57

**Red Tierra House is inside of the proposed Section 20 slurry wall lined Cell 8.*

The addition of the full build out of the Section 20 Gravel Mine increases mounding on the southern side of the Monarch DENM Site by limiting groundwater flow to the east. The additional slurry walls constructed along the eastern side of Highway 60 creates a groundwater corridor along Highway 60 north to the South Platte River, which causes the groundwater at the Sharp House to rise approximately twelve (12) feet from baseline conditions.

6.3 <u>Mitigation</u>

This section describes potential mitigation actions to decrease the mounding effect of slurry wall construction on the surrounding properties and the Town. The Section 20 Gravel Mine timeline, submitted to the DRMS, was utilized in conjunction with the Monarch DENM expected timeline to determine the phasing of mitigation construction. These timelines are approximate and are subject to change which may necessitate early construction of mitigation structures depending on measured groundwater conditions at the Site.

The shadow effect to the north and west will likely be minimized by the proximity to the unnamed slough and the South Platte River. At this time no mitigation is recommended to address shadowing to the north and west unless groundwater monitoring demonstrates that the drop in groundwater head elevations is larger than anticipated and has a demonstrable negative impact. Mitigation would be warranted if the well owner to the north of Cell 2 complains about decreased pumping rates or their wells going dry. This is not anticipated because the modeled saturated thickness of the alluvial deposit is still eighteen (18) to twenty (20) feet at full buildout of both sites and the proximity to the South Platte River.

The groundwater table to the south of the combined Monarch DENM and Section 20 sites and underlying the Town of Gilcrest is anticipated to rise as a result of the full buildout of the slurry walls at the Site and the Section 20 Site. Since depth to groundwater is relatively deep south of the Site, approximately 14 to 20 feet deep, mounding less than four (4) feet at the Site boundary is unlikely to cause conflicts with structures south of the Site. The mounding is expected to be greatest towards the southeast corner of the Site as described in the previous section and shown on Figure 5. To mitigate against possible groundwater elevation rise in the Town of Gilcrest and the properties to the south of the Site, an implementation trigger of three (3) feet above maximum observed groundwater level was used to implement mitigation at the south Site boundary. As discussed further in the section below, this threshold was exceeded after the construction of the Cell 3 Slurry Wall at which point a mitigation structure is warranted.

Model iterations were run for the following phases: construction of Cell 1 slurry wall, construction of Cell 2 slurry wall, and the construction of the combined Cell 3 and 4 slurry walls.

6.3.1 Cell 1 Slurry Wall Construction

This scenario was modeled to include the construction of the Cell 1 slurry wall at the Site as well as construction of the Section 20 Cell 3 slurry wall. The Cell 1 slurry wall is expected to be constructed four (4) years after the start of mining at the site.

The Cell 1 slurry wall is approximately 5,392 linear feet in length with an approximate average depth of fifty (50) feet. The length of obstruction to the prevailing groundwater flow to the northwest is approximately 2,522 linear feet with an estimated flow obstruction area of 126,100 square feet. The total flow entering this area that is obstructed by the construction of the slurry wall is 122,196 cubic feet per day or approximately 1.4 cubic feet per second, as determined by the seventeen (17) cell flow budget along the southern and eastern edge of Cell 1 from the base model. The installation of the Cell 1 slurry wall caused the modeled groundwater elevation at the southern end of the Site (PZ-27) to rise approximately 0.9 feet, see Table 5 below. No mitigation is recommended for this phase due to the relatively small size of the slurry wall and minimal mounding that was observed up gradient. Table 5 shows the groundwater elevation modeled after the addition of the Cell 1 slurry wall at the site and town monitoring well locations. Figure 7 shows the groundwater head contours for this model iteration.

Table 5
Base Model and Modeled Site Groundwater Level After Cell 1 Slurry Wall

Well	Base	Modeled	Difference	Cell (IJK)
PZ-01	4,712.3	4,712.3	0.0	146,111,1
PZ-04	4,712.4	4,712.4	0.0	136,119,1
PZ-09	4,725.4	4,725.4	0.0	142,136,1
PZ-15	4,724.4	4,724.1	-0.3	153,136,1
PZ-20	4,737.8	4,737.6	-0.2	162,133,1
PZ-25	4,733.1	4,733.1	0.0	162,115,1
PZ-27	4,741.2	4,742.2	0.9	148,122,1
BBA-MW4	4,740.3	4,740.4	0.1	148,122,1
BBA-MW11	4,736.9	4,737.0	0.1	148,122,1
BBA-MW17	4,734.4	4,734.5	0.1	166,164,1
BBA-MW18	4,737.3	4,737.4	0.1	148,122,1

6.3.2 Cell 2 Slurry Wall Construction

Mining in Cell 1 is expected to take approximately four (4) years. The Cell 2 slurry wall will likely be constructed one (1) year prior to completion of Cell 1, three (3) years after starting Cell 1 and five (5) years after the establishment of the Site.

The Cell 2 slurry wall is approximately 7,041 linear feet in length with an estimated curtain area of 345,772 square feet. Cell 2 is down gradient of Cell 1 and is partially in the groundwater shadow caused by the obstruction of the Cell 1 slurry wall. Additional flow area impeded by the Cell 2 slurry wall is approximately 2,100 linear feet, or ten (10) cells along the southeastern and eastern border of the cell. The flow budget into these ten (10) cells, prior to Cell 2 slurry wall construction but after Cell 1 is in place, is 127,755 cubic feet per day or an approximate 1.5 cubic feet per second.

The 1.5 cubic feet per second that is impeded by the insertion of the slurry wall into the model causes the greatest amount of mounding to occur in the southeastern corner of the cell at the location of PZ-20. Groundwater elevation at PZ-20 rises approximately 1.9 feet which is less than the three (3) feet used as the implementation cutoff for mitigation. Therefore, mitigation is not expected to be warranted as a result of construction of Cell 2. Table 6 below depicts the modeled groundwater elevations at the Site monitoring well locations and the Town. Figure 8 depicts the groundwater elevation head contours for this model iteration.

Table 6
Base Model and Modeled Site Groundwater Level After Cell 2 Slurry Wall

Well	Base	Modeled	Difference
PZ-01	4,712.3	4,712.4	0.1
PZ-04	4,712.4	4,712.4	0.0
PZ-09	4,725.4	4,725.7	0.3
PZ-15	4,724.4	4,723.0	-1.4
PZ-20	4,738.3	4,740.2	1.9
PZ-25	4,733.1	4,733.6	0.5
PZ-27	4,741.2	4,742.9	1.7
BBA-MW4	4,740.3	4,740.7	0.4
BBA-MW11	4,736.9	4,737.2	0.3
BBA-MW17	4,734.4	4,734.7	0.3
BBA-MW18	4,737.3	4,737.6	0.4

6.3.3 Cell 3 and 4 Slurry Wall Construction

Mining of Cell 2 is expected to take approximately seven (7) years. As with the case with Cell 2, it is anticipated that construction of the Cell 3 slurry wall will begin one (1) year prior to completion of mining in Cell 2. Since mitigation is warranted prior to construction of Cell 3, as will be discussed in this section, Cell 3 and Cell 4 slurry walls were modeled as one (1) slurry wall constructed at the same time. Most obstruction to groundwater flow is presented by the Cell 3 slurry wall as Cell 4 is in the groundwater shadow of Cell 3. Modeling both cells together allows for the correct sizing and location of the mitigation structures and allows for the potential of constructing one larger cell in the future if timing and financial conditions warrant it.

The Cell 3 and 4 slurry walls are approximately 13,693 linear feet in length around the perimeter of the cells and have a perimeter curtain area of approximately 685,000 square feet. The upgradient section of slurry wall obstructs approximately 6,652 linear feet of groundwater flow encompassing thirty-three (33) MODFLOW cells. The base flow into these cells is 304,518 cubic feet per day or 3.5 cubic feet per second.

Groundwater mounding is most prevalent south of Cell 3 and east of Cell 2, which is modeled to equate to a rise of 5.8' at PZ-20. Obstructing flow through Cells 3 and 4 causes the groundwater gradient to steepen between Cell 2 and Cell 3 to allow for more flow through the constrained area between the cells. The groundwater flow direction to the east of Cells 3 and 4 is changed slightly from a northwest to northward flow direction and causes mounding of approximately 4.8 feet along Highway 60 as shown at PZ-09. The elevation head contours are shown in Figure 9 and are listed in Table 7 below.

Table 7
Base Model and Modeled Site Groundwater Level After Cell 3 and 4 Slurry Walls

Well	Base	Modeled	Difference
PZ-01	4,712.3	4,713.1	0.8
PZ-04	4,712.4	4,712.3	-0.2
PZ-09	4,725.4	4,730.2	4.8
PZ-15	4,724.4	4,723.4	-1.0
PZ-20	4,737.8	4,743.6	5.8
PZ-25	4,733.1	4,737.8	4.7
PZ-27	4,741.2	4,743.8	2.6
BBA-MW4	4,740.3	4,740.7	0.4
BBA-MW11	4,736.9	4,737.2	0.3
BBA-MW17	4,734.4	4,734.7	0.3
BBA-MW18	4,737.3	4,737.6	0.4

Since mounding exceeds the three (3) foot mitigation cut off established in the DRMS monitoring plan, mitigation is warranted prior to completion of the Cell 3 slurry wall.

6.3.3.1 *Cell 3 and Cell 4 Mitigation*
Groundwater flow at base conditions was to the northwest across the Cell 3 and Cell 4 area. With the slurry walls in place, the flow to the river is obstructed and is forced to mound at the southern and southeastern end of the site to pass through the now constrained area between Cell 2 and Cell 3. In order to minimize mounding in these areas an underdrain was set along the southern end of Cell 3 and passing between Cell 2 and Cell 3. The underdrain acts to reroute groundwater that mounds at the southern end of the site and increases the hydraulic conductivity of the area between Cell 2 and Cell 3 thereby decreasing the gradient towards the river.

The underdrain was modeled using the MODFLOW Drain Package. The drain was set at an eastern invert elevation of 4,736.4 feet, approximately at base groundwater elevation and twenty-one (21) feet below surface elevation. The western invert elevation was set at 4,732.9 feet, approximately at below base groundwater elevation and eighteen (18) feet below surface.

The Drain Package allows groundwater to flow into the drain as the groundwater elevation rises above the drain bottom. Groundwater is removed from the model by the Drain Package simulating return flow directly to the river. The total flow returned to the river by the underdrain was 299,000 cubic feet per day or 3.46 cubic feet per second. Table 8 below lists the groundwater elevations with mitigation at the Site and Town monitoring well locations and the water elevation contours are shown on Figure 9.

Table 8
Cell 3 and 4 Slurry Wall with Underdrain Mitigation

Well	Base	Modeled	Difference
PZ-01	4,712.3	4,712.5	0.2
PZ-04	4,712.4	4,712.3	-0.1
PZ-09	4,725.4	4,727.6	2.2
PZ-15	4,724.4	4,722.7	-1.7
PZ-20	4,737.8	4,739.1	1.3
PZ-25	4,733.1	4,734.3	1.2
PZ-27	4,741.2	4,742.7	1.5
BBA-MW4	4,740.3	4,740.7	0.4
BBA-MW11	4,736.9	4,737.2	0.3
BBA-MW17	4,734.4	4,734.7	0.3
BBA-MW18	4,737.3	4,737.6	0.4

6.3.4 Combined Mitigation with Section 20

The Section 20 Gravel Mine is currently in the process of obtaining a DRMS Reclamation Permit. The Section 20 Site consists of eight (8) soil bentonite slurry wall lined cells to be constructed concurrently with the Monarch DENM Site. Slurry wall construction at the Section 20 Site is planned to start in the northwest corner of the site and be completed clockwise around the section. The Section 20 Mine Plan Map is included in Appendix A and the timeline is shown below. The timeline assumes that both sites are completed according to the submitted schedules.

Table 9
Monarch DENM and Section 20 Approximate Construction Timeline

Year	Monarch DENM Expected Slurry Wall Construction Date	Section 20 Expected Slurry Wall Construction Date	Mitigation Structure Installed
2023	-	Cell 3	-
2025	Cell 1	Cell 4	-
2027	-	-	Section 20 Eastern Mitigation
2028	Cell 2	-	-
2031	-	Cell 5N	-
2034	Cell 3	Cell 5S	Monarch Underdrain
2039	-	Cell 6	Section 20 Western Mitigation
2043	-	Cell 7	-
2045	-	Cell 8	-
2047	Cell 4	Site Reclaimed	-
2058	Site Reclaimed	-	-

6.3.4.1 *Monarch Cell 1 Slurry Wall with Section 20*

The timeline assumes that Section 20 is permitted and begins slurry wall construction in 2023. Mining at Monarch DENM was assumed to begin towards the end of 2023. Monarch DENM will begin by mining the Freshwater Pond and Siltation Pond which will take approximately 2.3 years. Approximately one (1) year prior to mining the cell it was assumed that the slurry wall would be constructed which is approximately the same year as construction on the Section 20 Cell 4 slurry wall and the Section 20 eastern mitigation structure. The Section 20 Groundwater Model Report dated December 2022 recommends an underdrain or dewatering wells along the southern border of Cell 5S.

A model iteration was run including the Monarch Cell 1, the Section 20 Cells 3 and 4, and three (3) dewatering wells removing 3.25 cubic feet per second from the model south of the Section 20 Cell 5S. The modeled groundwater elevation is included in the table below and the head contours are shown in Figure 10. The groundwater elevation at the site is below the three (3) foot threshold for mitigation and no mitigation is recommended for the Monarch DENM Site during this phase.

Table 10
Cell 1 and Section 20 Cell 3 and 4 Groundwater Elevations

Well	Base	Modeled	Difference	Cell (IJK)
PZ-01	4,712.3	4,712.1	-0.2	146,111,1
PZ-04	4,712.4	4,712.4	0.0	136,119,1
PZ-09	4,725.4	4,725.1	-0.3	142,136,1
PZ-15	4,724.4	4,724.1	-0.3	153,136,1
PZ-20	4,737.8	4,738.2	0.4	162,133,1
PZ-25	4,733.1	4,733.3	0.2	162,115,1
PZ-27	4,741.2	4,742.1	0.9	148,122,1
BBA-MW4	4,740.3	4,739.9	-0.4	148,122,1
BBA-MW11	4,736.9	4,736.5	-0.4	148,122,1
BBA-MW17	4,734.4	4,734.1	-0.3	166,164,1
BBA-MW18	4,737.3	4,737.0	-0.3	148,122,1

6.3.4.2 *Monarch Cell 3 Slurry Wall with Section 20*
Groundwater elevations at the Site reach the three (3) foot rise mitigation threshold with the construction of Cell 3. A model iteration was run incorporating the Cell 3 and 4 slurry wall along with the buildout of the Section 20 site to Cell 5S. The groundwater elevations at the monitoring wells for the Site and Town are shown below. The underdrain and Section 20 eastern dewatering wells were effective at minimizing mounding at the Site and at Town. Figure 11 shows the groundwater head contours for the phase.

Table 11
Cell 3 and Section 20 Cell 3, 4, 5N, and 5S Groundwater Elevations

Well	Base	Modeled	Difference	Cell (IJK)
PZ-01	4,712.3	4,712.2	-0.1	146,111,1
PZ-04	4,712.4	4,712.3	-0.1	136,119,1
PZ-09	4,725.4	4,727.4	2.0	142,136,1
PZ-15	4,724.4	4,722.7	-1.7	153,136,1
PZ-20	4,737.8	4,739.6	1.8	162,133,1
PZ-25	4,733.1	4,734.4	1.3	162,115,1
PZ-27	4,741.2	4,742.8	1.6	148,122,1
BBA-MW4	4,740.3	4,740.4	0.1	148,122,1
BBA-MW11	4,736.9	4,736.9	0.0	148,122,1
BBA-MW17	4,734.4	4,734.4	0.0	166,164,1
BBA-MW18	4,737.3	4,737.3	0.1	148,122,1

6.3.4.3 *Monarch DENM and Section 20 Full Buildout*
The Section 20 site is expected to be fully reclaimed by 2047 and the Monarch DENM site is expected to be reclaimed by 2058. A model iteration was run to account for the full buildout of both sites including all of the mitigation structures in place. The model included the three (3) dewatering wells at the southeastern corner of Section 20 removing 3.25 cubic feet per second from the model and a drain at the Section 20 site parallel to the southern end of the Cell 6 slurry wall. The inverts for the drain were placed approximately one (1) foot below base groundwater levels. The Monarch DENM

drain is described in Section 6.3.3.1. Groundwater head contours for the full buildout of the Sites are shown on Figure 12 and the groundwater elevations for the monitoring wells are listed in Table 12 and for the surrounding properties in Table 13.

Table 12
Total Buildout of Both Sites with Mitigation Groundwater Elevations

Well	Base	Modeled	Difference	Cell (IJK)
PZ-01	4,712.3	4,709.8	-2.5	146,111,1
PZ-04	4,712.4	4,712.1	-0.3	136,119,1
PZ-09	4,725.4	4,723.6	-1.8	142,136,1
PZ-15	4,724.4	4,722.7	-1.7	153,136,1
PZ-20	4,737.8	4,739.5	1.7	162,133,1
PZ-25	4,733.1	4,732.9	-0.2	162,115,1
PZ-27	4,741.2	4,742.7	1.5	148,122,1
BBA-MW4	4,740.3	4,740.5	0.2	148,122,1
BBA-MW11	4,736.9	4,736.9	0.0	148,122,1
BBA-MW17	4,734.4	4,734.4	0.0	166,164,1
BBA-MW18	4,737.3	4,737.3	0.1	148,122,1

Table 13
Total Buildout of Both Sites with Mitigation Groundwater Elevations at Surrounding Properties

Location	Basement (y/n)	Baseline	Full Buildout With Mitigation	Difference (FT Rise or Fall)	Groundwater Depth Below Surface	Surface Elevation (Google Earth)
Knutson Barn	n	4713.3	4709.5	-3.8	17.5	4727
Karbowski Brave House	n	4725.4	4723.4	-2.0	30.6	4754
Red Tierra House	n	4727.9	NA	NA	NA	4756
Sharp House	y	4738.3	4738.4	0.1	17.6	4760
Greybill House	y	4738.2	4738.3	0.1	18.7	4756
Poncelow House	n	4735.2	4734.6	-0.6	30.4	4757
Moran House	y	4738.8	4740.5	1.7	23.5	4765
Doolittle House	y	4740.2	4741.9	1.7	24.1	4764
Maroney House	y	4741.8	4743.4	1.6	22.6	4766
Scott House	y	4742.3	4744.4	2.1	25.6	4766
Meining House	y	4744.1	4745.8	1.7	19.2	4770
Schmunk House	y	4741.8	4743.9	2.1	18.1	4765
Guevara House	y	4741.2	4742.5	1.3	21.5	4762
Frank House	y	4739.7	4740.9	1.2	14.1	4764
Gutfelder House	n	4728.3	4725.3	-3.0	29.7	4755
Gilcrest Valley HS	NA	4737.0	4736.6	-0.4	9.4	4746

The amount of groundwater necessary for the underdrain to remove from the model with the Section 20 slurry walls in place is approximately 247,000 cubic feet per day or 2.86 cubic feet per second. This is less than the water removed without the Section 20 site since the east face of the Monarch Cell 3 and 4 is in the shadow of the Section 20 site. This should be taken into consideration when the Monarch DENM underdrain is designed.

The baseline groundwater level is based on six (6) months of piezometer readings taken at the site and further water level monitoring should be taken into account during design of the final mitigation structures.

7.0 CONCLUSION

Civil Resources makes the following conclusions and recommendations based on the modeling:

- An underdrain constructed south of Cell 3 will be effective at minimizing the groundwater elevation rise south of the Site, and similarly the Gilcrest area, by removing water from the aquifer and rerouting it through the Site to the South Platte River via the unnamed slough west of the Site. At total site buildout, including the Section 20 Site, the quantity of water to be piped to the river would be an estimated 2.86 cubic feet per second.

- If the shadow effect to the north causes negative impacts to the well north of the site (Gutfelder well) then a recharge drain or recharge pond could be constructed to the north of Cell 2 to received the groundwater from the underdrain.

- The models and data presented in this report are based on six (6) months of piezometer data collected at the Site. Further groundwater monitoring of baseline conditions and after the installation of slurry walls 1 and 2 will be necessary for designing the size and invert elevation for the underdrain.

- Since groundwater is expected to rise (mound) south of the Site the mine operator will continue to monitor the existing monitoring wells in accordance with the Groundwater Level Monitoring and Mitigation Plan to catch any mounding or shadow effects at the Site before it become an issue to the surrounding properties.

8.0 REFERENCES

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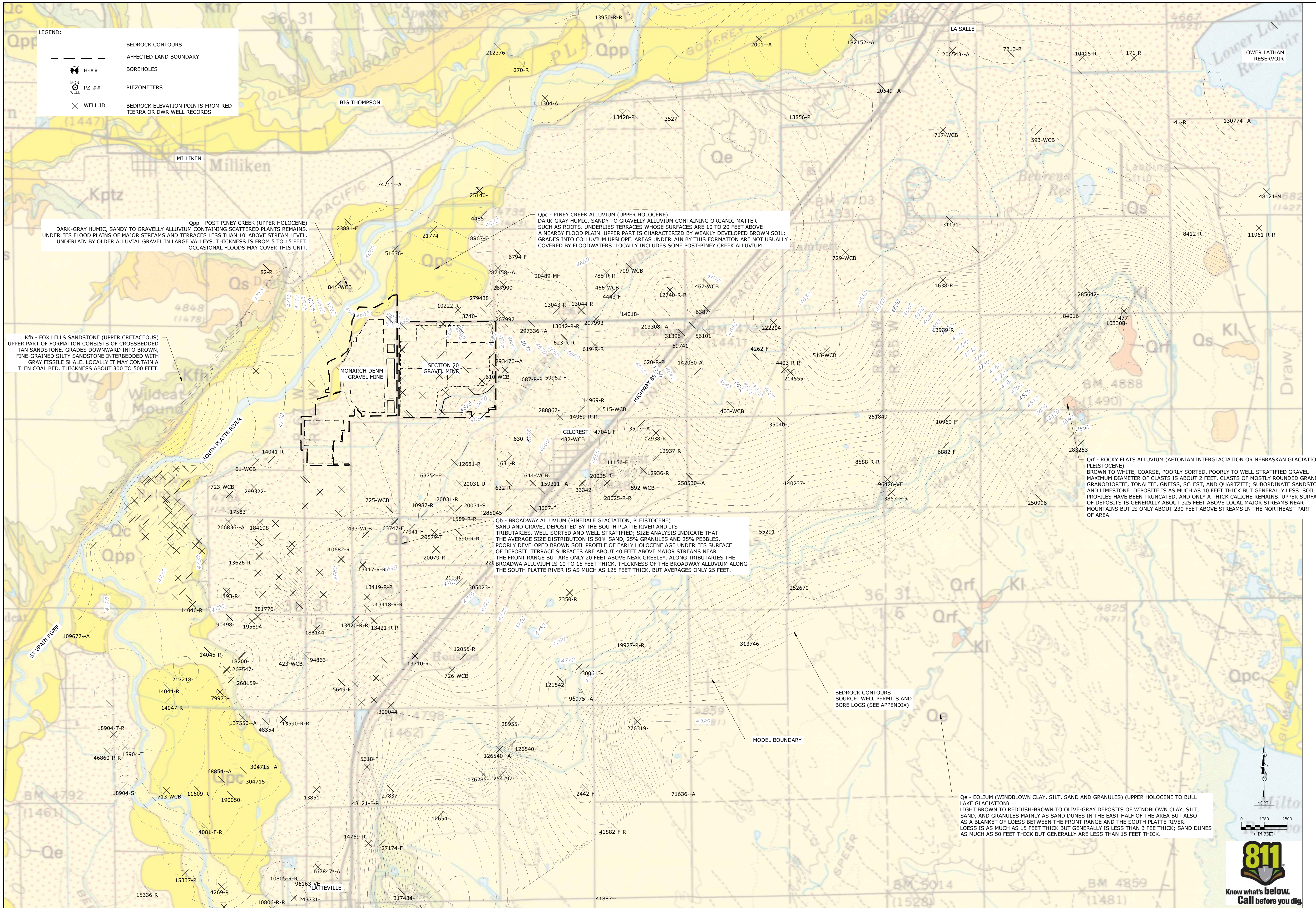
Figures



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ERIC LEIGH

GROUNDWATER MODEL
MONARCH DENM GRAVEL MINE
GILCREST CO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR
DATE: 7-20-2022
DRAWN BY: KSR
SCALE: AS NOTED
CHECKED BY: BLH
AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

REGIONAL BEDROCK SURFACE

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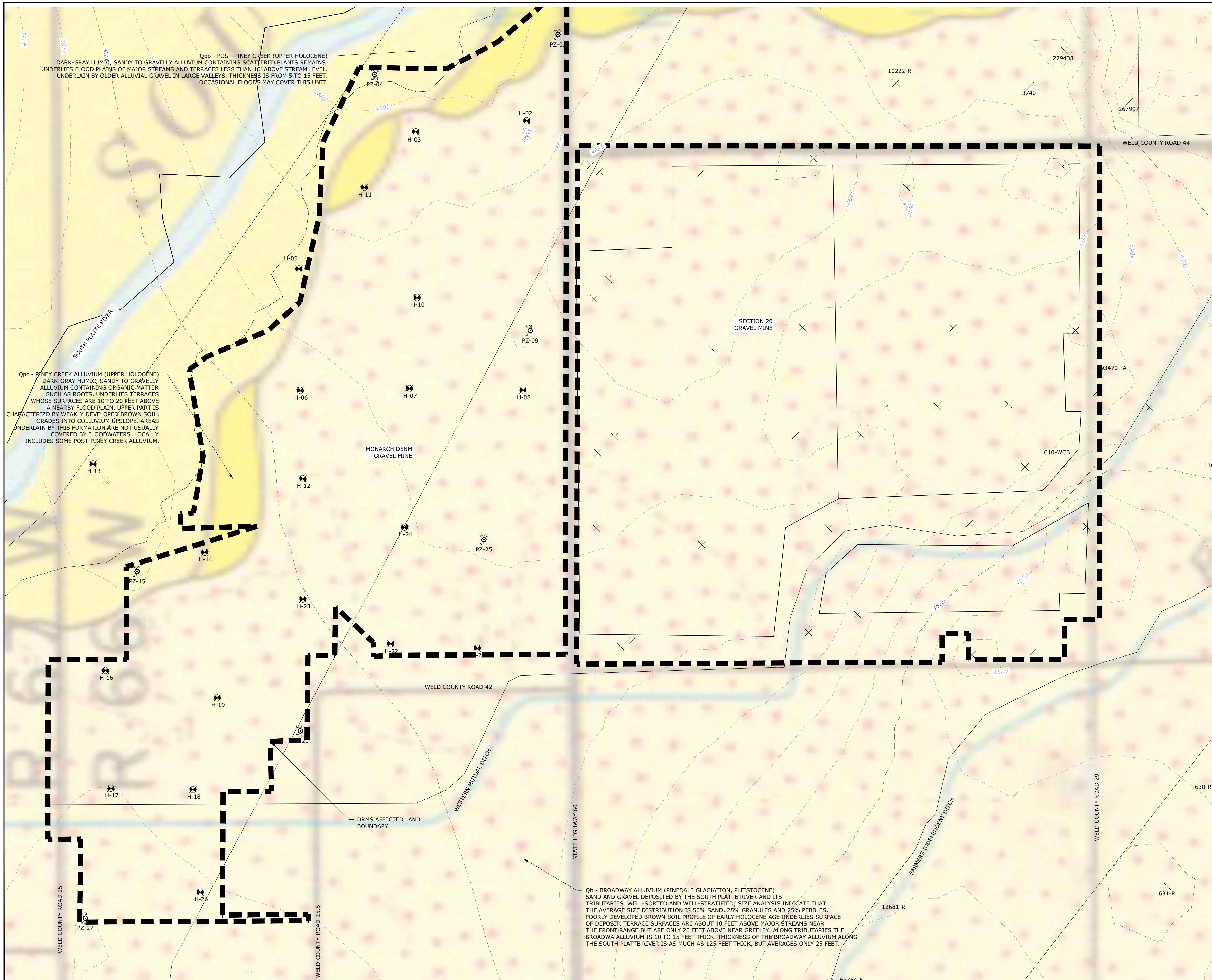

