Groundwater Availability Modeling for the Hudson Aquifer Sioux County, Iowa

Iowa Geological and Water Survey
Open File Report OFR-13-2

Iowa Department of Natural Resources
Chuck Gipp, Director

January 2014

Photo of Big Sioux River in Sioux County

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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EXECUTIVE SUMMARY

The Iowa Geological and Water Survey of the Iowa Department of Natural Resources completed a hydrogeologic investigation for the alluvial aquifer located in Garfield Township, Sioux County, Iowa. For the purposes of this summary report, the aquifer will be referred to as the Hudson aquifer. The current water users include Rock Valley Rural Water District (RVRWD), and approximately 21 irrigation wells. A proposed wellfield is also planned by Rural Water System #1 (RWS #1). The investigation was done at the request of RVRWD.

Based on the results of this evaluation, an increase in water production may be possible from two or more additional wells in the existing RVRWD wellfield. Total wellfield water production may increase from 3.8 million gallons per day (mgd) to 5.3 mgd with the addition of proposed wells PW-1 and PW-2. The final location and water production from the proposed wells will need to be determined following test drilling, test well installation, and aquifer pump tests.

Based on the groundwater flow model, the use of a recharge basin to the east of the RVRWD wellfield will substantially increase the total water production during a severe drought. If proposed wells PW-1 and PW-2 are added, along with the recharge basin, the wellfield water production may increase to a maximum of 8.3 mgd.

Based on the groundwater flow model, the proposed RWS #1 wellfield would have minimal impacts on the existing RVRWD wellfield. Approximately one foot of additional drawdown in RVRWD wells was simulated when the proposed RWS #1 wellfield was pumping at peak usage.

Based on the groundwater flow model, the proposed RWS #1 wellfield would have significant impact on the existing irrigation permits held by Murlynn Wennbloom, Ranschau Brothers, and Arnold Zomermaand. Approximately 3 to 5 feet of additional drawdown in nearby irrigation wells were simulated when proposed RWS #1 wellfield was pumping at peak usage during a severe drought.

Based on the groundwater flow model, the 21 permitted irrigation wells have significant impacts on the existing RVRWD wellfield and the proposed RWS #1 wellfield during a severe drought. Approximately four to eight feet of additional drawdown was simulated in RVRWD wells 1, 3, 4, and 6, and four to five feet of additional drawdown was simulated in the proposed RWS #1 wellfield after 60 days of maximum irrigation usage.

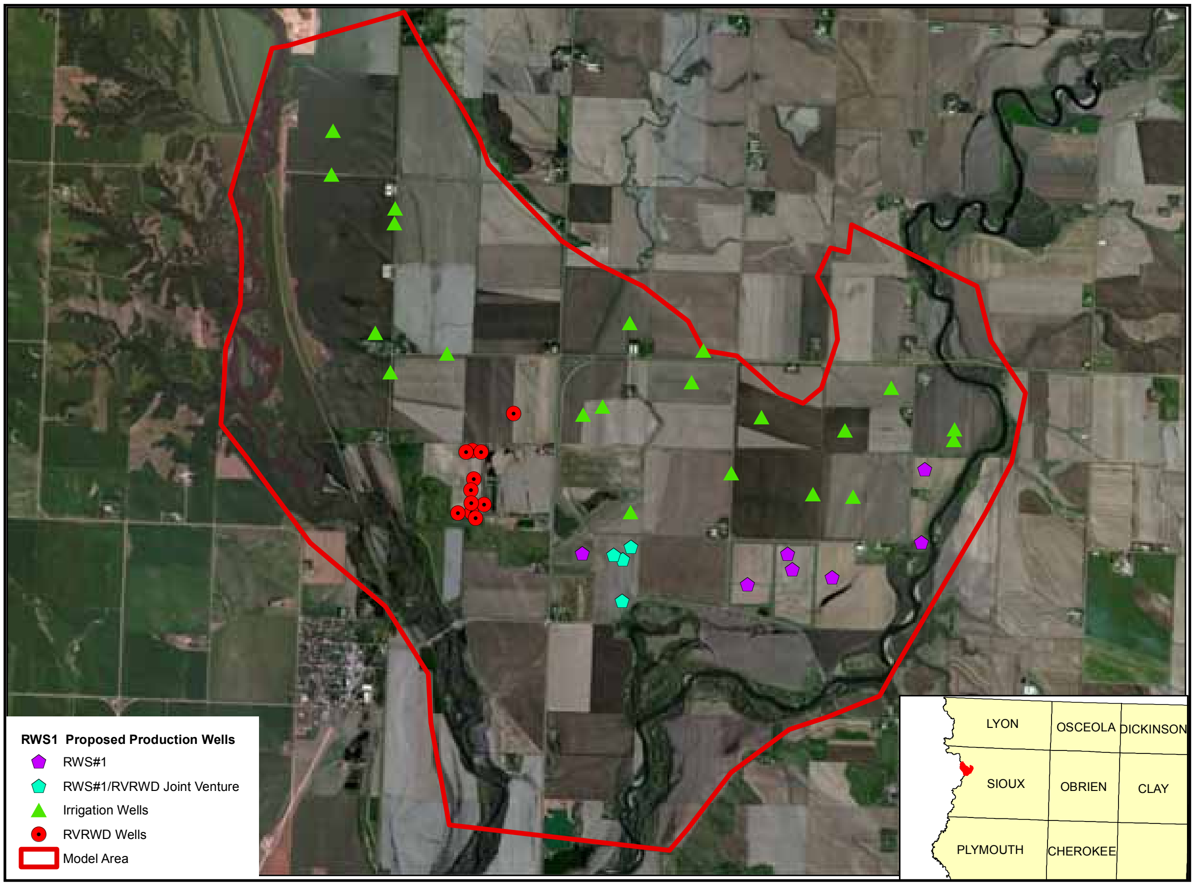


Figure 1. Hudson aquifer study area.

INTRODUCTION

The purpose of this hydrogeologic investigation is to evaluate the current and proposed groundwater withdrawals from the alluvial aquifer located in Garfield Township, Sioux County, Iowa. For the purposes of this summary report the aquifer will be referred to as the Hudson aquifer. The current users include Rock Valley Rural Water District (RVRWD) located in Section 7, Township 96 North, Range 47 West, and approximately 21 irrigation wells located to the north and east of RVRWD (Figures 1 and 2). A proposed well field is being planned by Rural Water System #1 (RWS #1) in parts of Sections 8, 10, 16, and 17 (Figure 3). The investigation was done at the request of RVRWD.

Previous investigations have been conducted by Quad States Services, Inc. (QSSI) (Groundwater Modeling Report-Rock Valley Rural Water Well field, December 2005), and by Leggette Bradshears & Graham, Inc. (LBG) (Potential Well-Field Interference, Rock Valley Rural Water District, August 15, 2005). A hydrogeologic evaluation was also conducted by the Iowa Geological Survey- Iowa Department of Natural Resources (IGS-IDNR) in October 2006. The current investigation uses water level data and pumping rates that were collected during the 2012 and 2013 drought.

Proposed Rural Water System #1

Rural Water System #1 has proposed a total of 11 production wells from four general

Figure 2. Rock Valley Rural Water District well field.

well field areas (Figure 3). The four general well field areas include, Van Serksum, Visser, Vander Lugt, and Solberg. The Van Serksum well field and Tract B of the Visser well field may benefit from the induced recharge from the Rock River, and the Solberg well field may benefit from the induced recharge from the Solberg pond and the unnamed creek. The Vander Lugt well field and Tract A of the Visser well field are considered inland wells.

GEOLOGY

The thickness of alluvial deposits in the Hudson aquifer varies from two to 90 feet, but averages approximately 30 feet (Thompson, 1987). The deposits are not uniform or homogeneous, but include clay, silt, sand, gravel, cobbles, and boulders. The Hudson aquifer appears to be terrace deposits associated with the ancestral Big Sioux River. Based on the width of the terrace and the heterogeneous channel fill material, the deposits may have been deposited by a braided stream system. The sand and gravel thickness varies from two to 80 feet. The sand and gravel is overlain by fine-grained sediments that consist of silt and fine sand that range in thickness from two to 20 feet. The base of the sand and gravel aquifer is underlain by either glacial till, alluvial clay, or cretaceous shale throughout the study area.

HYDROGEOLOGY

Regional groundwater flow in the Hudson aquifer is in a southerly direction toward the Big Sioux River on the west side of the aquifer,

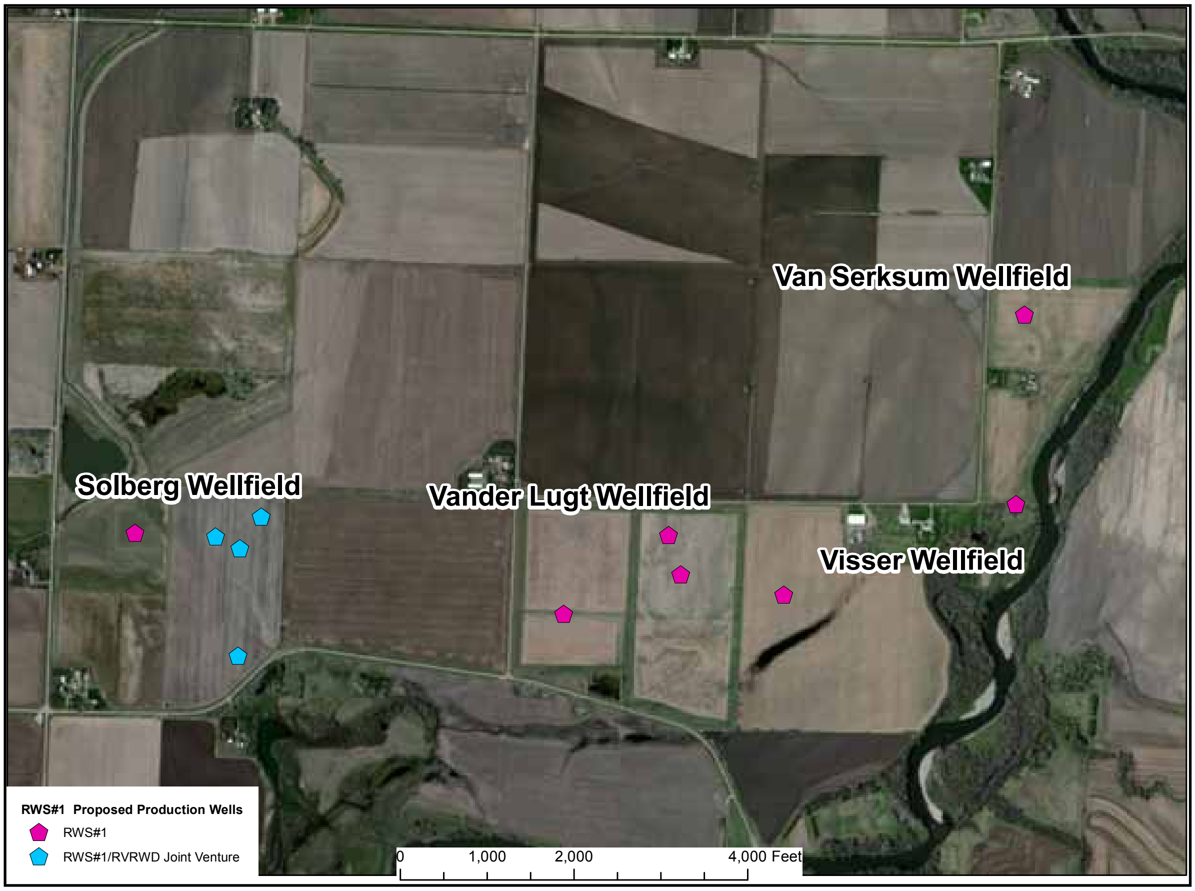


Figure 3. Proposed Rural Water System #1 (RWS #1) well fields.

