EXHIBIT
2

Applicants Exhibit #2
Case No. 15723

Expert Opinions Regarding
Bobcat SWD No. 1
Authorization to Inject
Lea County, New Mexico

Oil Conservation Division

Notice of Hearing: Case No. 15723

Prepared for **OWL SWD Operating, LLC**

July 24, 2017

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Table of Contents

Section **Page**

1. Introduction and Summary of Opinions 1

2. City of Jal Water Supplies 4
   2.1 Geology and Aquifer Systems 4
   2.2 Existing and Proposed Shallow Water Supplies 4
   2.3 Capitan Reef Aquifer 5

3. Fate and Transport of Injected Water 8
   3.1 Current and Historical Observations 8
   3.2 Simulation of Fate and Transport 9
      3.2.1 Model Extent and Discretization 10
      3.2.2 Boundary and Initial Conditions 10
      3.2.3 Initial Conditions 12
      3.2.4 Hydraulic Properties 12
      3.2.5 Predictive Simulation Results 13

References 16

List of Figures

Figure

1 Site Map

2 Stratigraphic Column and Corresponding Aquifer Units in the Vicinity of the Bobcat SWD Well

3 Cross Section D-D' from Hiss (1975a)

4 Capitan Reef Aquifer Water Quality Near Jal, New Mexico

5 Oil, Gas, and Water Fields in Permian Rocks Near Jal, New Mexico

6 Top of Yates Formation

7 Top of Capitan Reef Aquifer from Hiss (1976) and Model Grid

8 Model Layer Thickness

9 Conceptual Cross Section of Model Boundary Conditions

List of Figures (Continued)

Figure

10 General Head Boundary Conditions

11a Simulated TDS Concentration at 20 Years

11b Simulated TDS Concentration at 40 Years

11c Simulated Hydraulic Head at 20 Years

12a Simulated TDS Concentration at 20 Years – No Capitan Reef Aquifer Hydraulic Head

12b Simulated Hydraulic Head at 20 Years – No Capitan Reef Aquifer Hydraulic Head

List of Tables

Table

1 Groundwater Model Hydraulic Properties

List of Appendices

Appendix

A Water Quality Report for Maralo Sholes B No. 2 SWD Well

1. Introduction and Summary of Opinions

Oilfield Water Logistics SWD Operating, LLC (OWL) retained Daniel B. Stephens & Associates, Inc. (DBS&A) in May 2017 to assist with groundwater analysis as it relates to the Form C-108 Application (Application) for the Bobcat SWD No. 1 well (Bobcat SWD well). The Application requests a maximum injection rate of 30,000 barrels per day (bpd) of produced water at a maximum surface pressure at 580 pounds per square inch (psi) and an average volume of 25,000 bpd at 550 psi surface pressure (Lonquist & Co., 2017). The proposed Bobcat SWD well location is provided in Figure 1.

The City of Jal (Jal) uses shallow groundwater in the vicinity as a public water supply and may need additional future supplies from the area. The State Land Office (SLO) raised objections to the Application, claiming that the Seven Rivers Formation of the Artesia Group contains protected groundwater at some locations, and that injection of produced water into this zone should therefore not be allowed. The Oil Conservation Division (OCD) has raised the concern that the proposed injection might adversely affect the Capitan Reef Aquifer, thereby impacting the aquifer such that Jal will not be able to evaluate it as a potential future supply (Goetze, 2017).

A summary of my opinions regarding these and related issues is provided below. Details and technical analyses on which my opinions are based are provided in Sections 2 and 3.

1. Injection of produced water at the Bobcat SWD well as proposed will not adversely affect Jal's existing water rights, Jal's current applications for appropriation CP-1512 POD1 through POD9, or any other shallow groundwater. This opinion is based on the following facts and analysis:
   - Water from the proposed injection interval will not migrate upward to the Pecos Alluvium or the Santa Rosa Formation due to the thickness of the Tansill Formation (~140 feet), the Salado Formation (~1,250 feet), and the Dewey Lake Formation (~480 feet). The Salado Formation in particular is widely recognized as having permeability so low as to be essentially zero.

- The injection well will be constructed such that upward flow of injected fluids cannot occur along the well casing (Lonquist & Co., 2017).

2. The Capitan Reef Aquifer is not an expected future water supply for Jal due to its depth and, more importantly, the poor quality of water found in the aquifer. This opinion is consistent with that of Jal's water resources consultant (SMA, 2015). This opinion is supported by the following facts and analysis:

   - The nearest Capitan Reef Aquifer water supply well to the Bobcat SWD well location is EOG well CP-1446 POD1. This well produced Capitan Reef Aquifer water with a total dissolved solids (TDS) concentration of 13,298 milligrams per liter (mg/L) as of November 2015. Other Capitan Reef Aquifer wells, such as the Federal Davison Well northwest of Jal, have much higher TDS than the EOG well.

   - In addition to high TDS, Capitan Reef Aquifer water may contain high concentrations of hydrogen sulfide (H_2S), barium sulfate ($BaSO_4$), and other constituents that would render treatment to drinking water standards difficult and very expensive.

   - Jal has not made application for Capitan Reef Aquifer water rights; their current plan for future water supplies, as recommended by SMA (2015), is to expand use of their Westfield (Pecos Valley Aquifer) water rights and use Santa Rosa Aquifer water in the vicinity of Jal.

3. Produced water injected at the Bobcat SWD well will not reach the Capitan Reef Aquifer, either through horizontal or vertical migration. This opinion is supported by the following facts and analysis:

   - The hydraulic head in the Capitan Reef Aquifer is greater than that in the Bobcat SWD well injection zone by more than 2,000 feet; therefore, if there were a hydraulic connection, the direction of groundwater flow would be from the Capitan Reef Aquifer into the injection zone, not from the injection zone into the aquifer. Field data indicate that hydraulic head in the injection zone is very low, indicating a very poor hydraulic connection between the Capitan Reef Aquifer and the injection zone in the Artesia Group.

- Predictive simulations that account for the density of the injected water, the structure of the Artesia Group, the structure of the Capitan Reef Aquifer, and reasonable hydraulic properties of the Artesia Group sediments indicate that there will be no impact of Bobcat SWD injected water on the Capitan Reef Aquifer.

2. City of Jal Water Supplies

This section discusses Jal's existing and future water supplies, and explains why the Bobcat SWD well will have no effect on these supplies.

2.1 Geology and Aquifer Systems

A summary geologic column designating geologic and hydrogeologic units in the Jal area is provided in Figure 2. An example geologic cross section is provided in Figure 3. The following geologic descriptions for the Artesia Group members from youngest to oldest are taken from Hiss (1975a). The Tansill Formation is dominantly anhydrite. The Yates Formation consists of interbedded sandstone, siltstone, and anhydrite. The Seven Rivers Formation is primarily composed of anhydrite, but also contains interbedded shale, dolomite, siltstone, and sandstone. The Queen Formation consists primarily of sandstone and anhydrite with thin interbedded dolomite and shale. The Grayburg Formation is composed of dolomite with thin interbedded sandy dolomite, sandstone, and anhydrite. These descriptions are based on a reference well in Eddy County; rock types can change based on location relative to the shelf margin at a given time-synchronous horizon (Hiss, 1975a).

2.2 Existing and Proposed Shallow Water Supplies

Jal currently obtains its water supply from five wells screened in the Pecos Valley Aquifer about 7 miles southwest of the City and about 6 miles southwest of the Bobcat SWD well (Figure 1). These wells tap first groundwater in the Jal Underground Water Basin, and range from about 500 to 700 feet deep (SMA, 2015). Based on the recommendation of Souder, Miller & Associates (SMA) (2015), Jal has filed applications to appropriate water from the Capitan Underground Water Basin in the vicinity of Jal from nine wells (CP-1512 POD1 through POD9) up to 700 feet in depth, which would correspond to production from the Santa Rosa Sandstone Aquifer (Figure 1). Thus, Jal's current and future water supply will continue to be obtained from shallow groundwater sources (Pecos Valley and Santa Rosa Sandstone Aquifers), separated vertically from the Bobcat SWD well injection zone by about 2,000 feet of low-permeability rocks. These low-permeability rocks include the Salado Formation, which is essentially impermeable, and the Dewey Lake Formation, which has very low permeability.

As indicated in the Application (Lonquist & Co., 2017), the Bobcat SWD well would be constructed with a surface casing to the top of the Salado Formation and a production casing to the top of the injection zone. The annular space of both casing strings would be cemented by circulation to surface. This type of well completion is common in the oil and gas industry, and will ensure that there will be no contamination of shallow groundwater through migration of injection fluids vertically upward along the well casing.

2.3 Capitan Reef Aquifer

Goetze (2017, p. 4) states that a hydrologic investigation report prepared by SMA (2015) for Jal identified the Santa Rosa Formation and the Capitan Reef Aquifer as potential groundwater sources for the City to exploit. Mr. Goetze then provides the following conclusion on page 6 of his report:

> If the City of Jal is going to have the opportunity for the future assessment of this portion of the Capitan Reef Aquifer for municipal use, the Division should make every effort to minimize all potential sources that may impact the aquifer. This should include commercial disposal operations in shallower zones above the Capitan Reef Aquifer in the vicinity.

It is important to clarify that although SMA (2015) mentions the Capitan Reef Aquifer in their report, they do not recommend that Jal pursue the Capitan Reef Aquifer as a future water supply. SMA (2015, p. 10) states "The potential for poor water quality as well as the extreme depth to the formation in this [City of Jal] area will limit the use of this formation as a municipal water supply." In the conclusions section of their report, SMA recommends that Jal construct additional water supply wells in the Pecos Valley Aquifer, and pursue additional groundwater appropriations in the Dockum (Santa Rosa Sandstone) Aquifer (Figures 1 and 2). These additional water rights would be within the Capitan Underground Water Basin as defined by the New Mexico Office of the State Engineer (OSE), but they would not be from the Capitan Reef Aquifer.

I concur with SMA that the Capitan Reef Aquifer is not a suitable future water supply for Jal, primarily due to its water quality and secondarily due to its depth. This opinion is consistent with past and current municipal users that have considered the Capitan Reef Aquifer as a groundwater supply. The only municipalities that use Capitan Reef Aquifer water are located near the aquifer recharge areas where the water quality is substantially better, and the aquifer is much shallower, than in the Jal area. Examples include Carlsbad, New Mexico and Fort Stockton, Texas. Each of these localities is more than 60 miles from Jal.

Figure 4 provides a summary of Capitan Reef Aquifer groundwater quality in the vicinity of Jal. As indicated in the figure, the nearest Capitan Reef Aquifer water supply well to the Bobcat SWD well location is EOG well CP-1446 POD1. This well produced Capitan Reef Aquifer water with a TDS concentration of 13,298 mg/L as of November 2015 (NM OSE, 2016).

The Federal Davison 1 U.S. Geological Survey (USGS) monitor well northwest of Jal (Figure 4) has preliminary sampling results with TDS concentration of 140,028 mg/L (Land, 2016). This is one of the monitor wells originally used by Hiss (1975a) for his research; the TDS concentration of water from the Federal Davison 1 well was 173,448 mg/L from a spot sample in the fluid column in 1972 (Hiss, 1973). TDS was not reported by Hiss (1973) for other spot samples in the fluid column at this well collected in 1966, but chloride concentrations ranged from 157,000 to 161,000 mg/L. The Southwest Jal Unit 1 well (also a USGS monitor well) southwest of Jal (Figure 4) had a reported chloride concentration of 82,500 mg/L in 1966 (Hiss, 1973).