LEGEND:

BEDROCK CONTOURS

AFFECTED LAND BOUNDARY

H-## BOREHOLES

PZ-## PIEZOMETERS

WELL ID BEDROCK ELEVATION POINTS FROM RED TIERRA OR DWR WELL RECORDS

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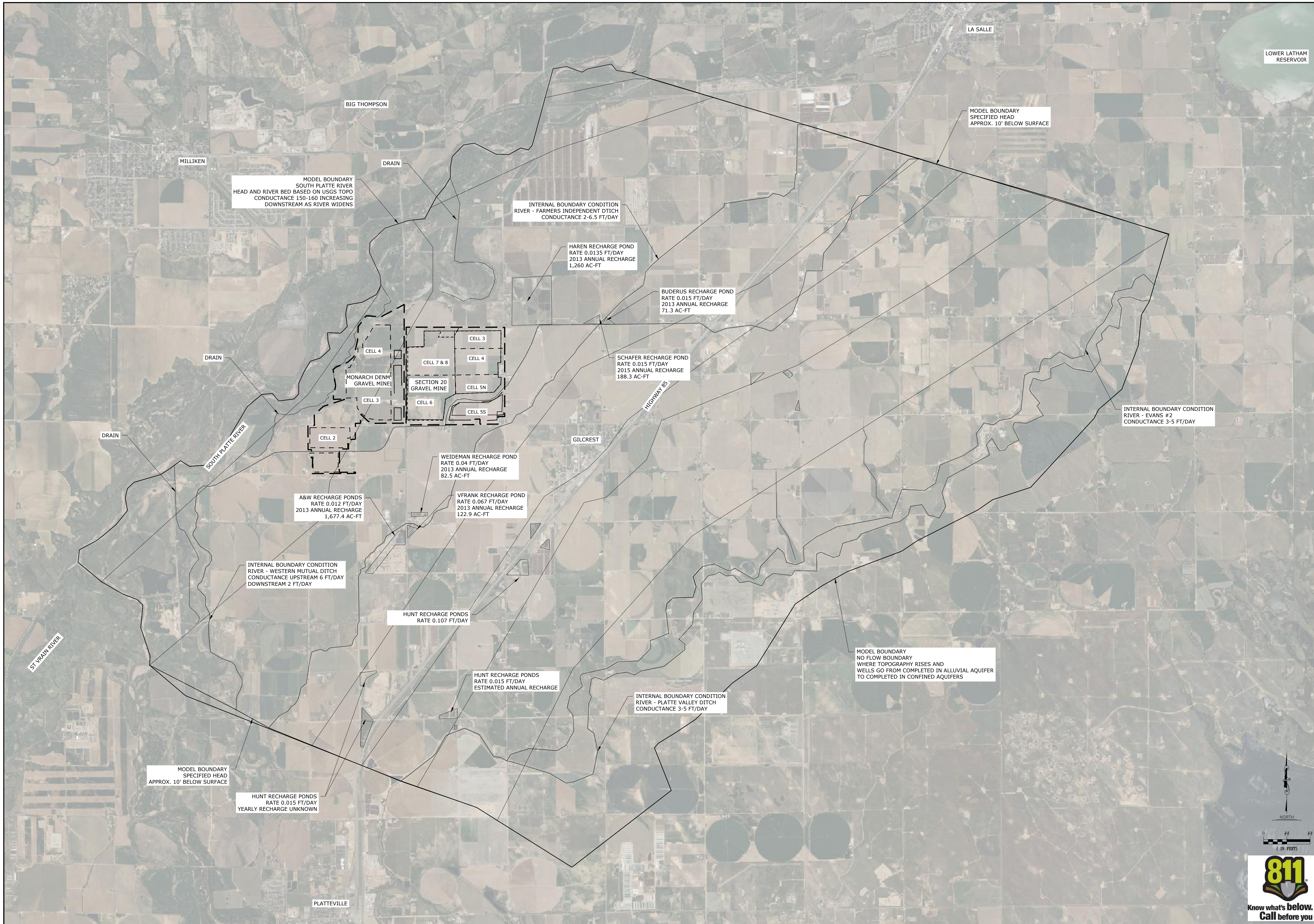

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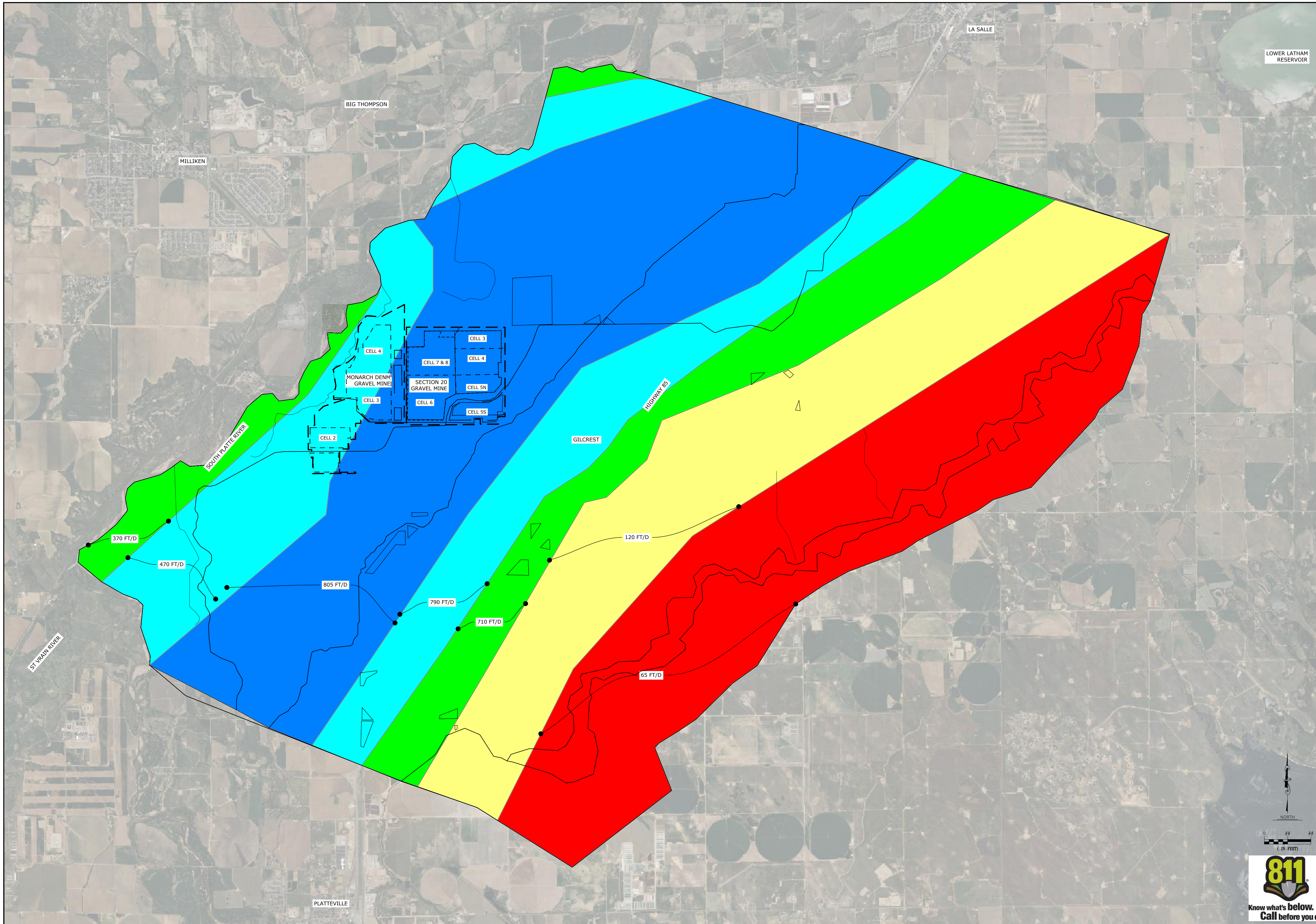

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JOB NO.: 303.001.04
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HORIZONTAL HYDRAULIC CONDUCTIVITY

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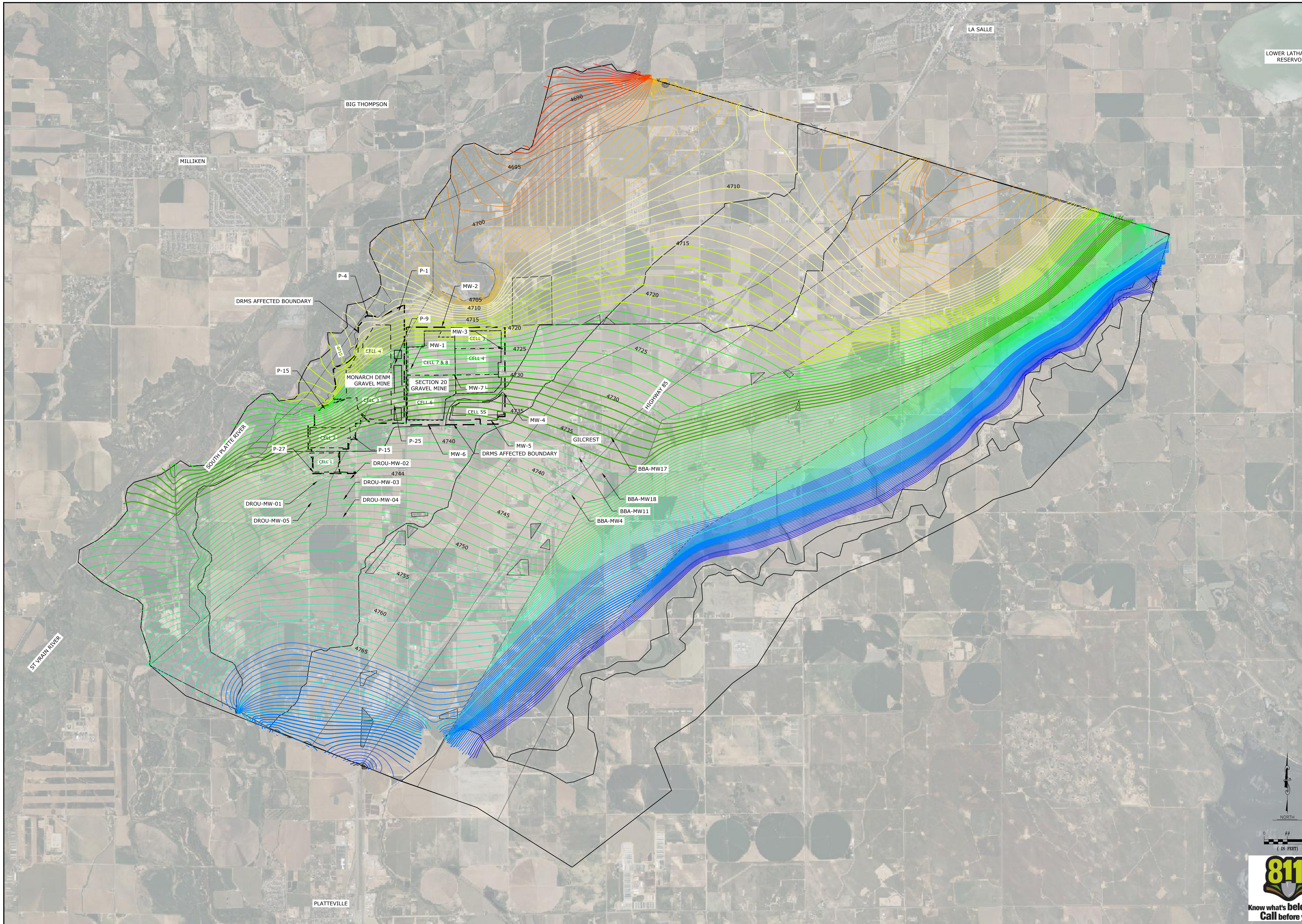

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MOUNDING SHADOW MODEL
SECTION 20 GRAVEL MIN
GILCREST CO

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JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

EXISTING CONDITION CONTOURS

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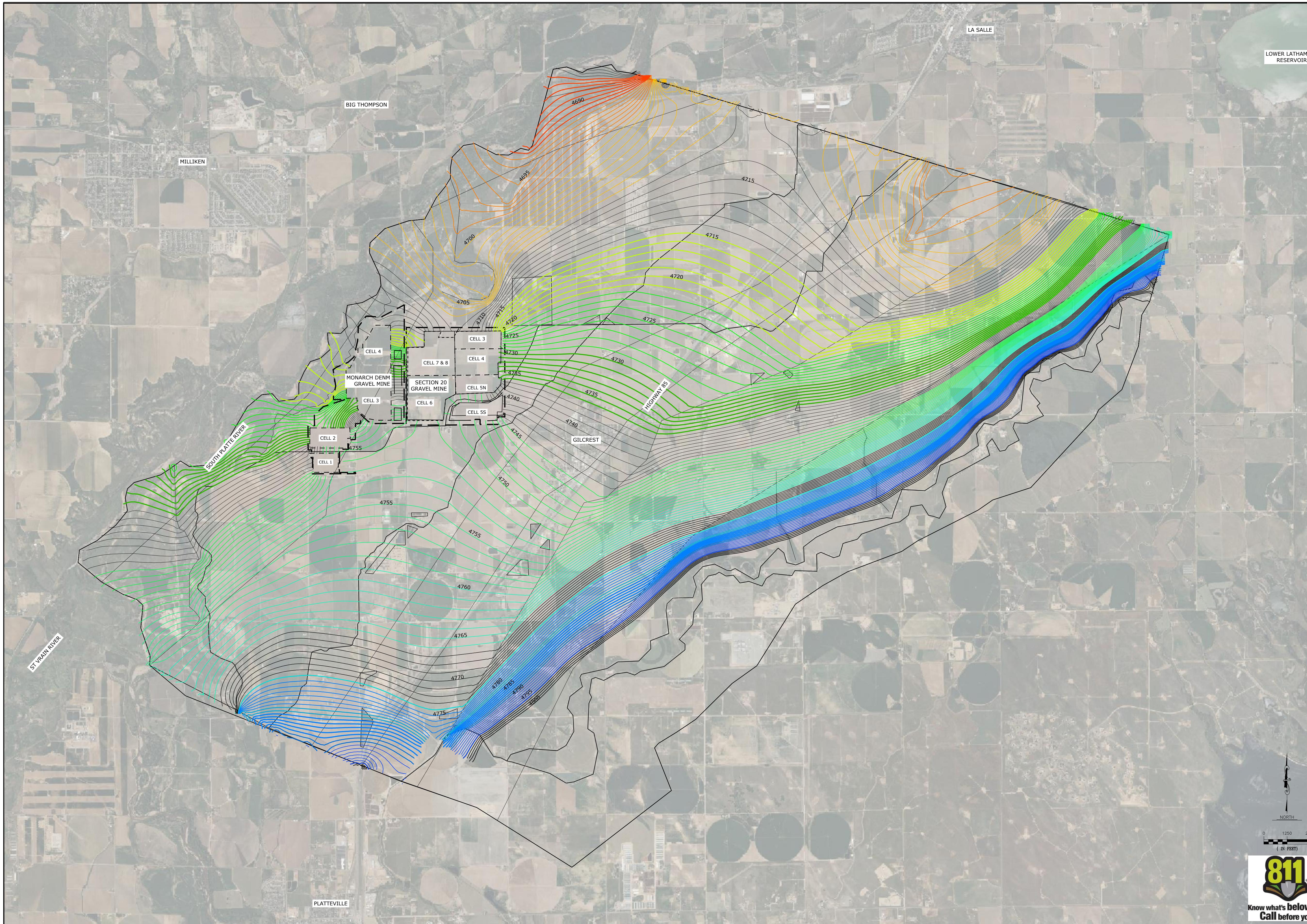

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MOUNDING SHADOW MODEL
SECTION 20 GRAVEL MIN
GILCREST CO

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CHECKED BY: BLH AS NOTED
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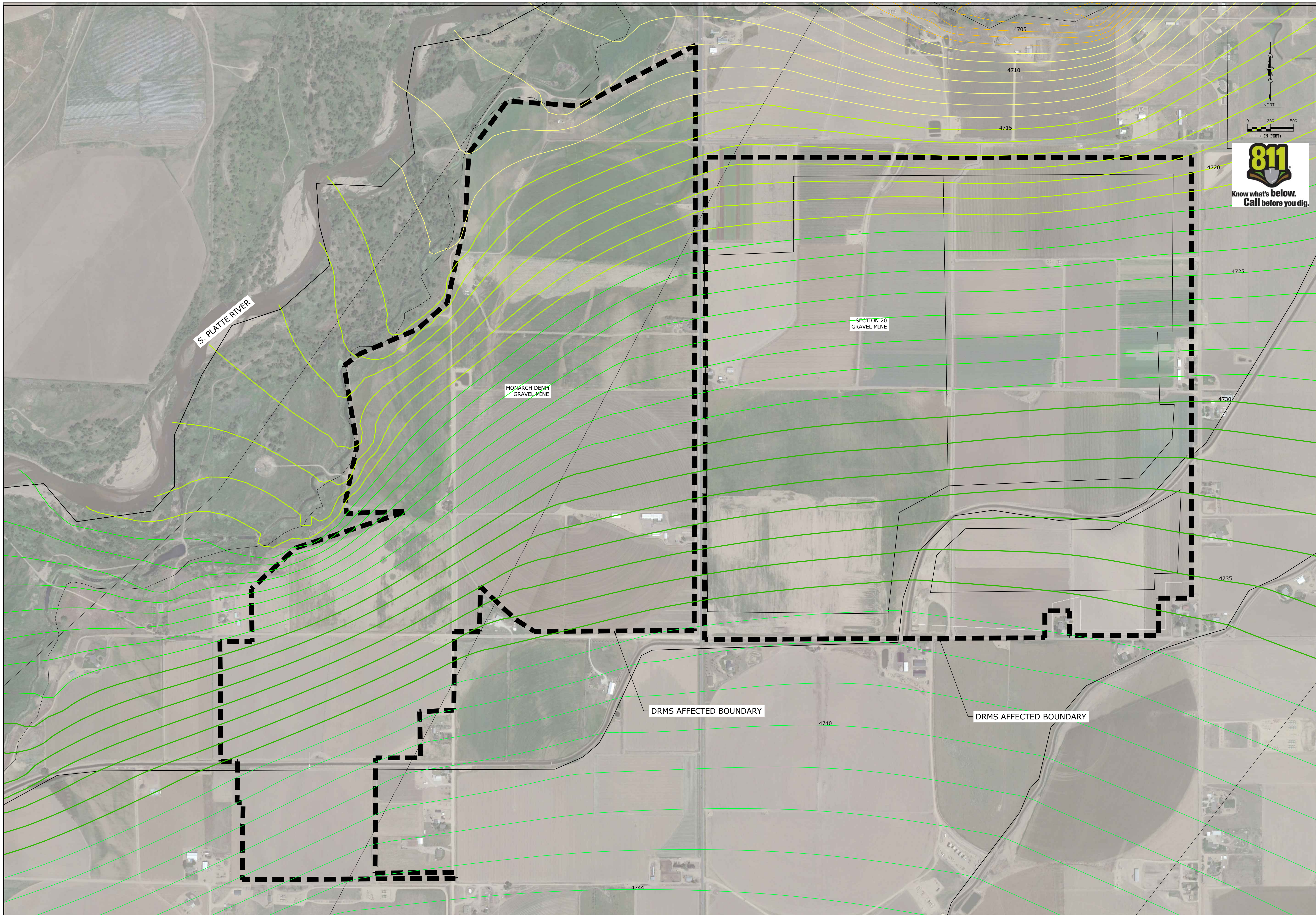

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MONARCH DENM GRAVEL MINE
WELD COUNTY, CO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR
DATE: 7-20-2022
DRAWN BY: KSR
SCALE: AS NOTED
CHECKED BY: BLH
AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

EXISTING CONDITION CONTOURS

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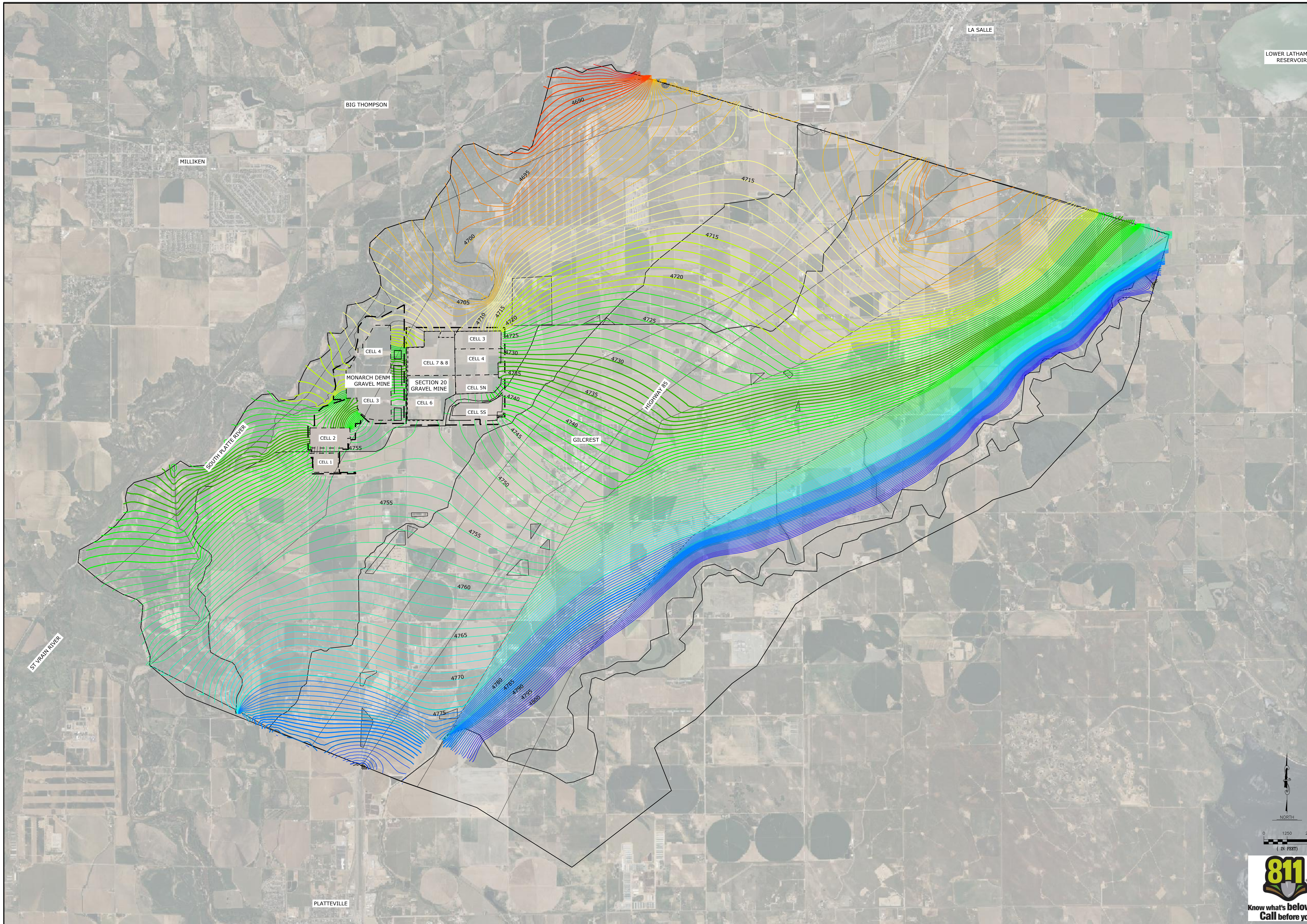

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303.833.1416
WWW.CIVILRESOURCES.COM

RED TIERRA EQUITIES, LLC
8301 E. PRENTICE AVE #100
GREENWOOD VILLAGE, CO 80111

MOUNDING SHADOW MODEL
SECTION 20 GRAVEL MIN
GILCREST CO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR DATE: 7-20-2022
DRAWN BY: KSR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

SLURRY WALL FULL BUILD OUT CONDITION CONTOURS

SHEET: 5

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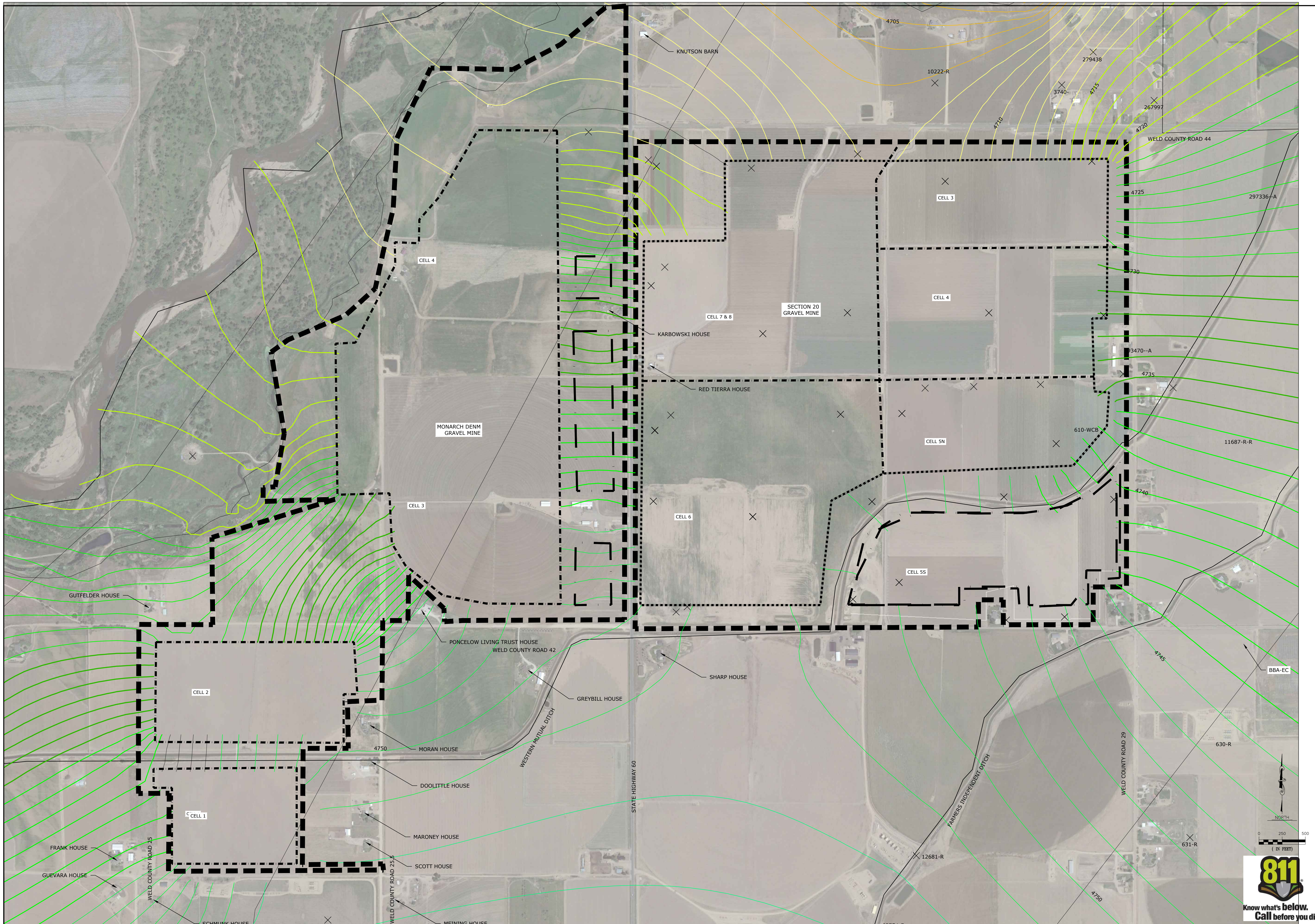

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MONARCH MOUNTAIN M&A
5 CONCOURSE PKWY, SUITE 1900
ATLANTA, GA 30328
720.289.5584
ERIC LEIGH

GROUNDWATER MODEL
MONARCH DENM GRAVEL MINE
WELD COUNTY, CO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR DATE: 7-20-2022
DRAWN BY: KSR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

