SOURCE WATER PROTECTION PROGRAM

PHASE II ENVIRONMENTAL SITE INVESTIGATION RESULTS

for

CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

GRISWOLD, CASS COUNTY, IOWA

June 24, 2011
(Revised September 1, 2011)

IOWA DEPARTMENT OF NATURAL RESOURCES

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1.0 INTRODUCTION

At the request of the Iowa Department of Natural Resources, Source Water Protection Program, the Iowa Department of Natural Resources, Contaminated Sites Section (IDNR), has completed a Phase II environmental assessment around Municipal Water Wells Number 3, 4 and 5, City of Griswold, Cass County, Iowa. The purpose of the investigation was to evaluate the areas hydrological profile and identify possible source(s) for the elevated nitrate levels found in Municipal Well Number 3, 4, and 5.

2.0 SITE DESCRIPTION

2.1 Location

The City of Griswold Municipal Well Field (well field) is located in the NW ¼ of the NW ¼ of Section 9 Pleasant Township, Tier 74 North, Range 37 West in Cass County, Iowa. The well field is found approximately 1.5 miles east of Griswold, Iowa along the south side of State Highway 92. (Figure 1 and Figure 2).

2.2 Site Description

Municipal wells 3, 4 and 5 are located in an area surrounded by agricultural land with no structures, other than State Highway 92, within 1,100 feet. Until the municipal wells were installed the land had not been used for any specific purpose other than agriculture crop land.

Griswold, Iowa is located within the Southern Iowa Drift Plain with loess, glacial till, gravel, and sand seams (Pleistocene Group, Peoria Formation) from the surface down 25 to 30 feet below the surface overlying the Fort Benton (Lower Colorado) Sandstone locally known as the Dakota Sandstone. The Dakota Sandstone surface (bedrock surface), identified on Figure 3, shows the Dakota surface as highly eroded and channelized. The City's municipal wells are known to be finished in the Dakota Sandstone at approximately 100 feet below the land surface. Well records do exist for the well field but it is unclear as to what records belong to what municipal well (Appendix B). All three municipal wells have detectable levels of nitrates that approach the maximum contaminant level (MCL) of 10 mg/L.

2.3 Operational History and Waste Characteristics

As noted above, until the municipal wells were installed the land surrounding the well field has not been used for any other purpose other than agriculture crop land. A search of IDNR's spill database found no record chemical spills in the area.

3.0 MUNICIPAL WELL PUMP TEST

3.1 Pump Test Information

A pump test (or an aquifer test) is conducted to evaluate an aquifer by "stimulating" the aquifer through constant pumping, and observing the aquifer's

"response" (drawdown) in observation test wells. Aquifer testing is a common tool that hydrogeologists use to characterize a system of aquifers, aquitards and flow system boundaries. Most commonly an aquifer test is conducted by pumping water from one well at a steady rate and for at least 24 hours, while carefully measuring the water levels in observation wells. When water is pumped from the pumping well the pressure in the aquifer that feeds that well declines. This decline in pressure will show up as drawdown (change in hydraulic head) in the observation wells. Drawdown decreases with distance from the pumping well and drawdown increases with the length of time that the pumping continues. The information gathered during the pump test was used to determine the quantity and source of the City of Griswold's municipal well field

3.2 Pump Test Observation Wells

Six test wells were installed by a certified well driller around the municipal well field in order to observe the effect pumping had on the aquifer, the locations of the test wells are shown on Figure 4. The test wells were placed in a specific pattern to determine if the groundwater pumped from the well field was originating from Baughman's Creek. Boring data was collected from each test well to determine geological data and depth to the Dakota Sandstone (Appendix C). The test wells were installed on April 5, 2011 and were allowed to equilibrate over night.

Solinst® Levelogger Gold groundwater transducers were placed in each test well below the waterline to electronically record the groundwater level during the pump test. A Solinst® Levelogger Gold barometric pressure transducer was placed in one well above the waterline to record the atmospheric pressure during the pump test. A change in atmospheric pressure will cause a water level change in groundwater wells, therefore, must be compensated for during the pump test. The clocks in all the transducers were synchronized and programmed for a specific start time (4 hours before the start of the pump test) and then were manually shut off after the pump test as they were removed from the test wells. The transducers were also placed in the wells the night before the pump test to allow them to equilibrate. Additional information concerning the Solinst® Levelogger Gold transducers can be found in Appendix D.

3.3 Pump Test

Municipal Well 3 and Municipal Well 4 were both configured to discharge to waste at the maximum pumping rate and the pump test was started 8:00am the morning of April 6, 2011 and ran for 24 hours. The flow meter on Municipal Well 4 indicated it was operating at 375 gallons per minute, Municipal Well 3 did not have a flow meter but information from earlier testing indicated it was pumping at 250 to 275 gallons per minute. Both wells were discharging through the same length and size of fire hose and visual observations indicated well 3 was pumping a little less than well 4, confirming the estimated flow rate of well 3.

Six hours into the pump test Municipal Well 4 started cycling on and off and the City of Griswold water operator was notified of the problem. After about an hour of

trouble shooting it was determined well 4 was pumping too fast and the water level in the well was dropping below a limit switch that was installed to prevent the pump from running dry. Well 4 was idled back to reduce the water flow to 275 gallons per minute and had no further problems for the remainder of the pump test.

4.0 COLLECTION OF SAMPLING DATA

4.1 Soil Boring Logging

Soil boring logs were created for each test well using Geoprobe's® conductivity probe. The conductivity probe is designed to measure the conductivity of the soil allowing the operator to determine stratigraphic features of the subsoil. As the conductivity probe is advanced down through the soil, conductivity readings are sent back to the surface and recorded. The conductivity probe was advanced until refusal indicating the sandstone surface. The information collected during the probing was used to create the soil boring logs. The soil boring logs for Test Wells 1 through 6 are found in Appendix C.

4.2 Groundwater Sampling

Groundwater samples were collected from the 6 test wells identified on Figure 4. The depth of the temporary test wells were determined using the results of the conductivity probe and were finished at the sandstone interface. Groundwater samples were collected from each location and analyzed for nitrate levels using a HACH DR 2800 field sampling system. Testing was performed using HACH Method 10206 with TNTplus 836 Nitrate Vials. Sampling results for the test wells are found in Table 1.

4.3 Surface Water Sampling

Surface water samples were collected from Baughman's Creek, tributaries of, and tile outlets at different locations throughout the watershed to help identify where the nitrates may be originating from. The sample results for the 12 locations sampled are found on Figure 5.

4.4 Sample Collection Methods

Sample containers, preservation, and holding times were listed in the State Hygienic Laboratory (SHL) Guidebook, which describes the required sample submission information for SHL. Each sample had a label attached to the sample container and a corresponding Sampling Information Sheet. Labels were supplied by SHL with a SHL identification number. The facility, location, or sample identification was site-specific and descriptive of where the sample was taken for each sample. Date, time, and collector's name was also written on the sample label. All sample labels were completed in waterproof ink.

Samples were stored in a cooler at or below 4° Celsius and maintained in the custody of the collector until sample analysis was completed.

All groundwater samples were collected in a manner utilizing the procedures in ASTM D6001-96e1, *Standard Guide for Direct-Push Water Sampling for Geo-Environmental Investigations*, for the direct push groundwater sampling and ASTM D4448-85a (1992), *Standard Guide for Sampling Groundwater Monitoring Wells*, for existing monitoring wells. All groundwater collecting equipment was decontaminated after sample collection was complete in accordance with Quality Assurance Project Plan for Iowa Department of Natural Resources Land Quality Bureau Contaminated Sites Section.

The Geoprobe® samples were collected with the following SOPs and manuals;

- Geoprobe® FC4000 Field Instrument (Conductivity Probe) User's Guide; Manual No. 20777
- Geoprobe® Screen Point 15 Groundwater Sampler SOP; Technical Bulletin No. 95-1500

5.0 FIELD ACTIVITIES

Field personnel traveled to the site on April 5th, 6th, and 7th, 2011. Field activities were performed in Level D personal protective equipment that consisted of steel-toed boots, safety glasses, hearing protection and a hard hat.

6.0 PROJECT MANAGEMENT

The IDNR project manager for the site, Daniel Cook, scheduled field activities, verified site access authority, and oversaw all IDNR onsite and offsite activities associated with the investigation.

7.0 CONCLUSIONS

7.1 Surface Water

Twelve surface water samples were collected from the Baughman's Creek watershed to identify areas where nitrates were entering the system (Figure 5). The water found in Baughman's Creek comes from seepages, springs, and tile outlets with each surface water source averaging 7.5 mg/L nitrate (as nitrogen) as the majority of feeder tributaries and tile outlets were in the range of 6 to 8 mg/L for nitrate. This implies the average impact to the shallow groundwater from farming practices in the Baughman's Creek watershed is around 7.5 mg/L nitrate.

The two main exceptions were the tributary just north of the municipal well field at 14.1 mg/L and the tributary that passes through the 800 head beef cattle open feed lot on 590th Street with nitrate levels at 48.1 mg/L. This stream also had ammonia levels at 47.6 mg/L showing that all the ammonia had not yet converted to nitrate. This is demonstrated at a sample location further downstream in the same tributary (just before it reaches Baughman's Creek) with a nitrate level of 52.9 mg/L nitrate. A sample collected from Baughman's Creek just upstream of

the feed lot tributary was measured at 8.07 mg/L for nitrate and a sample collected just downstream of where the tributary enters Baughman's Creek shows 26.2 mg/L nitrate. This indicates the 800 head beef cattle feed lot is a significant source of nitrates in Baughman's Creek.