Intercontinental Potash Corporation (ICP) has proposed to construct and operate the Ochoa Mine Project in south-central Lea County. The mine would be west of the Capitan Reef Aquifer, but the water supply would be obtained from the aquifer (Intera, 2012). Two water supply wells, CP-1056 and -1057, were completed in the Capitan Reef Aquifer in 2012. The wells are about ½ mile apart. After well development was completed, a step test and subsequent 7-day constant-rate aquifer test were conducted for well CP-1057 (Intera, 2012). Measured TDS concentration for the pumped well, CP-1057, was 69,900 mg/L (Figure 4).

Information on the Skelly Oil Company Jal Water System industrial supply wells, operational from the late 1960s through the early 1980s, is provided in Exhibits H, M, and N of

CEK Engineering (2017). Well locations and several TDS concentrations are plotted in Figure 4. The information provided indicates that, in addition to high TDS or chloride concentration, the Capitan Reef Aquifer water may contain high concentrations of hydrogen sulfide (H_2S) and barium sulfate ($BaSO_4$), rendering treatment to drinking water standards even more difficult and expensive. The Skelly Jal Water System records also indicate frequent pump failures.

Goetze (2017, p. 7) references the Jal Water System industrial water supply and incorrectly states that these wells were a former municipal water source. These wells were never used as municipal supply; in fact, the Capitan Reef Aquifer has never been tapped for municipal supply anywhere in the southern Lea County area.

The most logical and appropriate use for Capitan Reef Aquifer water is for industrial supply, as occurred extensively in the past for oil and gas operations (Hiss, 1975a) and as is being pursued currently by entities such as ICP (wells CP-1056 and 1057), Chevron U.S.A. (Application CP-1487 PODs 1-6), and EOG Resources (well CP-1446). This recent trend toward increased use of the Capitan Reef Aquifer for industrial purposes is consistent with the view espoused in Land (2016), who states that use of brine from the Capitan Reef Aquifer for industrial purposes is favorable because it will reduce the impacts of groundwater withdrawals on limited freshwater resources.

As use of water from the Capitan Reef Aquifer increases in the future, the aquifer potentiometric surface (water levels) will decline. The minimum historical water level elevation occurred during the mid-1970s, when there was significant groundwater pumping from the aquifer for oil and gas purposes. The largest pumping center was in northern Winkler County in Texas (Hiss, 1975a and 1980). Since the mid-1970s, Capitan Reef Aquifer water levels have recovered significantly (Goetze, 2017; Land, 2016) due to the cessation of groundwater pumping from the oil and gas water supply fields.

3. Fate and Transport of Injected Water

This section presents observations and analyses related to hydraulic communication between the injection zone and the Capitan Reef Aquifer, and addresses the fate and transport of the Bobcat SWD well injected water.

3.1 Current and Historical Observations

The proposed injection zone for the Bobcat SWD well is the base of the Yates Formation and the top of the Seven Rivers Formation; both formations are included in the Artesia Group (Figures 2 and 3). The proposed injection zone was formerly saturated with gas and to a lesser extent oil, and is part of a regional trend of oil and gas fields that have been exploited for many decades (Figure 5).

As illustrated in Figure 3, the Artesia Group rocks lie on top of, and to the west transition into, rocks of the Capitan Reef Complex. In some regions, there is good hydraulic communication between the Capitan Reef Aquifer and the Artesia Group, but in other regions there is poor connection (Hiss, 1975a). For example, Hiss (1973, p. 7) states that "The rock units surrounding the Capitan aquifer generally have significantly less permeability than the Capitan and, in most places, act as partial hydrologic barriers to movement of water into or out of the aquifer."

South of Jal in Winkler County, Texas, there is very good hydraulic communication between the Capitan Reef Aquifer and the Seven Rivers and Yates Formations of the Hendrick Field (Hiss, 1975a). This conclusion is supported by similar reservoir pressures, pressure declines that occur at similar rates between the formations, and significant amounts of water production in addition to oil and gas.

The Yates and Seven Rivers Formations, however, are in very poor hydraulic communication with the Capitan Reef Aquifer in the Jal area. This is evidenced by the lack of corresponding reservoir pressures and corresponding trends. The hydraulic head in the Yates and Seven Rivers Formations is around sea level or even below sea level (Section 3.2.3), while the Capitan

Reef Aquifer hydraulic head is about 2,600 feet above mean sea level (feet msl). Despite this enormous difference in hydraulic head, the Bobcat SWD well injection zone hydraulic head has remained very low, and volumes of water production have historically been small in the Jalmat field (CEK Engineering, 2017, Exhibit F) despite many decades of active oil and gas production. If there were any effective hydraulic communication between the Capitan Reef Aquifer and the Bobcat SWD injection zone, injection zone fluid pressures and the corresponding hydraulic head would be much higher, more in line with those in the Capitan Reef Aquifer.

3.2 Simulation of Fate and Transport

In order to evaluate the fate and transport of water injected at the Bobcat SWD well, a groundwater flow and transport model was constructed for the Artesia Group rocks, excluding the Tansill Formation (Figure 2), which is assumed to be impermeable. The model was constructed to address the concerns of OCD that computations of injection fluid migration provided in CEK Engineering (2017, Exhibit K) do not account for the structure of the top of the Capitan Reef Aquifer or the density of the injected fluid (Goetz, 2017, p. 5). The model was developed using the MODFLOW-USG (MF-USG) computer code (Panday et al., 2013), as recently modified for the Texas Water Development Board to simulate density-dependent groundwater flow and solute transport in the Lower Rio Grande Valley of Texas (Panday et al., 2017).

When analyzing flow and transport of groundwater with variable density, the terms environmental hydraulic head and equivalent freshwater hydraulic head are used (e.g., Hiss, 1975a). Environmental head refers to the water level measured in the field. The density of the water, through TDS concentration, is used to determine the equivalent freshwater head, which is necessary to determine the true groundwater flow velocity and direction. In the fate and transport modeling presented in this section, all water and boundary conditions are assigned an environmental head (hydraulic head as it would be observed in the field) and an associated TDS value; the MF-USG model code uses this information to compute equivalent freshwater hydraulic head, which is then used to calculate groundwater flow and solute transport.

3.2.1 Model Extent and Discretization

The top of the groundwater model is equivalent to the top of the Yates Formation as provided by CEK Engineering (2017) (Figure 6), and the base of the model is equivalent to the top of the Capitan Reef Aquifer is defined by Hiss (1976) (Figure 7). South of the Bobcat SWD well, the top of Capitan Reef Aquifer –250 feet msl contour of Hiss (1976) was adjusted as indicated in Figure 7 based on observed data from Standen et al. (2009). There are no data points in Hiss (1976) to confirm this contour, and subsequent data analysis of Standen et al. (2009) indicates that this feature likely does not exist.

The groundwater model extent is presented in Figures 6 and 7. In the western direction, the model extends to the Yates Formation shelf margin as determined by CEK Engineering (2017, Exhibit B). The model extends far beyond the region that will be affected by injection at the Bobcat SWD well in the northern, southern, and eastern directions, such that the simulation results will not be influenced by the lateral boundary conditions. The horizontal spacing of the model cells is uniform at 250 feet by 250 feet.

Six model layers are used in the vertical dimension to represent the Artesia Group rocks. The top of model layer 1 (shallowest layer) is the top of the Yates Formation (Figure 6), and the base of the model is the top of the Capitan Reef Aquifer (Figure 7). Model layer thicknesses are based on observed conditions at the Bobcat SWD well, and model layers were constructed from the top of the Yates Formation downward. Model layer thicknesses are provided in Table 1 and Figure 8. Model layer 2 represents the primary injection interval, which is about 50 feet thick based on the Maralo Sholes B No. 2 injection test (CEK Engineering, 2017, Exhibit J). Model layers do not correspond to geologic formations because the injection zone crosses geologic units, and all members of the Artesia Group contain interbedded evaporite units leading to very low vertical hydraulic conductivity.

3.2.2 Boundary and Initial Conditions

The top of the model is a no-flow boundary, based on the assumption that the Tansill Formation is essentially impermeable. All other model boundaries are general head boundaries, where the flow across the boundary is calculated by the model according to a conductance term that depends on cell size and hydraulic conductivity, and according to the simulated hydraulic head in the model cell and an assigned hydraulic head representative of conditions outside the model domain near the model cell.

The conceptual approach to the assignment of boundary conditions between the Artesia Group and the Capitan Reef Aquifer is provided in Figure 9. As indicated in the figure, all model cells that contact the Capitan Reef Aquifer are designated as general head boundary cells. Where flow would occur in the vertical dimension to or from the Capitan Reef Aquifer, the boundary conductance term is based on the vertical hydraulic conductivity of the appropriate model layer. Where flow would occur in the horizontal (lateral) dimension to or from the Capitan Reef Aquifer, the boundary conductance term is based on the horizontal hydraulic conductivity of the appropriate model layer. Figure 9 is a conceptual diagram and is not drawn to scale; Figure 10 illustrates the actual distribution of vertical and horizontal general head boundaries used in the model. Lateral model boundaries (north, south, and east) that do not intersect the Capitan Reef Aquifer are assigned general head boundaries representative of assumed initial conditions within the Artesia Group described in Section 3.2.3.

Capitan Reef Aquifer environmental hydraulic head was assumed to be 2,610 feet msl based on recent observations at the Southwest Jal Unit USGS observation well (Land, 2016; Goetze, 2017) (Figure 5). For the environmental head, a TDS concentration of 13,298 mg/L was assumed based on the EOG Resources well CP-1446 (Figure 4). Hiss (1973) reports a chloride concentration at the Southwest Jal Unit well of 82,500 mg/L (Figure 4), which would lead to even higher equivalent freshwater hydraulic head than is computed for boundary conditions in the model. Using the TDS concentration from the CP-1446 well is therefore conservative. As detailed in Section 3.1, if there were a good (or even moderate) hydraulic connection between the injection zone and the Capitan Reef Aquifer, the fluid pressures in the injection interval would be similar to that in the Capitan Reef Aquifer. The fact that the fluid pressures in the injection zone and the Capitan Reef Aquifer are drastically different (by more than 2,000 feet of hydraulic head) is very strong evidence that there is very limited hydraulic connectivity between these two units.

3.2.3 Initial Conditions

The initial environmental hydraulic head in the model domain was assumed to be 13 feet msl (approximately sea level), which provides about 5 feet of saturation at the base of the injection zone at the Bobcat SWD location. Although a fluid level or static pressure for the Maralo Sholes B No. 2 well is not available, the injection test results indicate very low pressure, with injection occurring under vacuum (free drainage) conditions. This condition is consistent with the fact that the injection occurs within a depleted portion of oil and gas fields that have been exploited for many decades. Hiss (1980) notes for the region around Jal and east of the Capitan Reef that "The potentiometric surface is extremely low over oil fields on the Central Basin platform wherever the hydraulic communication of the oil reservoir with the Capitan aquifer is poor." Hiss (1975a) also states that the potentiometric surface of the shelf aquifers (Artesia Group) south of Jal has apparently been lowered below sea level, but "the effects have not spread very far into surrounding areas due to the very low transmissivity of the shelf aquifers."

The same initial hydraulic head was applied throughout the model domain, even though formation pressures below the injection zone (middle and lower Artesia Group) are probably higher because oil and gas were not produced from these units. The assumed TDS concentration for the Artesia Group water was 20,000 mg/L, consistent with water quality data summaries provided in CEK Engineering (2017, Exhibit L), which is based on Hiss (1975b).