SLURRY WALL
FULL BUILD OUT
CONDITION
CONTOURS

SHEET:
5A

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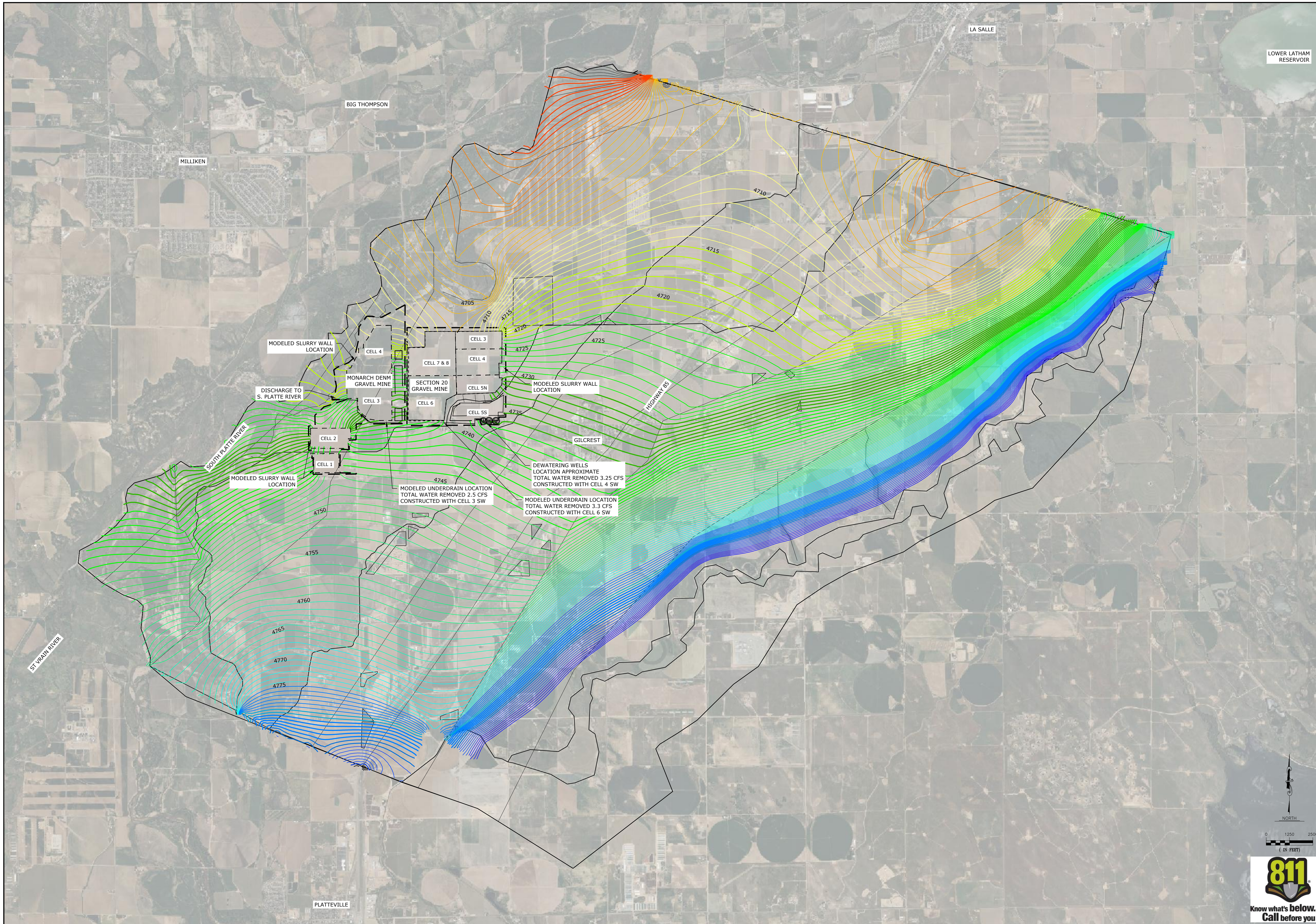

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MONARCH MOUNTAIN M&A
5 CONCOURSE PKWY, SUITE 1900
ATLANTA, GA 30328
720.289.5584
ERIC LEIGH

MOUNDING SHADOW MODEL
MONARCH DEMN GRAVEL MINE
WELD COUNTY, CO

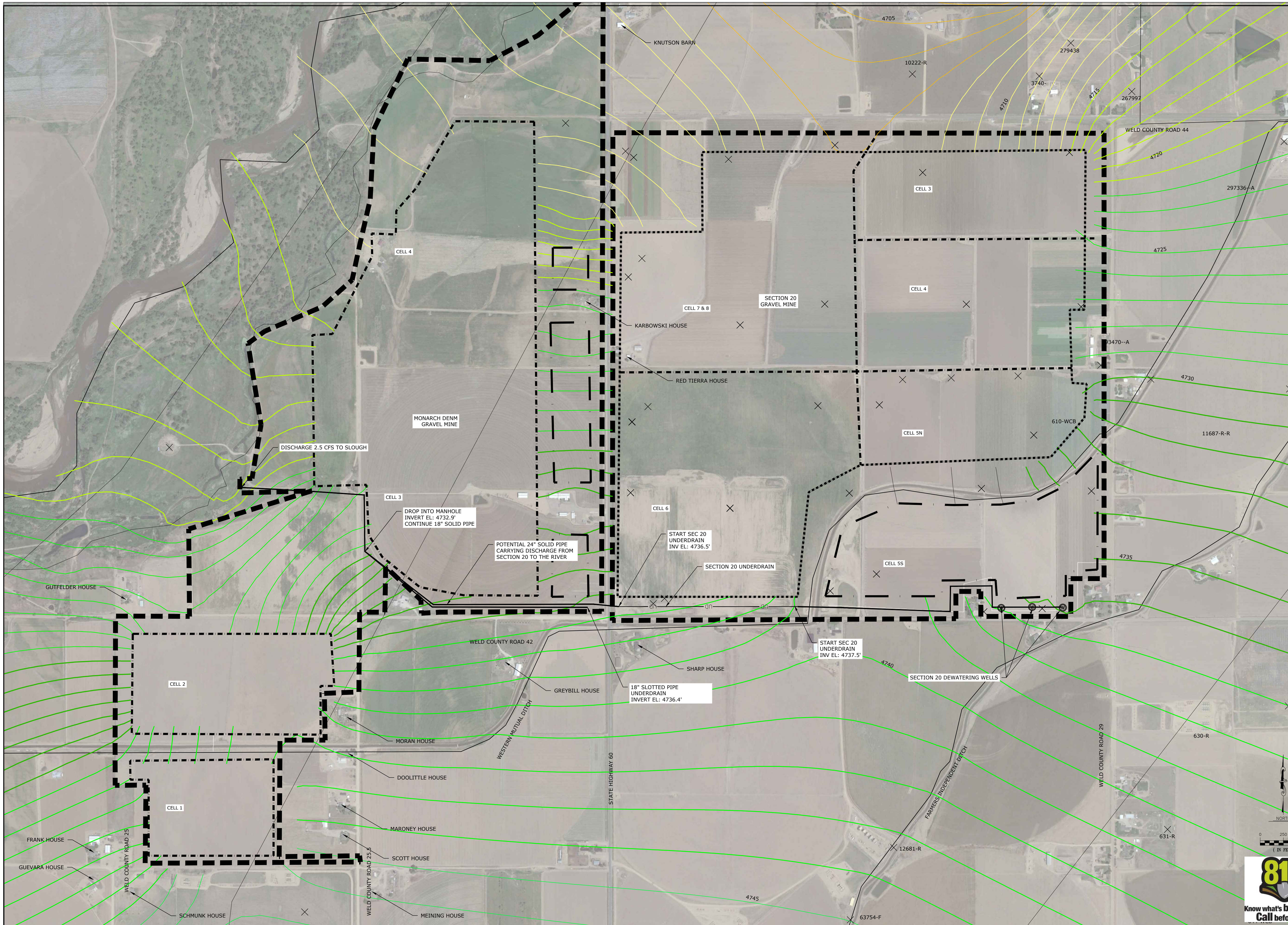
REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR
DRAWN BY: KSR
CHECKED BY: BLH
DATE: 7-20-2022
SCALE: AS NOTED
AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

FULL BUILDOUT WITH MITIGATION

SHEET:
6



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MONARCH MOUNTAIN M&A

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ATLANTA, GA 30328
720.289.5584
ERIC LEIGH

GROUNDWATER MODEL
MONARCH DENM GRAVEL MINE
WELD COUNTY, CO

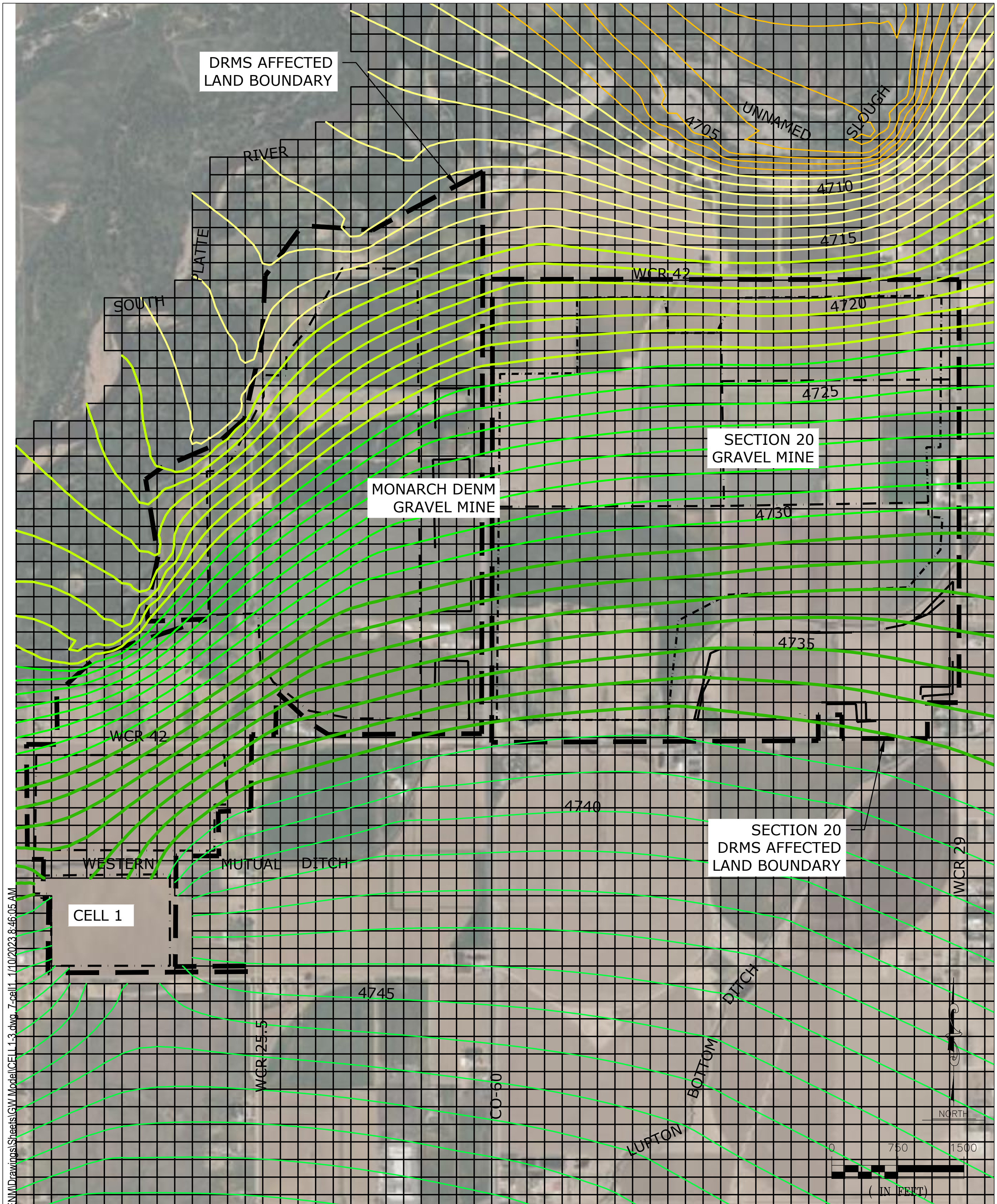
REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: KSR DATE: 7-20-2022
DRAWN BY: KSR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.: 303.001.04
DWG NAME: GW MODEL_10112022.dwg

SLURRY WALL WITH DRAIN CONDITION CONTOURS

SHEET:
6A



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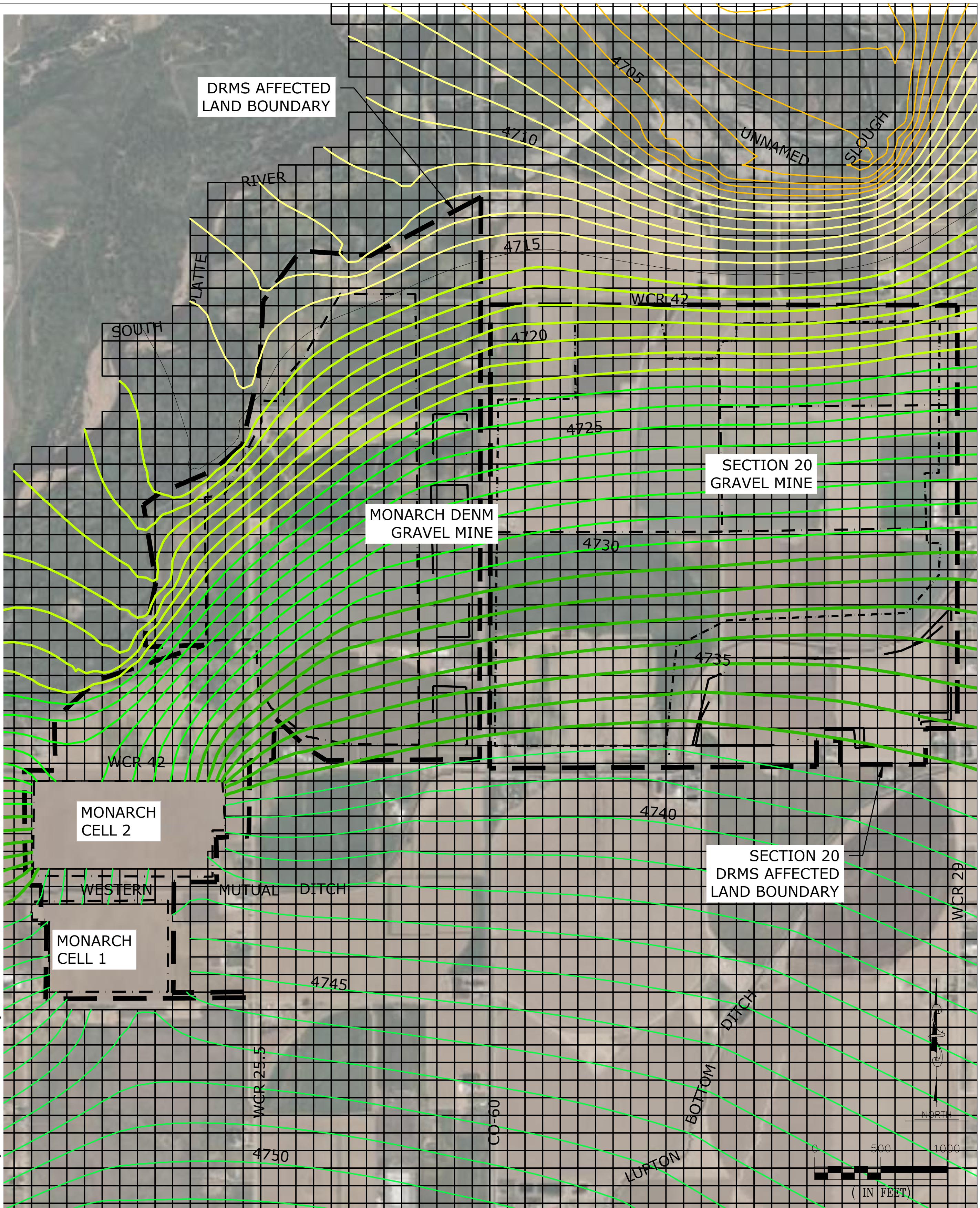
NOTES:
1. THIS MODEL ITERATION INCLUDES A SLURRY WALL AROUND CELL 1
2. NO MITIGATION IS MODELED IN THIS ITERATION

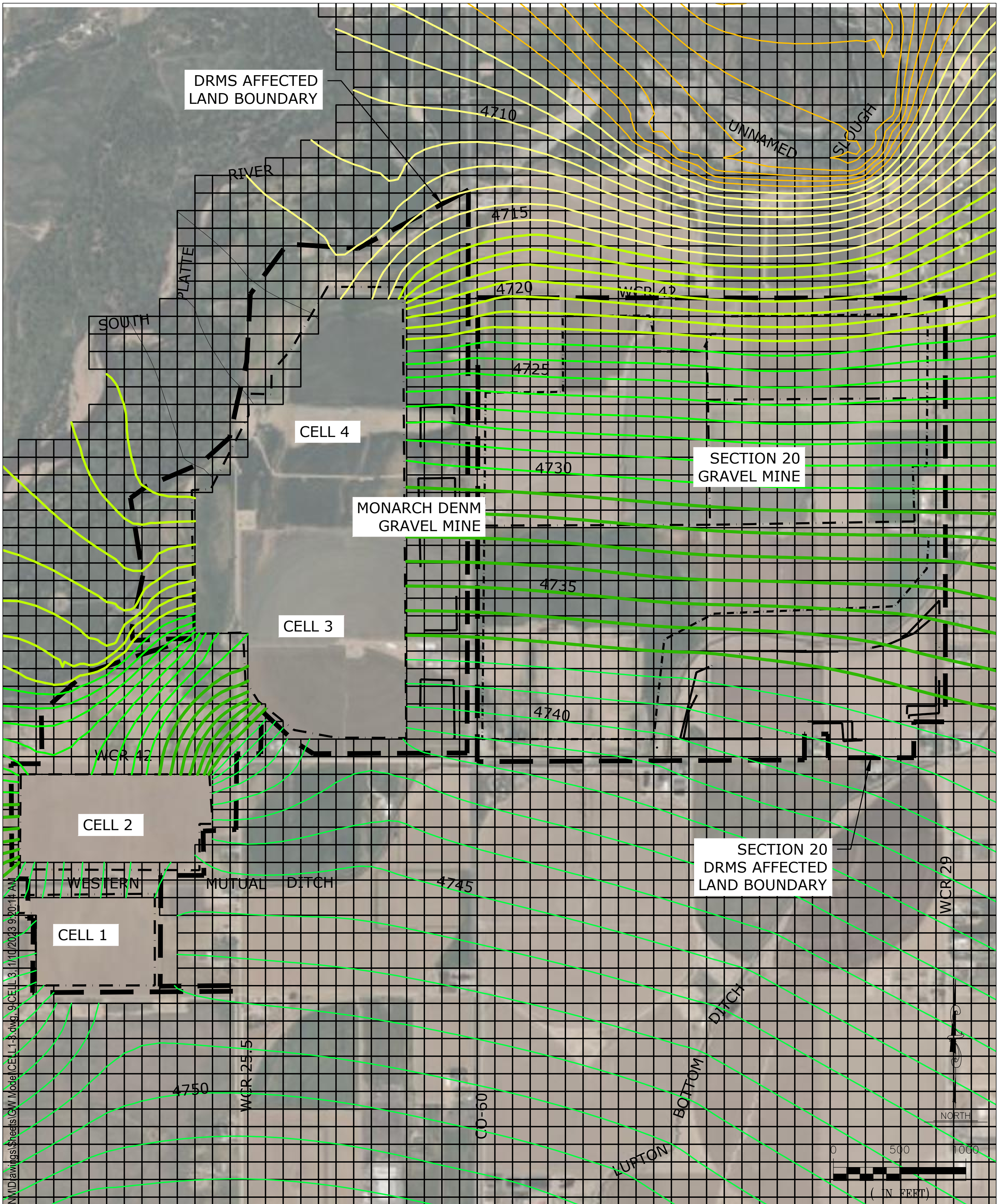
		MONARCH MOUNTAIN M&A MONARCH DENM
DATE: January, 2023	FIGURE: 7	HEAD CONTOURS WITH CELL 1 SLURRY WALL



NOTES:
1. THIS MODEL ITERATION INCLUDES A SLURRY WALL AROUND CELL 1, AND CELL 2.
2. NO MITIGATION WAS INCLUDED FOR THIS STAGE.

		MONARCH MOUNTAIN M&A MONARCH DENM MODEL
DATE: January, 2023	FIGURE: 8	HEAD CONTOURS WITH CELL 2 SLURRY WALL

J:\Quikrete - 282\Monarch DENM\Drawings\Sheets\GW Model\CELL 1-3.dwg, 8-cell 2, 1/10/2023 8:48:35 AM



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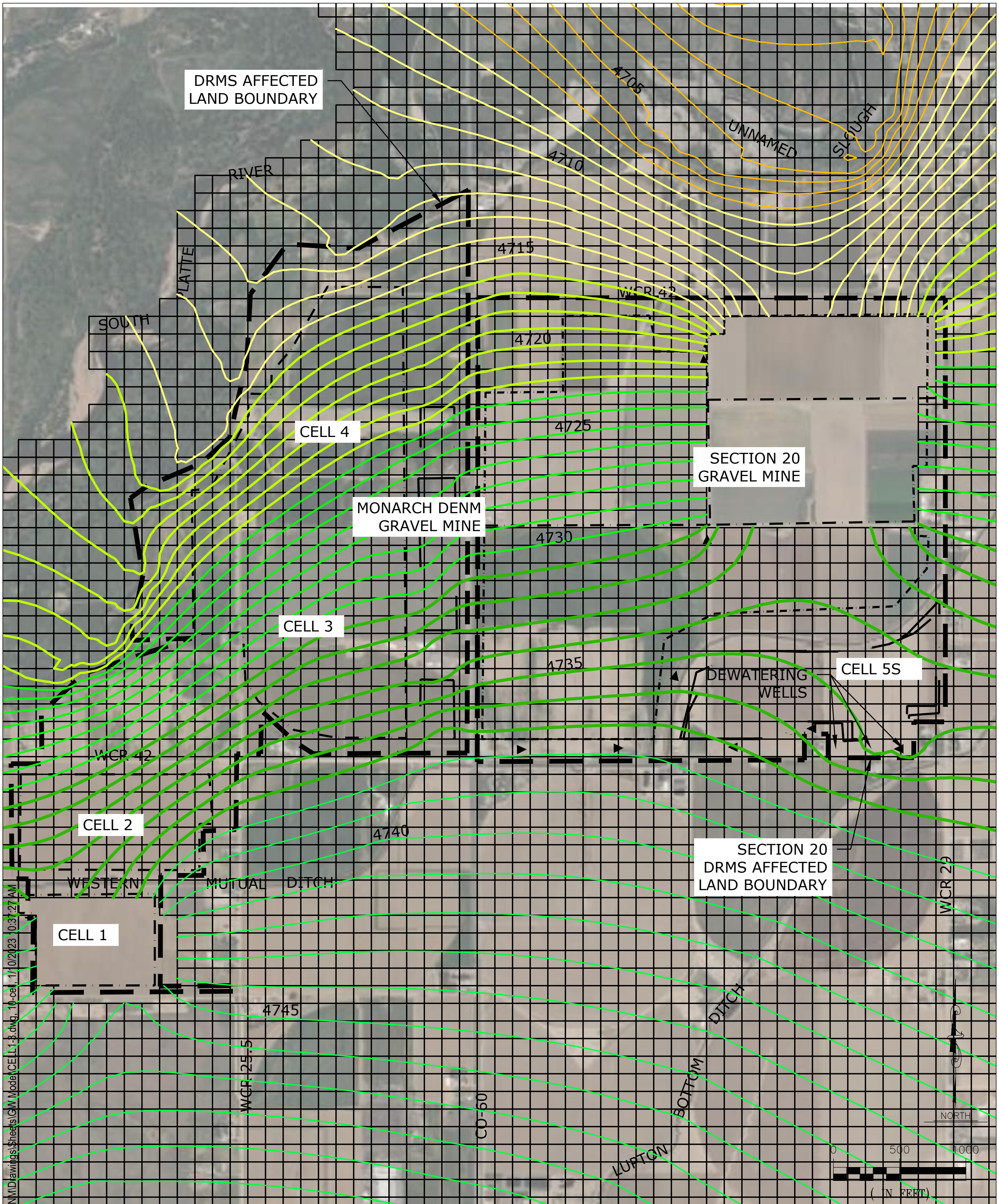
NOTES:

1. THIS MODEL ITERATION INCLUDES A SLURRY WALL AROUND CELL 1, CELL 2, CELL 3 AND 4

		MONARCH MOUNTAIN M&A MONARCH DENM
DATE: January, 2023	FIGURE: 9	HEAD CONTOURS WITH CELL 3 AND 4 SLURRY WALL



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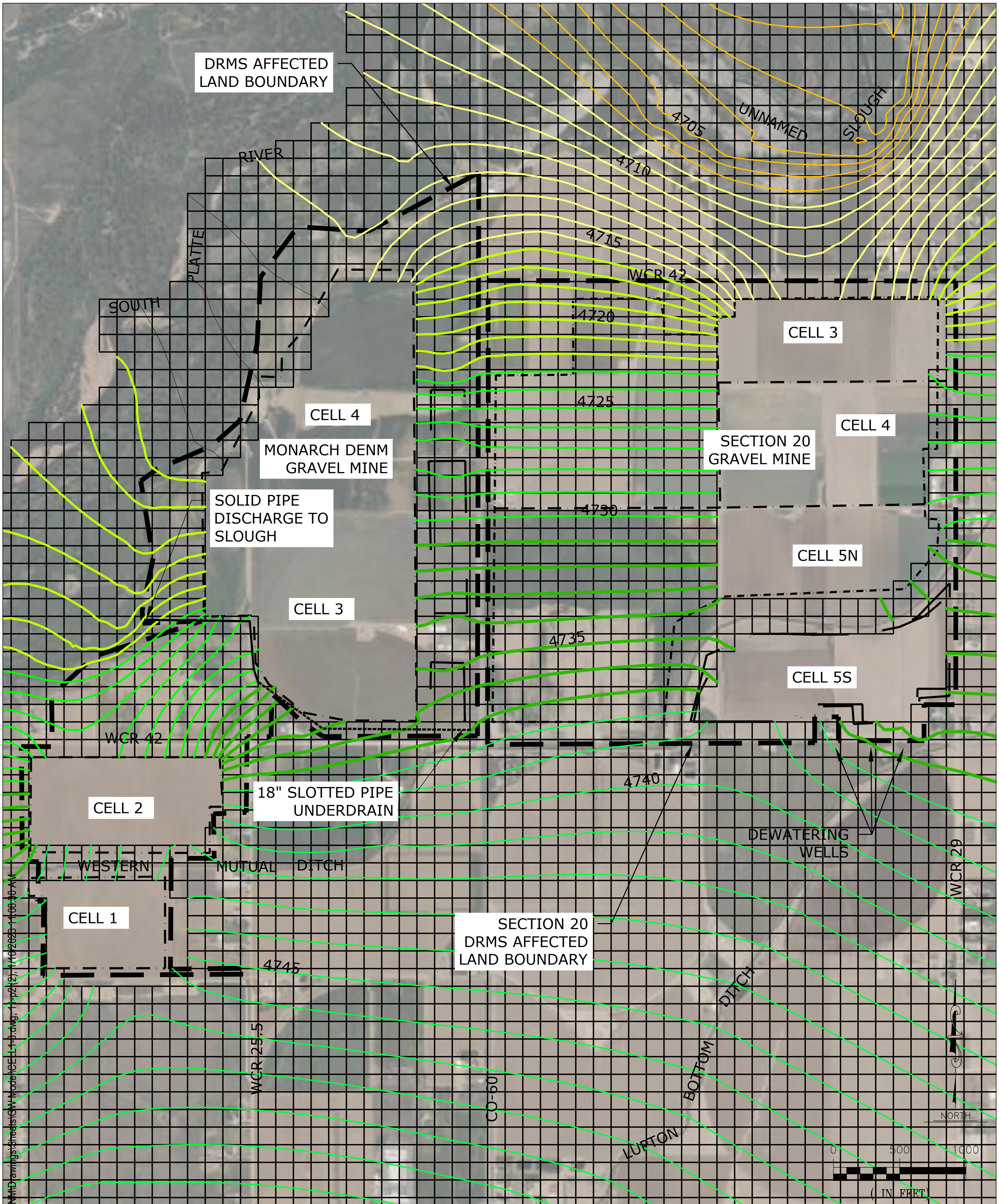
NOTES:

1. THIS MODEL ITERATION INCLUDES THE MONARCH CELL 1 AND THE SECTION 20 CELL 3 AND CELL 4.
2. MITIGATION IN THIS ITERATION INCLUDES 3 DE-WATERING WELLS IN THE SOUTHEAST CORNER OF SECTION 20 REMOVING 3.25 CFS FROM THE MODEL.