and toward the Rock River on the east side of the aquifer. There is a groundwater divide within the Hudson aquifer as shown on Figure 4. Water level data from 13 observation wells were used to develop the water table map (Table 1). The hydraulic gradient is very similar to the land surface topography, and the Rock River and the Big Sioux River are groundwater discharge areas. Induced recharge or river recharge occurs in the Hudson aquifer along the Rock River during the summer due to the pumping stress caused by the nearby irrigation wells. Induced recharge also occurs in the Hudson aquifer when there is flow in unnamed creek. Groundwater recharge sources are precipitation, induced recharge from surface water, and seepage from glacial drift and terraces along the valley wall.

Table 1. Model calibration results for steady-state (nonpumping) conditions for the Hudson aquifer groundwater study under drought conditions.

Well ID	Observed WL (ft)	Simulated PWL (ft)
JV-1	1189.9	1194
JV-2	1193.6	1194
JV-3	1184.5	1194
JV-4	1190.3	1193
H-1	1195.1	1193.5
H-2	1189.5	1191
H-4	1190.9	1192
H-5	1193.2	1193.3
H-6	1187	1194
Jay Grevengoed	1196	1193.5
Marvin Vonk	1196	1194.5
Westra #1	1199	1201
Ranschau	1193	1197

Measuring groundwater recharge based on annual precipitation data is difficult. In Iowa

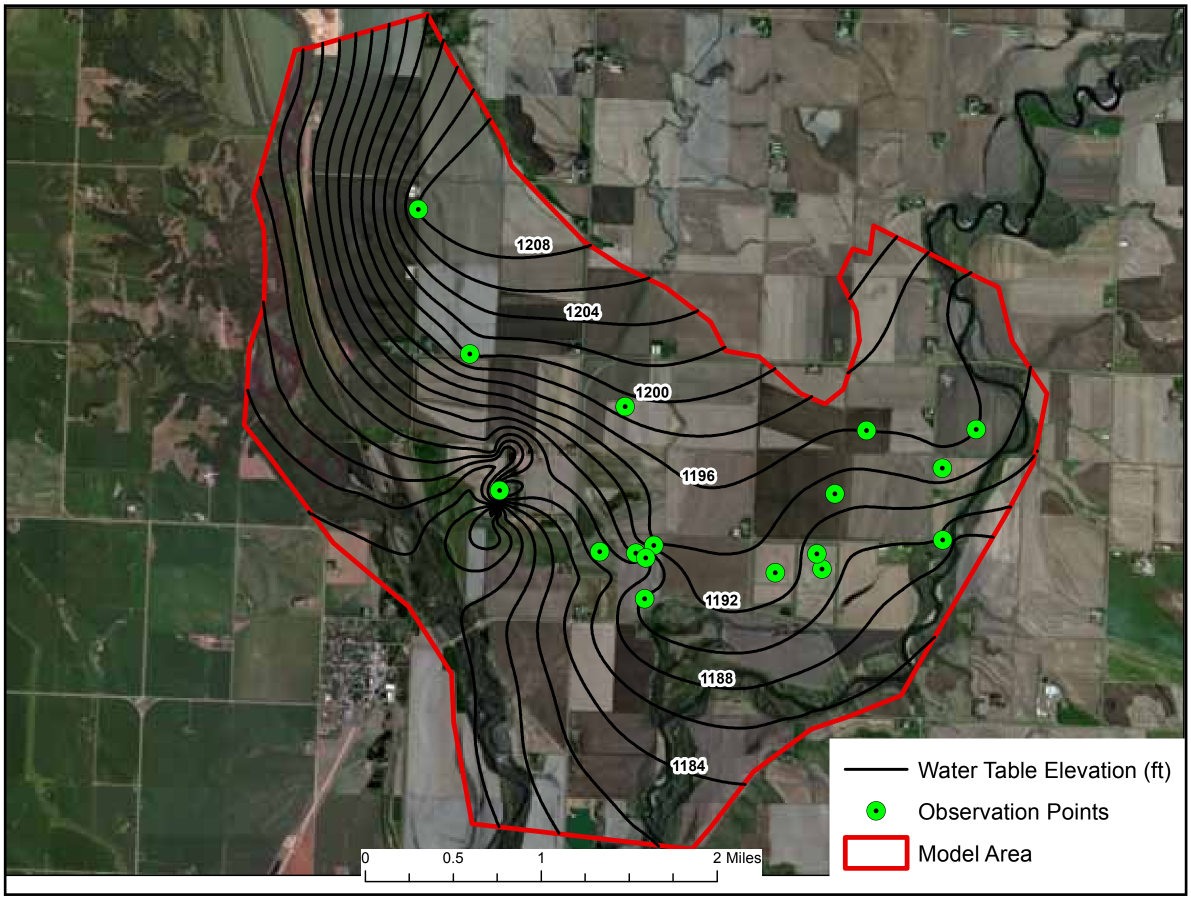


Figure 4. Static water table elevation map of the Hudson aquifer based on 2013 water levels.

much of the groundwater recharge occurs in the early spring and fall. The actual amount of groundwater recharge depends on the intensity and distribution of the precipitation events, and when they occur seasonally. The annual rate of precipitation recharge during 2012 was calibrated to be four inches/year in the Hudson aquifer, and zero inches per year during the summer of 2012 (June 1 through August 31).

Aquifer Test Results

Hydraulic properties are used to define and characterize aquifers and include specific yield or storage, transmissivity, and hydraulic conductivity. The most reliable aquifer properties are those obtained from controlled aquifer pump tests with known pumping rates, pumping duration, accurate well locations, and accurate water level measurements. Pump tests were conducted in seven test wells installed by RWS #1 in 2005, and one test well installed by RVRWD in 2007. Observation wells were used to measure drawdowns. Table 2 shows the test results, which indicate transmissivity values that range from 5,000 ft^2/day in TW31, to 39,000 ft^2/day in TW-20. In addition to the aquifer parameter estimation, the observed drawdown data was also used to help calibrate the groundwater flow model. This will be discussed later in the report.

Hydraulic conductivity can be calculated by dividing the transmissivity by the overall aquifer thickness. Hydraulic conductivity was found to range from 136 to 1,060 feet/day, with an arithmetic mean of 686 feet/day.

Table 2. Results of aquifer pump tests for the Hudson aquifer groundwater study.

Well #	Duration (Days)	Thickness (ft)	T (ft^2/day)	K (ft/day)
TW-1	1			
OB 1 (r=5.25')		28	13,950	500
OB 2 (r=16.50')		28	10,500	370
OB 3 (r=32.14')		28	19,250	690
TW18	3			
OB 1 (r=21.0')		42	22,500	540
OB 2 (r=39.0')		41	21,500	520
TW20	1			
OB 1 (r=13')		41	39,000	940
OB 2 (r=23')		42	33,500	800
TW26	1			
OB 1 (r=13')		27	18,300	680
OB 2 (r=29.5')		27	20,800	770
TW31	3			
OB 1 (r=12.5')		39	10,900	280
OB 2 (r=29.5')		37	5,000	136
TW38	1			
OB 1 (r=14.5')		28	29,600	1060
OB 2 (r=34..5')		28	29,300	1060
IA27	5.9			
OW 18 (r=650')		28	24,400	860
OW 21 (r=700')		28	24,400	860
OW 22 (r=1300')		54	24,400	450
RVRWD 10	1			
RVRWD 9 (r=350')		34	32,600	960
OB 1 (r=200')		34	29,800	877

Geophysical Investigation

A geophysical investigation was conducted to gather additional information related to aquifer characteristics. An Advanced Geosciences Inc. (AGI) SuperSting R8, 8-channel electrical resistivity (ER) meter was used to collect all geophysical measurements. Field measurements were obtained by introducing a direct current into the ground through current electrodes and measuring resulting voltages through multiple potential electrodes. An array of fifty-six stainless steel electrode stakes were spaced approximately 20 feet apart, driven approximately one foot into the ground, and connected via electrode cables and a switch box to a central ER meter.