3.2.4 Hydraulic Properties

The Artesia Group hydraulic properties used in the fate and transport simulations are presented in Table 1. These properties were estimated in conjunction with Mr. Chad Kronkosky of CEK Engineering. The properties are reasonable based on the results of the injection tests completed for the Maralo Sholes B No. 2 SWD well, the geology and physical properties of the Artesia Group rocks, and information provided in Hiss (1975a). Hydraulic properties provided in Hiss (1975a) are based on oil and gas well core analysis. As noted in Hiss (1975a), hydraulic conductivity obtained from core analysis is likely biased toward higher values, as dense or tight beds are not tested, and tests are typically targeted at productive zones only.

The effective porosities are listed in Table 1, and the longitudinal dispersion coefficient was set to 50 feet.

3.2.5 Predictive Simulation Results

Predictive simulations were conducted for a period of 40 years. It was assumed that there would be 20 years of injection at the Bobcat SWD well, after which time injection ceases. The last 20 years of the simulation are therefore for a post-injection condition. Injection from other SWD wells is not included in the simulation. This is a reasonable assumption given current estimated pressure in the injection zone, and given that the volume of expected injection for the Bobcat SWD well is significantly greater than recent injection volumes for the Maralo Sholes B No. 2 well. The injection rate was assumed to be 25,000 bpd (729 gallons per minute [gpm]), as specified in the Application. The injection water was assigned a TDS concentration of 125,367 mg/L based on a recent sample of the saltwater injected at the Maralo Sholes B No. 2 SWD well (Appendix A). Assigned hydraulic heads for the general head boundary cells remained unchanged during the predictive simulation.

The results of three predictive simulations are presented. In the first predictive simulation (Scenario 1), a Capitan Reef Aquifer hydraulic head of 2,610 feet msl is used for all general head boundary cells representing hydraulic connection between the Capitan Reef Aquifer and the Artesia Group (Section 3.2.2). The simulated water quality for each model layer at 20 and 40 years is presented in Figures 11a and 11b, respectively. The lowest contoured concentration in the figures is 20.1 grams per liter (g/L), or 20,100 mg/L, which distinguishes injected water from the initial assumed Artesia Group water quality of 20,000 mg/L. The gray areas in the figures represent dry model cells, which are cells that are not saturated with brackish water at the beginning of the simulation, and do not become saturated due to injection at the Bobcat SWD well. The white regions in the figures indicate the boundary of the Artesia Group rocks with the Capitan Reef Aquifer. For model layers 1 through 3, the Capitan Reef Aquifer lateral boundary is farther to the west, not visible due to the scale of the figures. In model layers 4 through 6, the lateral boundary of the Artesia Group with the Capitan Reef Aquifer is evident.

As indicated in the figures, the majority of injected fluid remains in model layers 1 and 2 for the entire simulation period. A small amount of injected fluid migrates into model layer 3, and no injected saltwater reaches model layers 4 through 6. In addition, the center of mass of the injected saltwater migrates to the east over time, as indicated by the location of the red zone (90,000 to 125,000 mg/L fluid) relative to the Bobcat SWD well. This eastward migration occurs due the influence of the Capitan Reef Aquifer hydraulic head, which is far higher than the hydraulic head throughout the Artesia Group, with the exception of very near the Bobcat SWD well in model layer 2.

The simulated hydraulic head after 20 years of injection is presented in Figure 11c. As would be expected, there is a significant increase in hydraulic head at the injection well in model layer 2, but there is also a significant increase in hydraulic head in other model layers due to the inflow of Capitan Reef Aquifer water. As explained in Section 3.1, existing data indicate that Capitan Reef Aquifer water has not entered the Bobcat SWD well injection zone. These simulation results indicate that the hydraulic conductivity of the Artesia Group rocks should be reduced substantially. However, there is no need to conduct a fate and transport simulation where hydraulic communication with the Capitan Reef Aquifer is essentially zero (as is the case in reality), so additional simulations with adjusted aquifer hydraulic properties were not conducted.

Two additional sensitivity simulations were also conducted. The first sensitivity simulation considered a lower Capitan Reef Aquifer hydraulic head of 2,109 feet msl, which was observed at the Southwest Jal Unit 1 monitor well about 40 years ago (Goetze, 2017; Land, 2016). The purpose of this run was to account for the potential that future Capitan Reef Aquifer hydraulic head may be lower than it is today due to increased use of the aquifer for oil and gas purposes (Section 2.3). The results of this simulation are very similar to those of the base-case simulation (Figures 11a and 11b); therefore, figures for this sensitivity run are not presented.

The second sensitivity run considered the case where the Capitan Reef Aquifer hydraulic head is assumed to be the same as that of the Artesia Group initial hydraulic head of 13 feet msl (slightly above sea level). This is obviously an unrealistic scenario; it is only presented to demonstrate the propagation of hydraulic head through the Artesia Group rocks attributable to the Bobcat SWD well, and to demonstrate the effects of the higher Capitan Reef Aquifer hydraulic heads on the simulation results through comparison with the base-case simulation scenario. The results of this sensitivity run are presented in Figures 12a and 12b. Figure 12a presents the simulated migration of the injected saltwater at 20 years. Because the higher Capitan Reef Aquifer hydraulic head values are not prescribed, the simulated distribution of the injected saltwater is more radial, centered around the injection well (compare Figures 12a and 11a). Even in this unrealistic scenario where the Capitan Reef Aquifer hydraulic heads are not considered, there is still no migration of the injected saltwater to the aquifer.

The simulated hydraulic head after 20 years of injection for this sensitivity simulation is presented in Figure 12b. The simulated hydraulic head presented in Figure 12b is the result of the injection at the Bobcat SWD well for a 20-year period, superimposed on the initial hydraulic head of 13 feet msl. The figure illustrates that the simulated hydraulic head in the injection layer (model layer 2) increases by over 2,000 feet. Simulated hydraulic head increases by nearly 200 feet in model layer 1, and by about 20 feet in the lower model layers.

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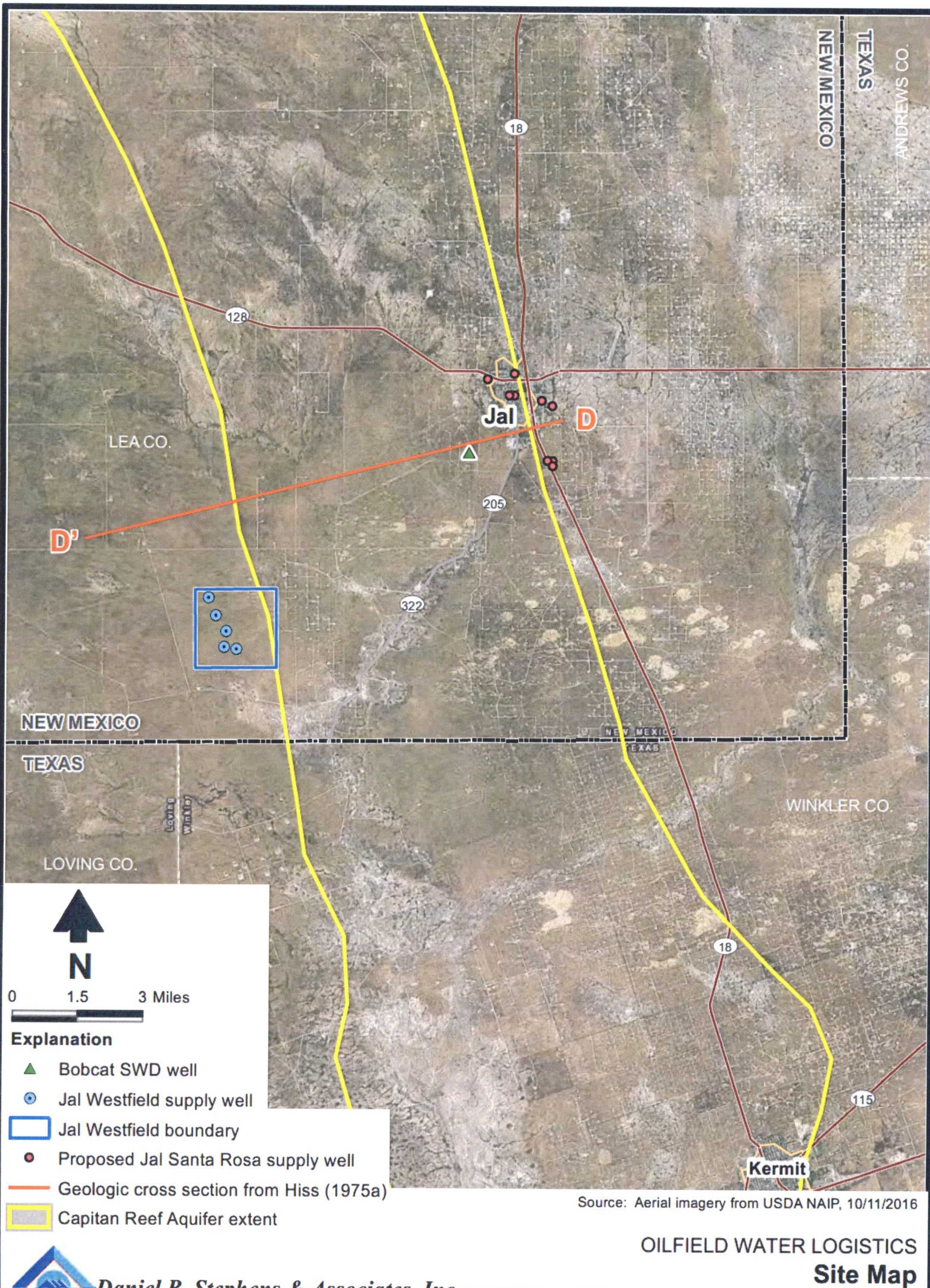
Figures



Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG01_SITE_MAP.MXD

OILFIELD WATER LOGISTICS
Site Map

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7/24/2017
JN DB17.1137

Figure 1

<table>
<tr><th>Period</th><th>Group/Series</th><th colspan="2">Formation</th><th>Nominal Thickness (feet)</th><th>Aquifer</th></tr>
<tr><td>Quaternary</td><td></td><td colspan="2">Sheet sand and windblown sand</td><td>~ 10–30</td><td>Above the water table (not saturated)</td></tr>
<tr><td>Tertiary</td><td>Late Pliocene to Miocene</td><td colspan="2">Pecos Valley Alluvium</td><td>~ 200</td><td>Pecos Valley Aquifer. Existing Jal wells completed in this aquifer.</td></tr>
<tr><td>Triassic</td><td>Dockum Group (lower)</td><td colspan="2">Santa Rosa</td><td>300</td><td>Santa Rosa Sandstone Aquifer. Jal Application CP-1512 POD1 through POD9 target this aquifer.</td></tr>
<tr><td rowspan="7">Permian</td><td rowspan="3">Ochoan Series</td><td colspan="2">Dewey Lake</td><td>480</td><td>Confining unit, composed predominantly of siltstone and mudstone.</td></tr>
<tr><td colspan="2">Rustler</td><td>340</td><td>Rustler Aquifer, permeability occurs primarily within Magenta and Culebra Dolomite members</td></tr>
<tr><td colspan="2">Salado</td><td>1,250</td><td>Confining unit, effectively impermeable</td></tr>
<tr><td rowspan="4">Guadalupian Series</td><td rowspan="3">Artesia Group</td><td>Tansill</td><td>140</td><td rowspan="3">Oil and gas production from Yates and Seven Rivers. Production predominantly from siliclastic units; evaporite units have low permeability. Called "shelf aquifers" by Hiss (1975a).</td></tr>
<tr><td>Yates</td><td>245</td></tr>
<tr><td>Seven Rivers
Queen
Grayburg</td><td>~ 540 combined</td></tr>
<tr><td colspan="2">Capitan Reef Complex</td><td>~ 1,500</td><td>Capitan Reef Aquifer</td></tr>
</table>