		MONARCH MOUNTAIN M&A MONARCH DENM MODEL
DATE: January 2023	FIGURE: 10	MONARCH CELL 1 WITH SECTION 20 CELL 3 & 4

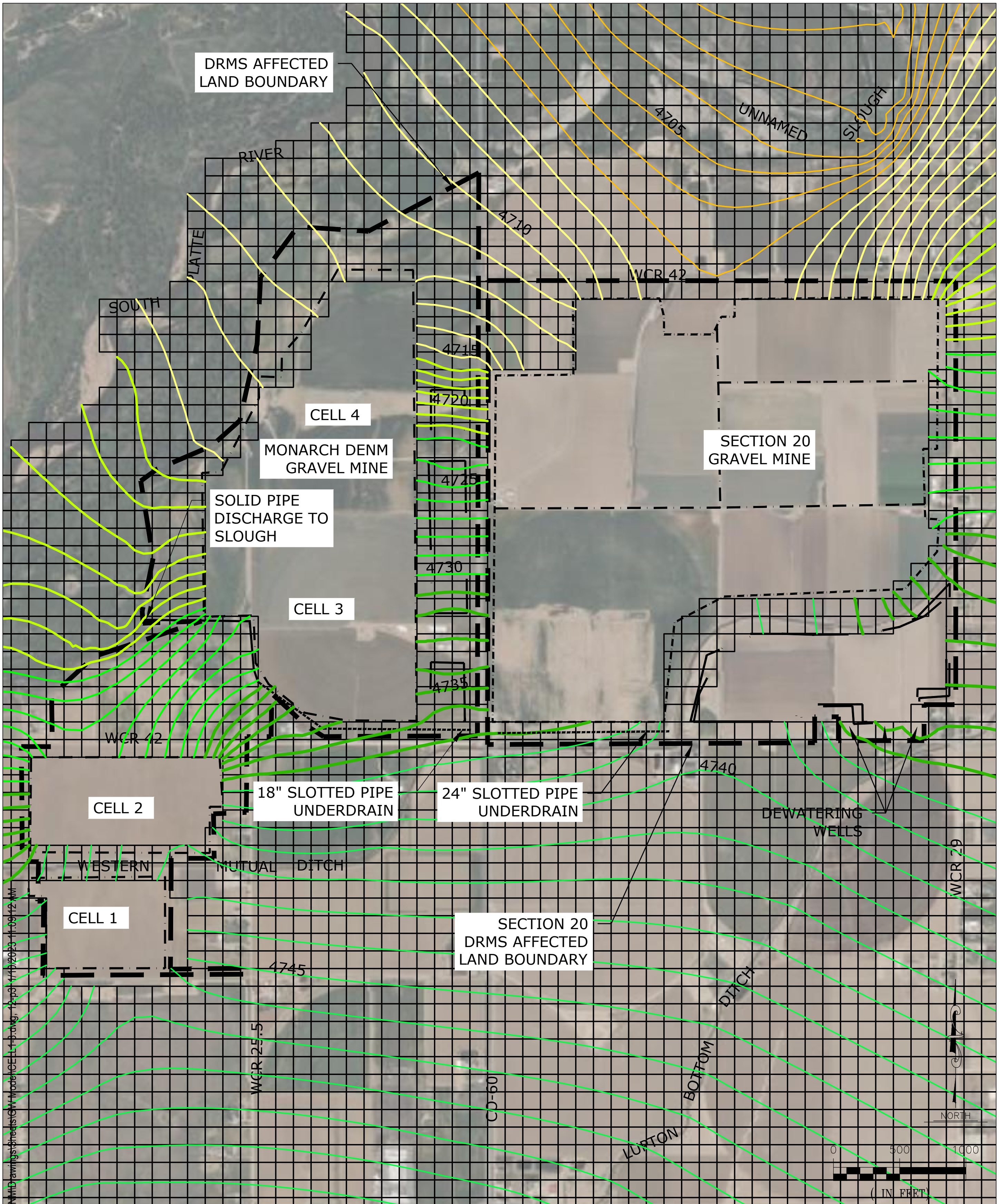


NOTES:

1. THIS MODEL ITERATION INCLUDES THE CONSTRUCTION OF ALL SLURRY WALLS AT THE SITE AND UP TO CELL 5S AT SECTION 20.
2. MITIGATION STRUCTURES ARE AN UNDERDRAIN AT THE SITE AND 3 DEWATERING WELLS AT THE SOUTHEAST CORNER OF SECTION 20

MONARCH MOUNTAIN M&A
MONARCH DENM MODEL

DATE:	FIGURE:	
January 2023	11	FULL BUILD-OUT & SECTION 20 TO CELL 5S

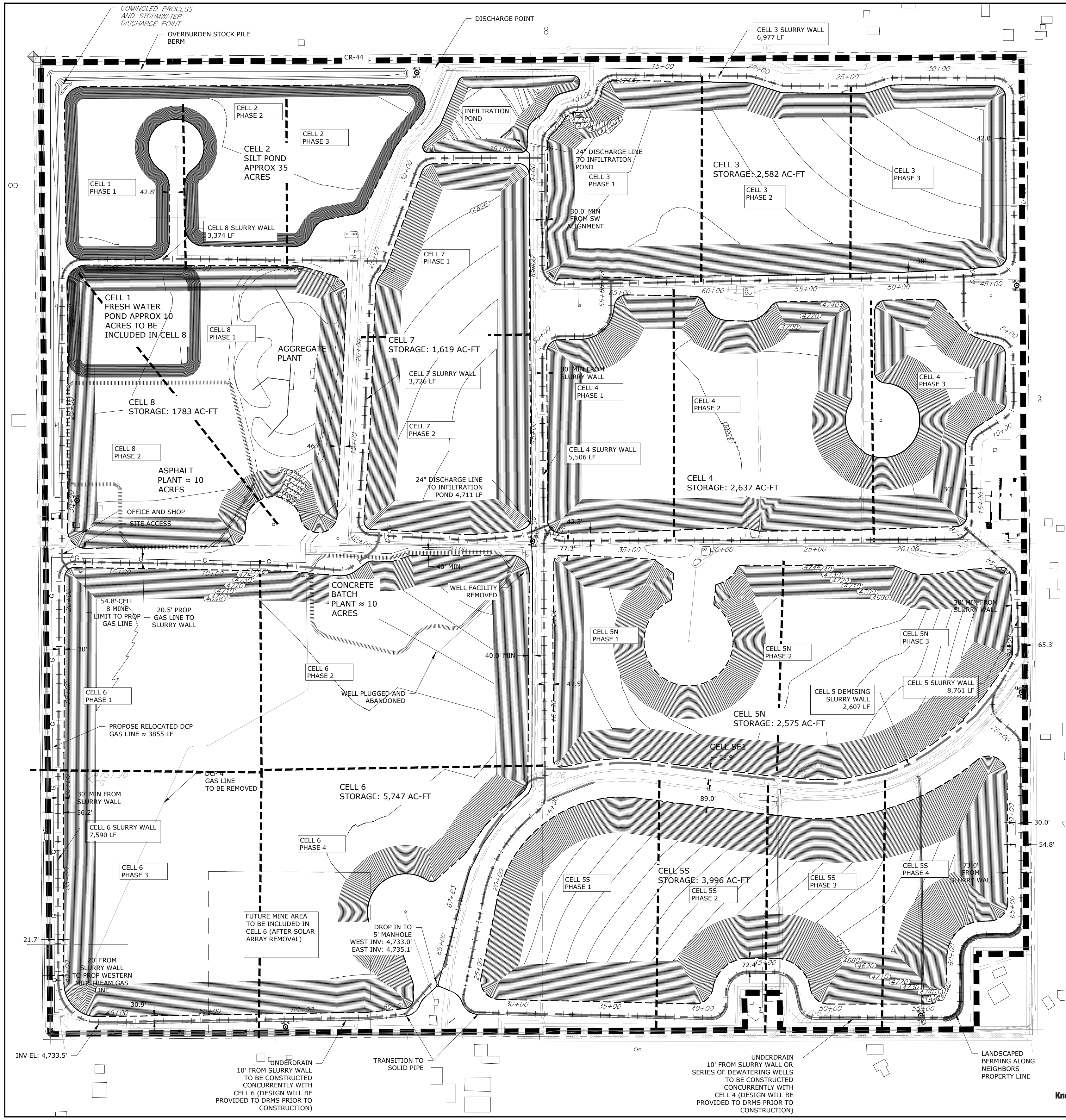


J:\Quikrete - 282\Monarch DENM\Drawings\Sheets\GW Model\CELL 1-3.dwg, 12-p3 1/10/2023 11:09:12 AM

NOTES:
1. THIS MODEL ITERATION INCLUDES THE CONSTRUCTION OF ALL SLURRY WALLS AT THE SITE AND SECTION 20.
2. MITIGATION STRUCTURES ARE AN UNDERDRAIN AT THE SITE, AN UNDERDRAIN AT THE SOUTHWEST CORNER OF SECTION 20 AND 3 DEWATERING WELLS AT THE SOUTHEAST CORNER OF SECTION 20

		MONARCH MOUNTAIN M&A MONARCH DENM MODEL
DATE: January 2023	FIGURE: 12	FULL BUILD-OUT & SECTION 20

Appendix A



NOTES:

1. VOLUMES ASSUMES MINING AT A 3:1 MINE SLOPE.
2. YEARS TO MINE FOR EACH PHASE ASSUME AN AVERAGE MINING RATE OF 2,000,000 TONS OF AGGREGATE PER YEAR AND 1.5 TONS OF AGGREGATE PER CUBIC YARD.
3. SLURRY WALL CURTAIN AREAS ASSUME THAT ADJACENT CELLS WILL SHARE ONE DIVIDING SLURRY WALL.
4. SLURRY WALL CURTAIN AREAS ASSUME THE FOLLOWING AVERAGE DEPTH TO BEDROCK
   - CELL 3: 50'
   - CELL 4: 55'
   - CELL 5: 55' ALONG WESTERN QUARTER, 80' ALONG SOUTHERN HALF
   - CELL 6: 55'
   - CELL 7: 55'
   - CELL 8: 50'

SECTION 20 PHASING TIMELINE

YEARS TO MINE	CELL #	PHASE	SLURRY WALL CURTAIN AREA SQ-FT
0.4	CELL 1 FWP		NA
1.4	CELL 2 SP		NA
0.5		1	
0.5		2	
0.4		3	
2.5	CELL 3 3:1		348,850
0.8		1	-
0.9		2	-
0.7		3	-
2.4	CELL 4 3:1		302,830
0.9		1	
1.0		2	
0.5		3	
2.3	CELL 5 3:1		562,000
1.1		1	
1.2		2	
3.8	CELL 5S 3:1		NA
0.9		1	
1.1		2	
0.9		3	
0.8		4	
1.3		2	
1.1		3	
1.2		4	
4.0	CELL 6 3:1		355,300
1.1		1	
0.8		2	
1.1		3	
0.9		4	
1.6	CELL 7 3:1		231,880
0.9		1	
0.8		2	
1.5		4	
1.6	CELL 8 3:1		168,700
0.8		1	
0.8		2	
20.0	YEARS TOTAL		

* EASTERN UNDERDRAIN OR DEWATERING WELLS INSTALLED CONCURRENT WITH CELL 4 (APPROX 3 DEWATERING WELLS OR 2,500' OF 24" SLOTTED PIPE)
* CONSTRUCT INFILTRATION POND

* WESTERN UNDERDRAIN INSTALLED CONCURRENT WITH CELL 6 ≈ 1,894 LF OF 24" SLOTTED PIPE

PREPARED UNDER THE SUPERVISION OF:

6/2/22

NAME Kyle S. Regan P.G. DATE

QUALIFIED AS A PROFESSIONAL GEOLOGIST AS DEFINED BY COLORADO STATUTE.

LEGEND:

- PROPOSED PERMIT BOUNDARY
- SLURRY WALL ALIGNMENT
- PROPOSED MINE LIMIT
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- EXISTING BARBED WIRE FENCE
- EXISTING EDGE OF PAVEMENT
- EXISTING EASEMENT
- SECTION LINE
- EXISTING RIGHT OF WAY
- PROPOSED UNDERDRAIN
- EXISTING GAS LINE
- EXISTING WATER LINE
- PROPOSED ACCESS ROAD
- EXISTING DIRT ROAD
- EXISTING BURIED ELECTRICAL
- EXISTING OVERHEAD ELECTRICAL
- EXISTING FIBER OPTIC
- WATERWAY
- MONITORING WELLS
- ELECTRICAL BOX
- OVERHEAD ELECTRIC POLE

NORTH

0 150 300

(IN FEET)

811 Know what's below. Call before you dig.

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RED TIERRA EQUITIES, LLC
8301 E PRENTICE AVE #120
GREENWOOD VILLAGE, CO 80111
303.771.1005 (p)
CONTACT: DREW DAMIANO

SECTION 20 DRMS 112 RECLAMATION PERMIT GILCREST, COLORADO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: BLH DATE: 9/16/2021
DRAWN BY: KR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.: 303.001.04
DWG NAME: GILCREST-AREA-GEOLOGY.DWG

MINE PLAN AND TIMELINE

SHEET: EXHIBIT C-5

Appendix B

DEWATERING IMPROVEMENTS STUDY

FOR THE

Town of
Gilcrest, Colorado

OCTOBER 2016

SECTION 2 – PREVIOUS STUDIES, DATA COLLECTION, AND MAPPING OF DEPTH TO GROUNDWATER

PREVIOUS STUDIES AND DATA COLLECTION

Previous studies by CGS, Brown and Caldwell, and others were reviewed to identify aquifer and groundwater data available in the vicinity of the Town. The information and data included: groundwater level data, groundwater recharge data, groundwater model input data, mapping, geologic characterizations and other information pertaining to the shallow groundwater conditions within the Town. In addition, we completed a review of groundwater information available from Town staff, Palmetto Environmental, Tetra Tech, Central Colorado Water Conservancy District, the Division of Water Resources, Colorado State University and input from residents and individuals with relevant knowledge.

MAPPING OF DEPTH TO GROUNDWATER

The starting point for developing the Town dewatering plan is to identify the areas within the Town that are affected by shallow groundwater conditions. Water level data were compiled to prepare maps of groundwater elevation and depth to groundwater for the recent high-groundwater condition. Previous studies have included depth to groundwater mapping, but those studies did not include water level data from the Town's wells and were of a regional as opposed to local scale.

Ground level elevation data from the USGS and CDWR, were supplemented with new survey information developed from our own survey and data available from Tetra Tech and Palmetto for monitoring wells located adjacent to the Town. Additional water level data were collected from the Town's existing wells and new monitoring points in and around the Town, identified in Figure 2.1 and summarized in Table 2.1 on the following pages. Water level hydrographs were prepared for each of the monitoring wells relied upon in this study, as presented in Appendix A.

Historically, the depth to water within the Town limits has been as deep as 45 feet below ground surface, based on information reported on well permit forms and information provided by the Town regarding sewer line and pump station conditions. The current depth to water within the Town ranges from 9 to 17 feet below ground surface. During 2015, groundwater levels were as shallow as 6 feet below ground surface near Main Street and 11th Street (RE-1 Well) and 4 feet below ground surface near the wastewater treatment plant (located in the northeast corner of Town). The hydrographs indicate that water levels have generally trended down since the monitoring was initiated in 2015; with the water level decline for the approximate 16-month period ranging from 0.4 to 6.4 feet, and averaging approximately 2.5 feet.

R66W

T4N

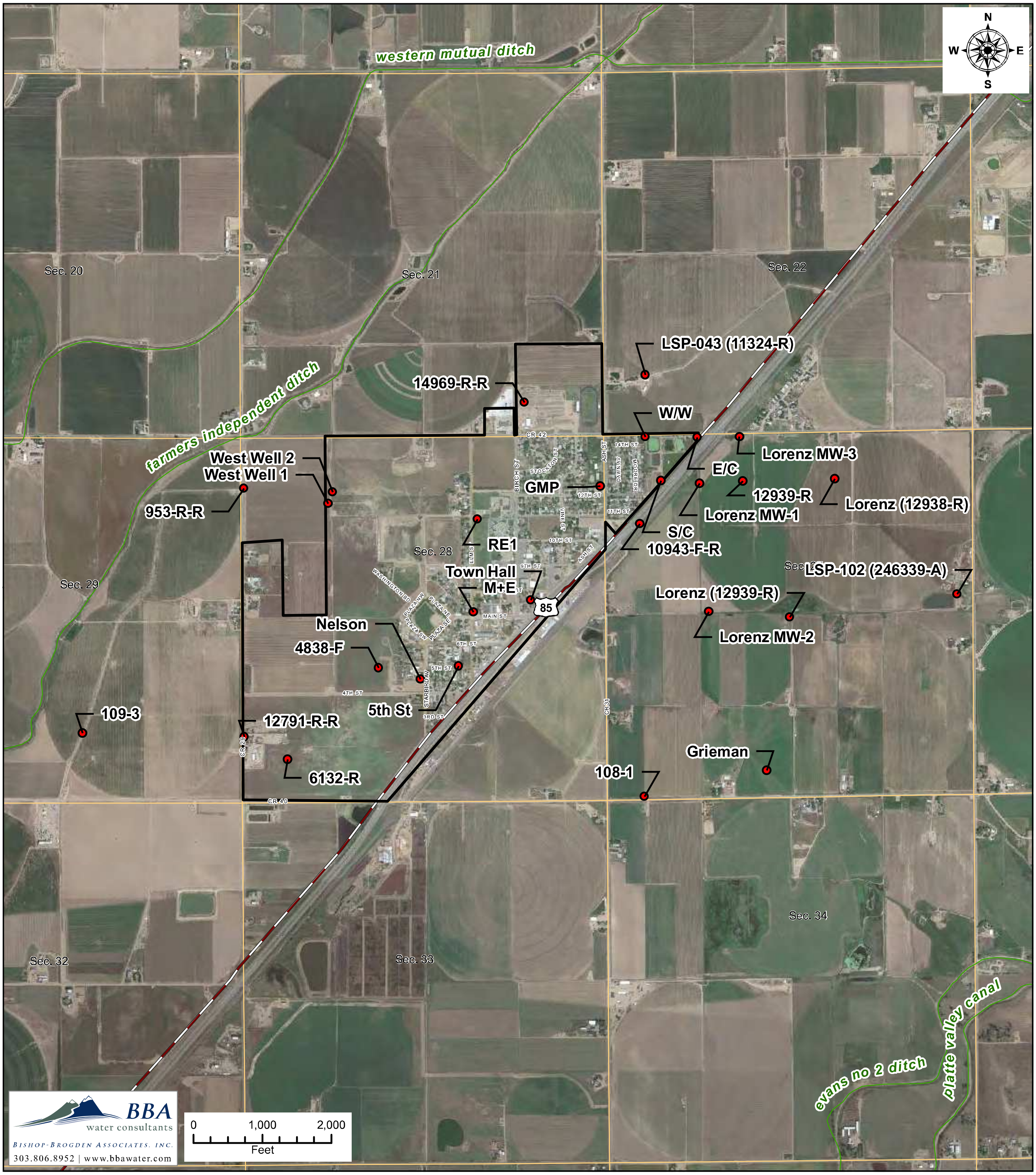


FIGURE 2.1 Town of Gilcrest Ground Water Measurement Locations

Date: 9/20/2016 | Job No. 1606.00

Legend

- Ground Water Measurement Location
- Town Boundary
- PLSS Section

Aerial Photo Date: 6/19/14

Data Source: Town of Gilcrest, BBA, CDSS, CDOT, USGS, BLM

Colorado

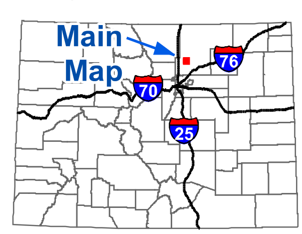


Table 2.1
Town of Gilcrest
Well Information in Vicinity of Town

Name	Permit No.	Registered Owner	Depth (ft)	Pumping Rate (gpm)	Static Water Level (ft)	Static Water Level Date	Q40	Q160	Section	Township	Range
Town of Gilcrest Pumping and Monitoring Wells											
Nelson	16163-F-R	Henry Keiser	92	1000	30	5/12/1955	NE	SW	28	4 N	66 W
5th St.	12390-R	Western Wholesale Produce	90	500	15	10/23/1945	NW	SE	28	4 N	66 W
M+E	13119-F-R	Town of Gilcrest	95	800	22	3/23/1970	SW	NE	28	4 N	66 W
RE1	59739-F	Weld County School District RE1	60	-	-	5/1/1951	SE	NE	28	4 N	66 W
TH	13118-F	Town of Gilcrest	90	800	35	5/1/1956	SE	NE	28	4 N	66 W
GMP	47041-F	Town of Gilcrest	92	700	20	9/26/1996	NE	NE	28	4 N	66 W
W/W	117787	Gilcrest Sanitation District	31	-	13	12/12/1980	NW	NW	27	4 N	66 W
E/C	117788	Gilcrest Sanitation District	31	-	13	12/12/1980	NE	NW	27	4 N	66 W
S/C	117789	Gilcrest Sanitation District	31	-	14	12/9/1980	NW	NW	27	4 N	66 W
Lorenz MW-1	297252	Town of Gilcrest	16	-	7.75	4/22/2015	NE	NW	27	4 N	66 W
Lorenz MW-2	297254	Town of Gilcrest	16	-	5.67	4/22/2015	NE	NW	27	4 N	66 W
Lorenz MW-3	297253	Town of Gilcrest	16.5	-	6.17	4/22/2015	SE	NW	27	4 N	66 W
State Monitoring Wells											
108-1	19468-R	Nelson Hans	66	550	12	5/6/1951	SW	SW	27	4 N	66 W
109-3	10987-R	Wiedman Terry	97	800	32	11/1/1968	SE	SW	29	4 N	66 W
LSP-043	11324-R	Kaveny A J Sr	102	1000	22	7/1/1954	NW	SW	22	4 N	66 W
LSP-102	246339--A	J Oliver Lorenz	45	10	20	1/7/2004	SE	NE	27	4 N	66 W
Greiman	11224-R	Greiman Grant	56	600	9	8/1/1943	SE	SW	27	4 N	66 W
Lorenz	12938-R	J Oliver Lorenz	34	450	8	7/1/1938	NW	NE	27	4 N	66 W
Nearby Wells											
West Well 1	630-R	Nelson Thyra	90	800	35	5/1/1934	NE	NW	28	4 N	66 W
West Well 2	19957-R	Western Equipment & Truck, Inc	75	1500	30	6/1/1917	NE	NW	28	4 N	66 W
	12939-R	J Oliver Lorenz	92	2500	-	7/1/1938	NE	NW	27	4 N	66 W
	12791-R-R	Benman Scott & Wendy	74	800	45	7/9/1994	SW	SW	28	4 N	66 W
	953-R-R	Wiedman Terry	80	1200	39	4/4/1997	NW	NW	28	4 N	66 W
	6132-R	Nelson Thyra	101	700	32	8/18/1958	SW	SW	28	4 N	66 W
	4838-F	Hunt David & Kayleen	98	2000	18	5/12/1964	NE	SW	28	4 N	66 W
	14969-R-R	Weld County Reorg School District	80	1200	25	9/3/1973	SE	SE	21	4 N	66 W
	10943-F-R	Scaefer Carl & Venice	94	800	21	3/20/1967	NW	NW	27	4 N	66 W

Notes:
Depth, pumping rate and static water levels from Division of Water Resources well permit files.

The depth to groundwater maps were used to identify and confirm those areas within the Town where water levels need to be lowered and to quantify the amount the water levels need to be lowered beneath the Town to achieve target water level depths. Utilizing the depth to groundwater maps and the Town's input regarding required water levels within Town, target depths for lowering the groundwater table were established, as discussed in more detail below.

HISTORICAL LOW GROUNDWATER CONDITIONS

Historical (1950 to 1980) groundwater levels beneath Town are reported to be 13 to 35 feet below ground surface, based upon well construction reports. Regular water level measurements begin in August 2014 for the three wells located within the wastewater treatment plant. However, regular water level measurements were not recorded in a majority of the Town's wells until April 2015. Historical pre-2015 reported groundwater level measurements for Town wells are summarized above in Table 2.1. The nearest well with a long-term continuous water level record (LSP-102) does not indicate substantial long-term water level change (see Appendix A). However, a well located less than 1,000 feet north of the wastewater treatment plant (LSP-43) has continuous water level data from 1956 through 1976 and 2013 through present (see Appendix A). That well shows an approximately 10-foot water level rise, which is consistent with anecdotal reports from the Town.

RECENT HIGH GROUNDWATER CONDITIONS

A recent depth to groundwater map was prepared for the Town based upon April 2016 water level data from the Town, CSU, Tetra Tech, CDWR and BBA's field visit. April 2016 was chosen for depth to water mapping because the greatest number of water level measurements were available, including recent measurements toward the west of Town collected as part of this study. To prepare the April 2016 depth to water level map, groundwater elevations were contoured and subtracted from land surface elevations within Town. April 2016 water levels are approximately 3.5 feet deeper than the peak depth to water measured near the wastewater treatment plant during September 2014.

The groundwater table was mapped at a 1-foot contour interval, as shown in Figure 2.2. The groundwater table beneath the Town shows groundwater flow direction from the southeast on the east side of the Town and from south-southwest through Town. The USGS 10-meter ground surface digital elevation model (DEM) was verified based upon surveyed elevation of the points within the Town, shown in Figure 2.3. The groundwater elevations from Figure 2.2 and ground surface elevations from Figure 2.3 were converted to a 15-meter grid spacing to determine April 2016 depth to groundwater, shown in Figure 2.4.

April 2016 depth to groundwater mapping shows extremely shallow groundwater five to ten feet beneath ground surface generally isolated to areas east of Birch Street and immediately north of Liberty Park (baseball field).