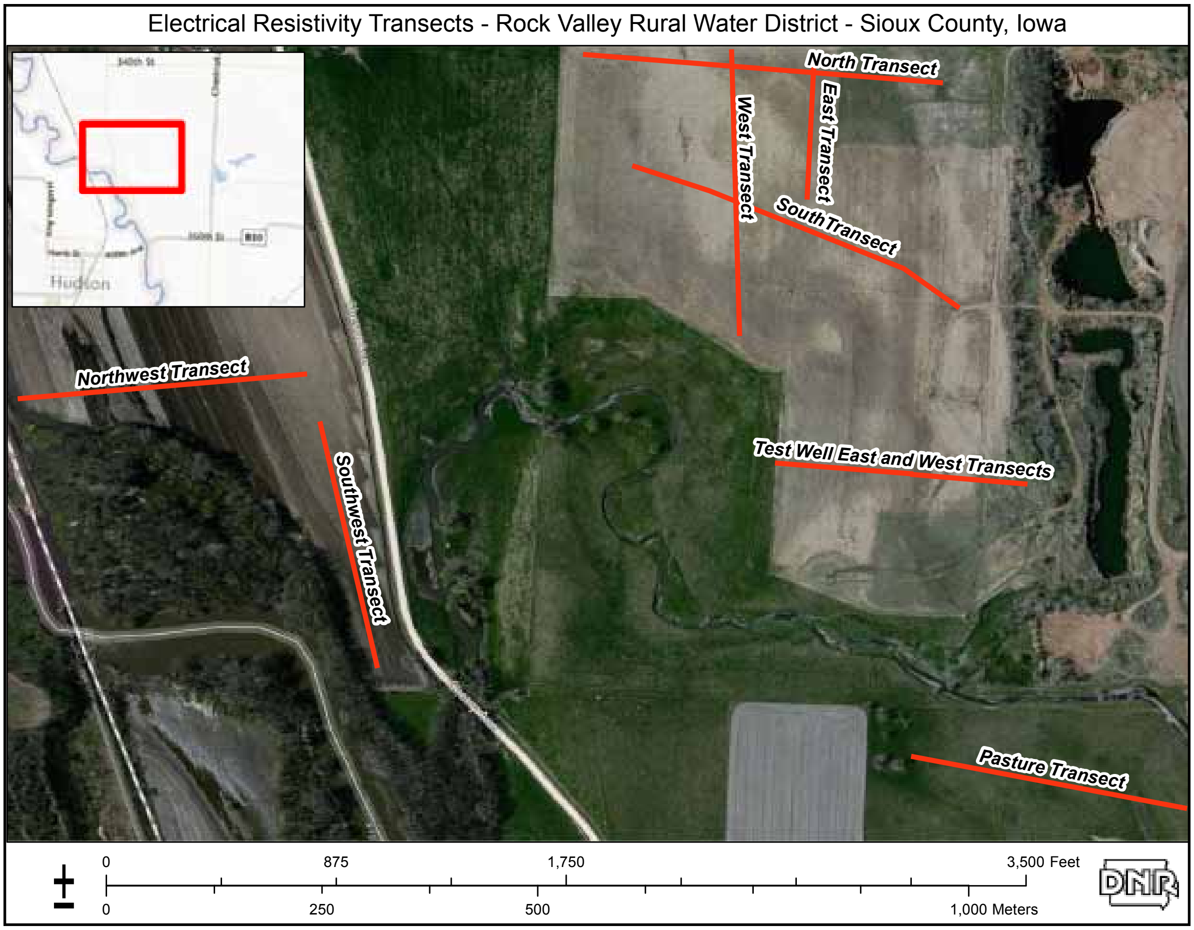


Figure 5. Locations of the eight geophysical cross sections.

Eight surveys were completed in the summer and fall of 2013 (Figure 5). A total of 8,515 individual resistivity measurements were collected. Using 1930s' aerial imagery, transect locations were chosen based on their proximity to old river channels where coarse sands and gravels may be present. Transects were oriented in a perpendicular arrangement to determine how geologic materials vary in either direction.

Field data were obtained using dipole-dipole configurations; chosen to maximize data collection by utilizing all channels to acquire data. Measure time was set at 7.2 seconds and measurements were stacked (averaged) twice, unless the standard deviation of all channels was less than 2 percent. In that case, a third or fourth measurement was taken and included in the average. To quantify error, overlapping data were collected in areas already covered by normal measurement. Reciprocal data were collected to further quantify error. When necessary, data were collected in "roll-along" fashion, resulting in a single data set along an entire transect.

Data were processed using AGI EarthImager 2D version 2.4.0 software. The inversion mesh was fine for the near-surface region in each transect and coarsened with depth. Resistivity values below one Ohm-m or above 10,000 Ohm-m were removed as these values are typically representative of erroneous data. Inversion was stopped after once root-mean-squared (RMS) values were at or below

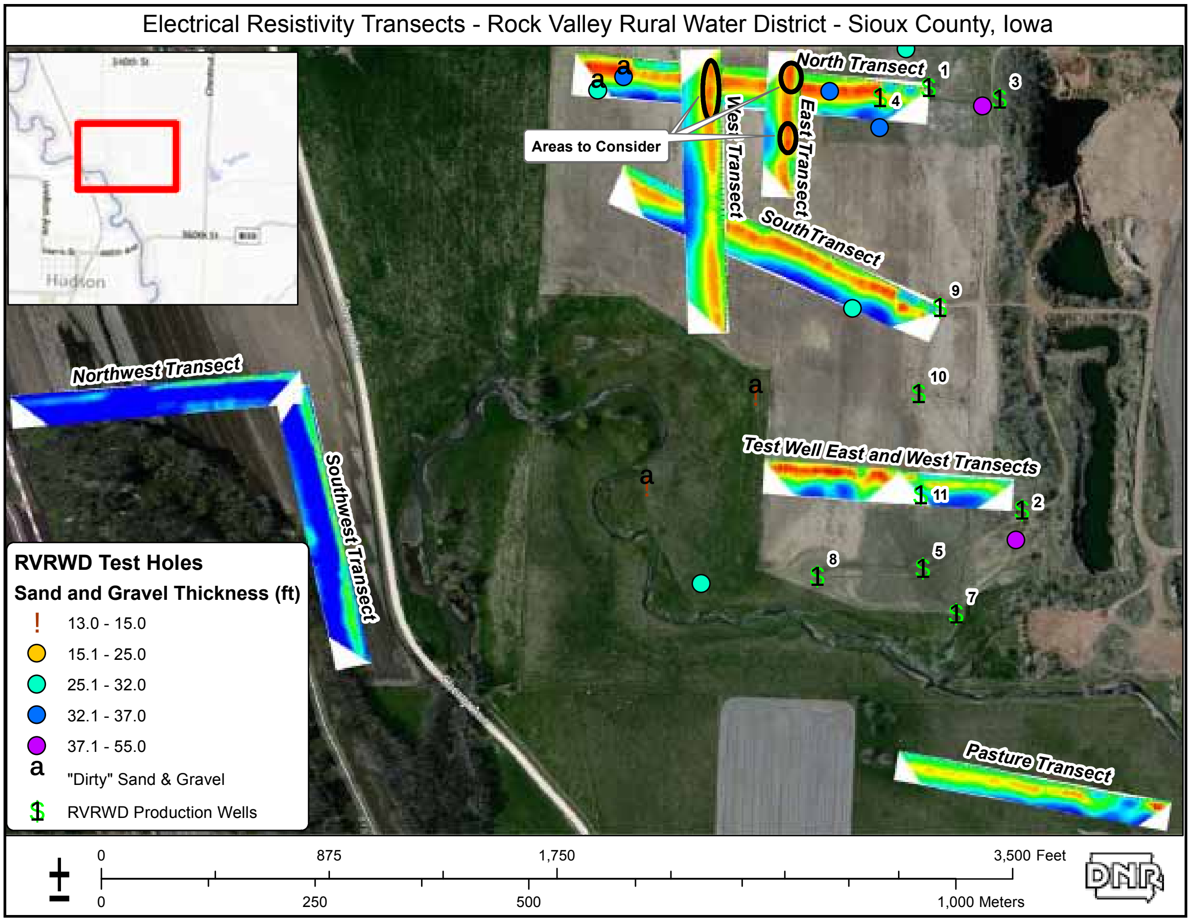


Figure 6. The geophysical (electrical resistivity) cross sectional results. Sand and gravel is indicated by the yellow and red zones, and silt and clay are indicated by the blue and green zones..

8 percent, and L2 norm ratio values were less than or equal to one.

Models provide an interpretation of how the subsurface responds to electrical influence. Model results can be indicative of a number of variables including, but not limited to, mineralogy, water saturation, compaction and available pore space, dissolved ions in pore fluid, as well as other geologic, biologic, and chemical factors. Interpretation of these data must be in the context of additional site information.

Electrical resistivity tomography uses direct current as a means of modeling the subsurface. Generally, coarse grained material is more resistive to electrical charge than fine grained material. This is especially important in alluvial aquifer settings where coarse grained material usually produces more groundwater. Drilling log records were analyzed from several test holes drilled in the well field and were used in the interpretation of the geophysical data.

Figure 6 shows the final geophysical models superimposed on aerial imagery in the well field. Final geophysical models for each transect are included in the Appendix. Each model was corrected for land surface elevation using LiDAR elevation data. The reds and yellows in the models correlate well to known sand and gravel units identified in neighboring boreholes. The geophysical models suggest that more sand and gravel may exist in the higher elevation areas near the current well field than

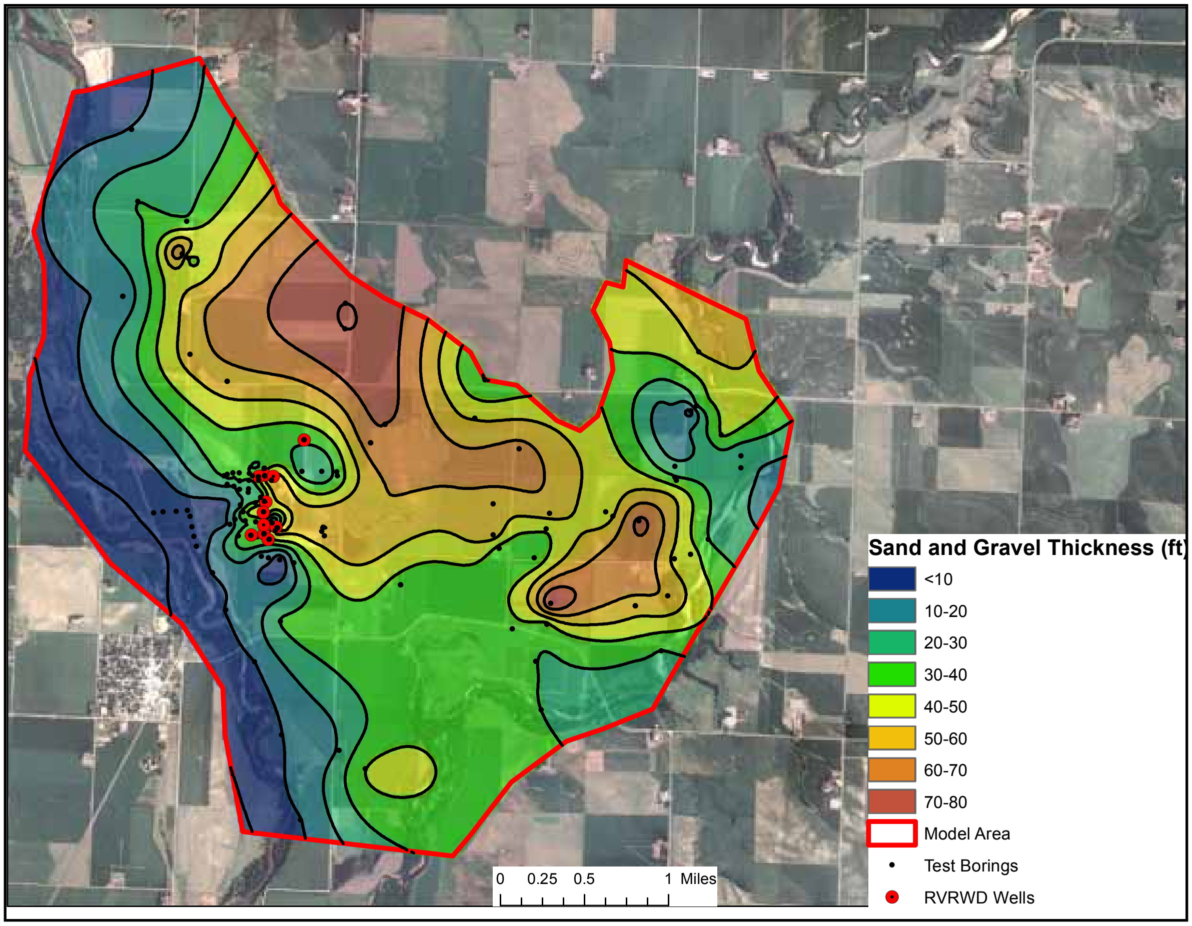


Figure 7. Isopach map showing the sand and gravel thickness for the Hudson aquifer.