Note: Formation thicknesses taken from Lonquist & Co. (2017) and Hiss (1976)

OILFIELD WATER LOGISTICS

Stratigraphic Column and Corresponding Aquifer Units in the Vicinity of Bobcat SWD Well

Figure 2

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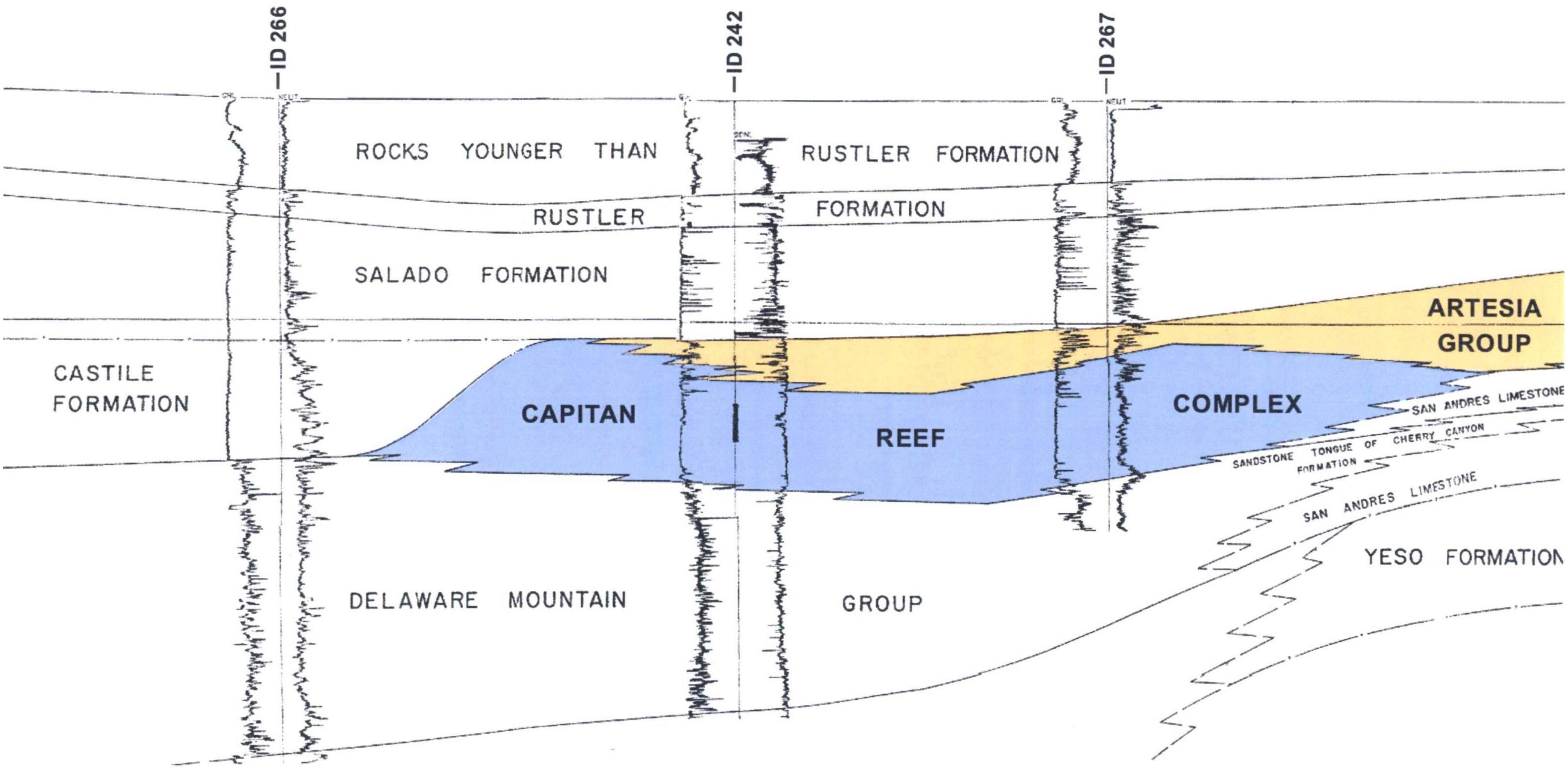
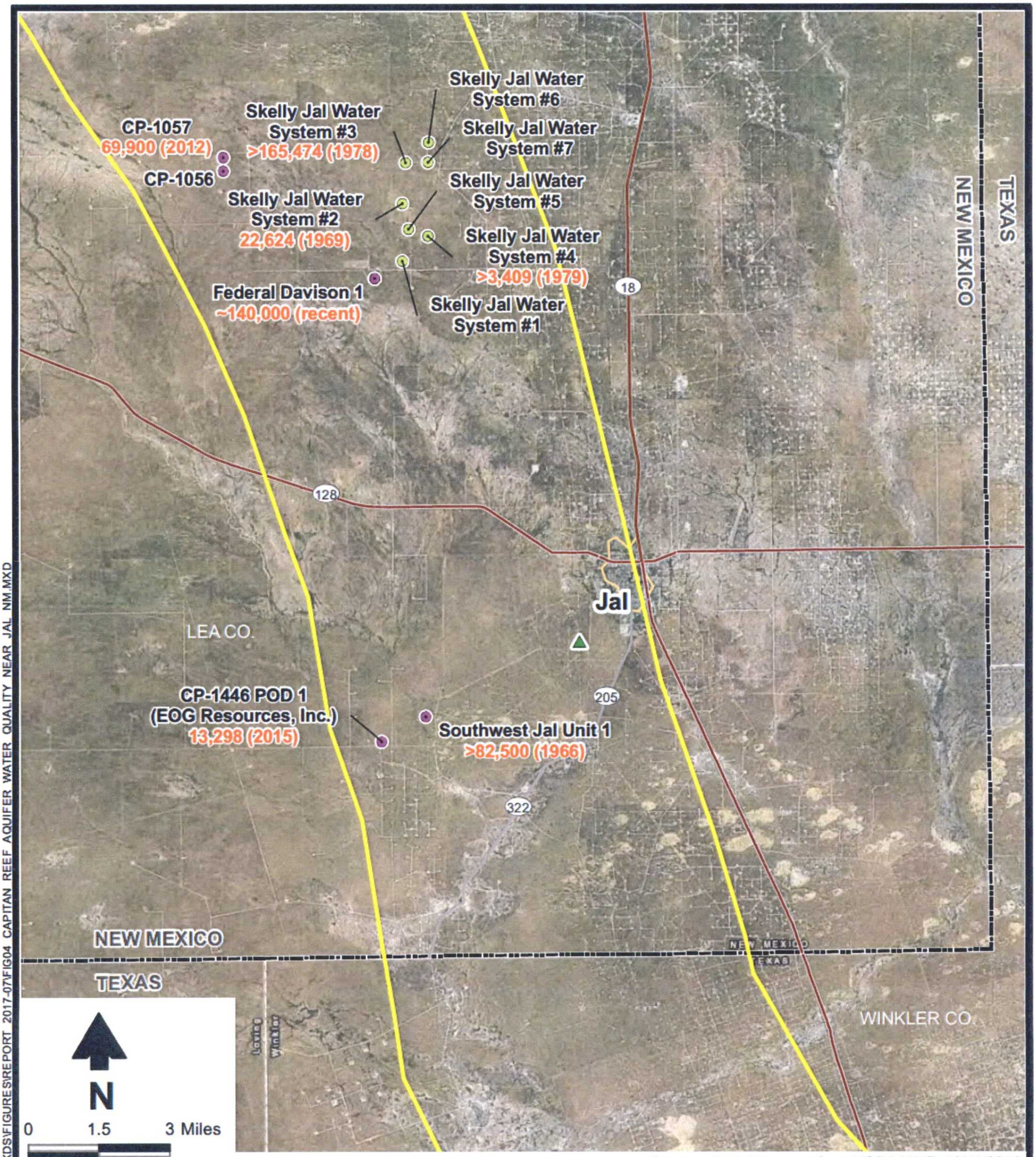
7/20/17


ID 266
ID 242
ID 267
ROCKS YOUNGER THAN
RUSTLER FORMATION
RUSTLER
FORMATION
SALADO FORMATION
ARTESIA
GROUP
CASTILE
FORMATION
CAPITAN
REEF
COMPLEX
SAN ANDRES LIMESTONE
SANDSTONE TONGUE OF CHERRY CANYON
FORMATION
SAN ANDRES LIMESTONE
YESO FORMATION
DELAWARE MOUNTAIN
GROUP



Source: Aerial imagery from USDA NAIP, 10/11/2016

Explanation

- Bobcat SWD well
- Skelly Jal Water System supply well
- Other water supply wells
- Capitan Reef Aquifer extent
- 13,298 (2015) TDS concentration (mg/L) (year)

OILFIELD WATER LOGISTICS

Capitan Reef Aquifer Water Quality Near Jal, New Mexico

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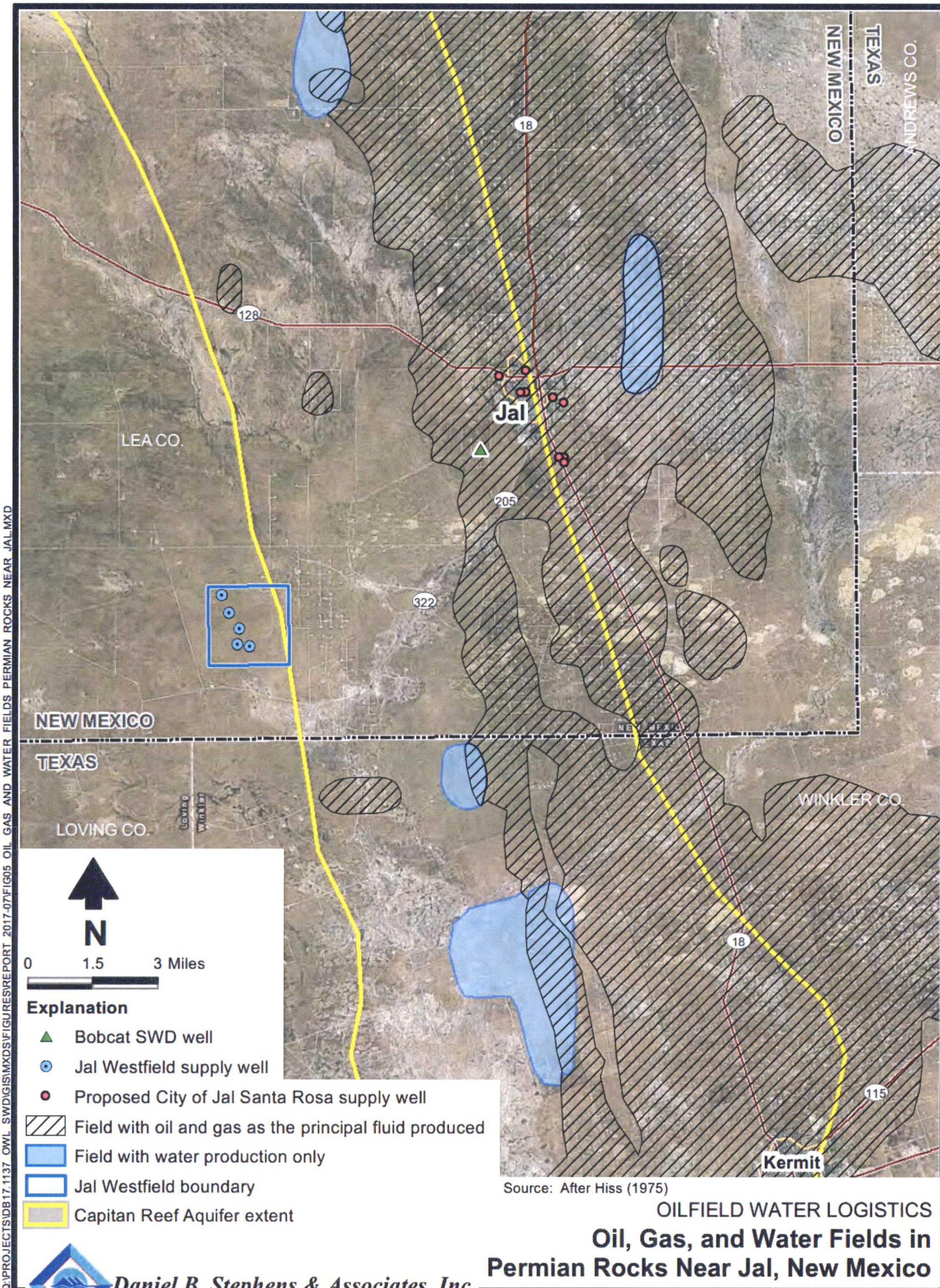
Figure 4