The high nitrates found in the small tributary just north of the municipal well field is again due to farming practices but in a more sensitive area. The soil makeup in the immediate area around this tributary consist of a thin layer of loam and loess (1 to 2 feet thick) followed by sands and gravel allowing agriculture chemicals applied to the surface to more easily leach to the shallow groundwater.

7.2 Groundwater

Groundwater samples were collected from each of the 6 test wells and from Municipal Wells 3 and 4 and analyzed for nitrates and Table 1 lists the levels of nitrates found. Sampling indicates groundwater found near Baughman's Creek and the tributary just north of the well field have significant amounts of nitrate while the two samples away from any stream are only slightly impacted with nitrates.

TABLE 1

Sample Location	Nitrate Level mg/L as N
Test Well 01	0.531
Test Well 02	0.132
Test Well 03	8.51
Test Well 04	12.4
Test Well 05	16.8
Test Well 06	14.4
City Well 3	8.93
City Well 4	7.58

Analyzed with HACH Model DR 2800
Method 10206 (TNT 836)

Additional sampling would be required to confirm this but the few samples collected indicate the groundwater underlying the nitrate contaminated stream water is also contaminated with nitrate.

The bedrock contour map found on Figure 3 shows the Dakota Sandstone surface is highly eroded with Baughman's Creek following one of the buried channels. Buried channels in the bedrock surface create preferential groundwater flow paths the same way that surface water travels in stream beds. However, the buried channel Baughman's Creek follows travels away from the City's well field indicating the groundwater flow would also flow away from the well field. This, along with the information collected during the well field pump test, would also

indicate the nitrate contaminated groundwater associated with Baughman's Creek is not the source of nitrates found in the City well field.

A small bedrock buried channel is also found on Figure 4 that runs parallel to State Highway 92 directly north of the well field. During the installation of the 6 test wells bedrock depth information was collected that confirm the existence of this channel. And, groundwater sampling also indicates the groundwater found in this smaller channel is contaminated with nitrates as high as 12.4 mg/L, the drinking water standard is 10mg/L. It is more likely the nitrate problem in the City wells is from this smaller channel and not associated with Baughman's Creek.

7.3 Pump Test

The pump test completed on Municipal Wells 3 and 4 corroborate groundwater sampling information. The pump test indicates the groundwater capture zone for Municipal Well 3 and 4, and most likely 5, is from the small bedrock buried channel (buried channel) directly north of the well field. The lithology Cross Sections A-A' (Figure 6a) and B-B' (Figure 6b) show that deep wells of Municipal Wells 3 and 4 are at the same level as the sands and gravel zone of the buried channel. Also, the Dakota Sandstone is made up of different types of sandstone with the upper most and the bottom layers far less conductive than the middle layers. The center more conductive layer, made up of cleaner sandstone, is at the same level as the sand and gravel seams in the buried channel. Additionally, during the pump test - Test Well 02 was placed right between Municipal Wells 3 and 4 and had around a foot of drawdown when both municipal wells 3 and 4 had 35 to 40 feet of drawdown. This indicated the top layer of sandstone, labeled Sandstone-Shale in Figures 6a and 6b, acts more like an aquitard preventing surface water and shallow groundwater from migrating through it. The Sandstone – Shale layer has most likely been eroded away in the buried channel allowing surface and shallow groundwater to flow freely into the clean sandstone layer (labeled Sandstone in Figure 6a and 6b). When Municipal Wells 3, 4 and most likely 5 are pumping they are drawing groundwater from the buried channel through the Sandstone layer.

The pump test also supports that the well field's water comes from the buried channel. As noted above Test Well 02 (200 feet from Municipal Well 3 and 4) had only a foot of drawdown during the 24 hour pump test but Test Well 03, 500 feet from Municipal Well 4, had a 7 foot drawdown. Test Well 03 was located in the sand and gravel seams in the buried channel with the pump test data indicating a connection between the buried channel and the Sandstone layer.

Figure 7a through 7f are graphical representations of the 24 hour pump test data including a logarithmic time interpretation which is used to determine the stability of the groundwater supply. The logarithmic interpretation shows the aquifer acts as a confined aquifer until the drawdown reaches the buried channel then acts more like an unconfined aquifer such as an alluvial aquifer. This also supports the statement that the buried channel is supplying the groundwater to the city well field.

7.4 Capture Zone

Based on the results of the surface water sampling, groundwater sampling, soil borings, and pump test a new groundwater capture zone map has been created to show the area where the City of Griswold well field groundwater most likely comes from. Figure 8 depicts an area encompassing the small buried channel directly north of the well field and represents the two year capture zone. Figure 9 shows the area where the groundwater recharge occurs that supplies the small buried channel with water. Figure 9 also shows the area where the nitrates, and other chemicals, most likely originate from that impact the City's water supply.

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SOURCE WATER PROTECTION PROGRAM