the current floodplain of the Big Sioux River. The northwest and southwest transect models show little potential for sand and gravel at depth. The models showing the greatest potential for sand and gravel were near the current well field. Three areas that have high potential for containing sand and gravel were identified for follow-up test drilling. These areas are circled in models in the Appendix. Electrical resistivity is successful at identifying coarse material but cannot differentiate between "clean" or "dirty" sand and gravel (i.e.: sand or gravel mixed with clay or silt). The subsurface variability shown in the models can be indicative of the depositional environments that created the geologic package. Based on existing data from 83 geologic logs (IGWS GEOSAM database and Martha Silks, QSSI), and the results of the geophysical investigation, the sand and gravel thickness (isopach) is shown on Figure 7.

Existing Rock Valley Rural Water District Wells

Figure 2 shows the location of the existing Rock Valley Rural Water well field. These wells vary in depth from 38 to 51 feet. Based on several driller's logs, the stratigraphy consists of between 0 and 4 feet of topsoil overlying sand and gravel. The logs also indicate several cobble or boulder zones, which are probably the zones of highest production. The sediments in this area are indicative of terrace deposits along the Big Sioux River and were

Table 3. Water use by RVRWD, irrigation permits for summer 2012, and the proposed peak season water use for RWS #1.

Permit Held	Number of Wells	Average Q (GPD)	Peak Q (GPD)	Maximum Historical Q (GPD)	Allocated Q (gpd)
RVRWD	11	2,220,000	3,800,000	Not Applicable	Not Applicable
RWS#1 (Proposed)	11	5,000,000	6,480,000	Not Applicable	Not Applicable
Harley Kats (Estate)	1	Not Applicable	Not Applicable	526,000*	869,000*
Jay Grevengoed 1	3	Not Applicable	Not Applicable	1,005,000*	435,000*
Jay Grevengoed 2	1	Not Applicable	Not Applicable	428,000*	435,000*
Marvin Vonk	1	Not Applicable	Not Applicable	602,000*	625,000*
Ranschau Brothers	1	Not Applicable	Not Applicable	977,000*	733,000*
Murlyn Wennblom	2	Not Applicable	Not Applicable	1,000,000*	896,000*
Hoogendoorn Farms 1	5	Not Applicable	Not Applicable	4,619,000*	4,290,000*
Hoogendoorn Farms 2	1	Not Applicable	Not Applicable	1,109,000*	978,000*
Roger Miller	1	Not Applicable	Not Applicable	908,000*	1,249,000*
Arnold Zomermaand	1	Not Applicable	Not Applicable	1,076,000*	815,000*
Westra Farms	2	Not Applicable	Not Applicable	358,000*	868,000*
Loren Groeneweg	2	Not Applicable	Not Applicable	1,090,000*	2,607,000*
* = Based on a 60 day Irrigation Season (Maximum and allocated usage)					
Q = Discharge (gallons per day)					
	= Irrigation discharge used in the model				

deposited prior to the current flood plain and river location. The annual and peak usage rates are found in Table 3.

Irrigation Wells

Most of the land use in the vicinity of the Hudson aquifer is in row crop agriculture. A large percentage of the acreage is irrigated due to the sandy soils in the valley. Approximately 21 irrigation wells were identified in the valley as shown in Figure 1. Annual irrigation rates are available for each irrigation permit (Mike Anderson, IDNR-Water Supply Engineering Section). The calculated daily usage rates are found in Table 3.

The average daily usage was calculated by dividing the total annual water usage by 60 days. The per well daily average was calculated by dividing the overall daily average usage by the number of wells.

Some of the irrigation wells have a longer pumping season than 60 days, but the model was set up to represent worse-case conditions. Using a shorter irrigation season represents a higher average daily pumping rate.

The justification for using a higher daily average is to try and represent an accurate instantaneous pumping rate or gallon per minute pumping rate. The average daily pumping rate is usually 60 percent to 75 percent lower than the instantaneous pumping rate.

Proposed Rural Water System #1

Rural Water System #1 has proposed a total of 11 production wells from four general well field areas Figure 3. The four general well field areas include Van Serksum, Visser, Vander Lugt, and Solberg. Proposed daily usage rates are found in Table 3.

GROUNDWATER MODELING

The model software Visual MODFLOW version 2011.1 was used to simulate the groundwater flow in the alluvial aquifer in the study area under severe drought conditions. A two-layered model was used for the simulation. Borehole logs were obtained from the

IDNR GEOSAM database, and elevation data were obtained from LiDAR (two-foot contour intervals). The model boundary conditions and inputs include the following:

- Layer 1 includes the thin topsoil and sand and gravel aquifer. The horizontal hydraulic conductivity was calibrated within the model. The vertical hydraulic conductivity value was assigned a value 1/10 of the horizontal hydraulic conductivity.
- Layer 2 is primarily silty clay (glacial till or shale). The horizontal hydraulic conductivity was assigned a value of 0.03 feet/day. The vertical hydraulic conductivity value was assigned a value 1/10 of the horizontal hydraulic conductivity.
- The uplands were considered no-flow boundaries. This was represented by deactivating the grids outside the alluvial aquifer boundary. This was estimated using Natural Resource Conservation Service (NRCS) soils data and LiDAR elevation data.
- The Rock River and Big Sioux River were represented as river boundaries. The surface water elevations were estimated using LiDAR data and subtracting two feet to represent drought conditions. A water level depth of one foot was used. Unnamed creek was dry for approximately 10 months. The vertical conductivity of the streambed was estimated at 1/10 the average horizontal conductivity of the alluvial aquifer. The model represented baseflow (summertime) conditions, and the stage was kept the same throughout the simulated time period.
- General head boundaries were used in the numerous sand and gravel pits in the area including Solberg Pond. These general head values were obtained from LiDAR elevation data. For the drought simulations, a water level drop of two feet occurred during the summer months in Solberg Pond.

Table 4. Model calibration results for transient (pumping) conditions for the RVRWD wellfield based on 2012 drought conditions.

Well ID	Observed PWL (ft)	Simulated PWL (ft)	Difference (ft)
RVRWD 1	1186.44	1183	-3.44
RVRWD 2	1181.41	1180	-1.41
RVRWD 3	1180.68	1181	0.32
RVRWD 4	1186.44	1185	-1.44
RVRWD 5	1169.75	1170	0.25
RVRWD 6	1193.44	1190	-3.44
RVRWD 7	1177.95	1178	0.05
RVRWD 8	1174.58	1175	0.42
RVRWD 9	1184.72	1181	-3.72
RVRWD 10	1184.41	1180	-4.41

- General head boundaries were used to represent the benches or terraces to the north of the Hudson aquifer. Groundwater elevations were estimated from the closest well or observation point.
- RVRWD wells, irrigation wells, and the proposed RWS #1 wells were included in the model simulation. Usage was obtained from the IDNR water use database, RVRWD, and RWS #1 (Table 3) .
- Specific yield value was 0.3 and specific storage value was 0.003.
- Average annual recharge was calibrated for drought conditions (four inches per year). During the summer drought conditions (90-day period) zero inches of recharge were used.
- The total number of rows and columns were 214 by 182. The grid size varied from 5 feet to 220 feet, which is a relatively standard grid size

Table 5. Simulated versus observed drawdown values for Hudson aquifer pump tests.

Well ID	Observed Drawdown (ft)	Simulated Drawdown (ft)
OB Well (RVRWD 10)	1.085	1.13
TW-9 (RVRWD 10)	0.82	0.88
OW-18 (Well 27)	0.385	0.4
OW21 (Well 27)	0.3	0.4
OW22 (Well 27)	0.11	0.13

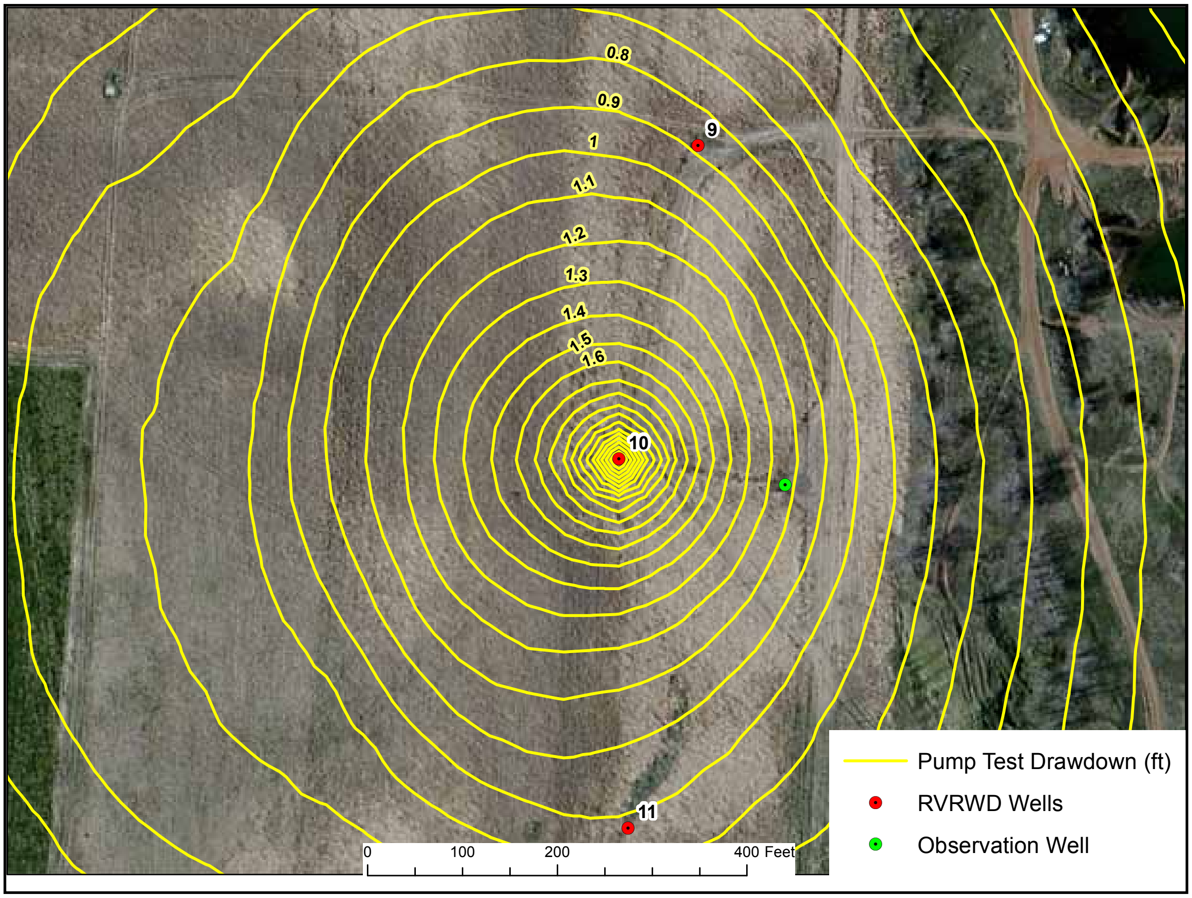


Figure 8. Simulated drawdown for the RVRWD (Well 10) pump test.