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG04_CAPITAN_REEF_AQUIFER_WATER_QUALITY_NEAR_JAL_NM.MXD



Source: After Hiss (1975)

OILFIELD WATER LOGISTICS

Oil, Gas, and Water Fields in Permian Rocks Near Jal, New Mexico

Figure 5

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG05_OIL_GAS_AND_WATER_FIELDS_PERMIAN_ROCKS_NEAR_JAL.MXD

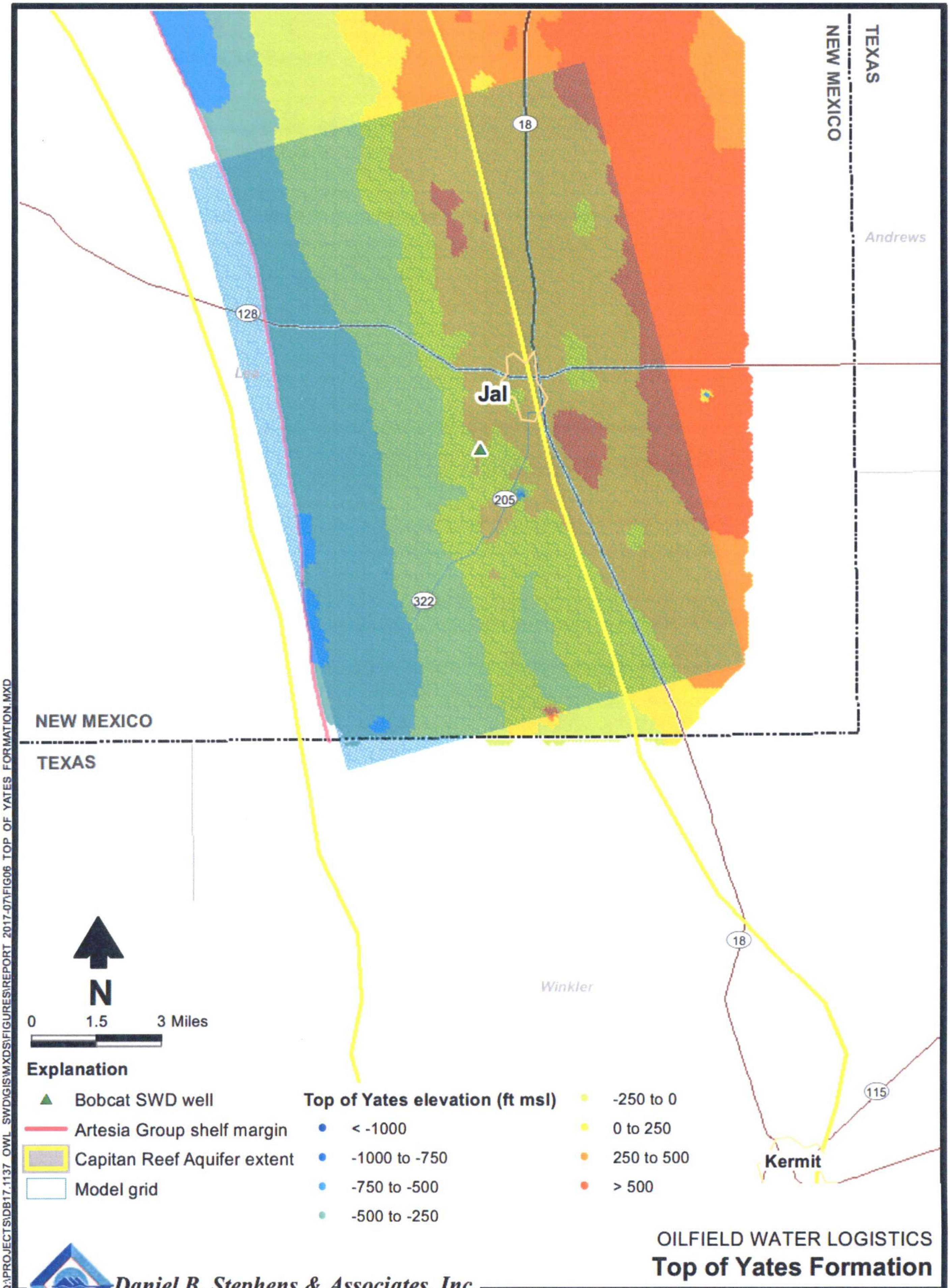
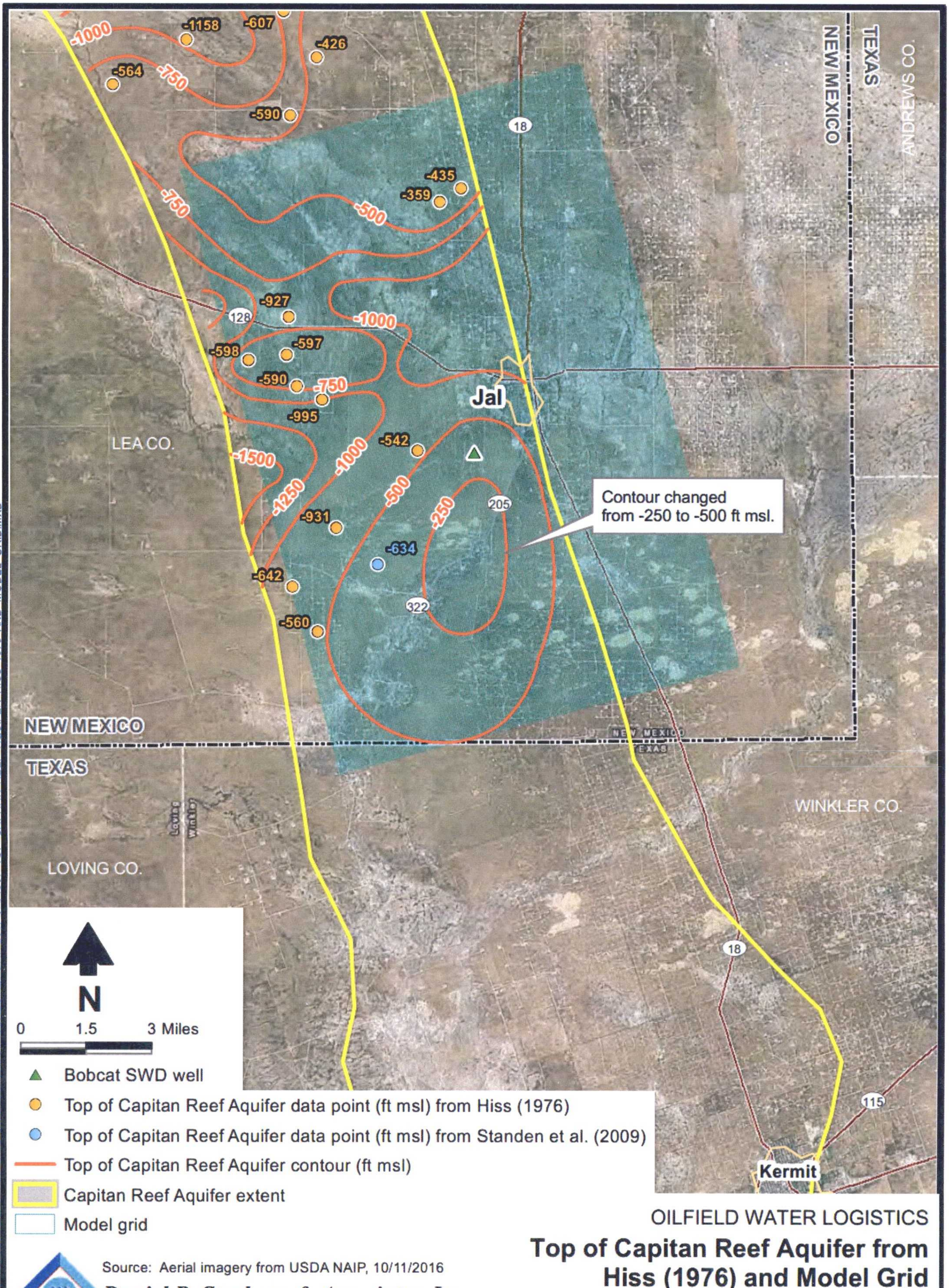


Figure 6

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT 2017-07\FIG06 TOP OF YATES FORMATION.MXD



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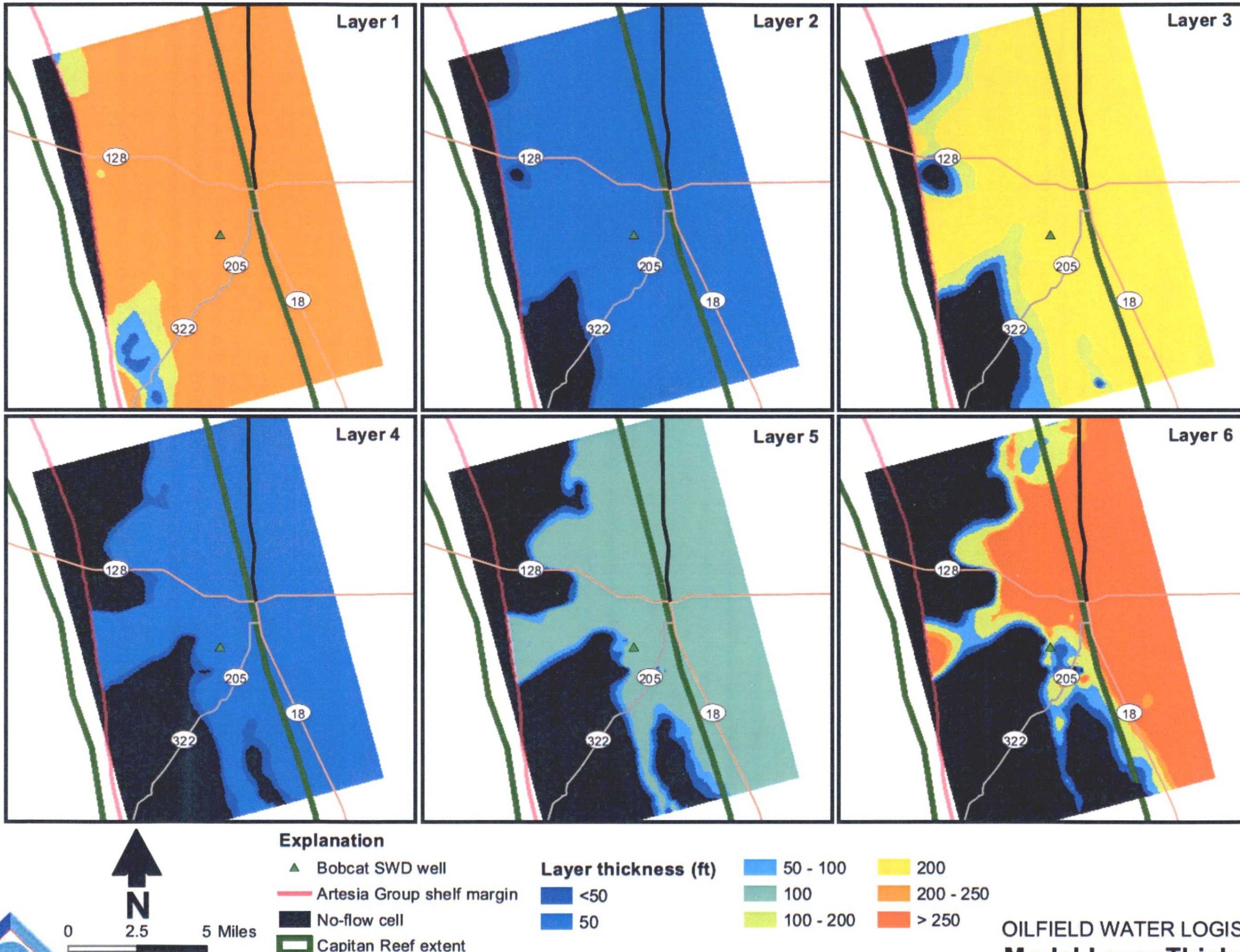
OILFIELD WATER LOGISTICS