PHASE II SITE ASSESSMENT RESULTS

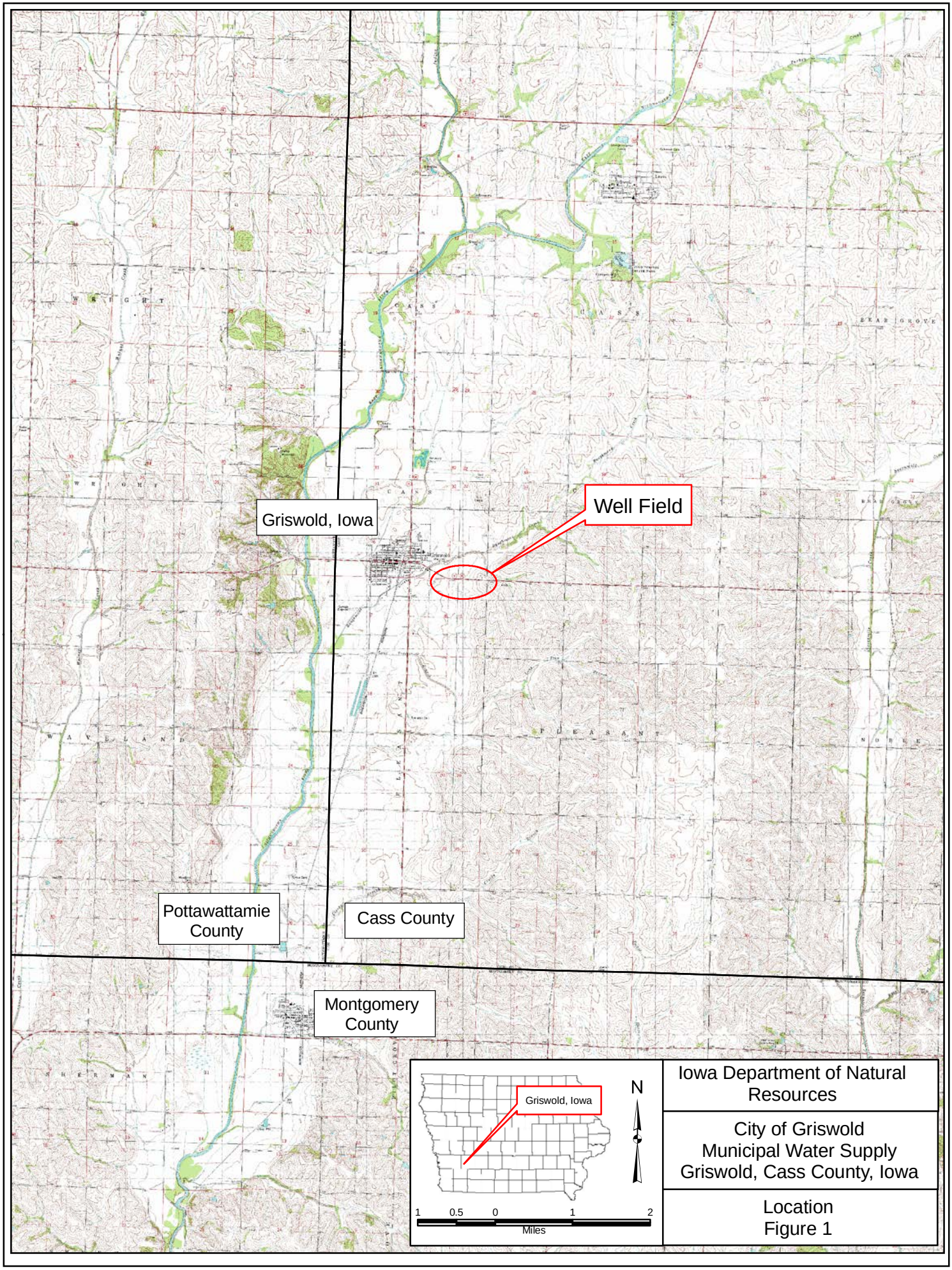
for

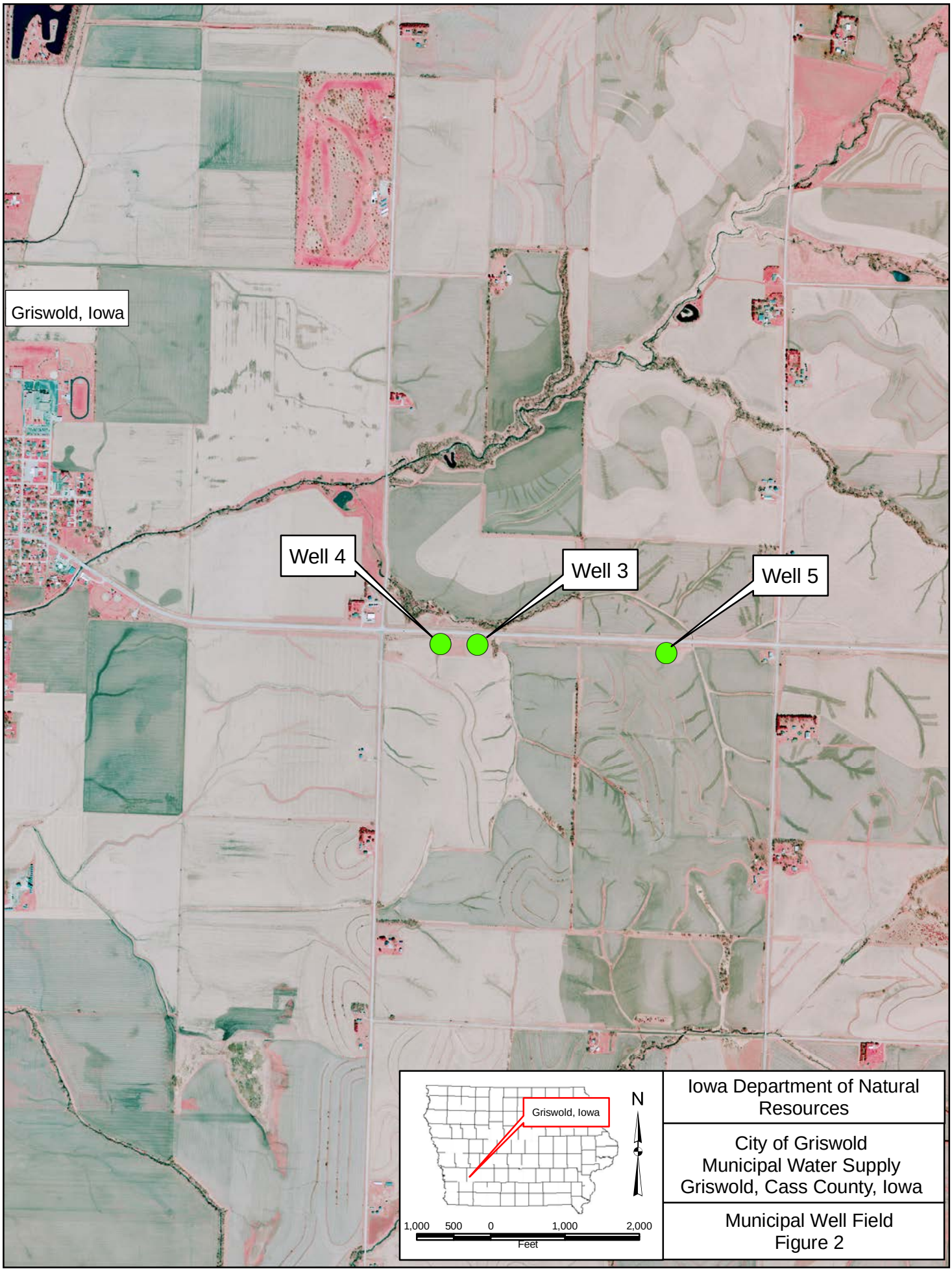
CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

GRISWOLD, CASS COUNTY, IOWA

APPENDIX A

Figures

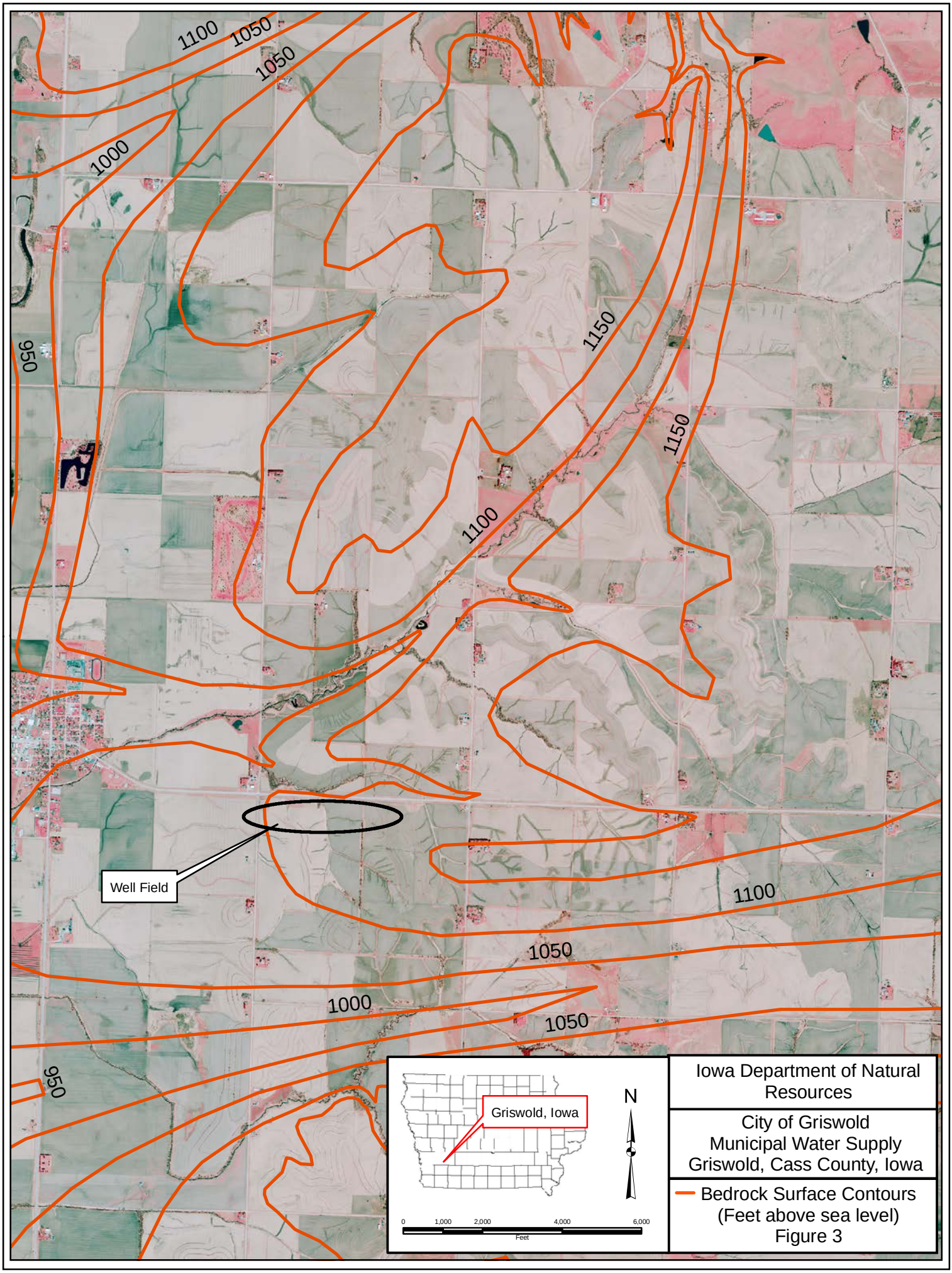

Griswold, Iowa
Well Field
Pottawattamie County
Cass County
Montgomery County
Griswold, Iowa
N
1 0.5 0 1 2
Miles
Iowa Department of Natural Resources
City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa
Location
Figure 1



Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

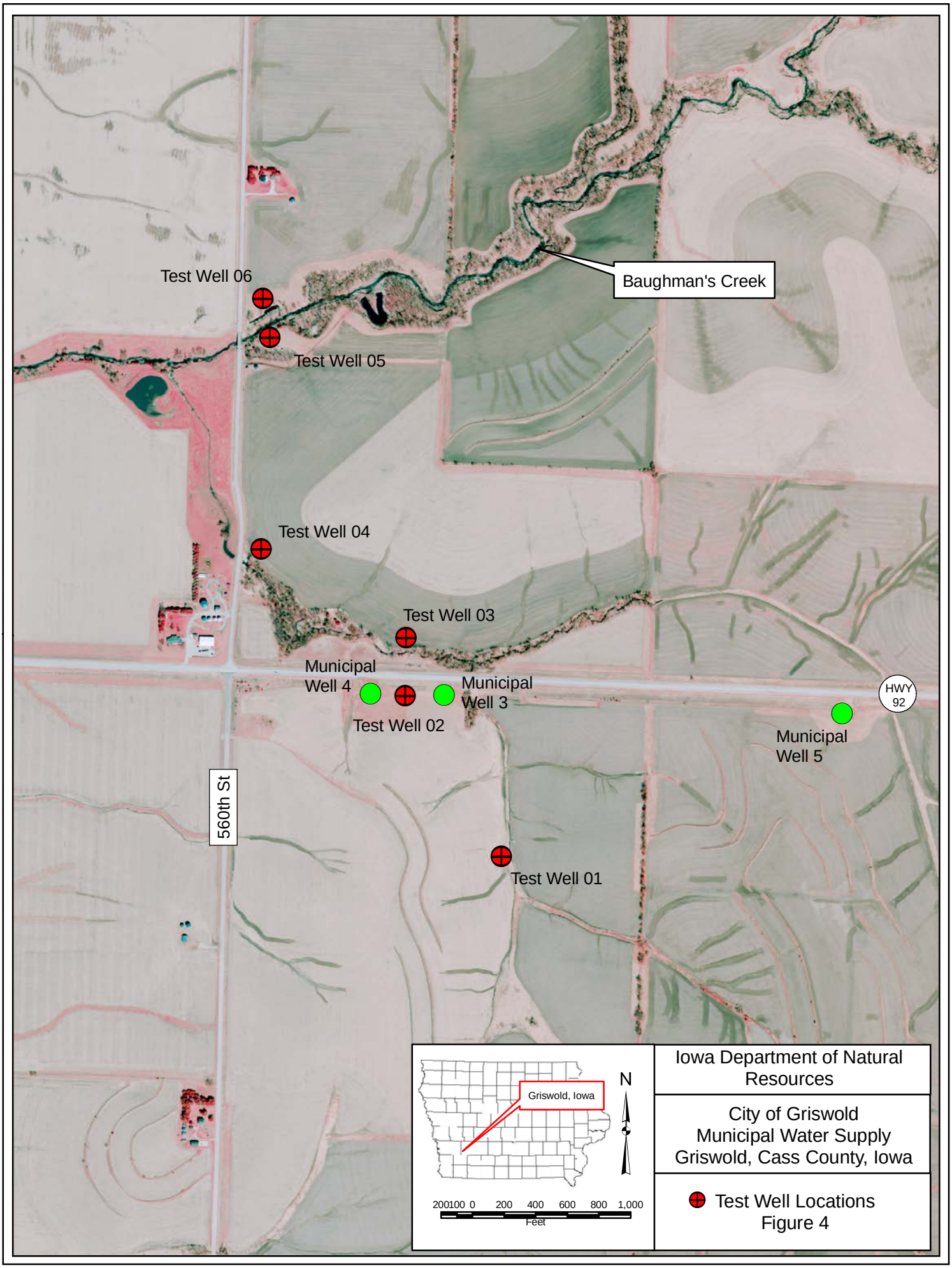
Municipal Well Field
Figure 2



Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

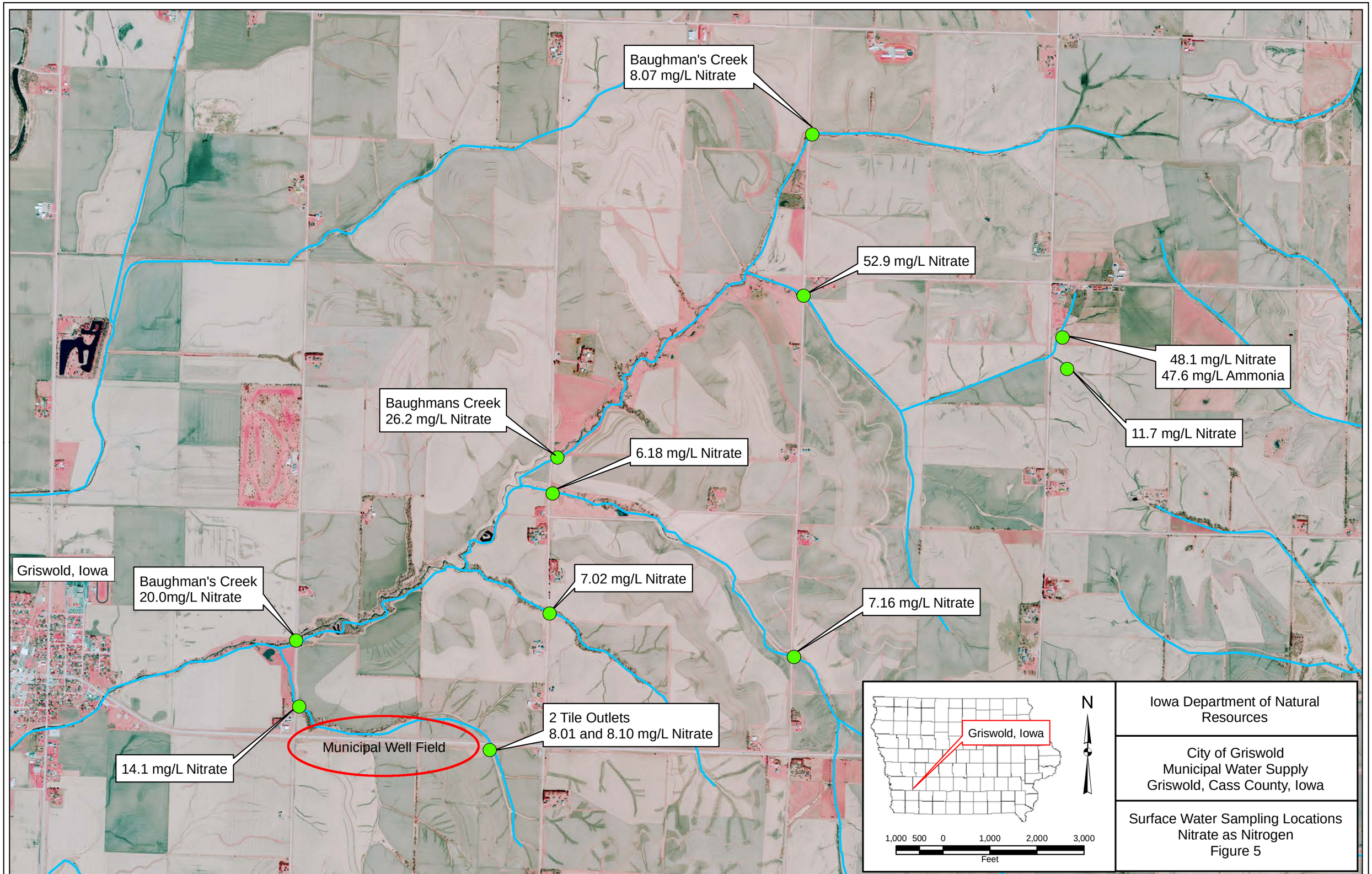
Bedrock Surface Contours
(Feet above sea level)
Figure 3