Calibration Results

The model was initially run to simulate non-pumping conditions, which provides a baseline for the water table elevation contours. The model was calibrated using static water levels found in IGWS database GEOSAM. Table 1 compares simulated values to observed water levels.

The model was also used to simulate pumping or transient conditions. The model was calibrated using pumping water elevations. Table 4 compares simulated values to observed water levels.

Local scale calibration was performed using pump test results from RVRWD Well 10 (one observation well used) and RWS#1 Vander Lugt sub-wellfield Well 27 (three observation wells used). Hydraulic conductivity and specific yield values were adjusted to match the simulated drawdown to the observed values. Figures 8 and 9 show the simulated drawdown values for the two aquifer pump tests. The simulated versus observed drawdowns are shown in Table 5.

RVRWD Well Field Model Simulations

The calibrated groundwater flow model was used to simulate the impact of adding additional production wells at the RVRWD well field. Figure 10 shows the proposed locations of the additional wells, which were provided by Garvin Buyert of RVRWD. The aquifer parameters at these locations are unknown, so

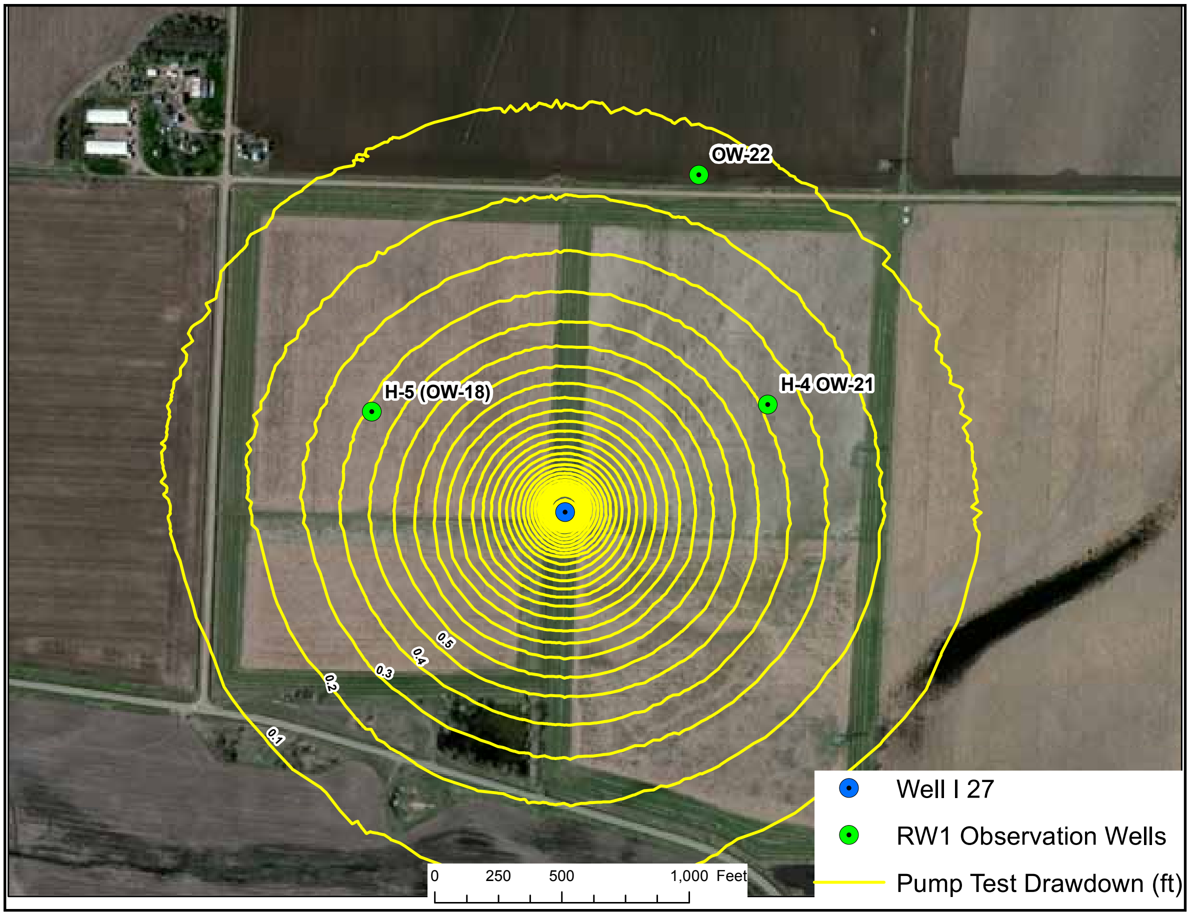


Figure 9. Simulated drawdown for the Rural Water System #1 well field pump test.

an average hydraulic conductivity (800 feet/day) and storage coefficient (0.1) were used at both locations.

Estimated Additional Pumping Capacity

The initial pumping rate for each proposed well was 100 gallons per minute (gpm), and increase by 50 gpm until one of the simulated wells created a dry cell, or the pumping water level was within one foot of the top of the proposed well screens.

Based on the model results, additional pumping capacity ranges from 500 gpm in PW-1 to approximately 600 gpm in PW-2. The lower simulated pumping rate in proposed well PW-1 is the result of being approximately 200 feet closer to the existing RVRWD wells, especially RVRWD Wells 1 and 4. Based on the model results, total water production at the RVRWD well field increased from 3.8 million gallons per day (mgd) to 5.3 mgd with the addition of proposed wells PW-1 and PW-2. The deciding factor in the final locations and maximum pumping rates of the proposed wells will be based on the results of the test drilling and the aquifer pump tests.

Recharge Basin Evaluation

An evaluation of a newly constructed recharge basin near the RVRWD well field was conducted using the calibrated groundwater flow model. The location of the proposed recharge

Figure 10. Additional proposed well locations at the RVRWD well field.

basin is shown in Figure 11, and uses the existing sand and gravel pit to the east of the well field. Water from unnamed creek flows naturally into the sand and gravel pit. Once the pit reaches an elevation of 1,203 feet, the overflow from the pit will flow back into the original channel. For modeling purposes, the approximate water elevation in the recharge basin was assumed to be 1,203 feet above sea level at the start of the simulation, and was represented by a general head boundary. The flow from unnamed creek was assumed to stop entering the basin at the start of the drought. The recharge was assumed to enter directly into the aquifer (layer one).

Figure 12 shows the upwelling in the water table at the end of the 90-day period caused by the recharge basin. Increases in water table

Table 6. Simulated maximum pumping rates for RVRWD well field expansion when the recharge basin is fully operational.

Well ID	Maximum Pumping Rate (gpm)
RVRWD 1	450
RVRWD 2	450
RVRWD 3	400
RVRWD 4	335
RVRWD 5	600
RVRWD 6	150
RVRWD 7	300
RVRWD 8	625
RVRWD 9	450
RVRWD 10	450
RVRWD 11	450
PW-1	500
PW-2	600
Estimated total Maximum Production = 5760 gpm	

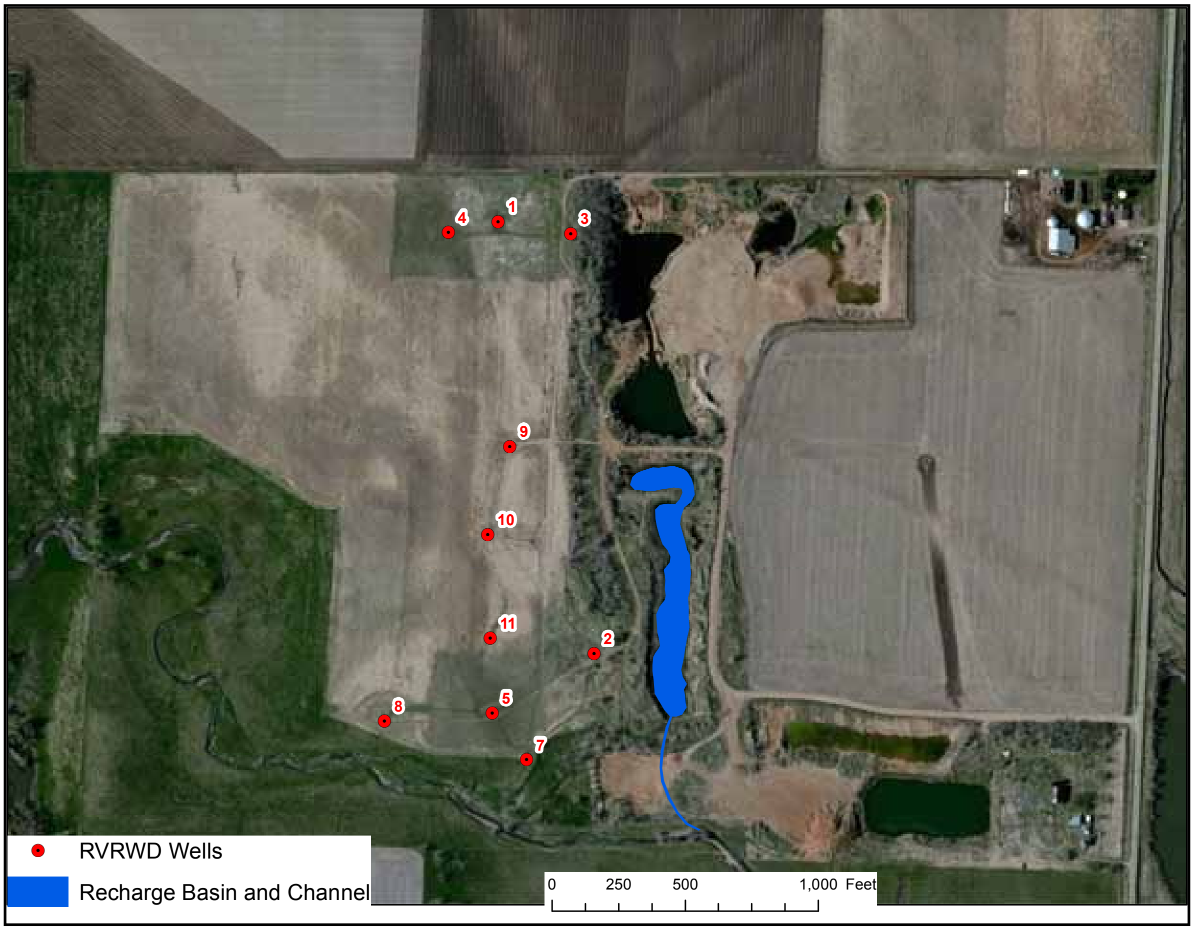


Figure 11. Proposed recharge basin east of the RVRWD well field.