Top of Capitan Reef Aquifer from Hiss (1976) and Model Grid

Figure 7

Q:\PROJECTS\DB17.1137 OWL SWD\GIS\MXDS\FIGURES\REPORT 2017-07\FIG07 TOP CAPITAN REEF AQUIFER HISS 1976 AND MODEL GRID.MXD



OILFIELD WATER LOGISTICS
Model Layer Thickness

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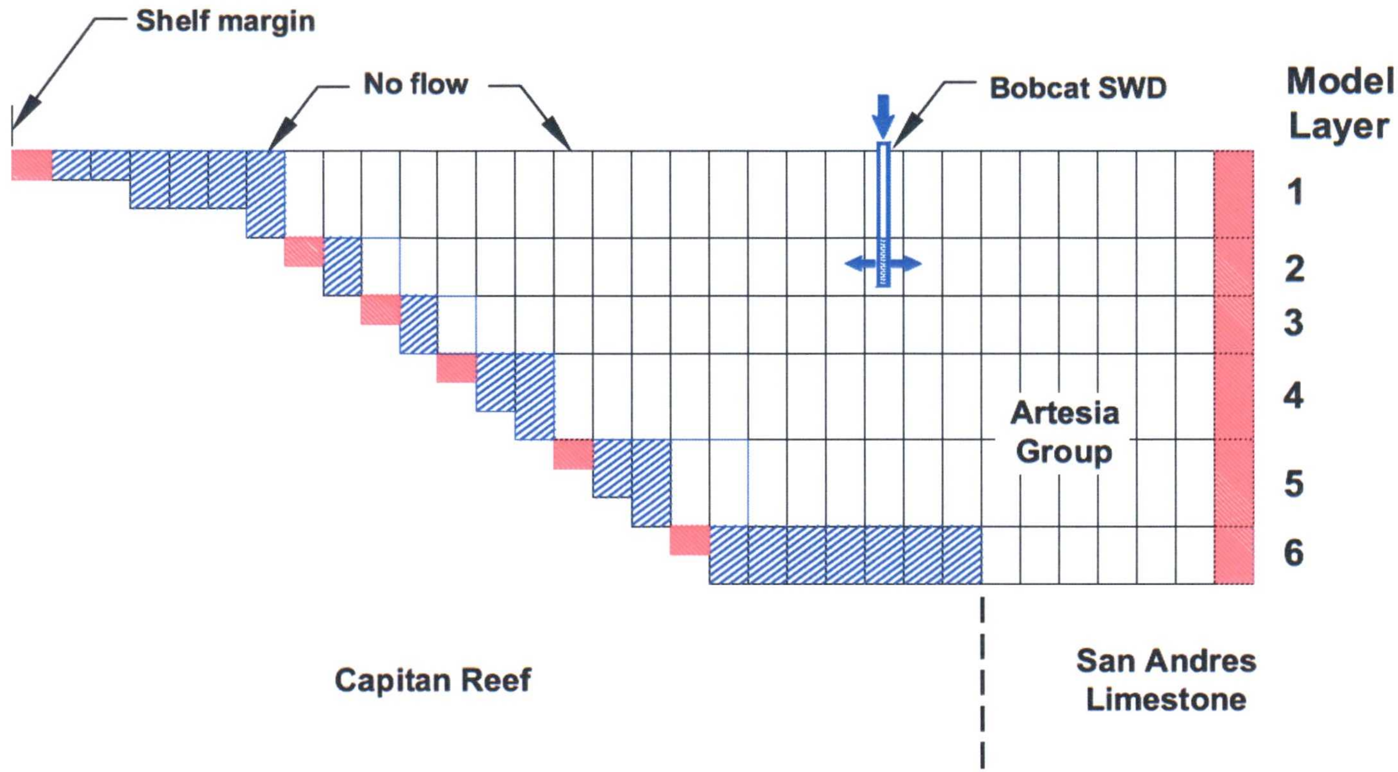
Figure 8

Q:\Projects\DB17.1137_OWL_SWD\VR_Drawings\Fig09_Concept_Cross_Sec_Model_Boundary_Conditions.dwg



Explanation

Grid cell

General head boundary cell representing horizontal groundwater flow

General head boundary cell representing vertical groundwater flow

Not to scale

OILFIELD WATER LOGISTICS

Conceptual Cross Section of Model Boundary Conditions

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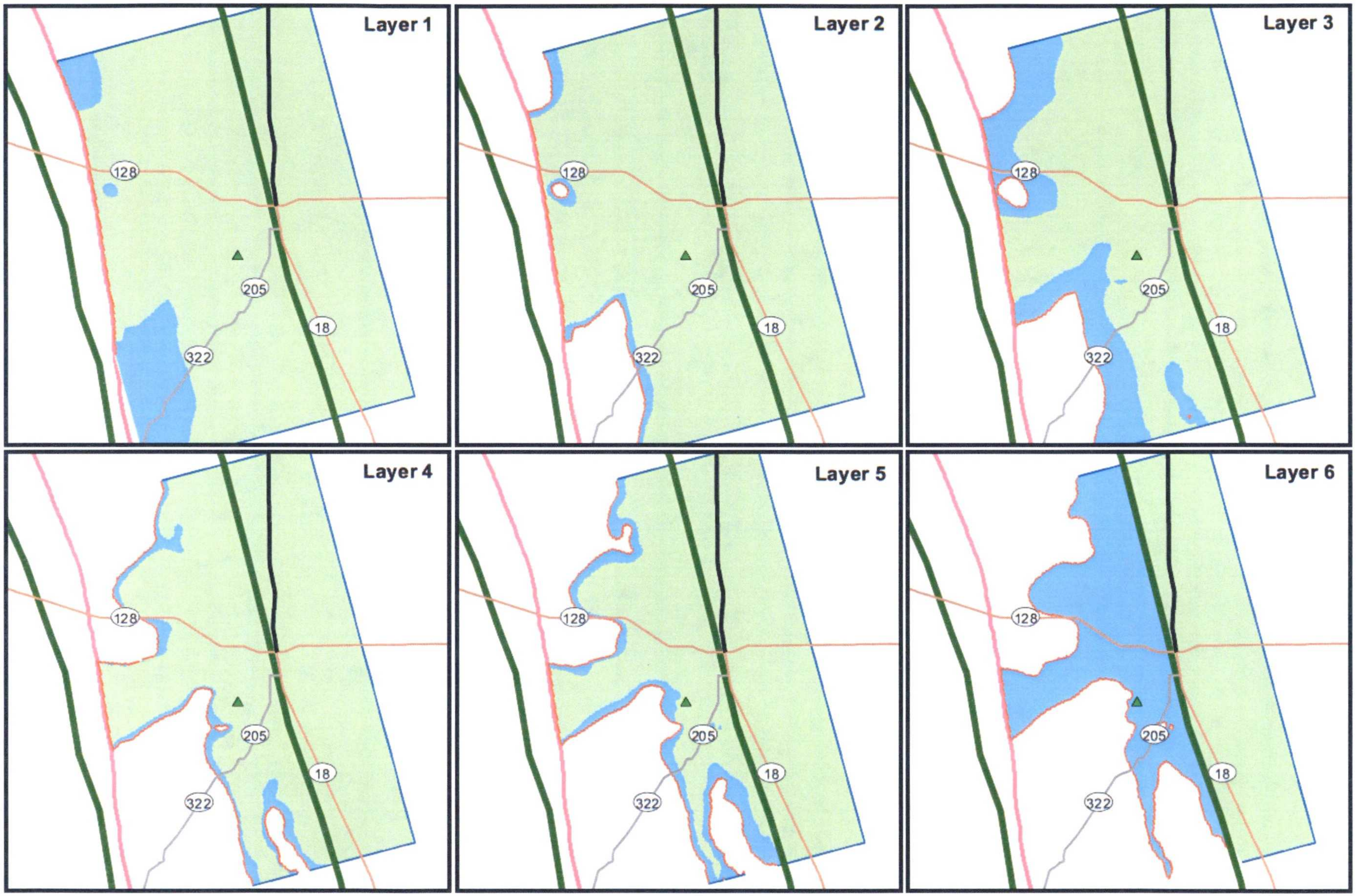
Figure 9

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG10_GENERAL_HEAD_BOUNDARY_CONDITIONS.MXD



Explanation

- ▲ Bobcat SWD well
- Active model cell - no boundary condition
- Artesia Group shelf margin
- Capitan Reef extent
- Vertical conductance to Capitan Reef Aquifer
- Horizontal conductance to Capitan Reef Aquifer
- Horizontal conductance to Artesia Group