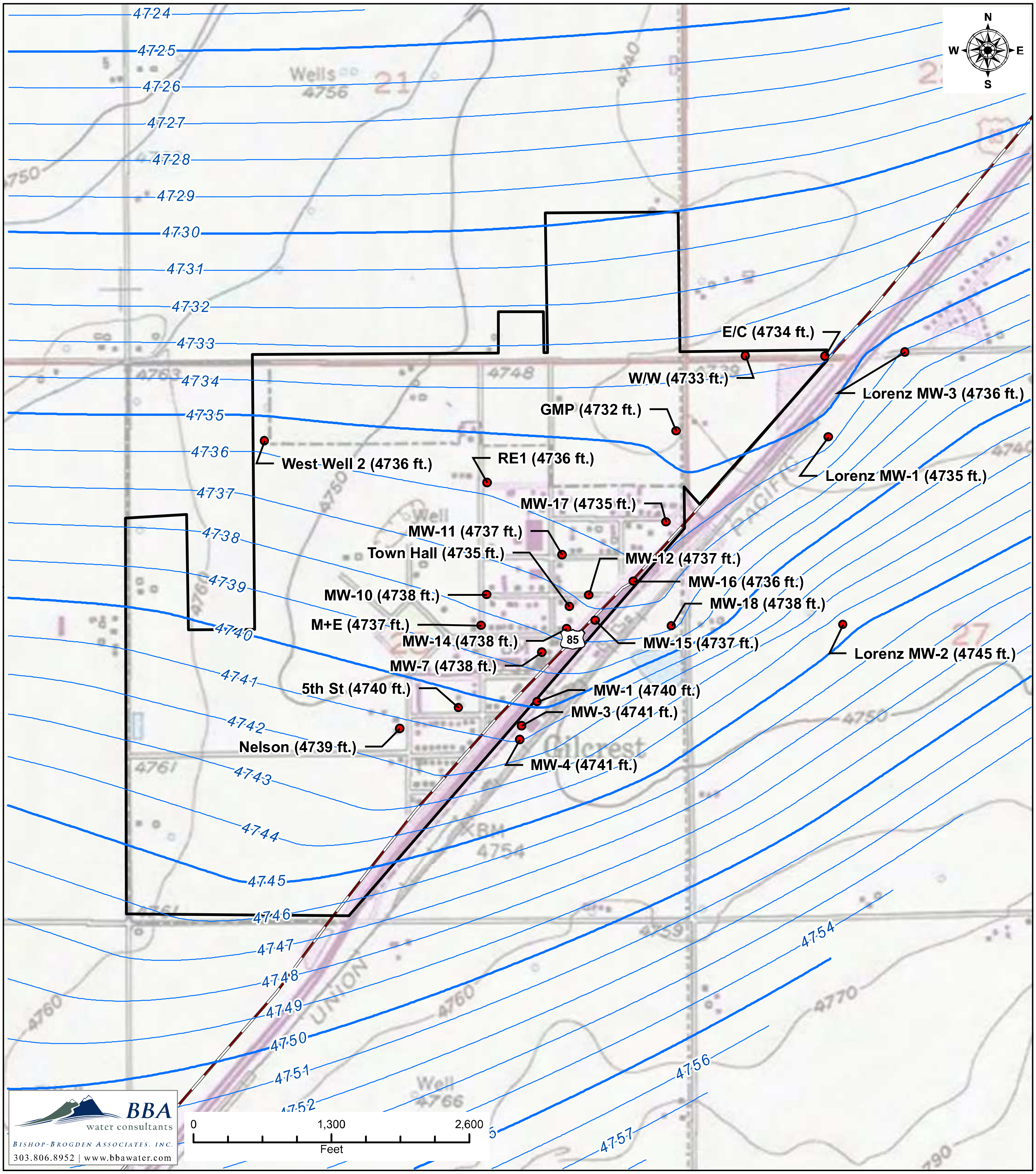


FIGURE 2.2
Town of Gilcrest
April 2016 Ground Water Level Elevation

Date: 8/25/2016 | Job No. 1606.00

Legend

- WL Elevation Data Points - April 2016
- 1 ft. WL Contours - April 2016
- Town Boundary

Data Source: Town of Gilcrest, BBA, TetraTech, CDSS, CDOT, USGS, BLM

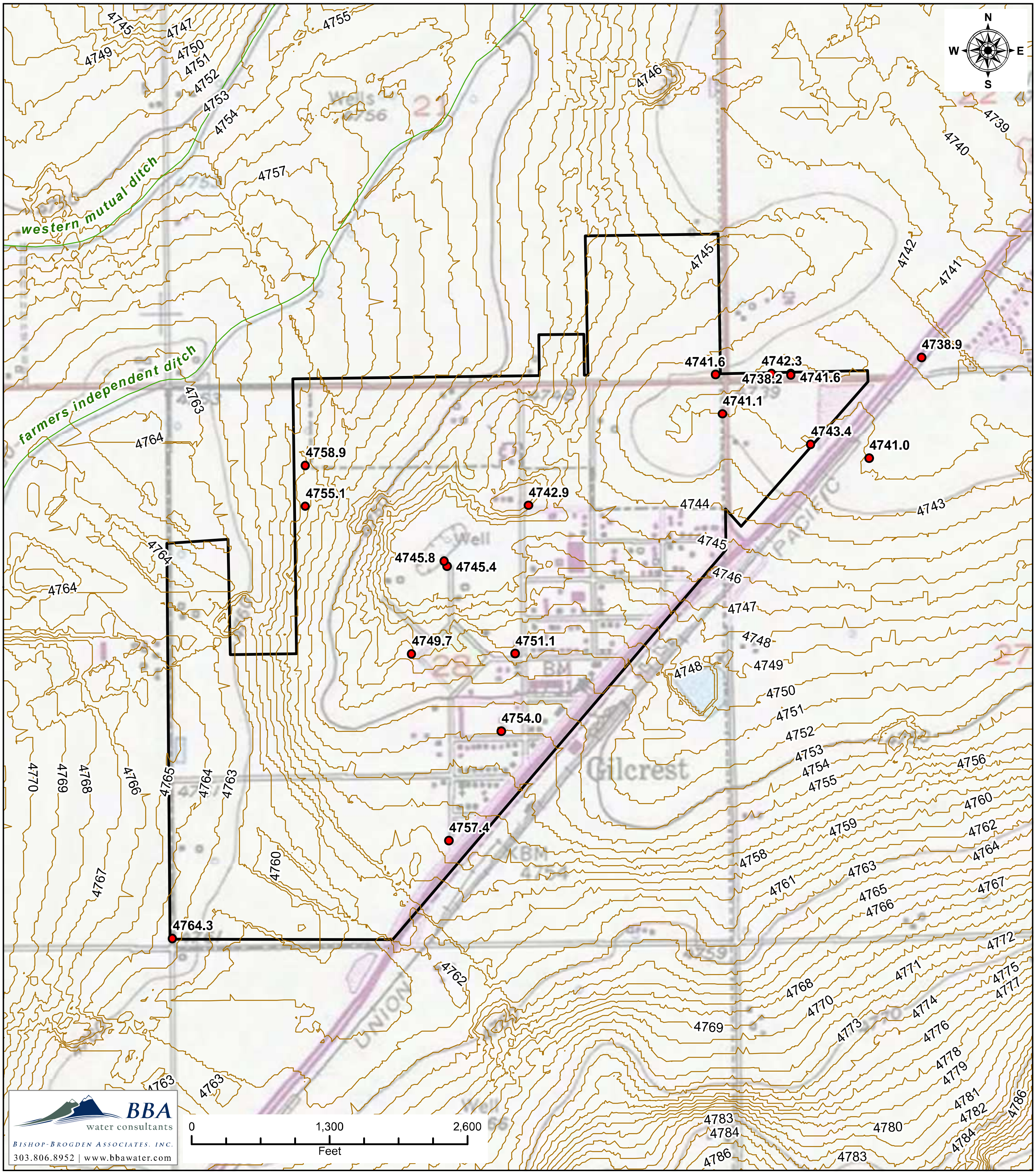


FIGURE 2.3
Town of Gilcrest
Ground Surface Elevation

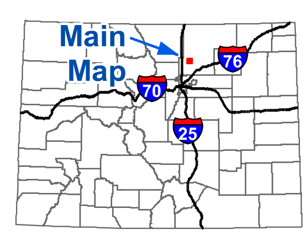
Date: 8/25/2016 | Job No. 1606.00

Legend

- Survey Points Relied Upon
- 1 Ft. Contours (From 10m DEM, USGS)
- Town Boundary

Data Source: CDSS, CDOT, USGS, BLM

Colorado



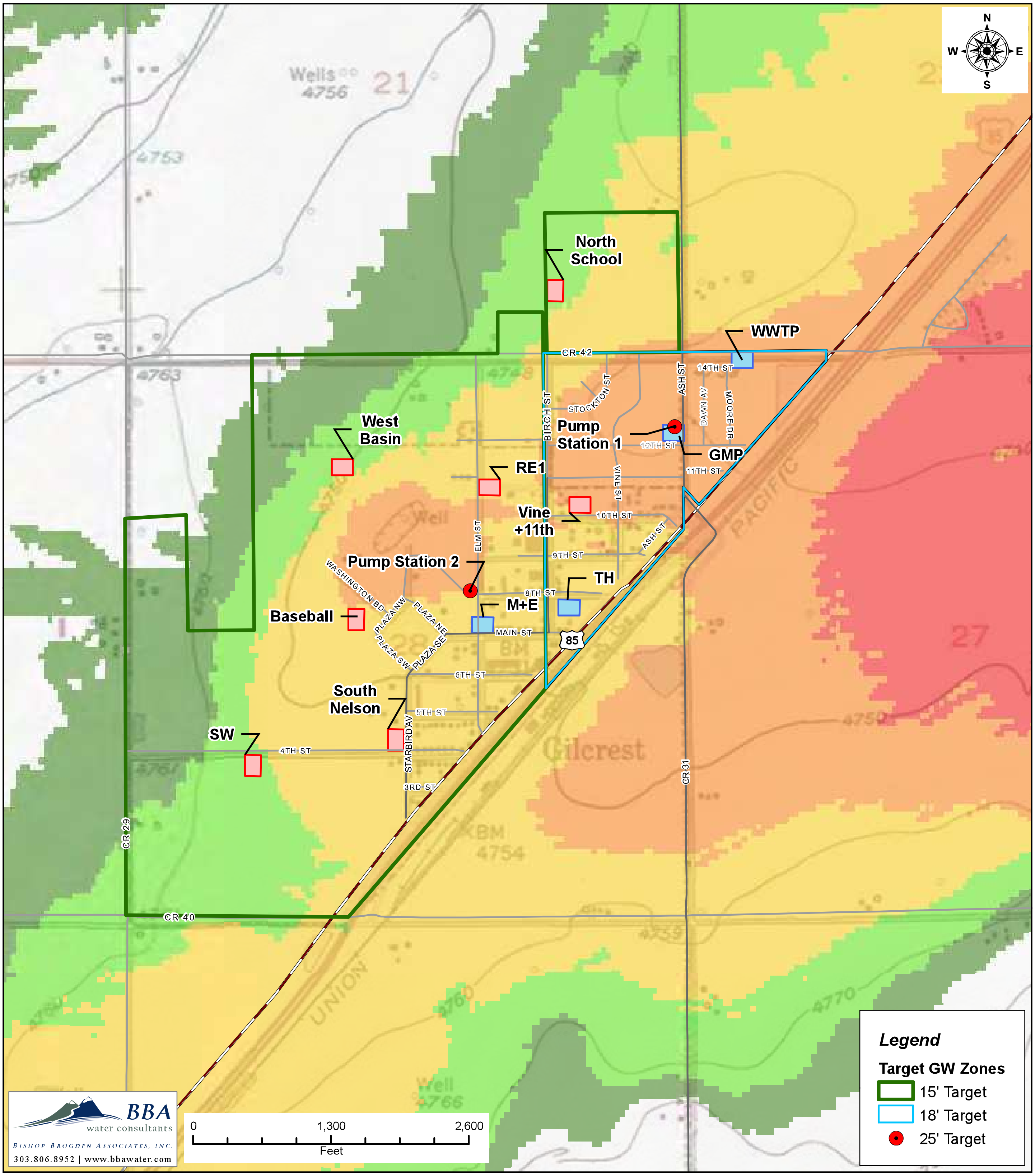


FIGURE 2.4

Town of Gilcrest
April 2016 Depth to Ground Water, Target Ground Water Depths and Dewatering Well Locations

Date: 9/9/2016 | Job No. 1606.00

Legend

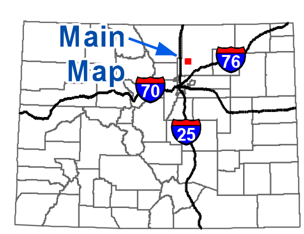
- Town Boundary
- Proposed Dewatering Well Site
- Alternative Dewatering Well Site

Depth to Ground Water

< 5	15 - 20
5 - 10	20 - 25
10 - 15	>25

Data Source: Town of Gilcrest, BBA, TetraTech, CDSS, CDOT, USGS, BLM

Colorado



Depth to Groundwater Targets

Depth to groundwater targets were developed based upon input from the Town for protection of critical infrastructure, shown in Figure 2.4. A depth to groundwater target of 18 feet was chosen for areas of the Town south of County Road 42 and east of Birch Street based upon a 12-foot depth of wastewater basins at the Town's wastewater treatment plant, depth of sewer lines and existence of basements in the historically developed portion of Town. The Town has two wastewater pump stations, one located at 12th Street and Ash Street and a second located at 8th Street and Elm Street identified in Figure 2.4. A depth to groundwater target of 25 feet was chosen at these locations to protect pump station infrastructure and minimize I&I. For all other areas of Town, a 15-foot depth to water target was chosen to prevent I&I to existing and future wastewater collection facilities. The depth to groundwater targets are conservatively deep and accommodate the relatively small water level decline observed in some wells between 2014 and 2016.

Groundwater Level Drawdown Targets

The depth to groundwater targets were subtracted from the April 2016 depth to groundwater mapping to determine the amount of groundwater level drawdown required throughout the Town, shown in Figure 2.5. The greatest drawdown targets are at the Town's two wastewater pump stations and in the northeast portion of Town near the wastewater treatment facility.

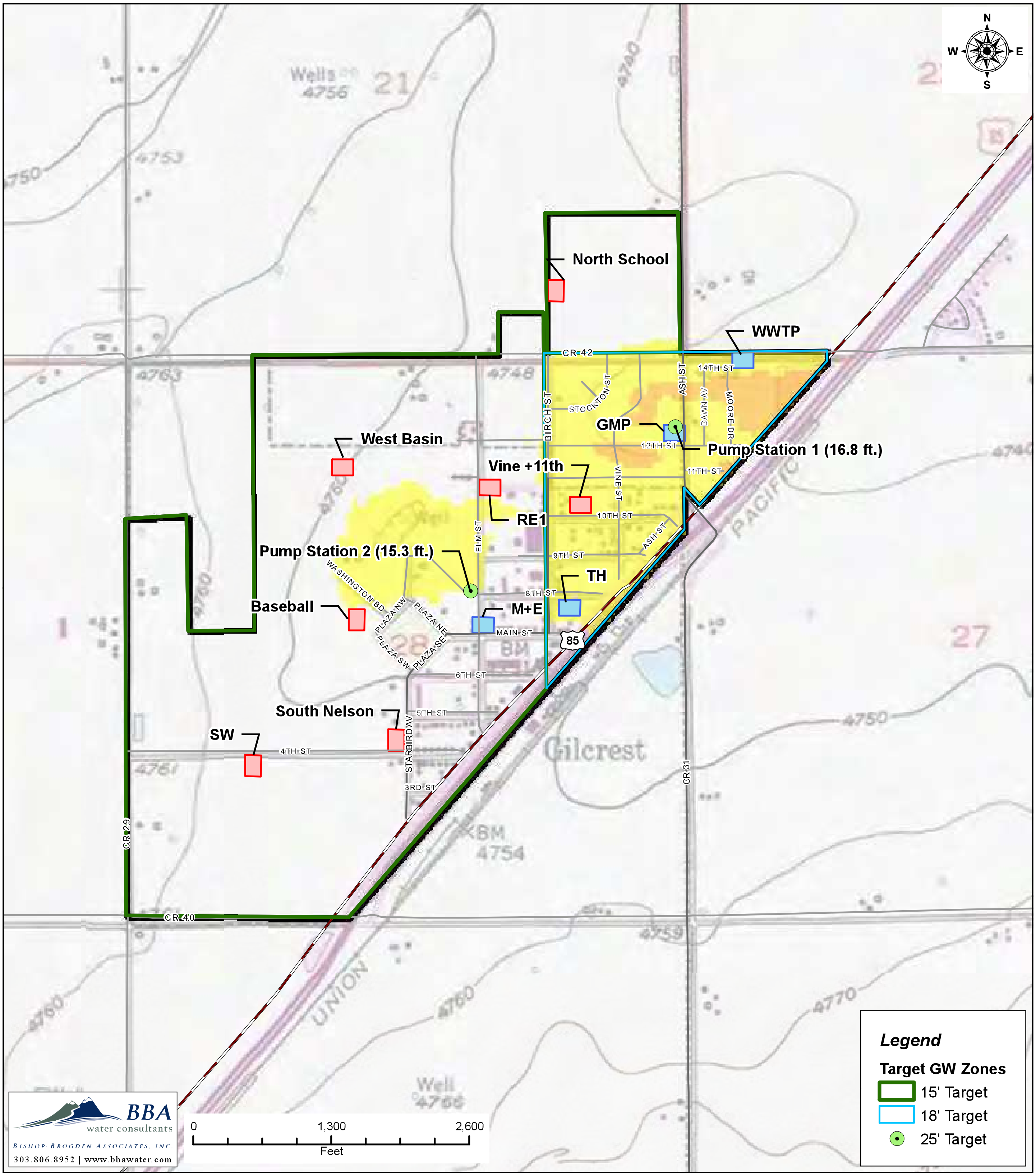


FIGURE 2.5
Town of Gilcrest
Drawdown Targets

Date: 9/9/2016 | Job No. 1606.00

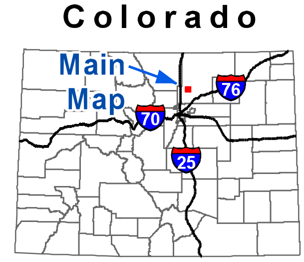
Legend

- Town Boundary
- Proposed Dewatering Well Site
- Alternative Dewatering Well Site

Drawdown Targets

- < 5
- 5 - 10
- 10 - 15
- 15 - 20

Data Source: Town of Gilcrest, BBA, TetraTech, CDSS, CDOT, USGS, BLM



SECTION 3 – GROUNDWATER RECHARGE

EXISTING SOURCES OF GROUNDWATER RECHARGE

The purpose of this task was to identify sources of groundwater recharge that may most directly impact groundwater levels beneath the Town. The locations of recharge ponds, irrigation ditches and irrigated lands located near the Town were inventoried, as shown in Figure 3.1. We reviewed the DWR database and water rights decrees to identify the proposed location of additional structures and future potential infiltration (recharge) facilities and recharge rates for all structures. A summary of existing and proposed groundwater recharge facilities is presented in Table 3.1, including recharge facility location, historical recharge amount and maximum recharge rate.

Recharge operations at the GMS Hunt, PVIC Hunt, Hunt W and Hunt SW recharge facilities are located immediately up-gradient from the Town and are likely to have the greatest impact on groundwater conditions. However, the historical amount of recharge at these facilities has been relatively small (25.1 to 162.1 acre-foot per year [af/yr]), compared to calculated groundwater underflow and the estimated rates necessary for dewatering described in later sections of this report. Although it is desirable to minimize recharge operations at these sites, they are not the sole cause for shallow groundwater conditions at the Town.

The Evans No. 2 Ditch is located southeast of Town and previous groundwater modeling simulations have indicated that up to 5,614 af/yr of seepage from this ditch is a substantial source of groundwater flow beneath the Town. Anecdotal reports from irrigators that use the Evans No. 2 Ditch indicate that modeled ditch seepage may be overstated. The Evans No. 2 Ditch directly up-gradient from the Town can be used for recharge operations, (see decree in Case No. 05CW331, Water Division 1). However, irrigators report that this up gradient reach is not currently used for recharge.

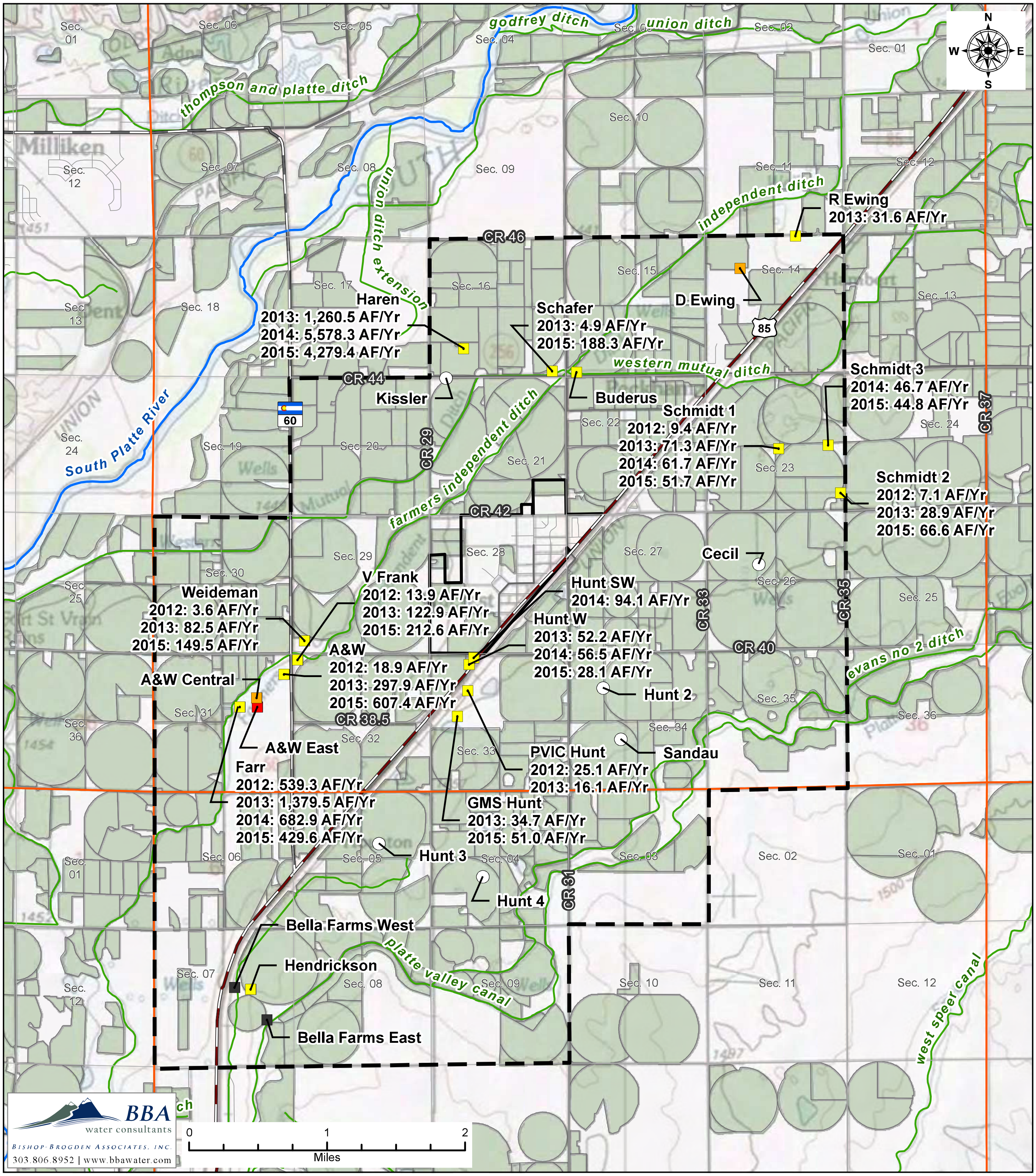


FIGURE 3.1
Town of Gilcrest Recharge Facilities in Vicinity of Town

Date: 9/1/2016 | Job No. 1606.00

Legend

Recharge Facilities

- Active with diversion records
- Active no diversion records
- Historical with diversion records
- Inactive no diversion records
- Non-existent no diversion records

- Town Boundary
- Area of Interest
- Irrigated Area - 2010

Data Source: B&C, CDSS, CDOT, USGS, BLM

Colorado

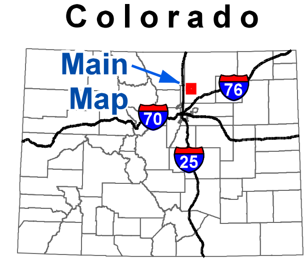


Table 3.1
Town of Gilcrest
Active Recharge Facilities in Vicinity of Town

Facility	Recharge Deliveries (af/yr)				Maximum Delivery Rate (cfs)
	2012	2013	2014	2015	
Farmer's Independent Ditch					
Weidman	3.6	82.5	0.0	149.5	2.4
V Frank	13.9	122.9	0.0	212.6	9.9
A & W	18.9	297.9	0.0	607.4	54.7
A & W Central	-	-	-	-	-
Farr	539.3	1379.5	682.9	429.6	16.6
R Ewing	0.0	31.6	0.0	0.0	2.2
D Ewing	-	-	-	-	-
Subtotal	575.7	1914.4	682.9	1399.1	-
Evans No. 2 Ditch					
Hunt SW	0.0	0.0	94.1	0.0	1.3
Hunt W	0.0	52.2	56.5	28.1	0.9
PVIC Hunt	25.1	16.1	0.0	0.0	1.1
GMS Hunt	0.0	34.7	11.5	51.0	3.5
Schmidt 1	9.4	71.3	61.7	51.7	1.0
Schmidt 2	7.1	28.9	0.0	66.6	1.2
Schmidt 3	0.0	0.0	46.7	44.8	1.1
Subtotal	41.6	203.0	270.5	242.1	-
Western Mutual Ditch					
Haren	0.0	1260.5	5578.3	4279.4	32.8
Schafer	0.0	4.9	0.0	188.3	1.3
Subtotal	0.0	1265.4	5578.3	4467.6	-
Other					
Buderus [3]	-	-	-	-	-
Hendrickson [3]	-	-	-	-	-
Total Recharge	617.3	3382.8	6531.8	6108.9	

Notes:
1. All recharge structures identified as "active" in CDSS records.
2. Recharge calculated utilizing daily diversion records from CDSS.
3. Structures are classified as active with diversion records in CDSS, but have no diversion records.

SECTION 4 – DEWATERING SYSTEMS

EXISTING DEWATERING STRUCTURES

An inventory was made of the existing wells and stormwater ponds that could potentially be used for dewatering. The Town's GMP, Main Street and Elm Street (M+E), Town Hall (TH) and 5th Street wells were identified as potential dewatering wells. These wells have estimated historical pumping capacities of approximately 300 gpm to 800 gpm. Details about these and other wells in Town are presented in Table 4.1. The GMP and M+E wells located at ideal dewatering sites, but are approximately 20 and 46 years old, respectively, and would need to be replaced to achieve maximum well yields.

NEW DEWATERING STRUCTURES

Additional potential dewatering well sites were identified based upon current and expected future land use within Town. Figure 4.1 presents a total of 11 potential well sites that were considered for dewatering. Of those sites, only the WWTP site was included in the conceptual dewatering alternatives.

Table 4.1 – Summary of Town Wells

Name	Permit No.	Year Constructed	Reported Rate	Status
5th St.	12390-R	1945	300	Active
M+E	13119-F-R	1970	800	Operational, Inactive
TH	13118-F	1956	800*	Not Operational
GMP	47041-F	1996	700	Active

Notes: Rates and statuses reported by Town of Gilcrest. *Rate reported on Permit No. 13118. Rates and statuses reported by Town of Gilcrest

600-FOOT SPACING

Water supply wells located within 600-feet of each potential dewatering well sites were identified based upon records available from the Division of Water Resources and communications with Town staff. Figure 4.1 identifies water supply wells located within 600-feet of potential dewatering well sites and information regarding those wells is summarized in Table 4.2. Pursuant to C.R.S. 37-90-137(2)(b) dewatering wells must be located more than 600-feet from any water supply well unless a waiver has been obtained from the well owner.