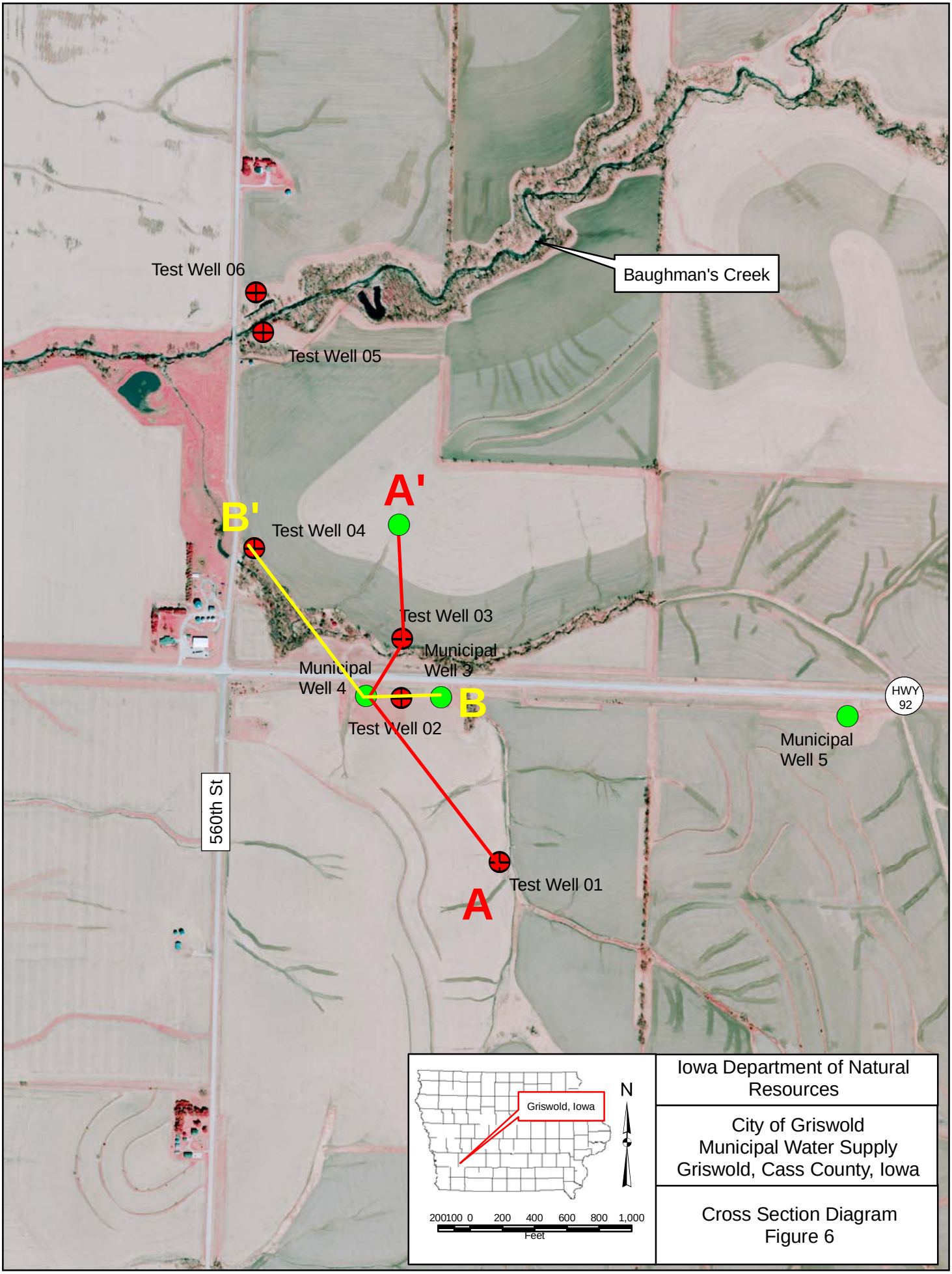


Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

Test Well Locations
Figure 4


Baughman's Creek
8.07 mg/L Nitrate
52.9 mg/L Nitrate
48.1 mg/L Nitrate
47.6 mg/L Ammonia
11.7 mg/L Nitrate
Baughmans Creek
26.2 mg/L Nitrate
6.18 mg/L Nitrate
Griswold, Iowa
Baughman's Creek
20.0mg/L Nitrate
7.02 mg/L Nitrate
7.16 mg/L Nitrate
2 Tile Outlets
8.01 and 8.10 mg/L Nitrate
Municipal Well Field
14.1 mg/L Nitrate
Griswold, Iowa
N
1,000 500 0 1,000 2,000 3,000
Feet
Iowa Department of Natural Resources
City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa
Surface Water Sampling Locations
Nitrate as Nitrogen
Figure 5



Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

Cross Section Diagram
Figure 6

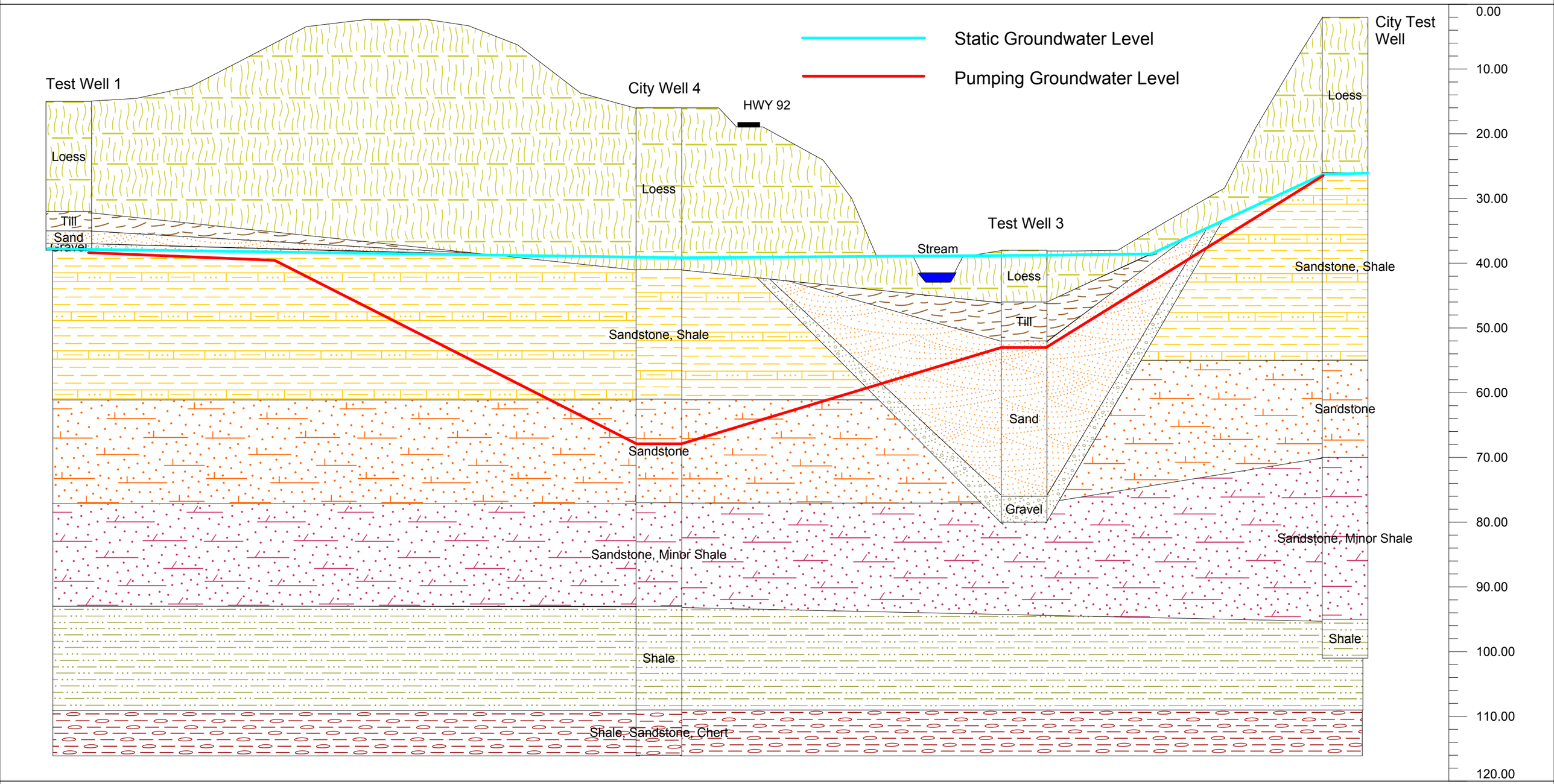
Legend Title

- Loess
- Till
- Sand
- Gravel
- Sandstone
- Sandstone, Shale
- Sandstone, Minor Shale
- Shale
- Shale, Sandstone, Chert

Figure 6a

Lithology Cross Section A - A'

Griswold Municipal Well Field

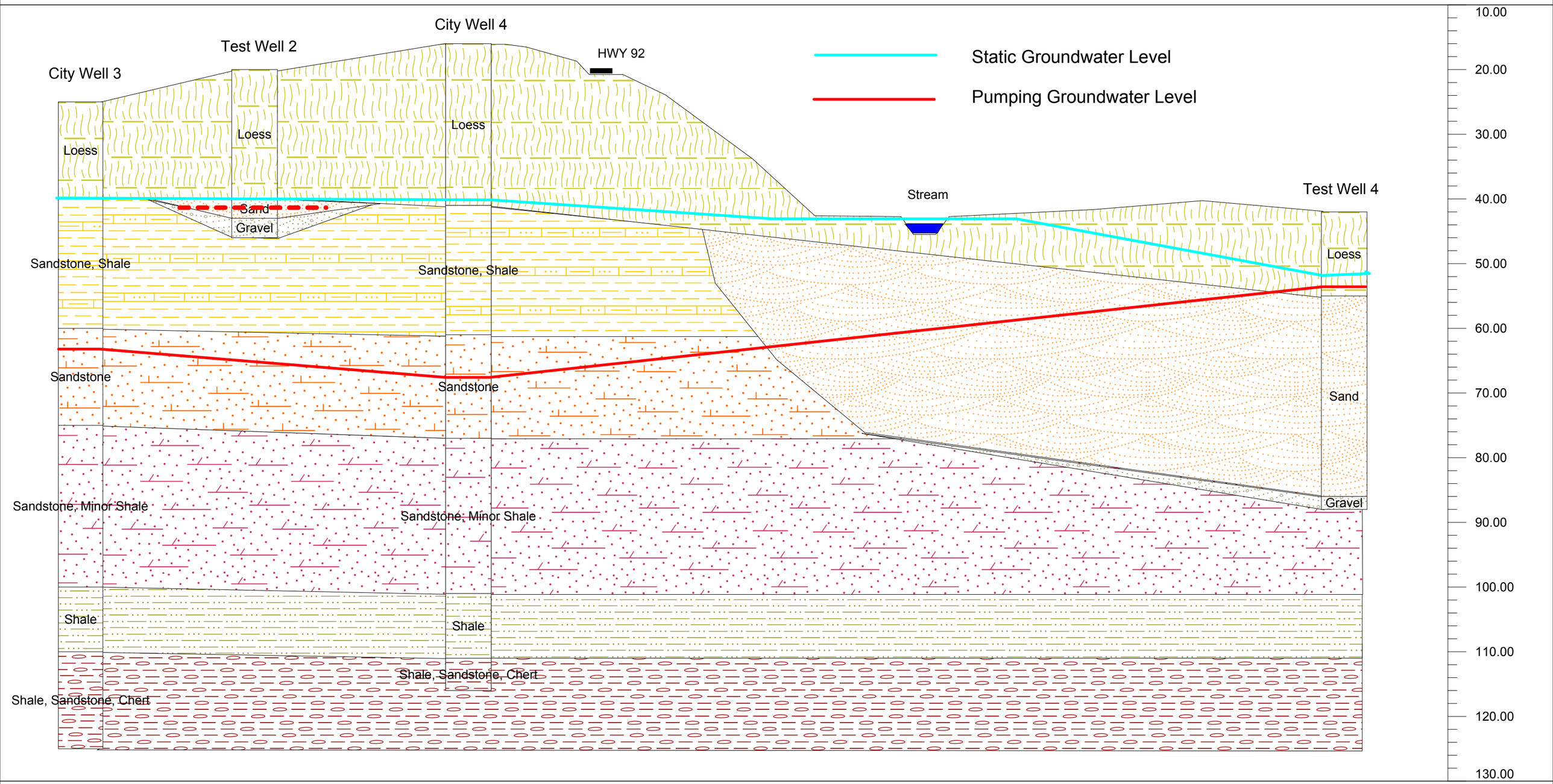


Vertical scale in feet (horizontal exaggeration = 6)
0 Feet = 1171 feet above sea level