N

0 2.5 5 Miles

OILFIELD WATER LOGISTICS

General Head Boundary Conditions

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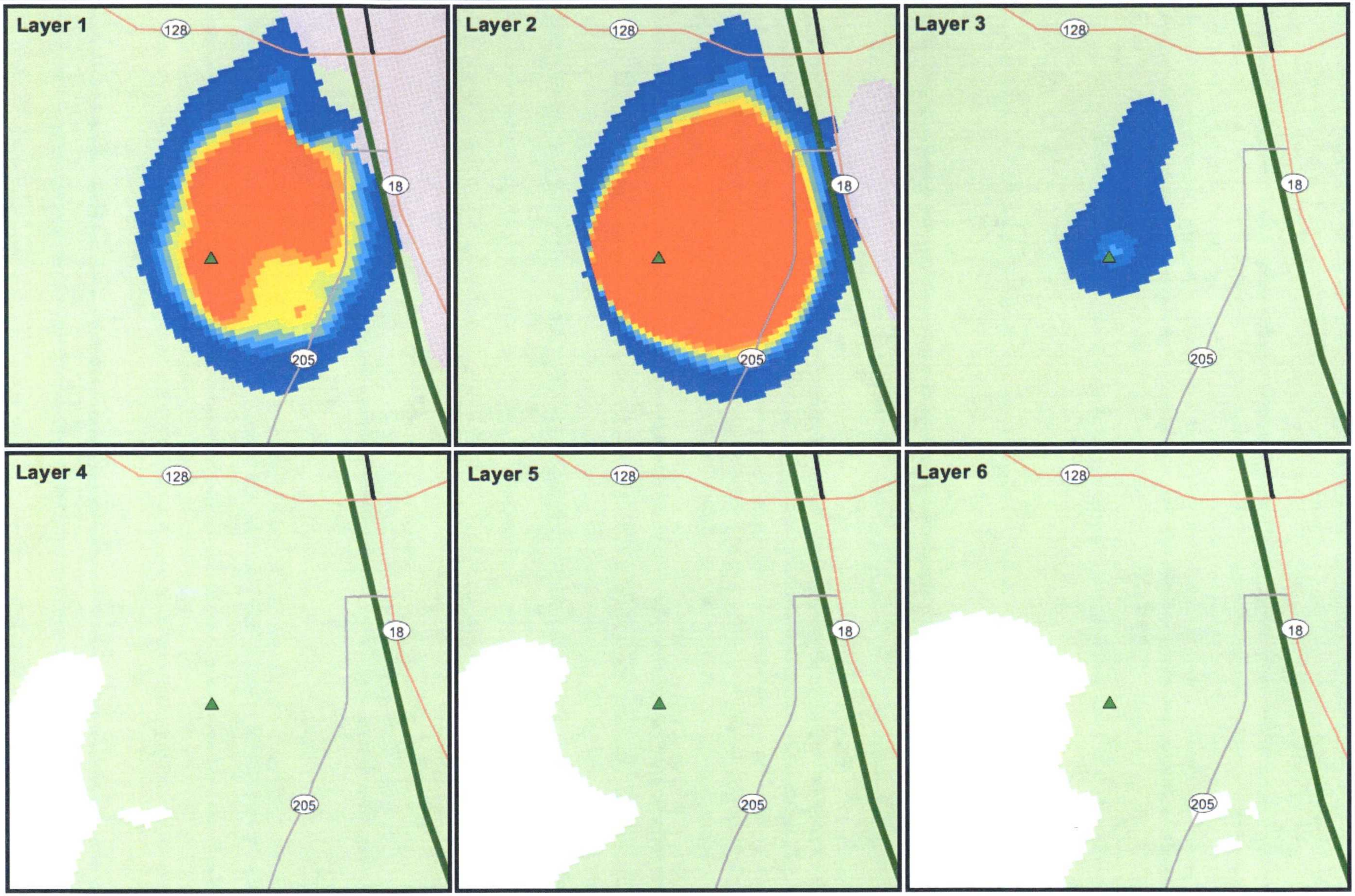
Figure 10

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG11A_SIM_TDS_CONC_AT_20_YRS.MXD



Explanation

- Bobcat SWD well
- Capitan Reef Aquifer extent
- Active model grid
- Dry cell

N

0 0.6 1.2 Miles

TDS concentration (g/L)

- 20.1 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 125

OILFIELD WATER LOGISTICS

Simulated TDS Concentration at 20 Years

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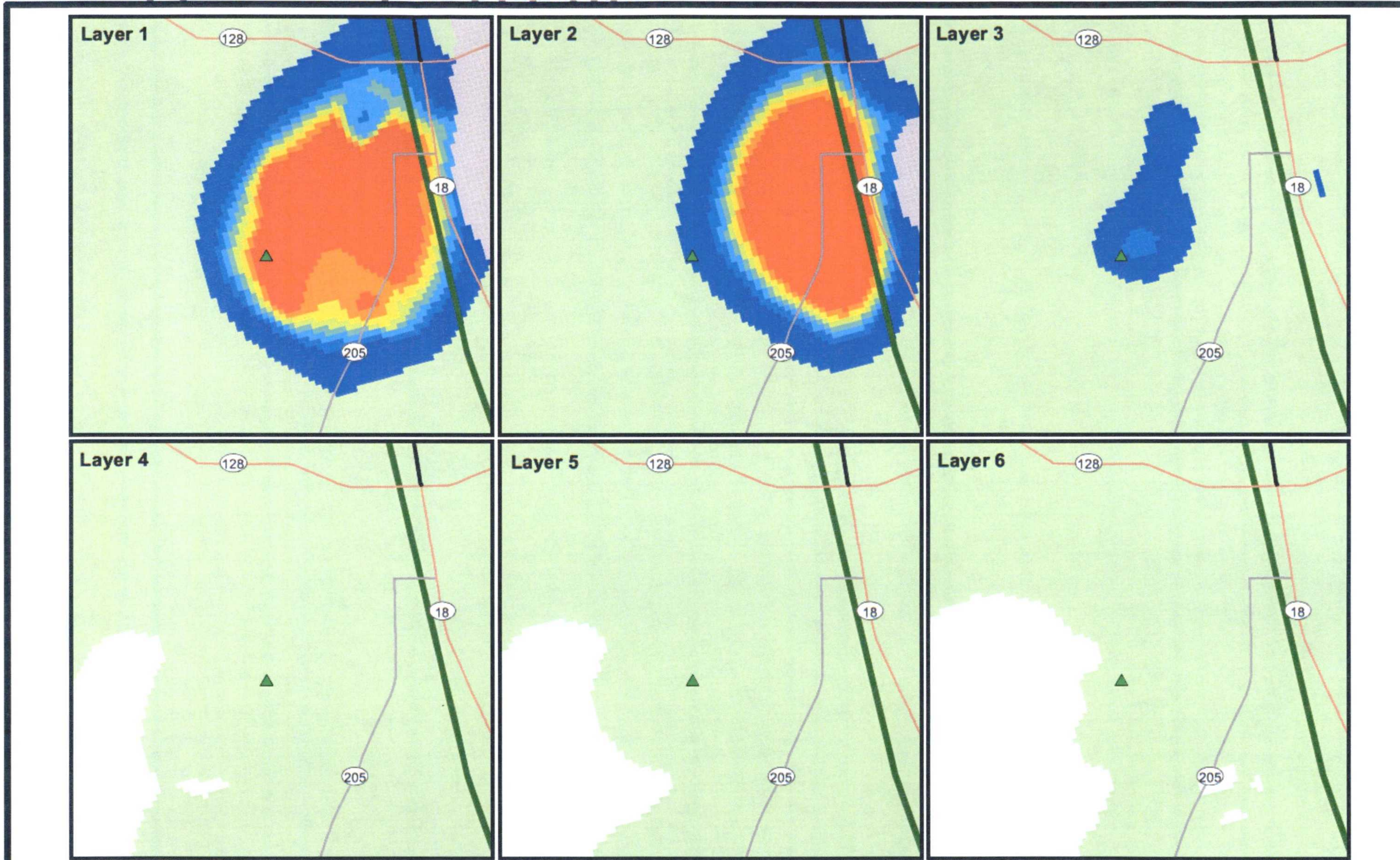
Figure 11a

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG11B_SIM_TDS_CONC_AT_40_YRS.MXD



OILFIELD WATER LOGISTICS

Simulated TDS Concentration at 40 Years

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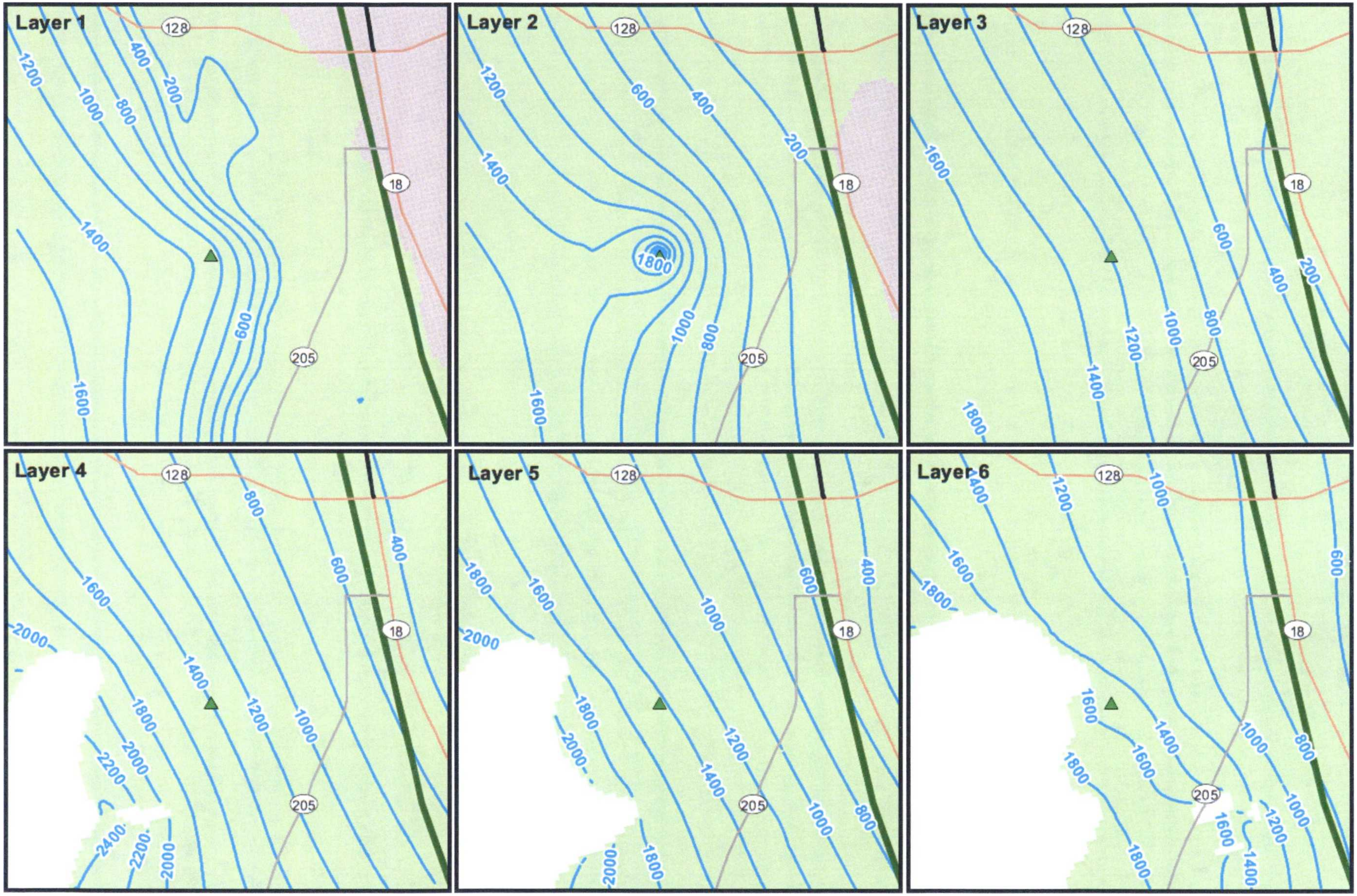
Figure 11b

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG11C_SIM_HYDRAULIC_HEAD_AT_20_YRS.MXD



Note: Maximum head in layer 2 is 2,855 feet

N

0 0.6 1.2 Miles

Explanation

- Bobcat SWD well
- Capitan Reef Aquifer extent
- Simulated hydraulic head (ft msl)
- Active model grid
- Dry cell