R66W

T4N

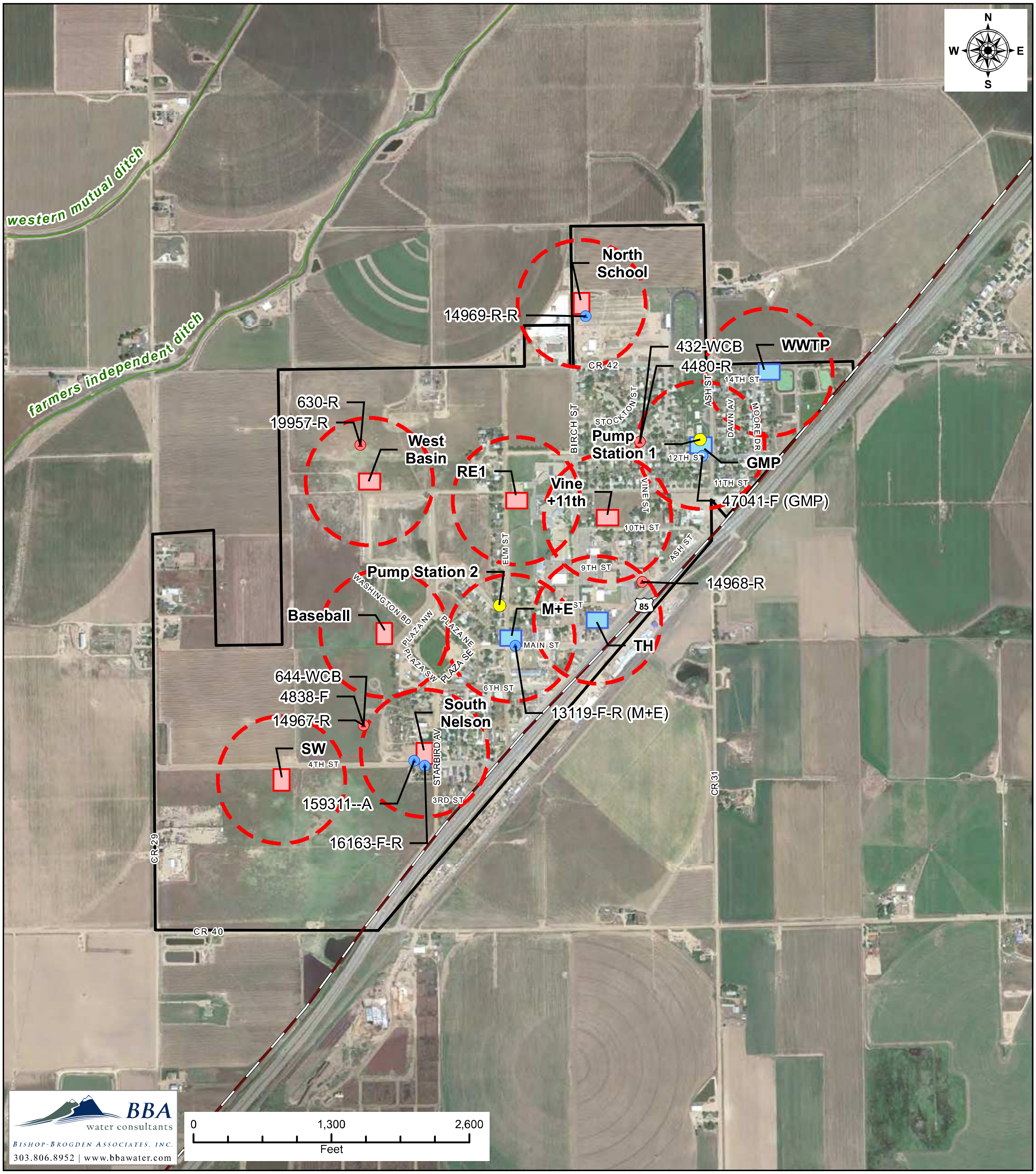


FIGURE 4.1
Town of Gilcrest Proposed Dewatering Well Locations

Date: 8/26/2016 | Job No. 1606.00

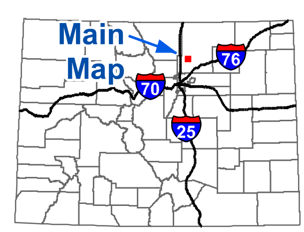
Legend

Wells within 600 ft. of Dewatering Sites - Permit No.

- Spotted From Quarters
- Spotted From Section Lines
- Town Sewer Pump Station
- Proposed Dewatering Well Site
- Alternative Dewatering Well Site
- 600 ft. Buffer
- Town Boundary

Aerial Photo Date: 6/19/2014
Data Source: Google Earth, CDSS, CDOT, USGS, BLM

Colorado



PRACTICAL PUMPING RATES

The maximum practical pumping rate for newly constructed dewatering wells was calculated based upon a range of assumed aquifer characteristics and two-thirds well drawdown. Table 4.3 summarizes estimated maximum pumping rates for various length pumping periods and aquifer characteristics discussed later in this report. Based upon a 1-year pumping period, the range of expected maximum well pumping rates is 1,849 gpm to more than 2,500 gpm.

Table 4.2 – Wells Within 600 Feet of Proposed Dewatering Wells

Permit No.	Owner	Depth (ft)	Pumping Rate (gpm)	Proposed Well Within 600 feet
16163-F-R	Keiser Henry	98	1000	South Nelson
159311--A	Keiser Henry	95	15	South Nelson
14968-R	Cogburn Earl	73	1200	Vine + 11th
14967-R	Cogburn Earl	80	1000	SW
4838-F	Hunt David W	98	2000	SW
630-R	Nelson Thyra	90	800	West Basin
19957-R	Western Equipment	70	1500	West Basin
14969-R-R	Weld School District	80	1200	North School
432-WB	Mcleod Royal	70	-	GMP
47041-F	Town of Gilrest	91	700	GMP
13119-F-R	Town of Gilcrest	95	800	M+E

Notes: Depth and pumping rate from Division of Water Resources well permit files.

Table 4.3 – Summary of Estimated Maximum Pumping Rates

Transmissivity (gpd/ft)	Storage	Radius (ft)	Saturated Thickness (ft)	Maximum Rate (gpm) / Pumping Period (days)					
				1	7	30	180	365	1826
100,000	0.2	1	90	> 2500	> 2500	2277	2039	1958	1796
300,000	0.2	1	90	> 2500	> 2500	> 2500	> 2500	> 2500	> 2500

Notes: Maximum drawdown is 2/3 of saturated thickness. Jacob equation is used for maximum pumping rate calculations. Transmissivity is adjusted for declining saturated thickness.

SECTION 5 – INITIAL DEWATERING RATE ESTIMATES

Quantitative evaluation of groundwater flow conditions was evaluated using three methods: (1) groundwater underflow calculation based upon groundwater mapping prepared in the 2014 CGS Report and 2015 CGS Report, (2) calculations based upon the water budget mass balance presented in the 2015 Brown and Caldwell Report and (3) superposition well drawdown analysis. These analytical methods allowed the study team to estimate the magnitude of dewatering rates required to achieve the Town's target depths and identify optimal dewatering sites. Estimated dewatering rates were refined through groundwater model analysis, summarized in Section 6. Aquifer characteristics were evaluated to support the dewatering rate estimates. The results of the analyses are presented in Tables 5.1 and 5.2, and discussed further below.

AQUIFER CHARACTERISTICS

Aquifer characteristics of saturated thickness, hydraulic conductivity and specific yield strongly influence groundwater flow and dewatering rates required to achieve the Town's depth to groundwater targets. Long-term aquifer pumping tests are the best source for data regarding aquifer characteristics, however there are limited aquifer pumping test data available in the immediate vicinity of the Town.

Based upon reported depth to bedrock and mapped groundwater levels in the vicinity of the Town, the average aquifer saturated thickness ranges from approximately 75 to 95 feet. Aquifer hydraulic conductivity was estimated to range from 400 to 800 ft/d in the vicinity of the Town based upon the 2014 CGS Report. The nearest controlled long-term aquifer pumping was completed 3 miles north of Town near the intersection of County Road 35 and U.S. Highway 85 in 1957, identified in Figure 5.1. That test is documented in Circular 11 (Pumping Test in Colorado, USGS, 1965) as B4-66-11adc, and shows a hydraulic conductivity of 1,270 ft/d, a transmissivity of 370,000 gpd/ft and storage coefficient of 0.03. During September 17 through November 1, 2015 water levels and pumping rates monitored near-continuous operation of the Lorenz well. Analysis of water level data from observation wells located near the Lorenz well indicate a hydraulic conductivity of approximately 150 ft/d and a transmissivity of approximately 100,000 gpd/ft.

Based upon published values and analysis of well pumping test data, a transmissivity (product of hydraulic conductivity and saturated thickness) ranging from 100,000 to 300,000 gpd/ft was used for groundwater analyses for the Town. That range is based upon an average saturated thickness of approximately 90 feet and a hydraulic conductivity ranging from 150 to 470 ft/d. Specific yield was assumed to be 20%, which is the same value used in regional groundwater models and in support of numerous water court decrees.

Table 5.1 – Underflow Calculation

Underflow Rate (cfs)	Underflow Rate per foot of Saturated Thickness (cfs/ft)	Hydraulic Conductivity (ft/d)	Saturated Thickness (ft)	Transmissivity (gpd/ft)	Hydraulic Gradient (ft/ft)
2.55	0.03	149	90	100,000	2.6E-03
3.37	0.04	149	90	100,000	3.4E-03
7.65	0.08	446	90	300,000	2.6E-03
10.10	0.11	446	90	300,000	3.4E-03

*Notes: Hydraulic gradient from Appendix C, 2013 Time-Series Historic Groundwater Elevation Contour Map, CGS Report. Transmissivity from CGS Report and Lorenz monitoring well calculations. Town width is 6,375 feet. Saturated thickness estimated at 90 feet based on nearby well depths and water levels. Underflow rate = transmissivity * hydraulic gradient * town width.*

Table 5.2 – Summary of Theis Equation Superposition Model Results

Location	Target Drawdown (ft)	T = 100,000 gpd/ft		T = 300,000 gpd/ft	
		Rate (gpm)	Simulated Drawdown (ft)	Rate (gpm)	Simulated Drawdown (ft)
Proposed Wells					
WWTP	9.4	785	27.1	2200	25.2
GMP / Pump St. 1	15.3	1500	45.5	2200	25.9
West Basin	4.0	-	7.5	-	8.8
RE1	10.6	-	10.6	695	14.8
Vine + 11th	8.3	-	13.2	-	12.5
Baseball Field	0.5	-	8.2	-	9.1
M+E	5.8	1022	29.5	2200	23.8
South Nelson	5.4	-	7.8	-	8.7
SW	0.0	-	5.2	-	6.6
Observation Points					
SW-Town Boundary	0.0	-	2.9	-	4.6
NW-Town Boundary	0.0	-	5.4	-	7.0
SE-Town Boundary	1.5	-	4.5	-	6.0
E/C	10.4	-	10.4	-	10.5
Pump Station 2	12.6	-	12.8	-	12.6
South Birch	4.1	-	6.2	-	7.4
North Birch	1.3	-	9.3	-	10.4
	Total (gpm):	**3307**		**7295**	
	Total (cfs):	**7.4**		**16.3**	

Note: Target drawdown calculated as the target water level at location less April 2015 water level.

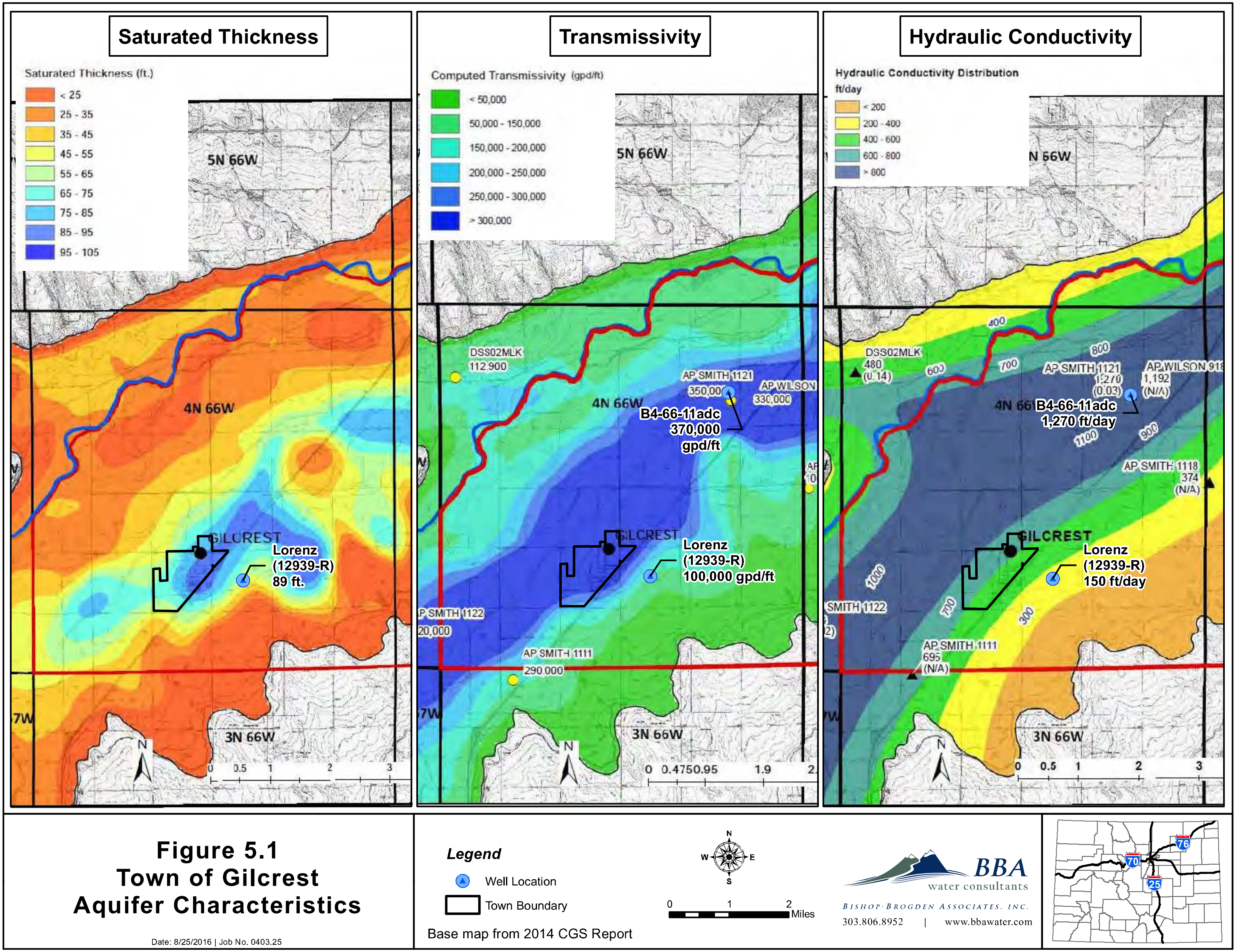


Figure 5.1
Town of Gilcrest
Aquifer Characteristics

Date: 8/25/2016 | Job No. 0403.25

Appendix C

PRINCIPIA

November 22nd, 2019

Gilcrest Groundwater Flow Model
Hypothetical Pumping Wells & Drains

Hypothetical Pumping Wells

Extracting from the October 2016 *Dewatering Improvements Study*[1] by JVA, Inc and Bishop-Brogden Associates, Inc. for the Town of Gilcrest, Colorado, three hypothetical pumping wells were selected to evaluate the effects of pumping. Three wells were simulated in the groundwater flow model to pump at varying rates for three years of operations to evaluate the effects of pumping on water level elevations in the immediate vicinity of the Town of Gilcrest. The locations of these three pumping wells were selected to match the locations of the Town of Gilcrest Waste Water Treatment Plant (WWTP), Pump Station 1 (PS1) and Pump Station 2 (PS2), as depicted in Figure 2.4 of the Dewatering Improvement Study report. The three hypothetical pumping wells and monitor wells in the vicinity are depicted in Figure 1.

Pumping Rates of the three wells:

Well	Pumping Rate (gpm)	Pumping Rate (cfs)
WWTP	450	~1.0
PS1	2500	~5.6
PS2	1400	~3.1

The hypothetical pumping rates for these three wells are shown in Figure 2. These three wells were each simulated to pump at their varying rates for a period of 36 months.

Hypothetical Drains

In addition to simulating pumping from three wells, a set of hypothetical drains were placed along the west and south-east perimeter of the Town of Gilcrest. The locations of the modeled drain cells are depicted in Figure 3. Two separate groundwater model simulations were undertaken with these perimeter drains, with the bottom drain elevations set at 2' and 5' below the starting water table. The locations of the pumping wells and drains, in relation to the model transmissivity, are depicted in Figure 4.

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Model Simulation Results: Pumping & Drains

The predicted head changes from the pumping simulations are depicted in Figure 5, at 6 month intervals. After 36 months of pumping, the predicted drawdown at PS1 is ~25', at PS2 is ~20', and at WWTP is ~19'. Within the 15' Target Groundwater Zone, the predicted drawdown after 36 months ranges from ~17' to ~25' at PS1. Within the 18' Target Groundwater Zone, the predicted drawdown after 36 months ranges from ~8' to ~20' at PS2.

The predicted change in water levels from the two separate drain simulations (2’ and 5’) are depicted in Figures 6 and 7, at 6 month intervals. After 36 months of drain operations (2' drain elevation), drawdown in the 15' Target Groundwater Zone is ~2', while in the 18' Target Groundwater Zone, drawdown ranges from ~1' to ~1.5'. For the simulation with a drain elevation of 5', drawdown in the 15' Target Zone is ~5', while in the 18' Target Zone, drawdown ranges from ~2.5' to ~4.5'.

The model predicted water level changes for the pumping and drain simulations, at monitor wells in the vicinity of the Town of Gilcrest are shown in Figures 8-29. The table below provides a tabulation of the predicted drawdown at each of the monitor wells, after 36 months of pumping/drain operations.

Water Budgets:

Monthly water budget results for the well pumping simulation are depicted in Figure 30. Well pumping was approximately 600 Acre-Feet/Month. Inflow from storage was approximately 600 Acre-Feet/Month initially, with storage inflow decreasing to approximately 275 Acre-Feet/Month after 36 months. Inflow from (or depletion to) the South Platte River was initially 0 Acre-Feet/Month, with inflow increasing to approximately 215 Acre-Feet/Month after 36 months. Initial constant head inflow (south and north ends of model domain) was initially 0 Acre-Feet/Month, with inflow approximately 110 Acre-Feet/Month after 36 months.

Monthly water budget results for the drain simulation with a bottom elevation of -2’ are shown in Figure 31. Outflow from the aquifer to the drains was approximately 245 Acre-Feet/Month initially, with outflow decreasing to approximately 60 Acre-Feet/Month after 36 months. Initial inflow from storage was approximately 245 Acre-Feet/Month, decreasing to 20 Acre-Feet/Month after 36 months. Inflow from the South Platte River was initially 0 Acre-Feet/Month, increasing to approximately 25 Acre-Feet/Month after 36 months. Constant head inflow from the southern and northern boundaries was initially 0 Acre-Feet/Month, increasing to approximately 15 Acre-Feet/Month after 36 months.

Monthly water budget results for the drain simulation with a bottom elevation of 5’ are shown in Figure 32. Outflow from the aquifer to the drains was approximately 615 Acre-Feet/Month initially, with outflow decreasing to approximately 145 Acre-Feet/Month after 36 months. Initial inflow from storage was approximately 615 Acre-Feet/Month, decreasing to 45 Acre-Feet/Month after 36 months. Inflow from the South Platte River was initially 0 Acre-Feet/Month, increasing to approximately 65 Acre-Feet/Month after 36 months. Constant head inflow was initially 0 Acre-Feet/Month, increasing to approximately 35 Acre-Feet/Month after 36 months.

[1] JVA, Inc. and Bishop-Brogden Associates, Inc, *Dewatering Improvement Study*, October 2016, 101 p.

Predicted Drawdown (After 36 Months)			
Well	**Pumping Simulation**	**Drain Simulation (-2')**	**Drain Simulation (-5')**
MW1: Lorenz West	9.2'	1.0'	2.6'
MW2: Lorenz South	13.4'	1.5'	3.6'
MW3: Lorenz North	14.7'	1.5'	3.8'
MW4: Fritzler East	5.9'	0.6'	1.6'
MW5: Fritzler Central	7.6'	0.8'	2.1'
MW6: Fritzler West	9.1'	1.0'	2.4'
MW7: Weideman	11.6'	1.3'	3.3'
MW8: Ulrich West	4.6'	0.5'	1.4'
MW9: Ulrich East	3.5'	0.4'	1.1'
Nelson	13.1'	1.5'	3.8'
Main & Elm	17.3'	1.9'	4.8'
5th Street	14.8'	1.8'	4.4'
Town Hall	18.2'	2.0'	5.0'
Pumping Well PS1	25.0'	1.8'	4.6'
Pumping Well WWTP	18.5'	1.7'	4.4'
WWTP South	19.2'	1.8'	4.5'
WWTP East	18.7'	1.8'	4.5'
RE1	16.7'	1.9'	4.8'
Lorenzo 12938-R	9.5'	1.0'	2.6'
CDA WL-M-003A	8.3'	1.0'	2.6'
Greiman 11224-R	6.3'	0.75'	1.9'
Pumping Well PS2	19.8'	1.9'	4.8'

Hypothetical Pumping Wells & Monitor Wells

Pumping & Monitor Wells

SPDSS Alluvial Groundwater Model

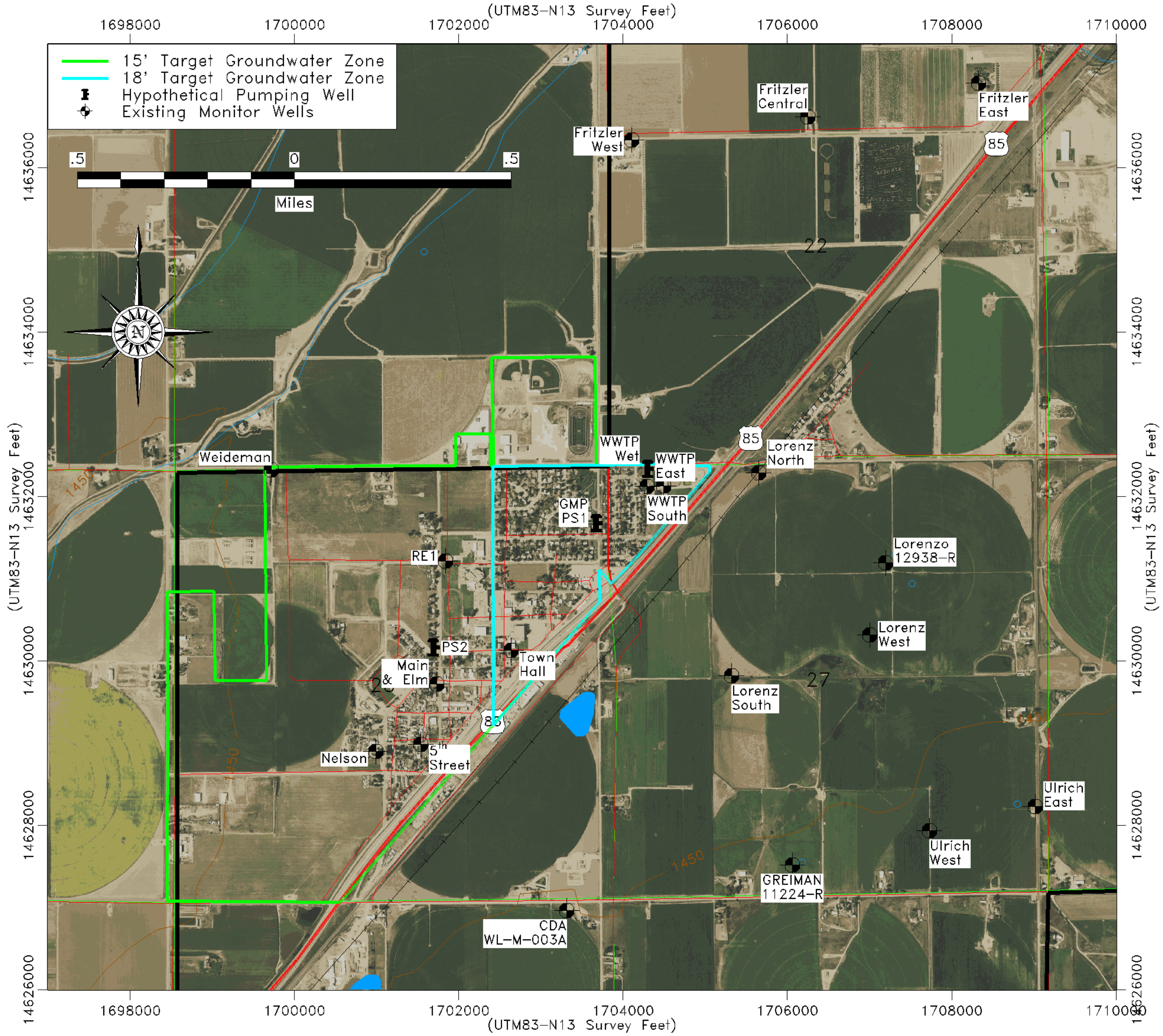


Figure 1

Hypothetical Pumping Rates

SPDSS Alluvial Groundwater Model

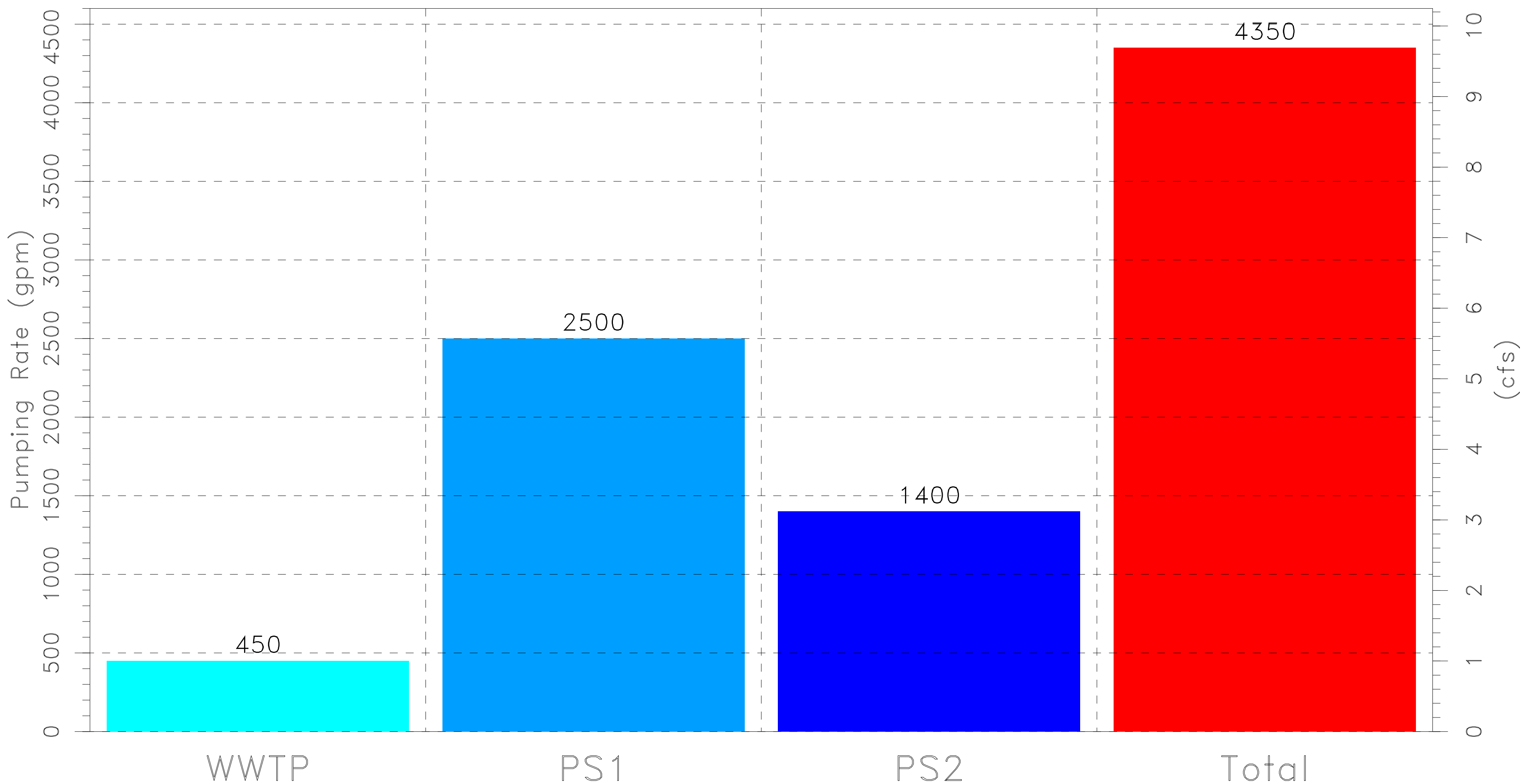


Figure 2

Hypothetical
Drains (2' or 5')