elevations range from 9 feet in Well 2 to 1.5 feet in Well 6. The recharge basin would allow all of the RVRWD wells to be used during a severe drought. Table 6 shows the simulated maximum pumping rates for the RVRWD wells including the additional proposed wells.

Based on the model results, the proposed recharge basin may increase the water production at the RVRWD well field to approximately 8.3 mgd. This is an increase of almost 4.5 mgd compared to present well field capacity, and would allow the existing productions wells and the two proposed production wells to pump at full capacity for 24 hours a day. A prolonged drought of six months or longer may require RVRWD to recharge the basin with water from an alternative water source such as the Big Sioux River.

The model indicates a substantial benefit of using a recharge basin. Water quality data will need to be collected in Wells 2, 7, 9, 10, and 11 to see whether the recharge basin has any significant impact on the RVRWD well field.

Proposed RWS #1 Well Field Model Simulations

Figure 3 shows the anticipated well locations at the proposed RWS #1 well field. The calibrated groundwater flow model was used to simulate the additional drawdown or well interference on the existing irrigation wells and RVRWD wells caused by the pumping of the proposed RWS #1 wells. The drawdown was estimated at the end of the irrigation season or

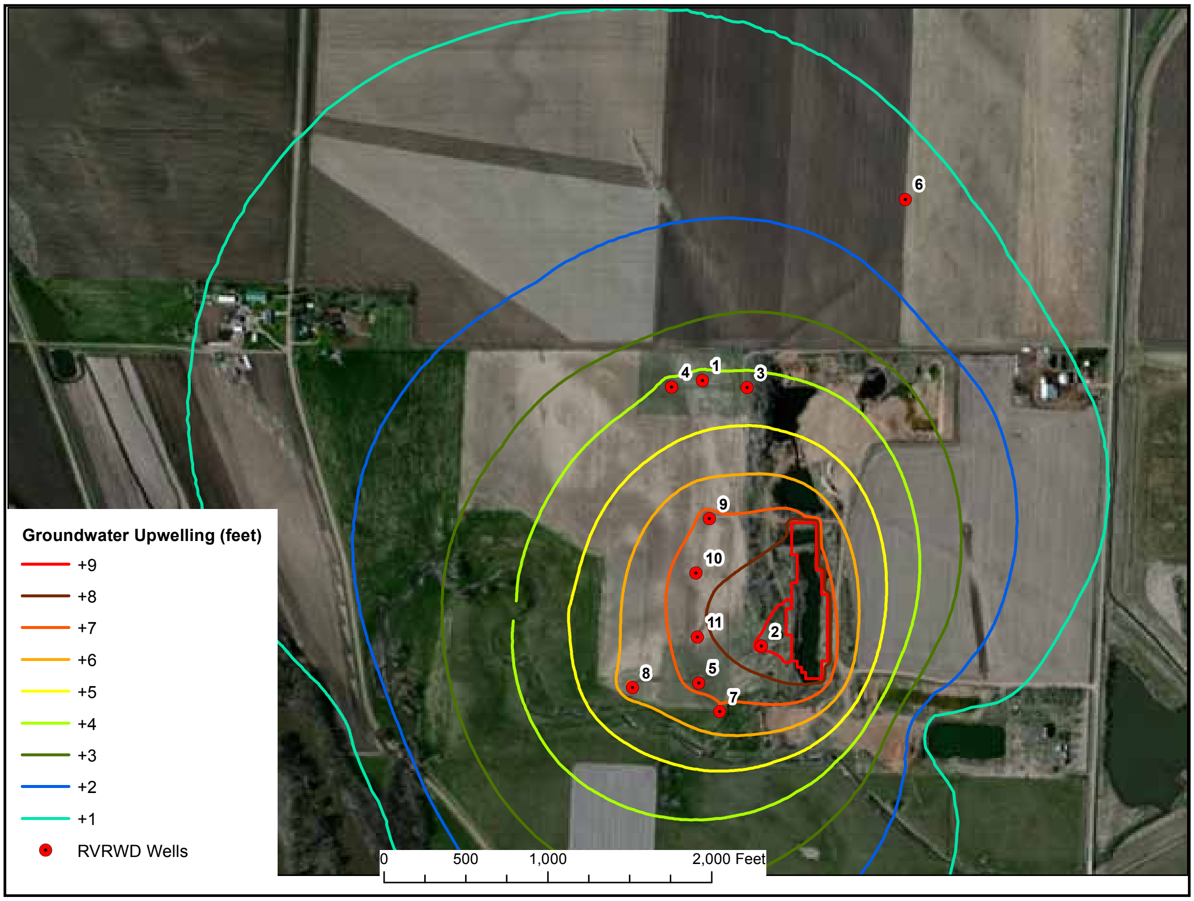


Figure 12. Simulated rise (upwelling) in the water table caused by proposed recharge basin.

approximately the end of August. The pumping rates were estimated using the allocated water use permit for RWS #1. The peak usage period was estimated at 30 days.

The simulated additional drawdowns caused by the proposed peak season pumping of the RWS #1 well field are shown in Figure 13. Based on the model results, the maximum additional drawdown near the proposed RWS #1 wells was 12 feet. Based on the model results, the nearby irrigations wells owned by Ranschau Brothers, Murlyn Wennblom, and Arnold Zomermaand had additional drawdown or well interference of between 3 and 5 feet. The proposed RWS #1 well field had only a slight impact on the RVRWD wells. RVRWD wells 2, 5, 7, 9 and 10 indicate approximately 1 foot of additional drawdown caused by the proposed RWS #1 wells pumping at peak summer-time capacity. Solberg Pond appears to act as a recharge boundary for the RWS #1 wells, which minimizes the well interference between the RVRWD well field and the proposed RWS #1 well field. In addition to the recharge boundary, zones or areas of lower permeable material exist between the RVRWD well field and the proposed RWS #1 well field. These channels or zones of higher and lower permeable material are the result of the former braided stream system that deposited the sand, gravel, silt and clay. These channels are evident in the geophysical cross section shown in Figure 6 and the Appendix.

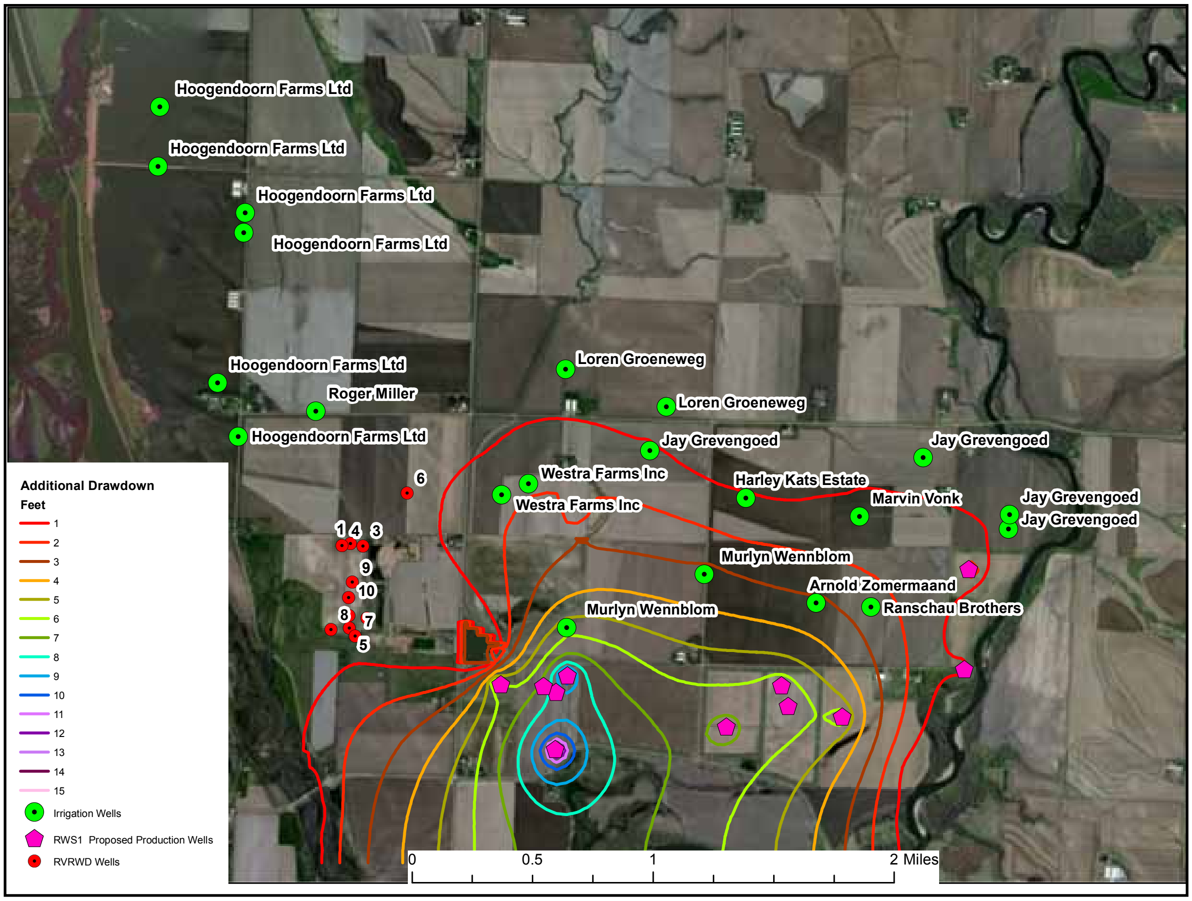


Figure 13. Simulated additional drawdown in feet caused by the proposed peak season pumping of the RWS #1 well field.