Figure 6b

Lithology Cross Section B - B'

Griswold Municipal Well Field



Vertical scale in feet (horizontal exaggeration = 6)
0 Feet = 1171 feet above sea level

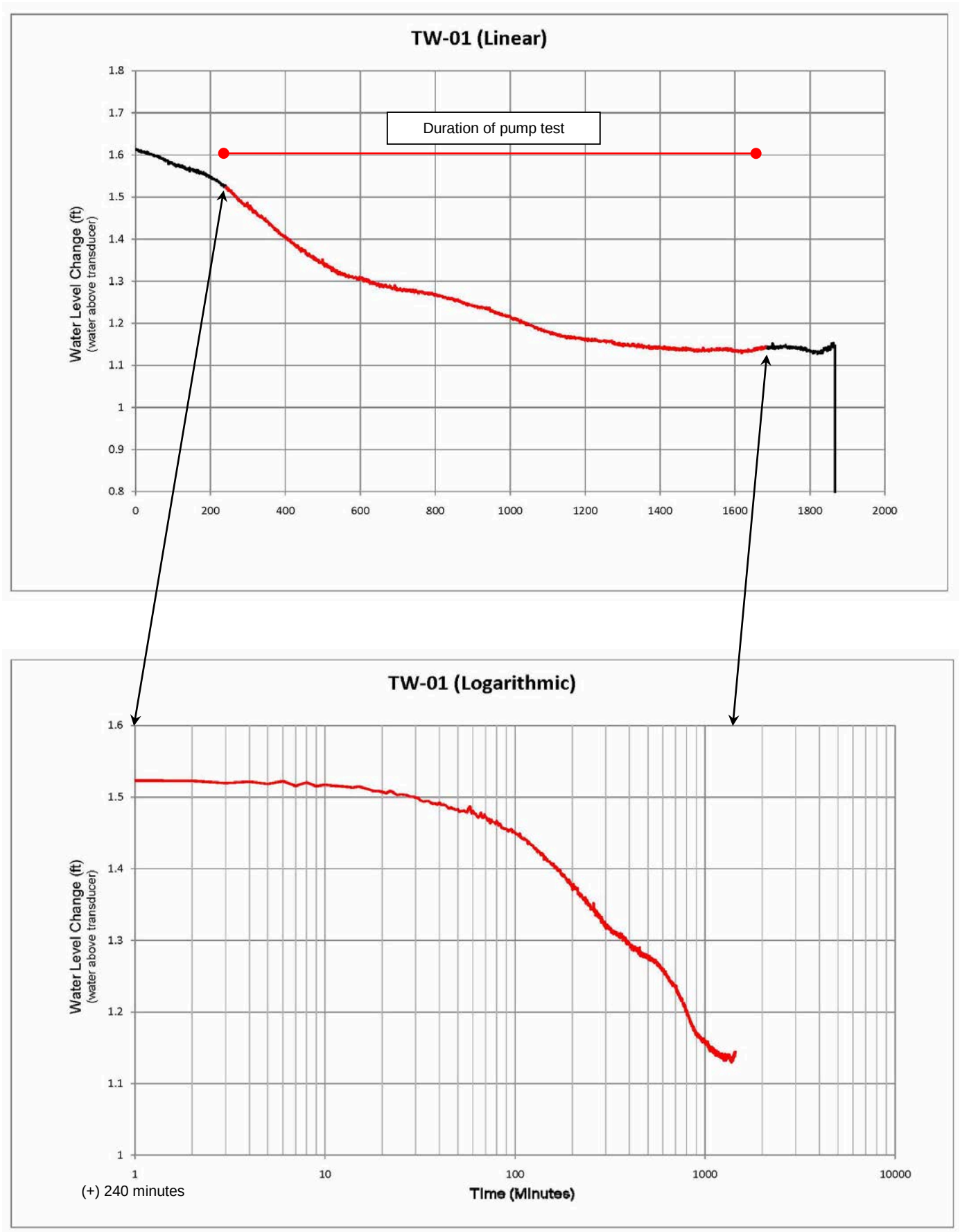
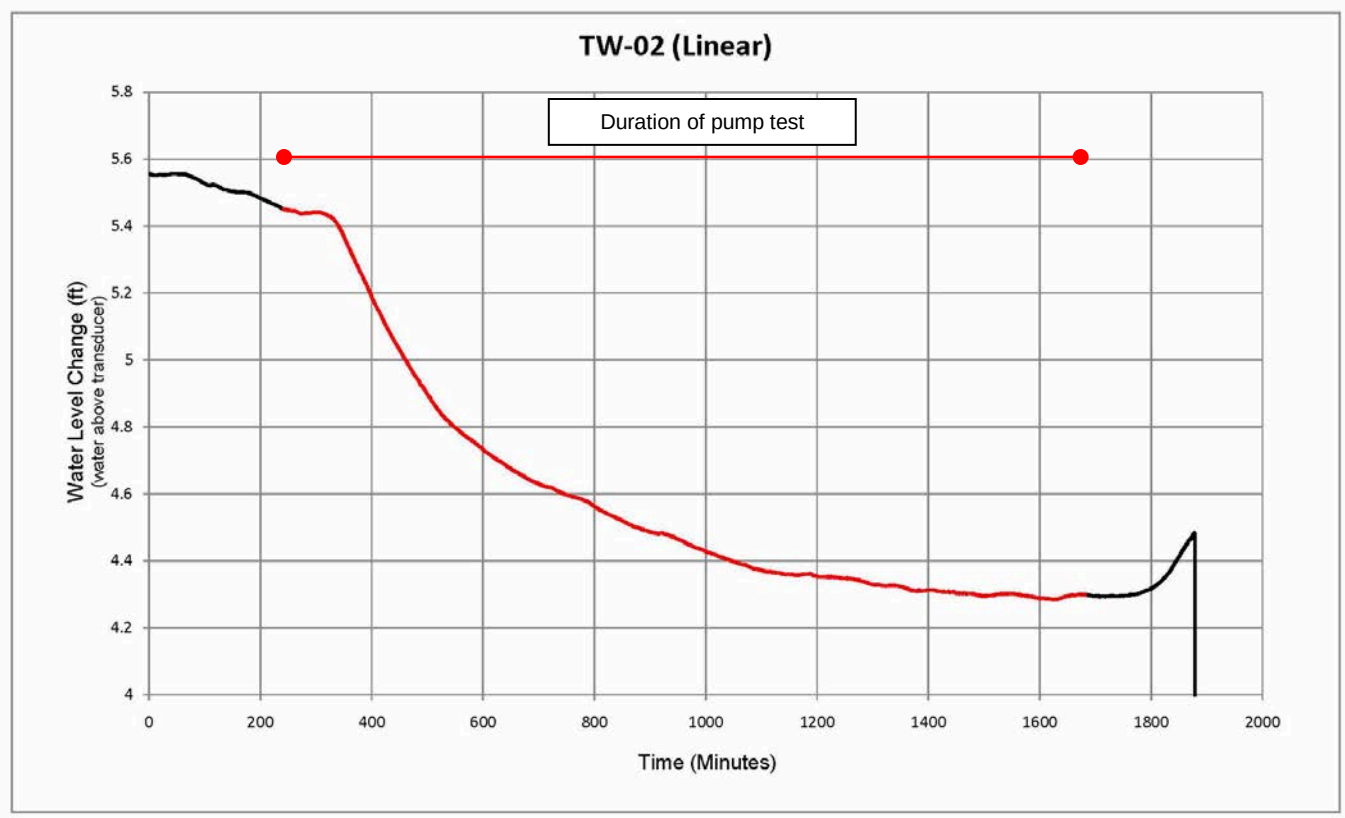

TW-01 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0
200
400
600
800
1000
1200
1400
1600
1800
2000
TW-01 (Logarithmic)
Water Level Change (ft)
(water above transducer)
1.6
1.5
1.4
1.3
1.2
1.1
1
1
10
100
1000
10000
(+) 240 minutes
Time (Minutes)

Figure 7a


TW-02 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (Minutes)