Hypothetical Drains & Monitor Wells

SPDSS Alluvial Groundwater Model

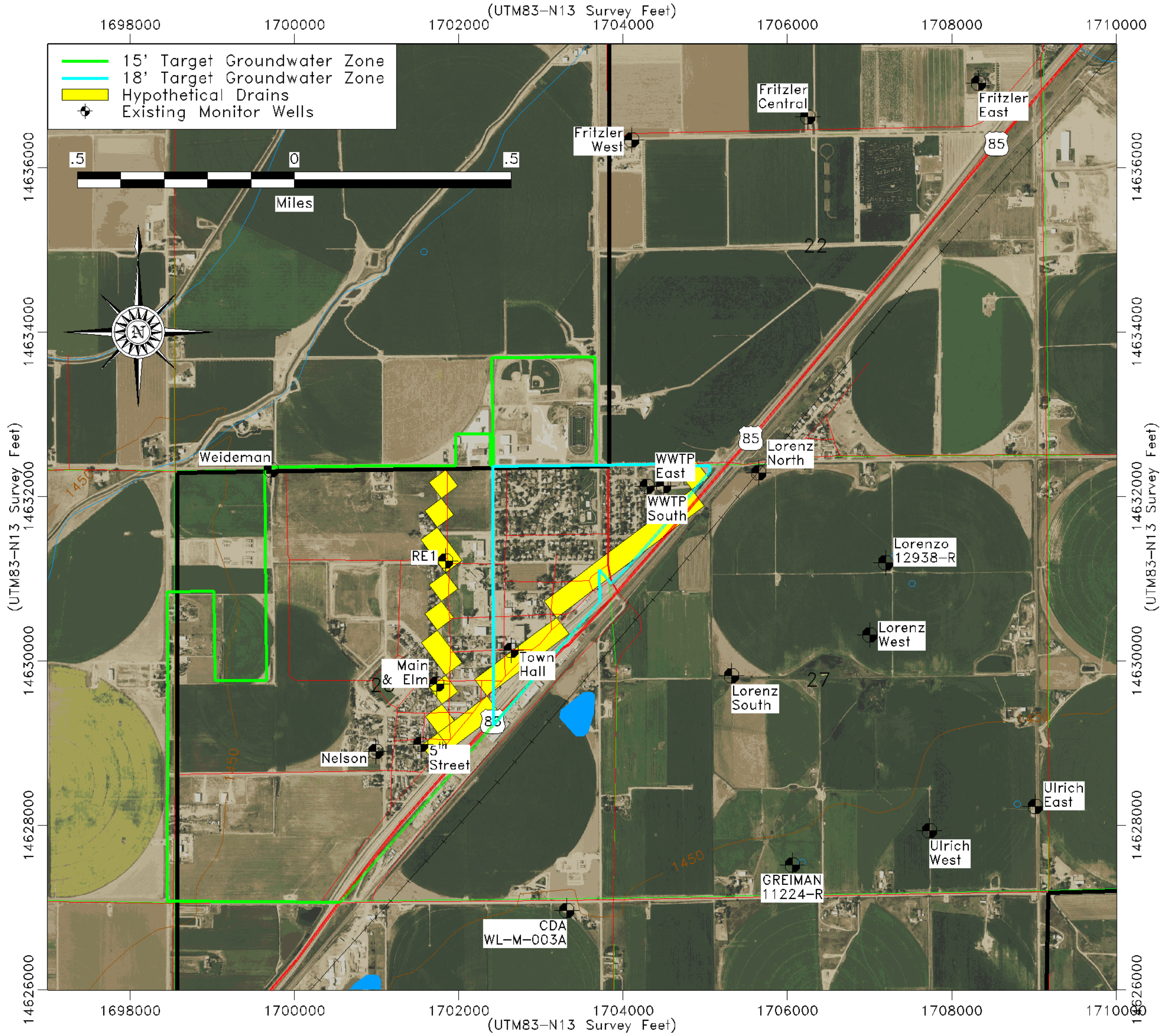


Figure 3

Model Transmissivity: Hypothetical Pumping Wells & Drains

Transmissivity, Wells & Drains

SPDSS Alluvial Groundwater Model

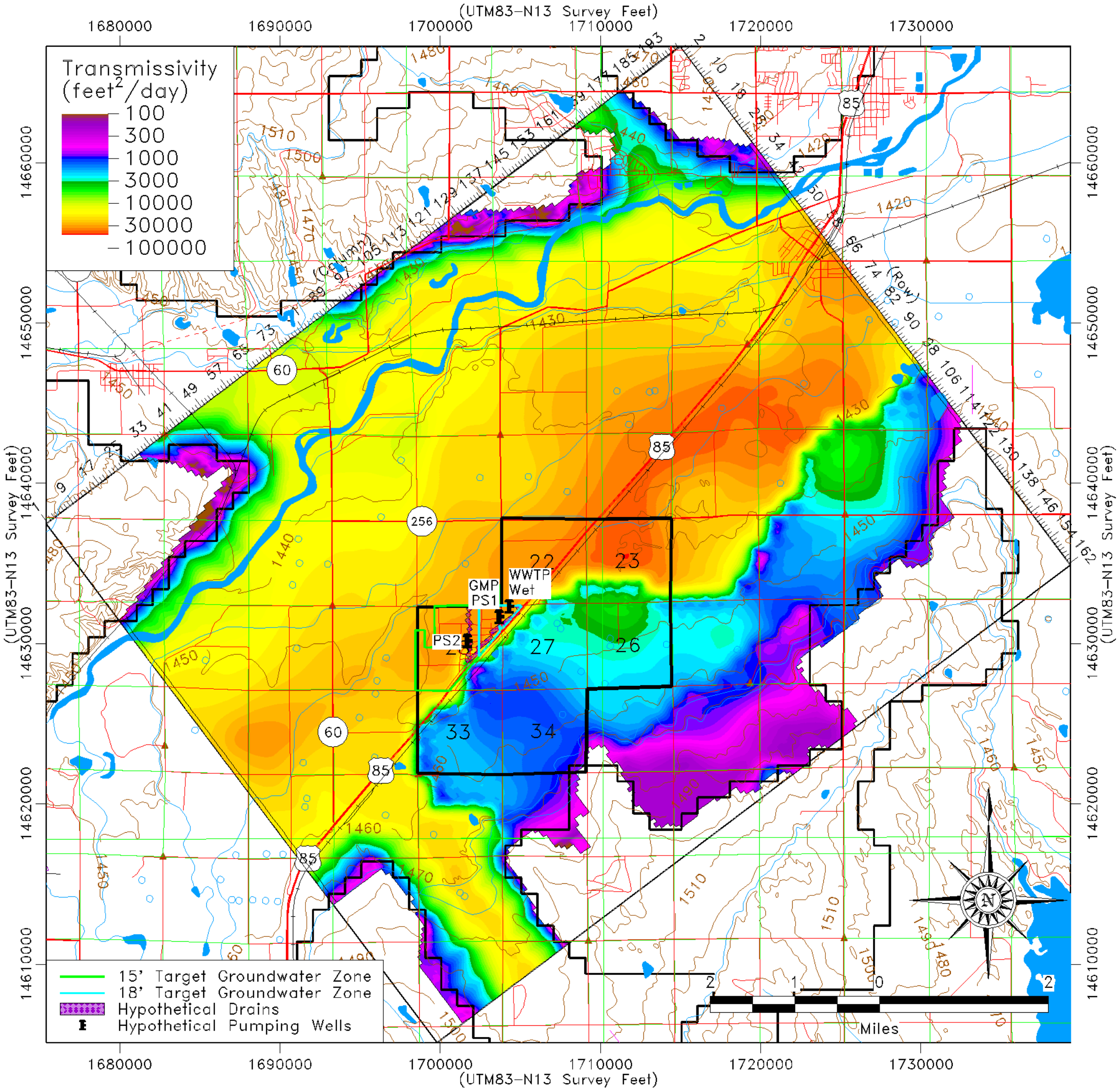


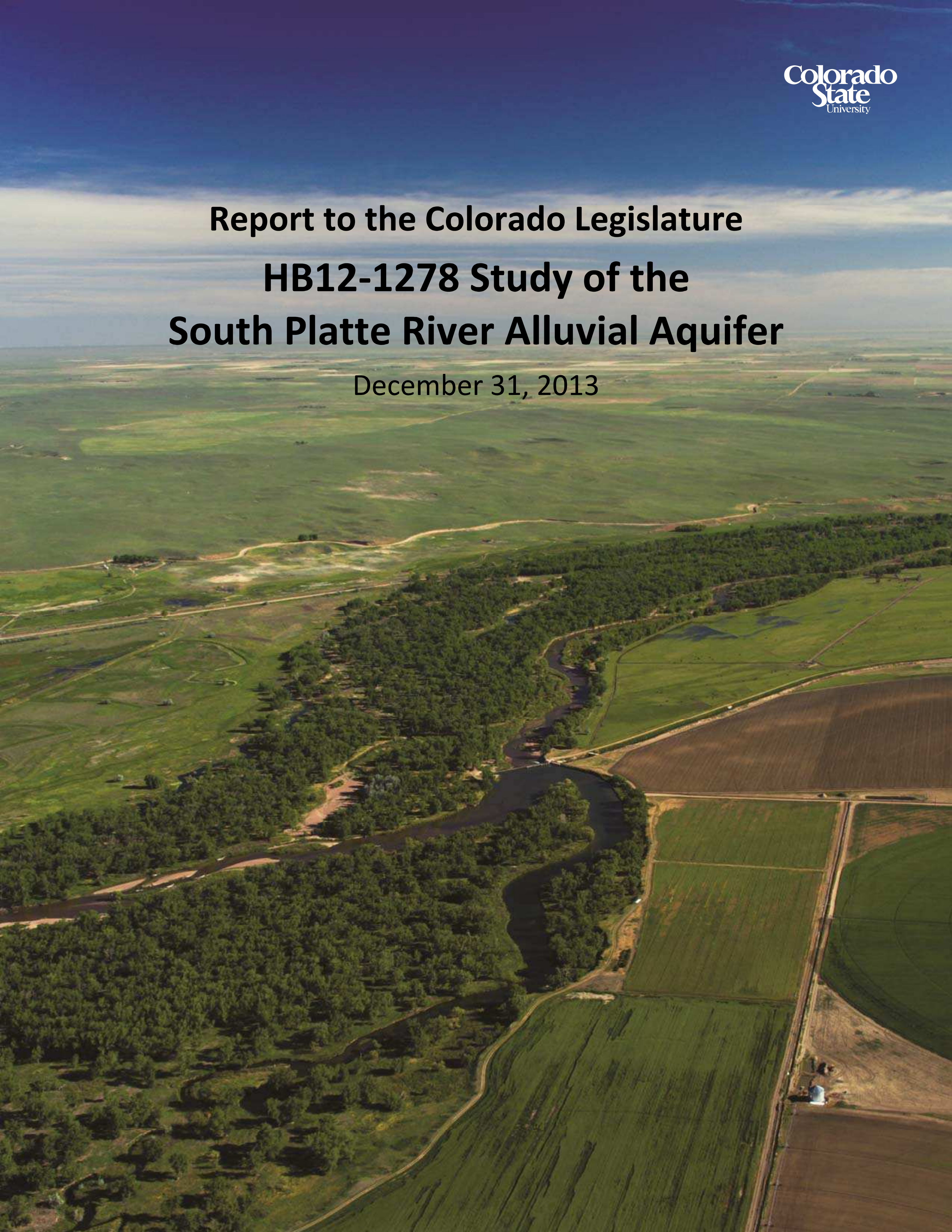
Figure 4

Appendix D

Report to the Colorado Legislature

HB12-1278 Study of the South Platte River Alluvial Aquifer

December 31, 2013



GROUNDWATER PUMPING

Key Points

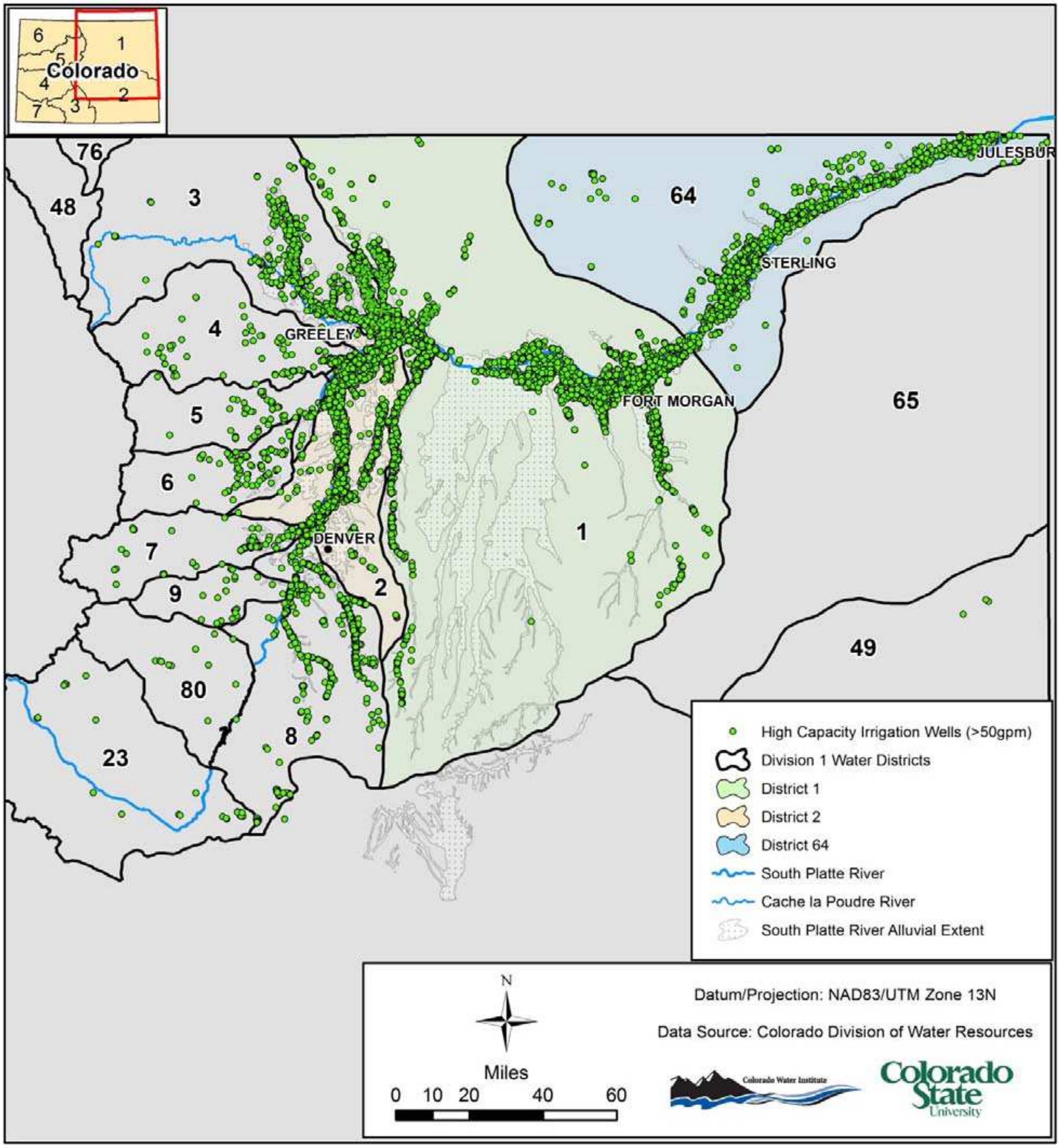
- The SB06-193 study conducted by the Colorado Water Conservation Board (CWCB) estimated 10 MAF of water is stored in the S. Platte alluvial aquifer.
- Prior to 2003, approximately 8,200 high capacity wells pumped on average nearly 500,000 AF/yr from the alluvial aquifer. There are now approximately 6,500 high capacity wells in the alluvial aquifer, and total annual groundwater pumping in the basin is now closer to 450,000 AF/yr, with agricultural pumping estimated in the 400,000 AF/yr range.
- In 2005, 60% of the 830,000 irrigated acres in the basin were watered solely with surface water, 18% solely with groundwater, and 22% with a mix of surface and groundwater.
- Most of the irrigation wells in adjudicated augmentation plans now have full or near full allocations in most years, however, the Central Colorado Water Conservancy District has approximately 1,200 wells in the WAS and GMS plans that are on a restricted quota and not able to pump 100% of full crop ET.
- The greatest groundwater pumping occurs in Water District 1, which correlates with the large amount of acreage served only by groundwater. The greatest percentage reduction in pumping has occurred in Water District 2 as Central WAS and GMS and other augmentation plans work to develop reliable augmentation supplies. Water District 64 has the most recharge and surface augmentation sources due to their downstream position in the basin. Pumping amounts have returned to previous levels in District 64.
- Groundwater pumping has shown a rebound in Water Districts 2, 1, and 64 since 2009 as additional augmentation supplies have been acquired and adjudicated.
- Groundwater pumping and consumptive use estimates were developed for the HB1278 study by the Wilson Water Group in collaboration with Leonard Rice Engineers. The well metering rules enacted in 2013 will enhance future pumping analyses.

Description of the South Platte Alluvial Aquifer

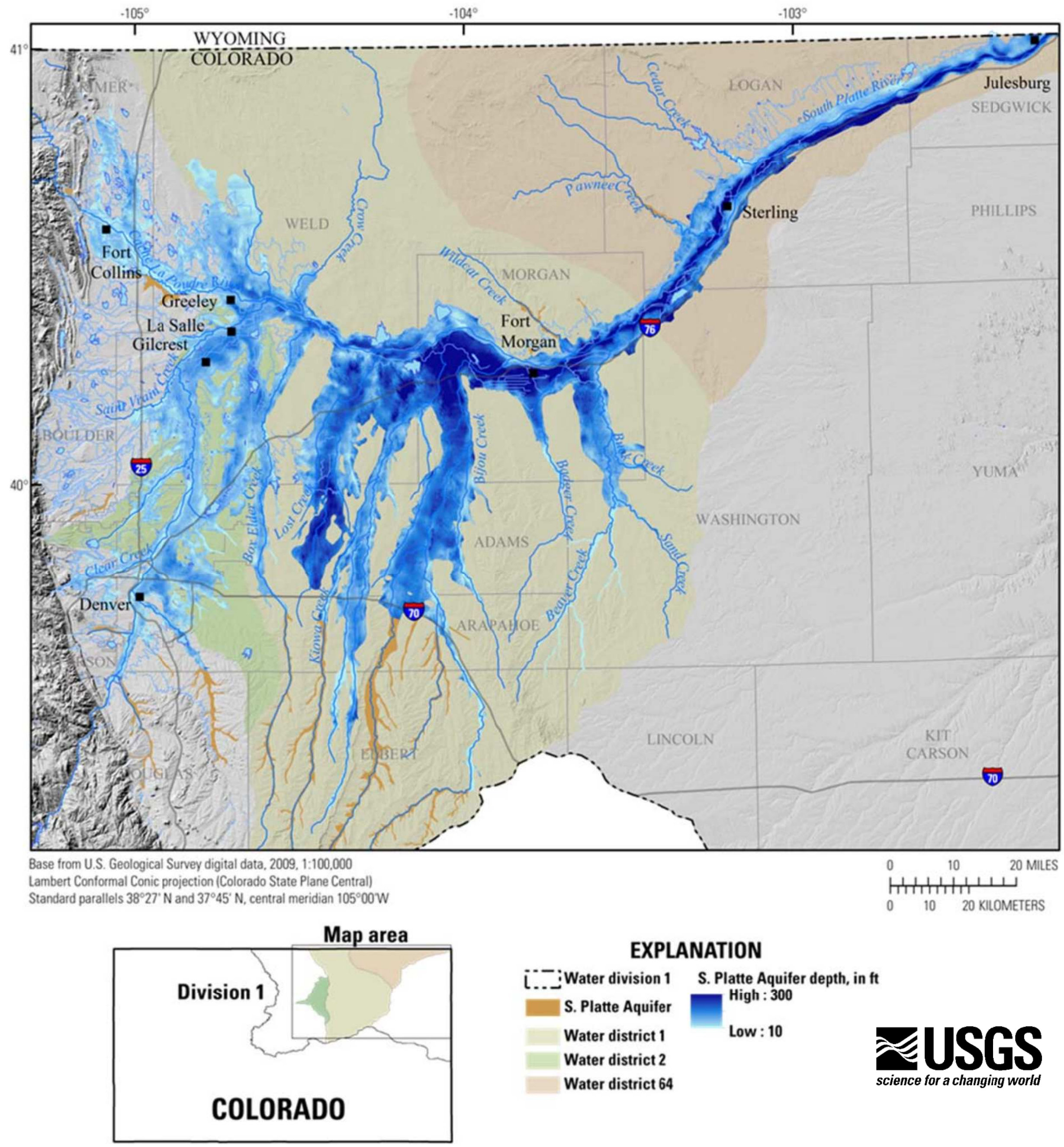
The S. Platte alluvial aquifer consists primarily of silt, sand, and gravel deposits of alluvial and aeolian origin that cover an area of over 4,000 square miles. Drilling logs indicate the deposits near the base of the alluvium are coarsest and become finer towards the surface, with considerable heterogeneity in the aquifer materials, particularly with respect to clay and silt. Clay layers are common throughout the basin, both laterally and vertically, and although clay layers may not be laterally continuous over great distances, they can affect pathways of groundwater movement. In addition, the aquifer grades from coarsest material in the west to finer material in the east. The ancient S. Platte River and its tributaries, swollen with snowmelt at the end of the last ice age (Pleistocene), left extensive alluvial deposits ranging in width from two to six miles wide and up to 200 feet deep in the main river channel. The flood plain of the S. Platte River east of the Front Range averages about a mile in width and has an irregular surface that consists of swamps, oxbow lakes, abandoned meander scars, and low, indistinct terraces (Smith et al., 1964). The overall surface drainage in the region is toward the northeast. Surface topography consists of many terraces and subtle changes in topographic relief that can make differences in water table depth over short horizontal distances. The major perennial tributaries of the S. Platte River in the project area are Clear Creek, Big and Little Dry Creeks, St. Vrain Creek, the Big Thompson River, Cache la Poudre River, Lone Tree Creek, and Crow Creek. Several intermittent streams also enter the river below Kersey, including Kiowa, Bijou, Badger, Wildcat, Beaver, Pawnee and Cedar Creeks.

The alluvial aquifer is in hydraulic communication with the surface water system throughout the basin, and the extensive development of irrigation, reservoirs, transbasin diversions, and wells has resulted in gaining conditions for the majority of the river since application of irrigation water results in deep percolation, and resulting return flows to the river. The maximum thickness of the alluvial deposits increases in a downstream direction on the mainstem with saturated thickness of 20 to 40 feet in the upstream region near Denver to more than 200 feet near Julesburg (Map 4). Well depths in the lower S. Platte River basin alluvium average about 75 feet below ground surface. The hydraulic characteristics of the aquifer are such that high-capacity irrigation wells may yield 1,200 to 2,000 gallons per minute. Hydraulic conductivity is the main physical parameter that governs the rate of groundwater flow, varying considerably within relatively small areas in the alluvial aquifer. Hydraulic conductivity (K) values in the S. Platte alluvial aquifer range from approximately 20 to 2,000 feet per day (with a median value near 500 ft/day) depending on the materials present. Infiltration from precipitation, irrigation, canal seepage, and pond seepage recharge the alluvial aquifers whereas groundwater tends to discharge to the main channel of the river. Groundwater discharge to the river channel creates baseflow for the river.

All groundwater in Water Division 1 that is not either Designated groundwater or Denver Basin groundwater is presumed to be tributary groundwater, in direct hydraulic connection to the surface stream system. However, there are a number of water right decrees in Water Division 1, generally entered from 1910 to 1970 that specifically declare the groundwater to be nontributary. The almost 500 so-called Coffin Wells in Water District 1 and 3 were decreed as non-tributary by Judge Coffin in 1953, although today we know they are in the alluvial aquifer and are indeed tributary to the S. Platte River.



Map 3. High Capacity Wells in the S. Platte Alluvial Aquifer.
Data Source: CO DWR HydroBase Version 20130710



Map 4. Aquifer Depths Across the S. Platte Alluvial Aquifer Showing Greatest Depths at the Channel Center to the East and Central Regions Near Fort Morgan and Along Lower Sections of the Lost Creek Tributary.

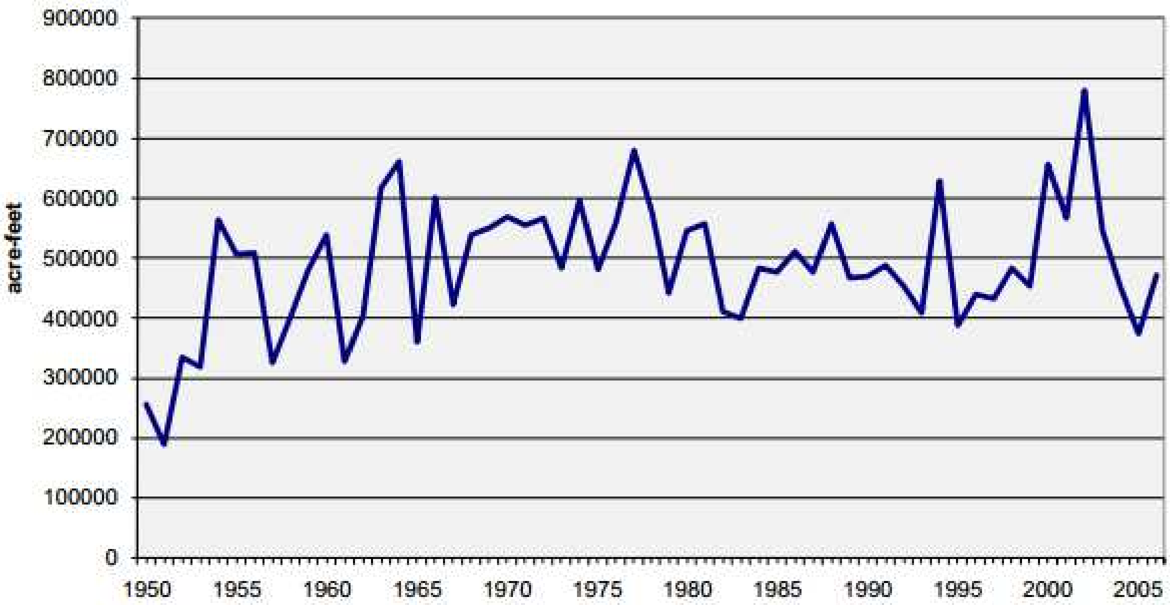


Figure 1. Estimated Groundwater Pumping for Irrigation from the S. Platte Alluvial Aquifer, 1950 – 2006.
Source: Historic Crop Consumptive Use Analysis South Platte Decision Support System (Final Report), p.44, by Leonard Rice Engineers, Inc., 2010, Denver, CO.