Impact of the Irrigation Wells on RVRWD and RWS #1 Well Fields

The water use by the 21 known irrigation wells in the Hudson aquifer during 2012 was at or near record levels. Model simulations were run to evaluate the impact the irrigation wells in the Hudson aquifer have on the RVRWD well field and the proposed RWS #1 well field during peak summer usage. The groundwater flow model was run with the irrigation wells turned off and turned on. The difference in these two model runs simulates the well interference generated by the irrigation wells on the two rural water systems. Based on the model results, the additional drawdown ranged from a maximum of 4 to 8 feet at the RVRWD well field to 4 to 5 feet at the proposed RWS #1 well field. RVRWD Wells 1, 3, 4, and 6 are impacted the most during the peak irrigation season.

CONCLUSIONS

The Iowa Geological and Water Survey-Iowa Department of Natural Resources completed a hydrogeologic investigation for the alluvial aquifer located in Garfield Township, Sioux County, Iowa. The current water users include RVRWD, and approximately 21 irrigation wells. A proposed well field is also being planned by RWS #1. The investigation was conducted at the request of RVRWD.

Based on the results of this evaluation, an increase in water production may be possible from two or more additional wells in the existing RVRWD well field. Total well field water production may increase from 3.8 mgd to 5.3 mgd with the addition of proposed wells PW-1 and PW-2. The final location and water production from the proposed wells will need to be determined following test drilling, test well installation, and aquifer pump tests.

Based on the groundwater flow model, the use of a recharge basin to the east of the RVRWD well field will substantially increase the total water production during a severe drought. If proposed wells PW-1 and PW-2 are added, along with the recharge basin, the well field water production may increase to a maximum of 8.3 mgd.

Based on the groundwater flow model, the proposed RWS #1 well field would have minimal impact on the existing RVRWD well field. Approximately one foot of additional drawdown in RVRWD wells was simulated when the proposed RWS #1 well field was pumping at peak usage.

Based on the groundwater flow model, the proposed RWS #1 well field would have significant impacts on the existing irrigation permits held by Murlynn Wennbloom, Ranschau Brothers, and Arnold Zomermaand. Approximately 3 to 5 feet of additional drawdown in nearby irrigation wells were simulated when proposed RWS #1 well field was pumping at peak usage during a severe drought.

Based on the groundwater flow model, the 21 permitted irrigation wells have significant impacts on the existing RVRWD well field and the proposed RWS #1 well field during a severe drought. Approximately 4 to 8 feet of additional drawdown was simulated in RVRWD wells 1, 3, 4, and 6, and 4 to 5 feet of additional drawdown was simulated in proposed RWS #1 well field after 60 days of maximum irrigation usage.

REFERENCES

Groundwater modeling report-Rock Valley Rural Water Wellfield, December 2005, Quad States Services, Inc.

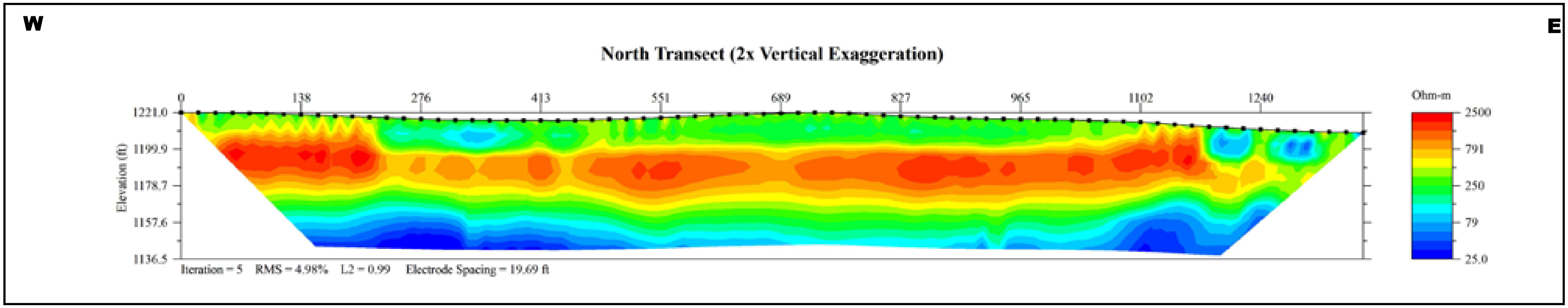
Hydrogeologic evaluation, Rock Valley Rural Wate District, October 2006, Iowa Geological Survey/Iowa Department of Natural Resources.

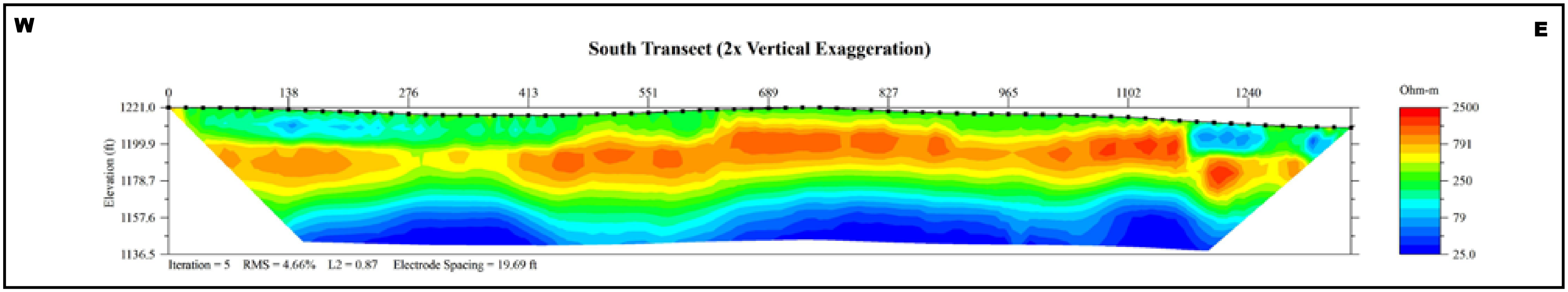
Potential Wellfield Interference, Rock Valley Rural Water District, August 15, 2005, Leggette Bradshears & Graham, Inc.

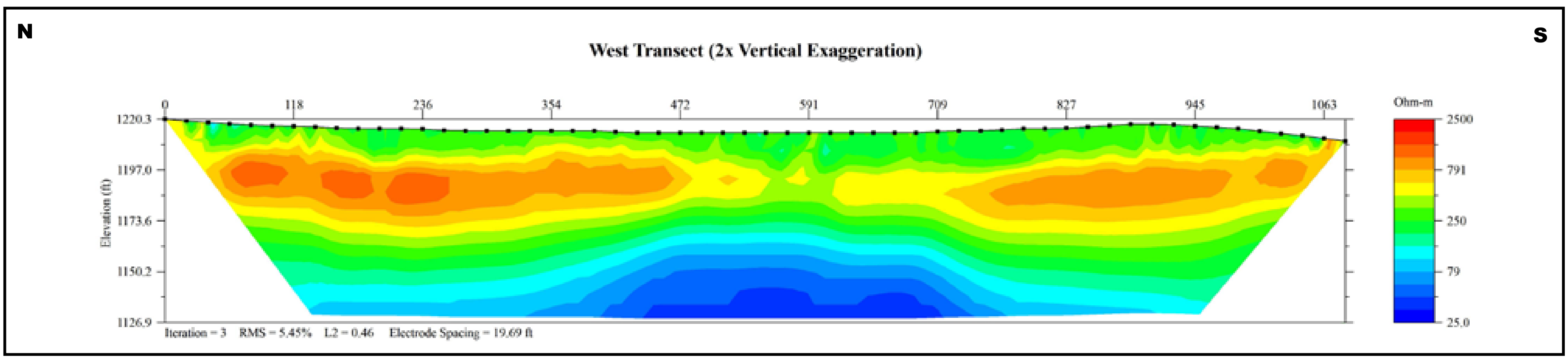
Thompson, C.A., 1987, Water resources of the Rock River alluvial aquifer, Open File Report 87-1, Iowa Geological Survey, 109 p.