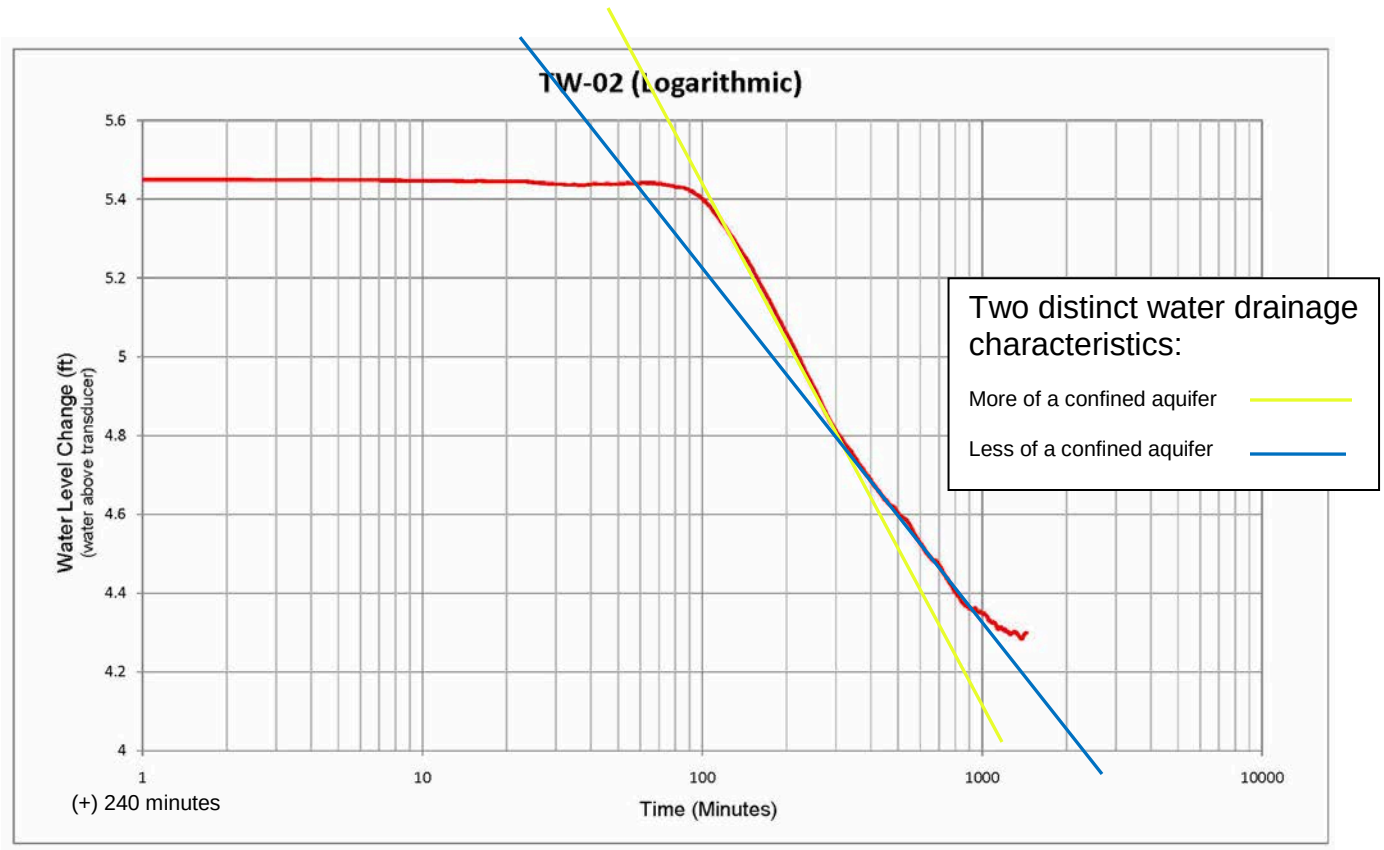
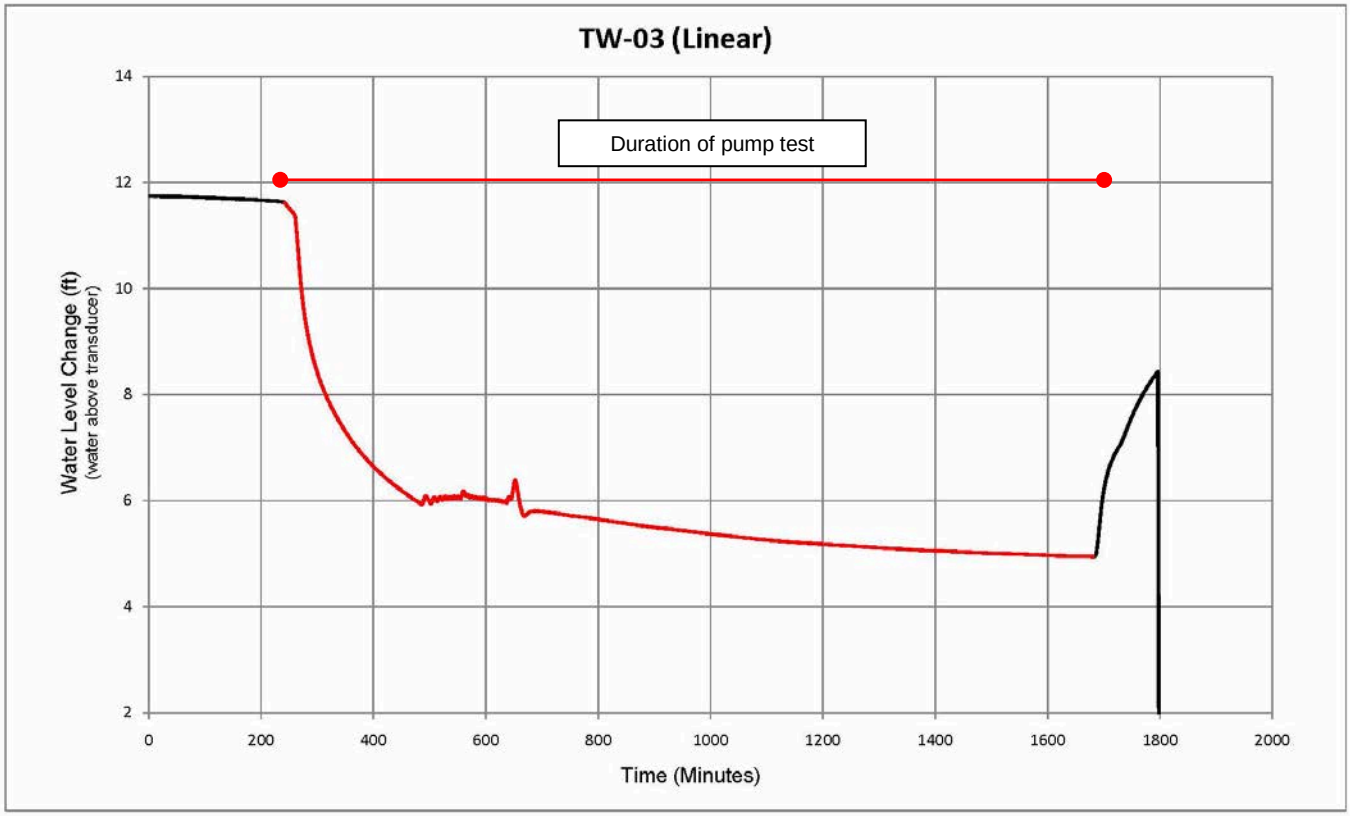

TW-02 (Logarithmic)
Water Level Change (ft)
(water above transducer)
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
1
10
100
1000
10000
Time (Minutes)
(+) 240 minutes
Two distinct water drainage characteristics:
More of a confined aquifer
Less of a confined aquifer

Figure 7b


TW-03 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
Time (Minutes)
14
12
10
8
6
4
2
0
200
400
600
800
1000
1200
1400
1600
1800
2000