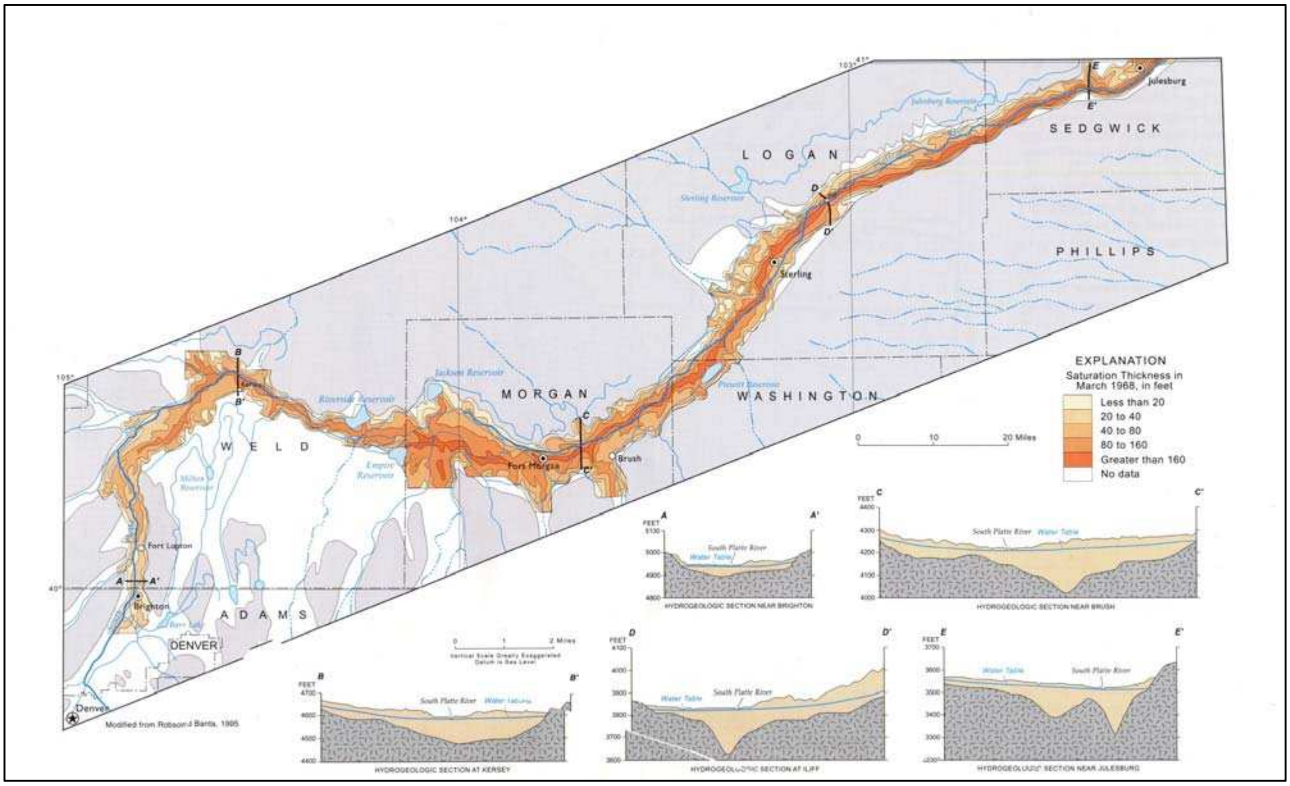
A number of studies have examined the alluvial aquifer of the S. Platte River and its tributaries. Stratigraphy of the alluvial deposits was originally described by Hunt (1954) and Scott (1960) and later by Scott (1963a). Several workers developed maps of the S. Platte alluvial aquifer extent, thickness, and depth to water beginning in the 1950s (Bjorklund and Brown, 1957; Smith and others, 1964; Duke and Longenbaugh, 1966; Nelson and others, 1967; Hurr, Schneider, and others, 1972a, 1972b, 1972c; Hurr and others, 1975; Konikow, 1975; Nadler and Schumm, 1981; Robson, 1996; and Robson, Arnold, and Heiny, 2000a, 2000b; Robson, Heiny, and Arnold, 2000a, 2000b). The South Platte Decision Support System (SPDSS) compiled selected maps of these features into Geographic Information System (GIS) data sets (CWCB, 2006b). Robson (1989) described the interconnection between bedrock and alluvial aquifers in the study area.

The SB06-193 study conducted by the CWCB revealed that there is an estimated 10 MAF of stored water in the S. Platte alluvial aquifer; 14 MAF if the designated basins are included. The study also estimated there is some 7 MAF of unsaturated alluvium that some fraction of which would be available for aquifer storage (Table 1).

Table 1. Estimated Storage Volumes in the S. Platte River Basin Alluvium[1].

Mainstem	Unsaturated Volumes[3]	Saturated Volumes[4]
Denver Metro	353,000	479,000
Metro to Greeley	169,000	920,000
Greeley to Ft. Morgan	94,000	1,143,000
Ft. Morgan Area	968,000	2,055,000
Balzac to State Line	890,000	4,058,000
Total	**2,474,000**	**8,655,000**
Tributaries		
Cache la Poudre River	291,000	859,000
Upper Beebe/Box Elder	268,000	494,000
Lower Beebe/Box Elder	61,000	259,000
Badger/Beaver Creek	311,000	600,000
Total	**931,000**	**2,212,000**
Designated Basins		
Upper Lost Creek	1,260,000	925,000
Lower Lost Creek	157,000	348,000
Upper Kiowa Creek	234,000	298,000
Lower Kiowa Creek	806,000	580,000
Upper Bijou Creek	466,000	450,000
Lower Bijou Creek	1,067,000	1,406,000
Total	**3,990,000**	**4,007,000**
Total Volume	7,395,000	14,874,000
Total Volume minus Designated Basins	3,405,000	10,867,000

Source: Based on data from the SPDSS and SB06-193 studies
1. Volumes rounded to the nearest 1,000 AF.
2. Sub-Regions defined in Figure 4 of SB06-193 Study
3. Unsaturated volumes exclude the upper 10 feet; from Table 2 of SB06-193 Study.
4. Saturated volumes are from average water table surface to base of alluvium.



Map 5. Aquifer Cross-Sections at Five Locations along the S. Platte River.
Source: Colorado Groundwater Atlas, Colorado Geological Survey.

Groundwater Use

Prior to 2003, on average nearly 500,000 AF of groundwater was pumped annually in the S. Platte basin from approximately 8,200 high capacity wells (Figure 1 and Map 3). Agricultural pumping between the years 1950 to 2000 was calculated to average 438,000 AF/yr with municipal and industrial pumping growing to approximately 50,000 AF/yr during this same period. There are now approximately 6,500 high capacity wells in the basin and total annual groundwater pumping in the basin is now closer to 450,000 AF/yr with agricultural pumping in the 400,000 AF/yr range (Table 2). Approximately 1,000 high capacity wells were abandoned through the 2010 Abandonment List, many of these were former GASP wells and of these, many had low pumping rates and were supplemental for drought insurance. Central Colorado Water Conservancy District has approximately 1,200 wells in the WAS and GMS plans that are on a quota system and not able to pump anywhere near 100% of full crop ET (GMS quota has been in the 35% range since 2006; WAS quotas have been even less). Most of the other irrigation wells in adjudicated augmentation plans have full or near full allocations in most years. While rules now require well owners to meter and provide pumping records, it will likely be several years before we have accurate accounting of wells metering records to determine exactly how much individual wells are pumping and how much water is extracted from the various reaches of the alluvium in the basin.

For the purposes of augmentation plans, two methods are generally used to determine the amount of stream depletion caused by well pumping: 1. crop potential consumptive or 2. presumed depletive factor. The crop potential consumptive method involves determining the potential crop consumptive use for the land irrigated by the wells in the plan. Any available surface water is subtracted from the potential consumptive use and the remainder is assumed to be the stream depletion caused by wells. This method was commonly used prior to 2003 but is not generally used in recent augmentation plans. The second and currently most commonly used method for estimating stream depletion is the presumed depletive factor (PDF). In this method, well volume is recorded or calculated and a specified percentage of that pumping is assumed to be consumptively used by the crop depending upon irrigation method (and hence the streamflow depletive amount). In most plans, sprinkler irrigation is assumed to have an 80% PDF and surface irrigation is assumed to have a 60% PDF.

Table 2. High Capacity Irrigation Well Count in Hydrobase by Water District in Division 1 Before and After Adjudication of the 2010 Abandonment List.

Water District	Wells Needing Augmentation Before 2010	Wells Needing Augmentation After 2010	Coffin Wells	Total Wells After 2010
WD 01	2279	2092	236	2328
WD 02	1939	1613	0	1613
WD 03	800	695	211	906
WD 04	112	77	0	77
WD 05	82	48	0	48
WD 06	91	25	0	25
WD 07	156	132	0	132
WD 08	591	456	0	456
WD 09	31	26	0	26
WD 23	24	24	0	24
WD 48	0	0	0	0
WD 49	4	4	0	4
WD 64	980	944	0	944
WD 65	0	0	0	0
WD 76	0	0	0	0
WD 80	13	12	0	12
Total for Div. 1	7102	6148	447	6595

Appendix E

June 1st, 2022

Mr. Eric Leigh
Monarch Mountain Minerals and Aggregates, LLC.
5 Concourse Parkway, Suite 1900
Atlanta, GA 30328

RE: Monarch DENM Gravel Mine – Mitigation Plan for Potential Groundwater Impacts

Dear Mr. Leigh

The purpose of this memo is to describe the existing groundwater regime in the vicinity of the Monarch DENM gravel mine including the potential groundwater impacts of the new soil-bentonite slurry wall(slurry wall) installations and wet mining of the Siltation and Freshwater Ponds. The Monarch DENM The site is located west of Highway 60, north of Weld County Road 40.5, and east and south of the South Platte River. It encompasses 545.90 acres (plus or minus) and consists of four slurry wall lined pits, an unlined Siltation Pond, and two Fresh Water Ponds. More specifically, the site is within parts of Section 18, 19 and 30, Township 4 North, Range 66 West, 6th P.M., County of Weld, State of Colorado. The site is approximately 550' south east of the South Platte River at its closest point. Land uses in the area include irrigated agricultural, oil and gas production, active gravel mines, mines reclaimed as below grade reservoirs, and low-density residential housing.

The Monarch DENM site will be mined in 5 phases comprising 7 cells. Phase 1 will consist of 2 unlined cells referred to as the freshwater pond and the siltation pond. The siltation pond will receive wash fines from the processing of mined sand and gravel. Phase 2 will be lined with a slurry wall and will contain Cell 1. Phase 3 will be lined with a slurry wall and will contain Cell 2. Phase 4 will be lined with a slurry wall and will contain Cell 3. Phase 5 will consist of 1 unlined Fresh Water Pond and a slurry wall lined Cell 4.

Existing Groundwater Conditions

The near surface groundwater is part of an alluvial aquifer in which permeable sand and gravel alluvium overlies relatively impermeable bedrock of the Denver Formation. Groundwater, measured in 7 piezometers, occurs at depths usually ranging from 4.6' to 29.3' feet with shallower groundwater to the north of the site. The prevailing groundwater flow at the site is to the north west reflecting the site topography. Groundwater in the area is tributary to the South Platte River located north of the site. Locally the groundwater levels and flow directions are likely influenced by:

- The South Platte River is north and west of the site. For most of the year, the river likely acts as a drainage way maintaining groundwater levels at elevations greater than water elevations in the river. In shorter periods of high run off, usually in the spring, river water levels will locally recharge the groundwater table.
- An unnamed slough runs between the South Platte River and the site. The slough likely acts as a drainage way maintaining groundwater elevations greater than water elevations in the slough.
- The Western Mutual Ditch traverses the southern portion property from west to east between Cell 1 and Cell 2 and then follows the east permit boundary until it flows underneath County Road 25.5. The ditch may act like a drain during the non-irrigation season maintaining water levels at or above the water levels in the ditch. During the irrigation season, the ditch may serve as a source of recharge to the water table.

- There are four (4) small pivot ponds at the site. These ponds likely cause elevated groundwater levels at the site during the irrigation season.

- Irrigation: The site is located in an area of irrigated cropland. Applied irrigation that is not lost to evaporation and transpiration likely recharges the groundwater.

- Alluvial wells: Other than the five monitoring wells drilled at the site for monitoring groundwater levels, there are also eight pumping wells permitted within 600 feet of the mine property. There are three wells north of the site, three wells east of the site, one well south of the site and one well west of the site. If pumping, groundwater will be drawn to these wells.

<u>Potential Slurry Wall and Mining Impacts to Local Groundwater Levels</u>

For all lined cells, a properly constructed slurry wall will tend to isolate these cells from the surrounding alluvial groundwater table. The liner around these cells could cause "mounding" of groundwater (increase in groundwater elevation) on the upgradient side (south and southeast) of the lined cells and a potential "shadow effect" (reduction in groundwater level) on the downgradient side (north and northwest) of the mine. Because the liner will tend to isolate these cells from the surrounding groundwater table, the effects of dewatering when mining lined cells will tend to not extend beyond the liner.

Any mounding effect on the upgradient side of the site (south and southwest) is anticipated to be on the order of a few feet or less and will dissipate with distance from the mine. Similarly, shadowing effects will be on the order of a few feet and will dissipate with distance from the mine. The shadowing effects will be minimized by the presence of the South Platte River to the northwest.

Dewatering of the unlined cells (Siltation Pond, and Freshwater Ponds) will result in decreases in water levels around these cells.

<u>Area Wells</u>

A review of the permitted wells on file with the State Engineer's Office (SEO), Division of Water Resources (DWR) indicates that there are eight permitted pumping wells within 600 feet of the permit boundary. All of these wells are screened in the alluvium. Three of these wells are located within 600 feet of the unlined cells (south Fresh Water Pond, Siltation Pond and North Fresh Water Pond).

Wells within 600 feet of the permit boundary(not owned by the site property owner) are discussed below:

- Carrol Sorrell Well 12462-R-R: This well is northeast of the plant area and is cross-gradient from the site. It is not expected to see a rise or fall due to the mine.
- Richard Karbowski Well 216684—8: This well is located between the north Freshwater Pond and the Siltation Pond. During mining of the North Freshwater Pond and Siltation Pond this well may see some drawdown due to the dewatering process. A monitoring well was installed approximately 250 feet to the west in order to monitor the effects of dewatering on the Karbowski well.
- Red Tierra Equities LLC Well 13689-R-R: This well is approximately 350 feet east of the Siltation Pond and may see some drawdown during dewatering of the Siltation Pond.
- United Water and Sanitation District Well 14028-R: This well is located approximately 365' southeast of the southern Fresh Water Pond. This well is upgradient from the unlined Fresh Water Pond and may see some drawdown during dewatering operations.
- Gerald Moran Well 187426—A: This well is located approximately 220 feet southeast and upgradient from the slurry wall lined Cell 2 and north of the Western Mutual Ditch. This well may see a groundwater mounding effect from the Cell 2 slurry wall on the order of a couple feet.

- Allan Frank Well 206387-: This well is located approximately 520' south west of the slurry wall lined Cell 1. The well is cross-gradient from Cell 2 and it is not anticipated to see changes in groundwater table.
- Janice Frank Well 14042-R: This well is located approximately 520' south west of the slurry wall lined Cell 1. The well is cross-gradient from Cell 2 and it is not anticipated to see changes in groundwater table.
- Ben Gutfelder Well 1874250-: This well is located approximately 275 feet northwest and downgradient from Cell 2. The well may see a groundwater shadow effect from the Cell 2 slurry wall on the order of a couple of feet. The groundwater shadow effect will likely be mitigated by the wells proximity to the South Platte River.

Groundwater Level Monitoring and Mitigation Plan

Dewatering during mining of the Siltation Pond and Freshwater Pond is unlikely to affect any wells in the area. However, if the miner receives a complaint, the following mitigation plan will be implemented.

The site monitoring wells will be measured monthly to identify potential changes in alluvial groundwater flow or elevation associated with mining and reclamation activities. Baseline data collected from the monitoring program will provide a range of relative water levels associated with pre-mining groundwater conditions. Experience at other mines in similar geologic settings has found that groundwater levels tend to fluctuate being highest in the summer irrigation season and lowest in the winter and early spring.

If, during mining or reclamation, the relative seasonal groundwater elevation at any monitoring wells differs from baseline conditions by more than 2 feet, and the condition was not observed during baseline monitoring, or if the miner receives a complaint from any well owner within 600 feet of the site boundary, then the miner will evaluate the cause and take action within 7 days and notify the DRMS.

After the DRMS has been notified, the miner will review the data and available information and submit a report to the DRMS within 30 days. The evaluation will include discussions with the well owner who has contacted the miner regarding a concern and review of baseline data from the well and vicinity to evaluate whether changes may be due to seasonal variations, climate, mining, slurry wall lining or other factors. The report will identify the extent of potential or actual impacts associated with the changes. If the extent of groundwater changes due to mining or reclamation activities is determined to be a significant contributing factor that has or may create adverse impacts, the mining associated impacts will be addressed to the satisfaction of the DRMS.

Miner will begin implementing one or more mitigation measures if mining and reclamation activity is determined to be a significant factor to groundwater changes requiring mitigation.

Mitigation measures may include, but are not limited to:

- Placing water in a recharge pond to raise groundwater levels around the well.

- Constructing a local clay liner at the edge of the mine Cell (i.e. between the dewatering point and the well) in order to raise water levels on the well side of the liner and mitigate dewatering effects.

- Cleaning the well to improve efficiency.

- Providing an alternative source of water or purchasing additional water to support historic well use in terms of water quantity and quality. If needed, water quality parameters will be checked in affected wells to ensure alternative sources support historic use.

- Modifying a well to operate under lower groundwater conditions. This could include deepening the well or lowering pumps. All work would be done at the miner's expense with the exception of replacing equipment that was non-functional prior to mining.

Attachments:
Existing Conditions Map
Proposed Reclamation Map

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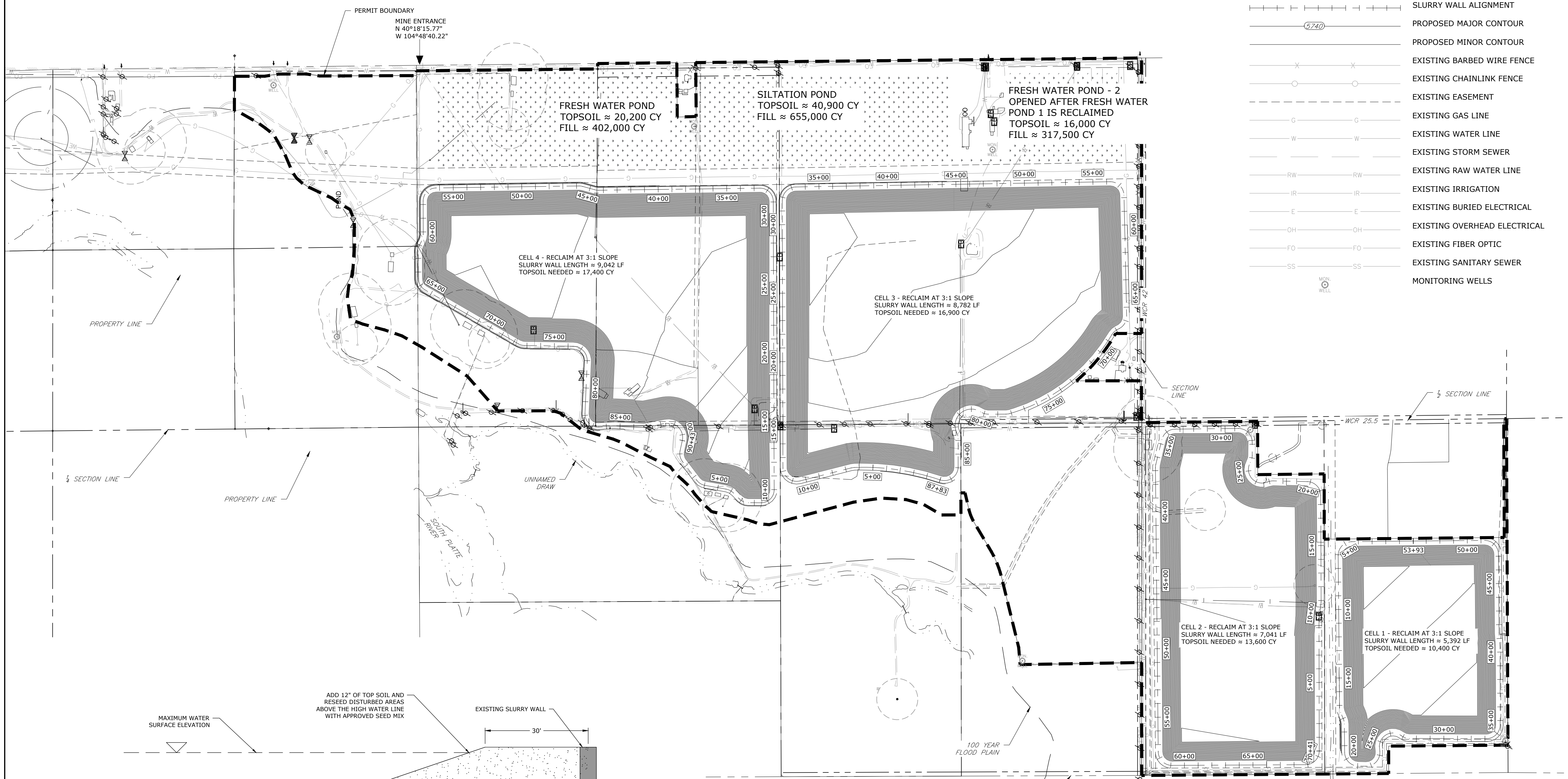
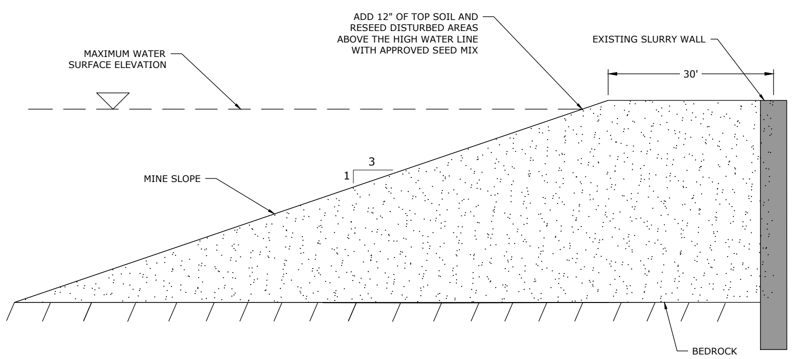


LEGEND:

- PROPOSED PERMIT BOUNDARY
- SLURRY WALL ALIGNMENT
- PROPOSED MAJOR CONTOUR (5740)
- PROPOSED MINOR CONTOUR
- EXISTING BARBED WIRE FENCE
- EXISTING CHAINLINK FENCE
- EXISTING EASEMENT
- EXISTING GAS LINE
- EXISTING WATER LINE
- EXISTING STORM SEWER
- EXISTING RAW WATER LINE
- EXISTING IRRIGATION
- EXISTING BURIED ELECTRICAL
- EXISTING OVERHEAD ELECTRICAL
- EXISTING FIBER OPTIC
- EXISTING SANITARY SEWER
- MONITORING WELLS



TYPICAL SECTION - RECLAMATION SLOPE

NOT TO SCALE

CIVIL RESOURCES
8308 COLORADO BLVD
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FIRESTONE, CO 80504
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WWW.CIVILRESOURCES.COM

MONARCH MOUNTAIN M&A
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ATLANTA, GA 30328
720.289-5584 (p)
ERIC LEIGH

MONARCH-DENM GRAVEL MINE
DRMS 112 PERMIT APPLICATION
WELD COUNTY, COLORADO

REVISIONS

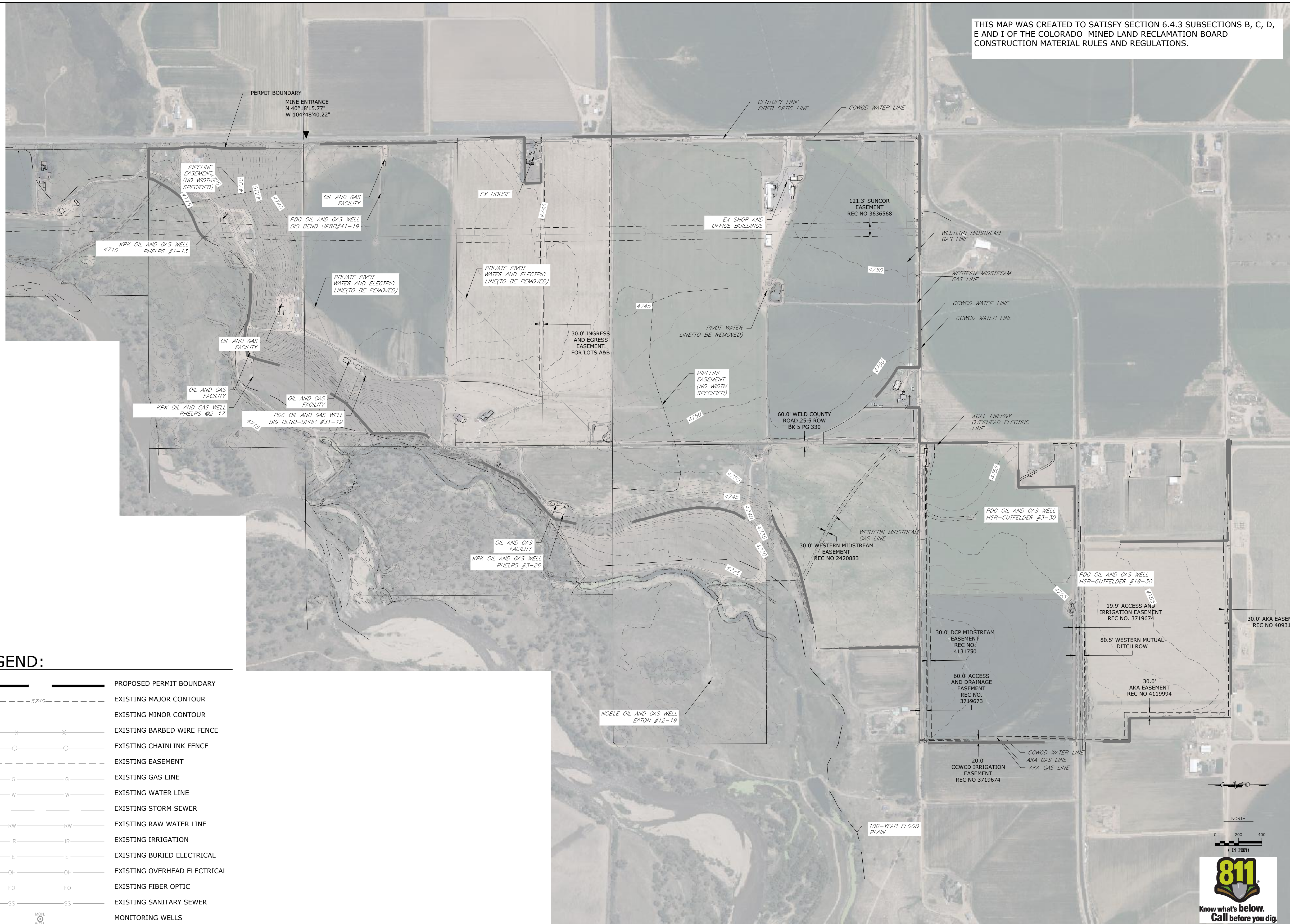
NO.	DESCRIPTION	DATE

DESIGNED BY: BLH DATE: 2/23/2022
DRAWN BY: KR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.:
DWG NAME: EX-C5-MINE PLAN AND REC PLAN.DWG

RECLAMATION PLAN MAP

SHEET: F-1

THIS MAP WAS CREATED TO SATISFY SECTION 6.4.3 SUBSECTIONS B, C, D, E AND I OF THE COLORADO MINED LAND RECLAMATION BOARD CONSTRUCTION MATERIAL RULES AND REGULATIONS.



LEGEND:

	PROPOSED PERMIT BOUNDARY
5740	EXISTING MAJOR CONTOUR
	EXISTING MINOR CONTOUR
X	EXISTING BARBED WIRE FENCE
O	EXISTING CHAINLINK FENCE
	EXISTING EASEMENT
G	EXISTING GAS LINE
W	EXISTING WATER LINE
	EXISTING STORM SEWER
RW	EXISTING RAW WATER LINE
IR	EXISTING IRRIGATION
E	EXISTING BURIED ELECTRICAL
OH	EXISTING OVERHEAD ELECTRICAL
FO	EXISTING FIBER OPTIC
SS	EXISTING SANITARY SEWER
MON. WELL	MONITORING WELLS

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720.289-5584 (p)
ERIC LEIGH

MONARCH-DENM GRAVEL MINE
DRMS 112 PERMIT APPLICATION
GILCREST, COLORADO

REVISIONS

NO.	DESCRIPTION	DATE

DESIGNED BY: BLH DATE: 1/24/2022
DRAWN BY: KR SCALE: AS NOTED
CHECKED BY: BLH AS NOTED
JOB NO.:
DWG NAME: EX-C-1 PREMINING MAP.DWG

PRE-MINING MAP

SHEET: C-1

Appendix F

Piezo ID	Riser Height	Water Depth (BGS)							
Date:		11/5/2021	2/28/2022	3/31/2022	4/29/2022	6/10/2022	7/5/2022	8/1/2022	Average(April - August)
P01	3.5	11.7	13.2	13.4	13.5	12.8	13.1	12.9	13.075
P04	3.8	4.6	5.5	5.8	6.1	4.8	5.3	5.4	5.4
P09	3.9	19.9	22.5	22.7	23.1	22.1	21.7	21.5	22.1
P15	3.2	26.3	28	28.5	29.3	27.9	27.4	26.5	27.775
P20	3.8	14.6	19.3	19.3	19.5	18.2	17.2	15.7	17.65
P25	3.5	15.6	19.1	19.4	19.6	16.3	15.3	12.5	15.925
P27	3.8	13	16.6	16.7	16.8	17.6	16.9	16.3	16.9