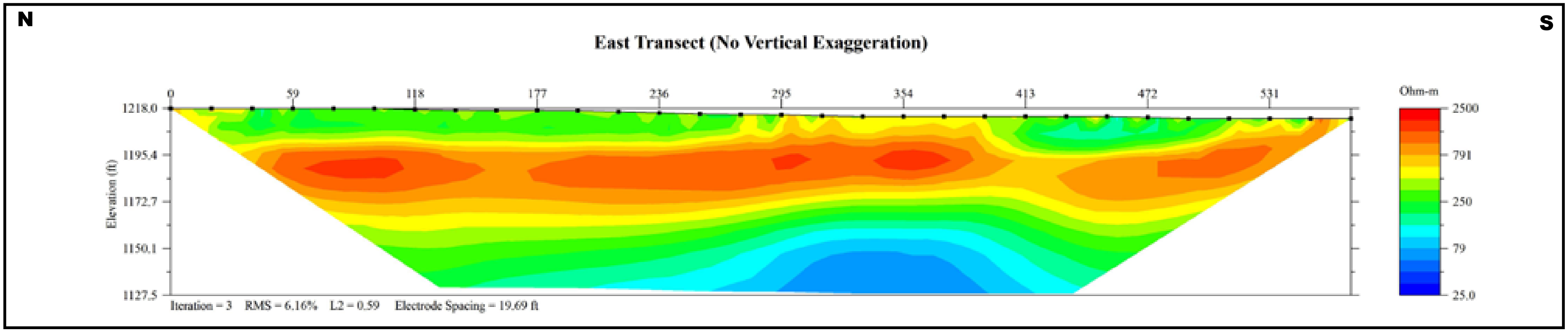
APPENDIX

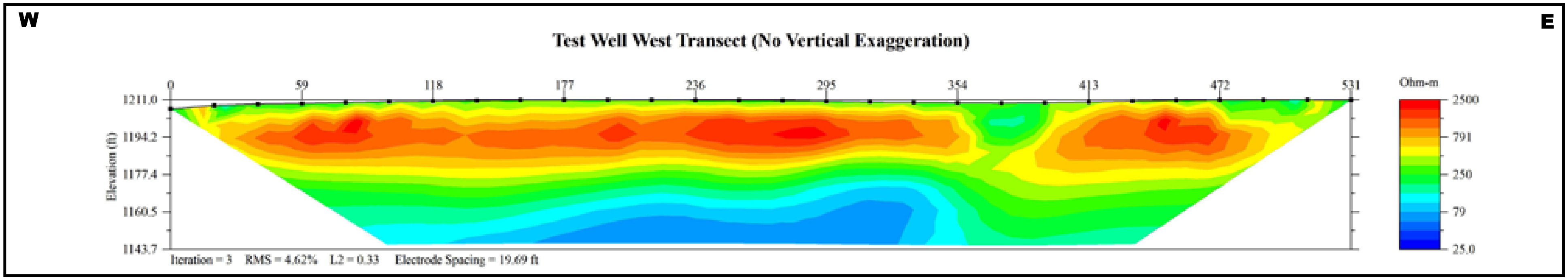
GEOPHYSICAL CROSS SECTION RESULTS USING ELECTRICAL RESISTIVITY

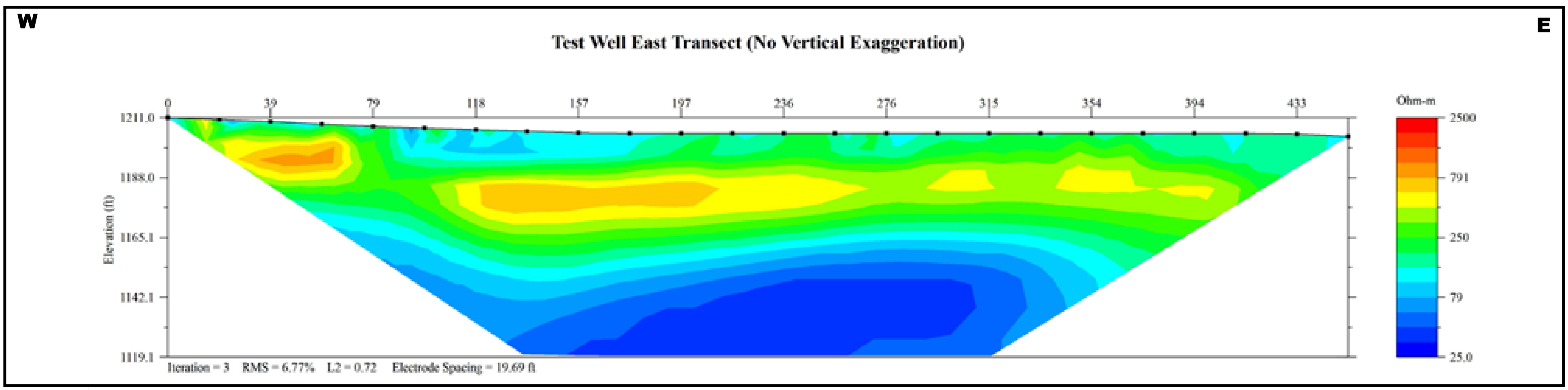

W
E
North Transect (2x Vertical Exaggeration)
0
138
276
413
551
689
827
965
1102
1240
1221.0
1199.9
1178.7
1157.6
1136.5
Elevation (ft)
Iteration = 5 RMS = 4.98% L2 = 0.99 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0

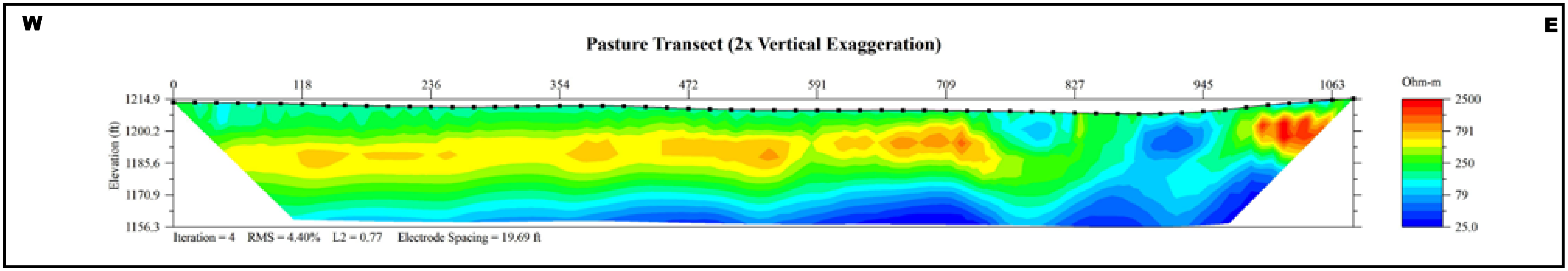

W
E
South Transect (2x Vertical Exaggeration)
0
138
276
413
551
689
827
965
1102
1240
1221.0
1199.9
1178.7
1157.6
1136.5
Elevation (ft)
Iteration = 5 RMS = 4.66% L2 = 0.87 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0

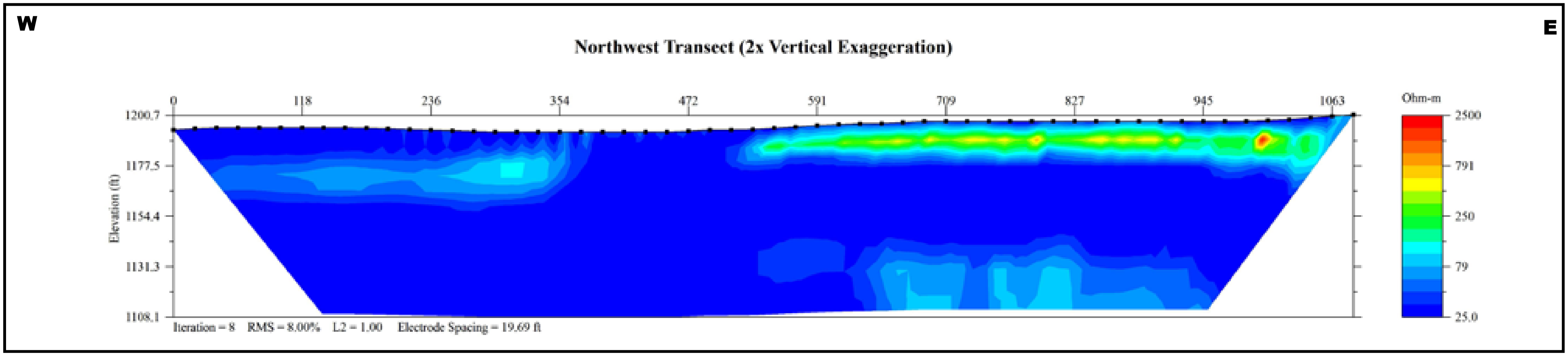

N
S
West Transect (2x Vertical Exaggeration)
0
118
236
354
472
591
709
827
945
1063
1220.3
1197.0
1173.6
1150.2
1126.9
Elevation (ft)
Iteration = 3 RMS = 5.45% L2 = 0.46 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0

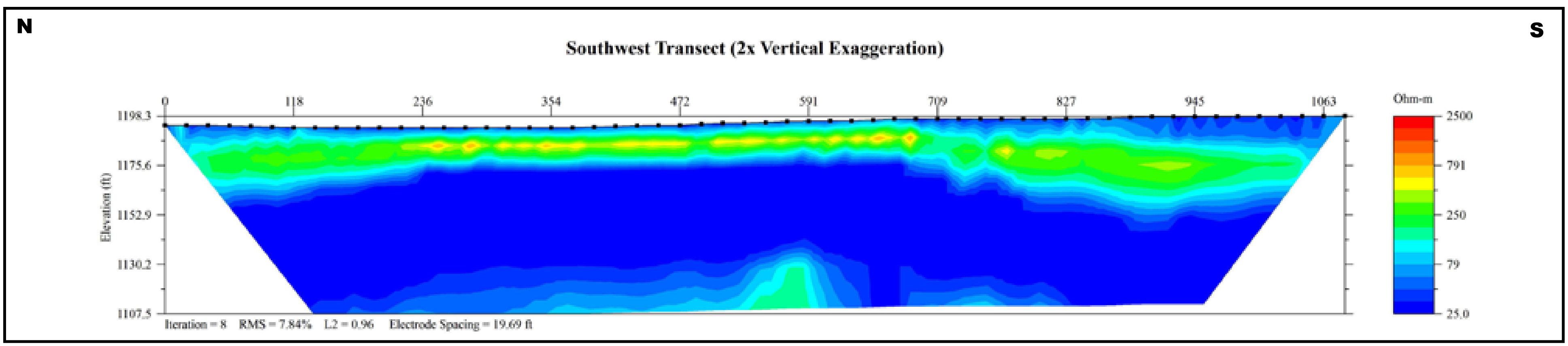

N
S
East Transect (No Vertical Exaggeration)
Elevation (ft)
1218.0
1195.4
1172.7
1150.1
1127.5
0
59
118
177
236
295
354
413
472
531
Ohm-m
2500
791
250
79
25.0
Iteration = 3 RMS = 6.16% L2 = 0.59 Electrode Spacing = 19.69 ft


W
E
Test Well West Transect (No Vertical Exaggeration)
Elevation (ft)
1211.0
1194.2
1177.4
1160.5
1143.7
0
59
118
177
236
295
354
413
472
531
Ohm-m
2500
791
250
79
25.0
Iteration = 3 RMS = 4.62% L2 = 0.33 Electrode Spacing = 19.69 ft


W
E
Test Well East Transect (No Vertical Exaggeration)
Elevation (ft)
1211.0
1188.0
1165.1
1142.1
1119.1
0
39
79
118
157
197
236
276
315
354
394
433
Ohm-m
2500
791
250
79
25.0
Iteration = 3 RMS = 6.77% L2 = 0.72 Electrode Spacing = 19.69 ft


W
E
Pasture Transect (2x Vertical Exaggeration)
0
118
236
354
472
591
709
827
945
1063
1214.9
1200.2
1185.6
1170.9
1156.3
Elevation (ft)
Iteration = 4 RMS = 4.40% L2 = 0.77 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0


W
E
Northwest Transect (2x Vertical Exaggeration)
0
118
236
354
472
591
709
827
945
1063
1200.7
1177.5
1154.4
1131.3
1108.1
Elevation (ft)
Iteration = 8 RMS = 8.00% L2 = 1.00 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0


N
S
Southwest Transect (2x Vertical Exaggeration)
0
118
236
354
472
591
709
827
945
1063
1198.3
1175.6
1152.9
1130.2
1107.5
Elevation (ft)
Iteration = 8 RMS = 7.84% L2 = 0.96 Electrode Spacing = 19.69 ft
Ohm-m
2500
791
250
79
25.0

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