OILFIELD WATER LOGISTICS

Simulated Hydraulic Head at 20 Years

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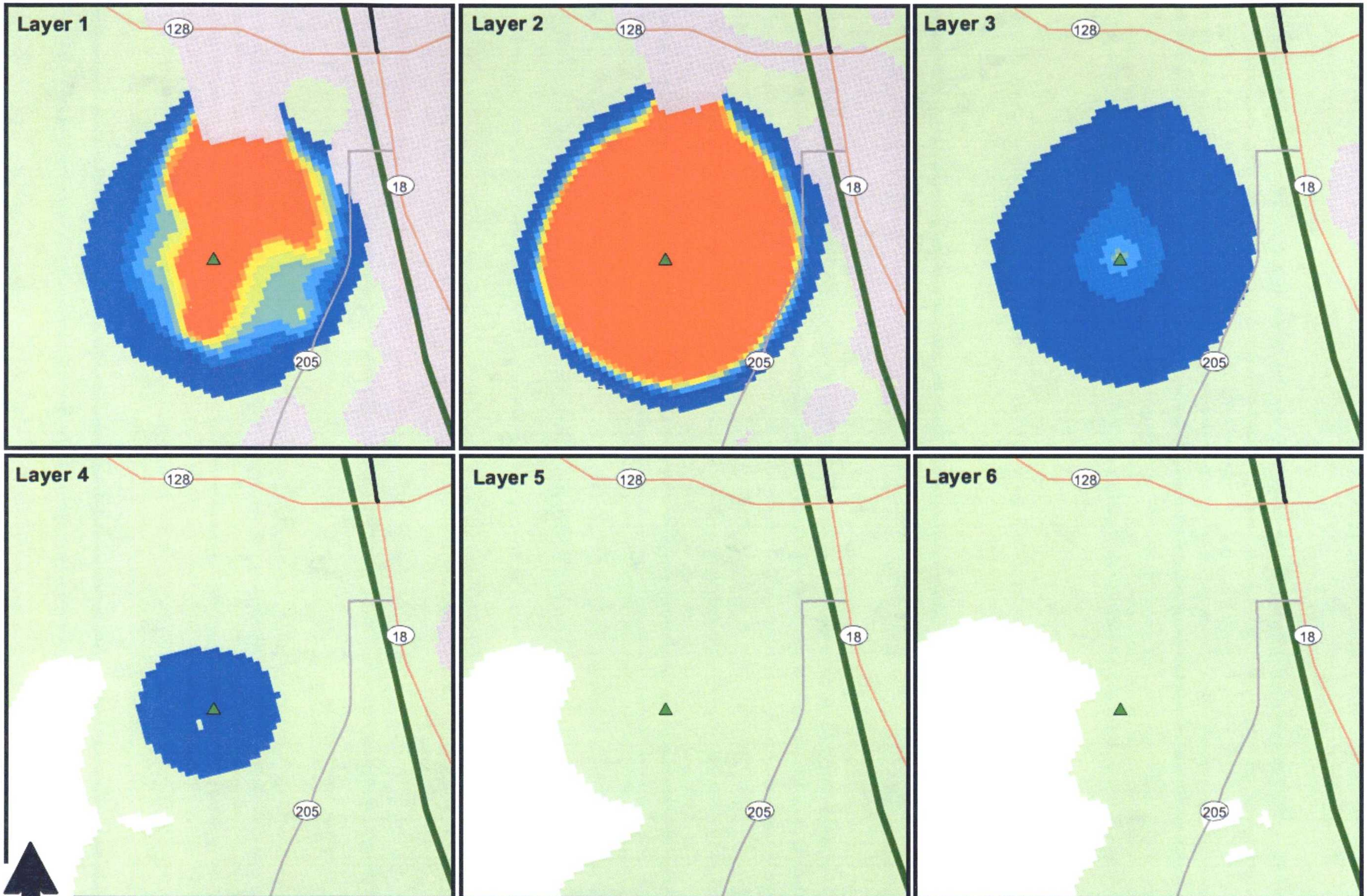
Figure 11c

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG12A_SIM_TDS_CONC_AT_20_YEARS_NO_CAPITAN_REEF_AQUIFER_HYD_HEAD.MXD



Explanation

- Bobcat SWD well
- Capitan Reef Aquifer extent
- Active model grid
- Dry cell

0 0.6 1.2 Miles

TDS concentration (g/L)

- 20.1 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 125

OILFIELD WATER LOGISTICS

Simulated TDS Concentration at 20 Years - No Capitan Reef Aquifer Hydraulic Head

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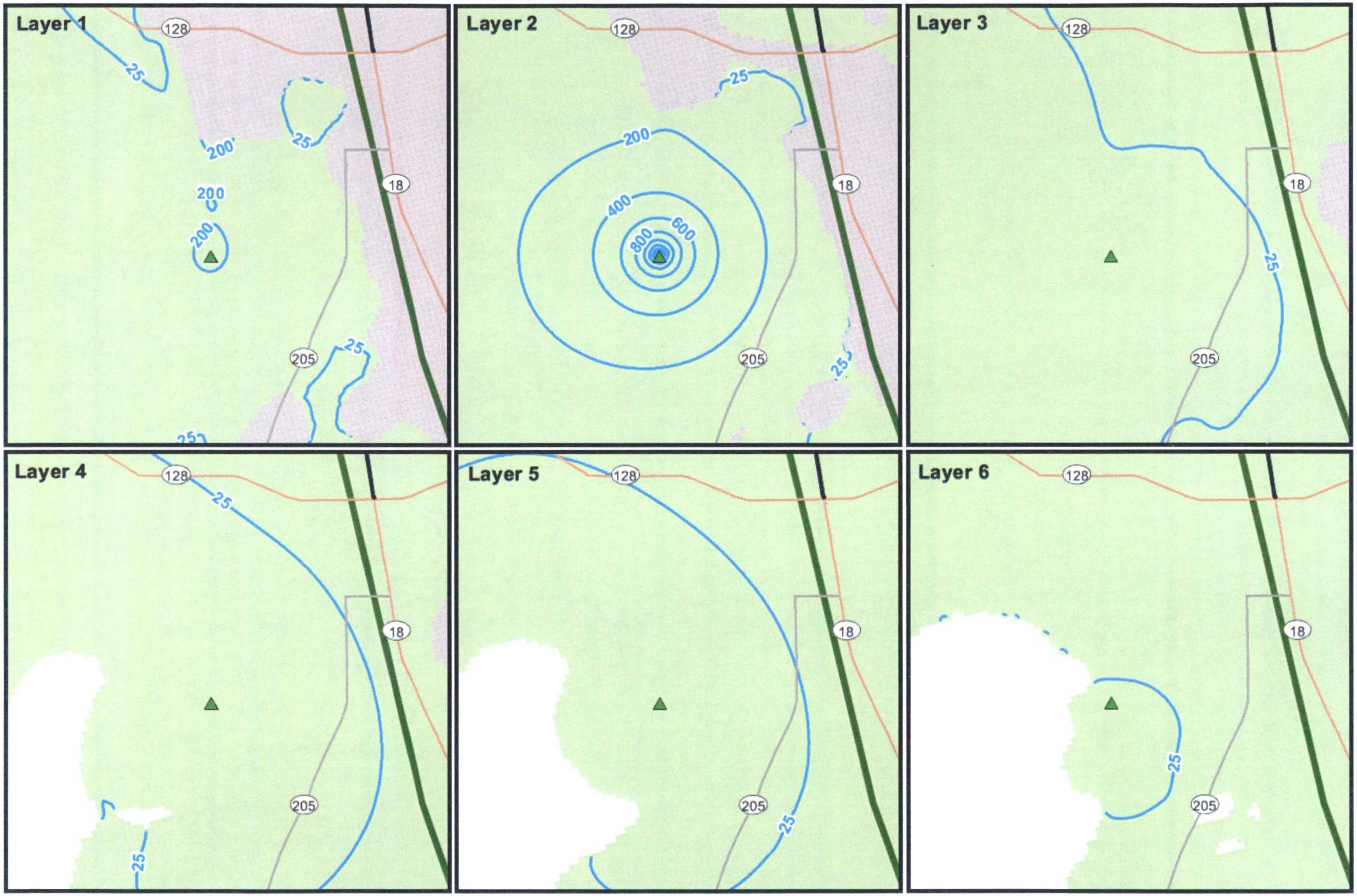
Figure 12a

Q:\PROJECTS\DB17.1137_OWL_SWD\GIS\MXDS\FIGURES\REPORT_2017-07\FIG12B_SIM_HYDRAULIC_HEAD_AT_20_YEARS_NO_CAPITAN_REEF_AQUIFER_HYDRAULIC_HEAD.MXD



Note: Maximum head in layer 2 is 2,137 feet

N

0 0.6 1.2 Miles

Explanation

- Bobcat SWD well
- Capitan Reef Aquifer extent
- Simulated hydraulic head (ft msl)
- Active model grid
- Dry cell

OILFIELD WATER LOGISTICS

Simulated Hydraulic Head at 20 Years - No Capitan Reef Aquifer Hydraulic Head

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Figure 12b

Table

Table 1. Groundwater Model Hydraulic Properties

Model Layer	Description	Thickness (feet)	Intrinsic Permeability (md)		Anisotropy Factor (k_x/k_z)	Porosity (%)	Ss (ft^{-1})
			k_x	k_z			
1	Yates above injection zone	Top of Yates to top of injection zone ~ 200 feet at Bobcat SWD	10	0.1	100	7	1×10^{-7}
2	Injection zone (base of Yates/top of Seven Rivers)	50	350	3.5	100	15	1×10^{-7}
3	Dolomitic low k zone in Seven Rivers below base of injection zone	200	20	0.02	1,000	7	1×10^{-7}
4	Second assumed higher k zone, but not as high as injection zone	50	150	1.5	100	10	1×10^{-7}
5	Bottom of Artesia Group; low k	100	10	0.01	1,000	5	1×10^{-7}
6	Bottom of Artesia Group; low k	Remaining thickness	10	0.01	1,000	5	1×10^{-7}

md = Millidarcies; 1 md = 0.00274 feet per day (ft/d) hydraulic conductivity, assuming fresh water
k_x = Intrinsic permeability in the horizontal direction
k_z = Intrinsic permeability in the vertical direction
Ss = Specific storage

Appendix A

Water Quality Report for Maralo Sholes B No. 2 SWD Well

MITCHELL ANALYTICAL LABORATORY

2638 Faudree
Odessa, Texas 79765-8538
561-5579

Company: ***WadeCo Specialties, LLC***

Well Number:	Bobcat SWD H-Pump	**Sample Temp:**	96.62
Lease:	OWL	**Date Sampled:**	5/15/2017
Location:	WC61437	**Sampled by:**	Wade Havens
Date Run:	5/22/2017	**Employee #:**	
Lab Ref #:	17-may-h27255	**Analyzed by:**	GR

			Mg/L	Eq. Wt.	MEq/L
		Dissolved Gases			
Hydrogen Sulfide	(H2S)		5.00	16.00	.31
Carbon Dioxide	(CO2)		800.00	22.00	36.36
Dissolved Oxygen	(O2)		.50	8.00	.06
		Cations			
Calcium	(Ca++)		4,824.00	20.10	240.00
Magnesium	(Mg++)		732.00	12.20	60.00
Sodium	(Na+)		42,871.64	23.00	1,863.98
Barium	(Ba++)	**NOT ANALYZED**			
Manganese	(Mn+)		1.26	27.50	.05
Strontium	(Sr++)	**NOT ANALYZED**			
		Anions			
Hydroxyl	(OH-)		.00	17.00	.00
Carbonate	(CO3=)		.00	30.00	.00
BiCarbonate	(HCO3-)		733.20	61.10	12.00
Sulfate	(SO4=)		790.00	48.80	16.19
Chloride	(Cl-)		74,581.95	35.50	2,100.90
Total Iron	(Fe)		27.61	18.60	1.48
Total Dissolved Solids			125,367.16		
Total Hardness as CaCO3			15,061.20		
Conductivity MICROMHOS/CM			160,000		

pH 6.300 Specific Gravity 60/60 F. 1.087

CaSO4 Solubility @ 80 F. 42.25MEq/L, CaSO4 scale is unlikely

CaCO3 Scale Index

70.0	.261	100.0	.581	130.0	1.161
80.0	.381	110.0	.851	140.0	1.161
90.0	.581	120.0	.851	150.0	1.491