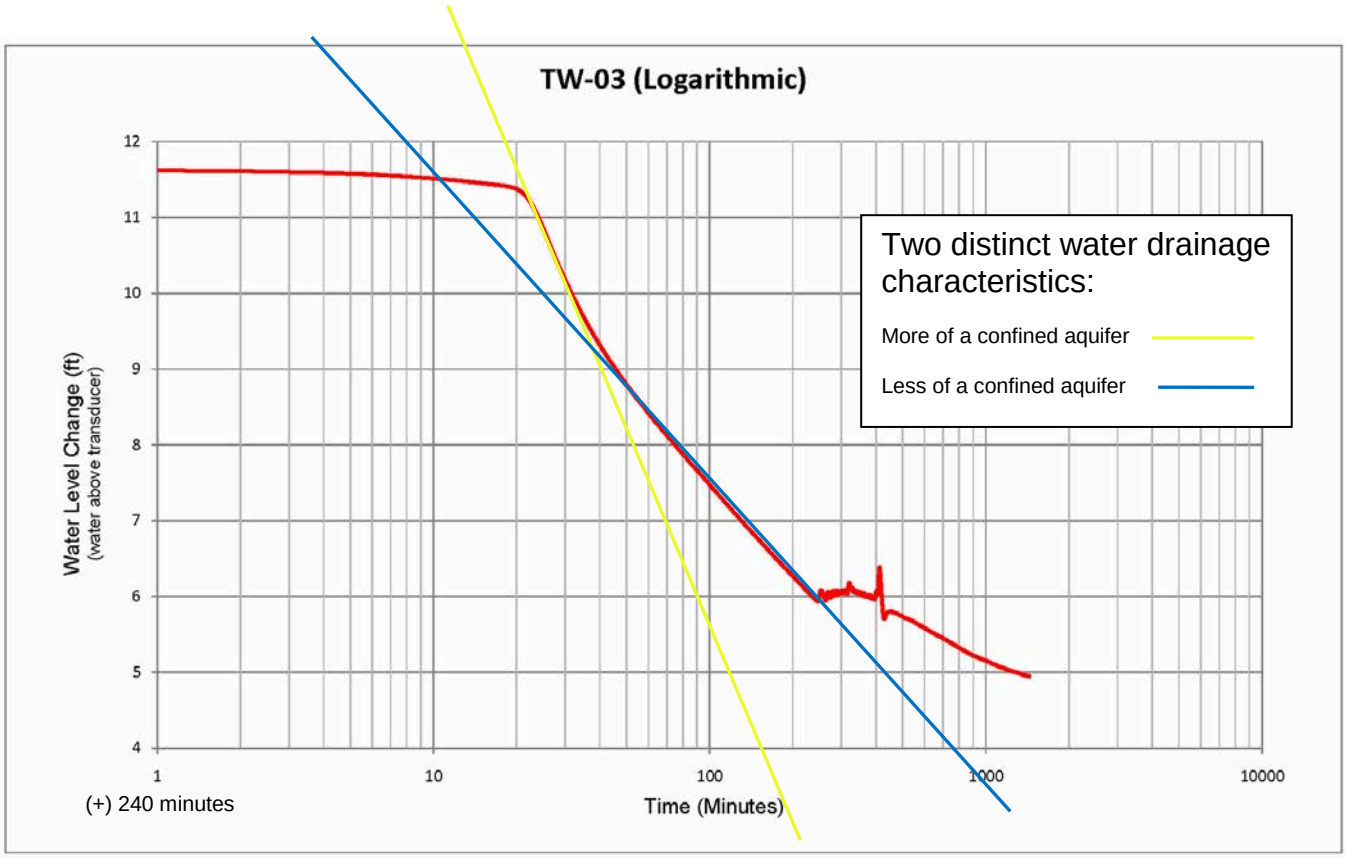
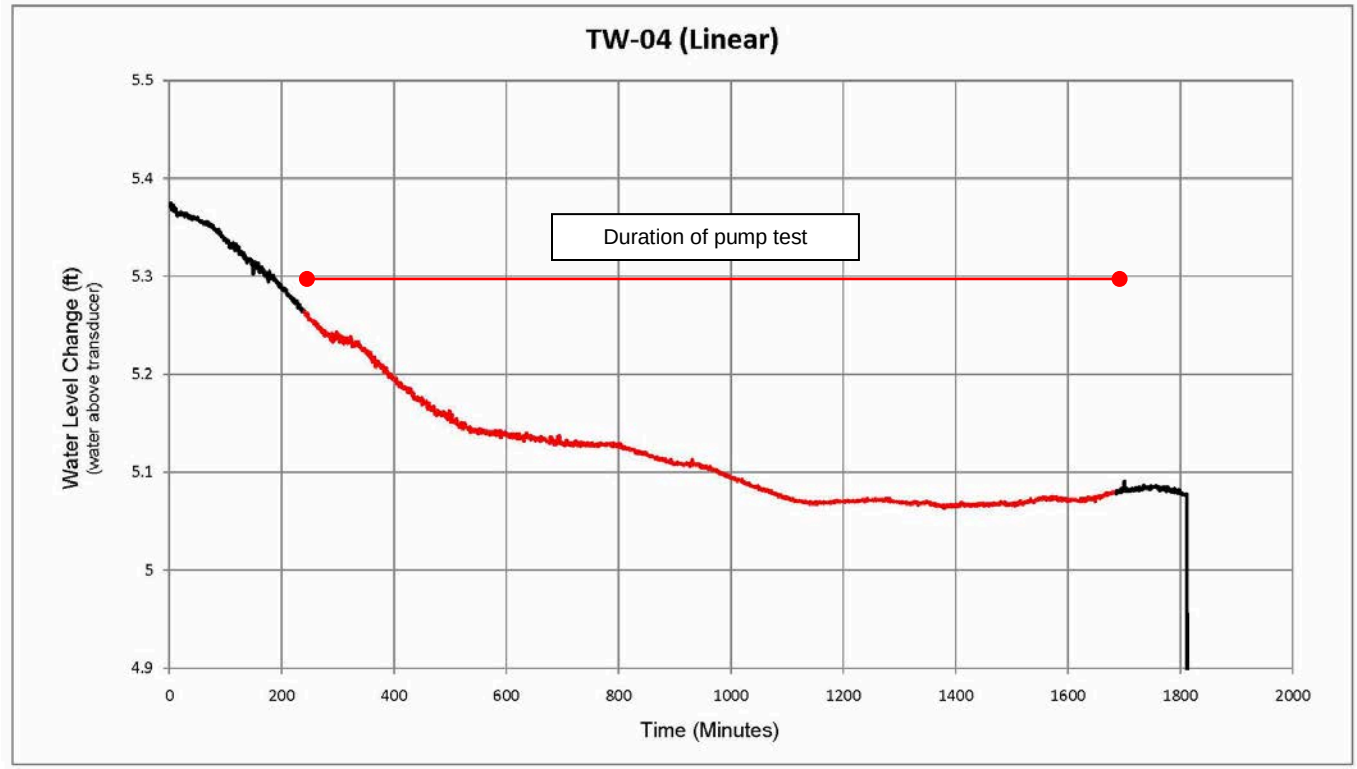

TW-03 (Logarithmic)
Two distinct water drainage characteristics:
More of a confined aquifer
Less of a confined aquifer
Water Level Change (ft)
(water above transducer)
Time (Minutes)
12
11
10
9
8
7
6
5
4
1
10
100
1000
10000
(+) 240 minutes

Figure 7c


TW-04 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
5.5
5.4
5.3
5.2
5.1
5
4.9
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (Minutes)

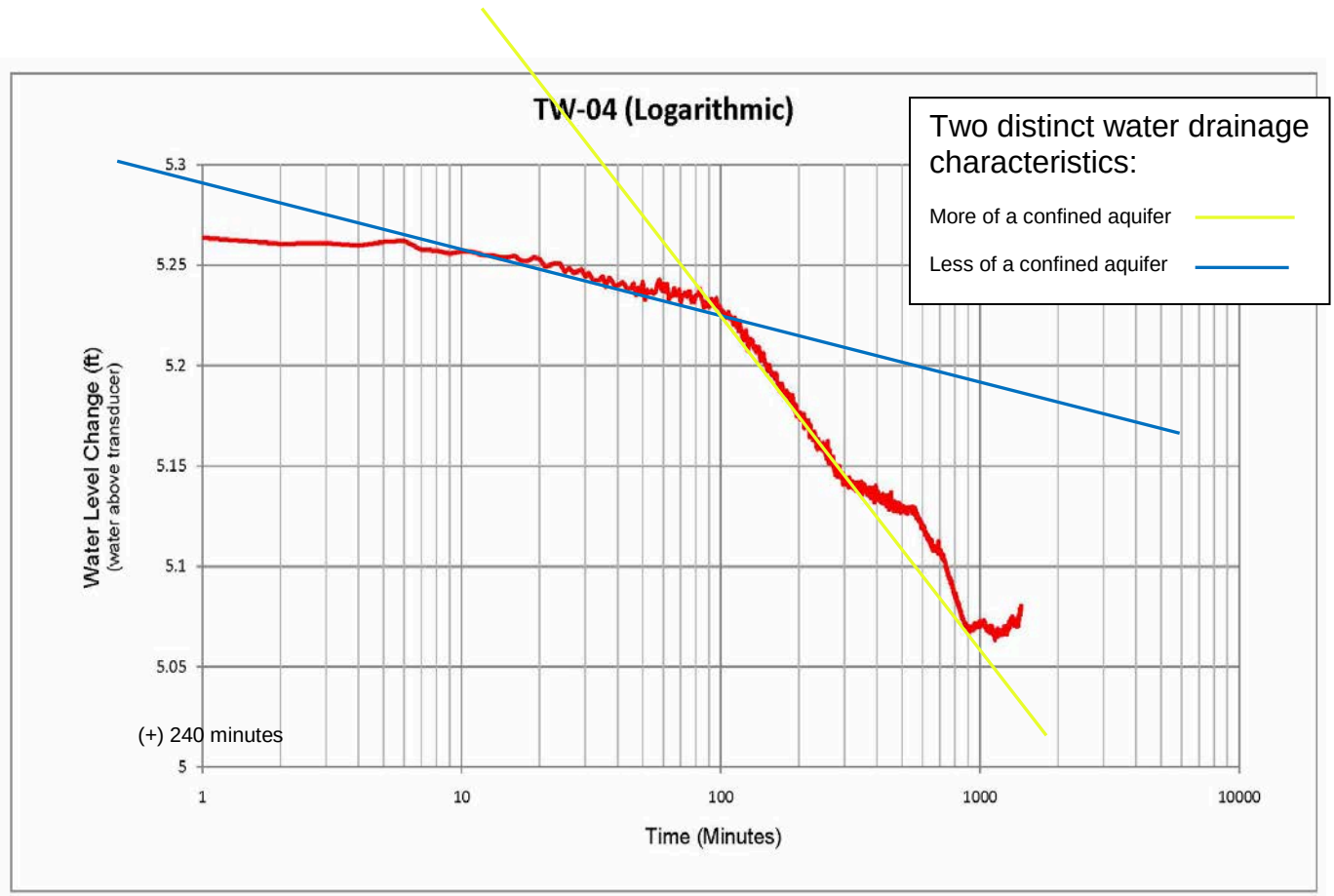
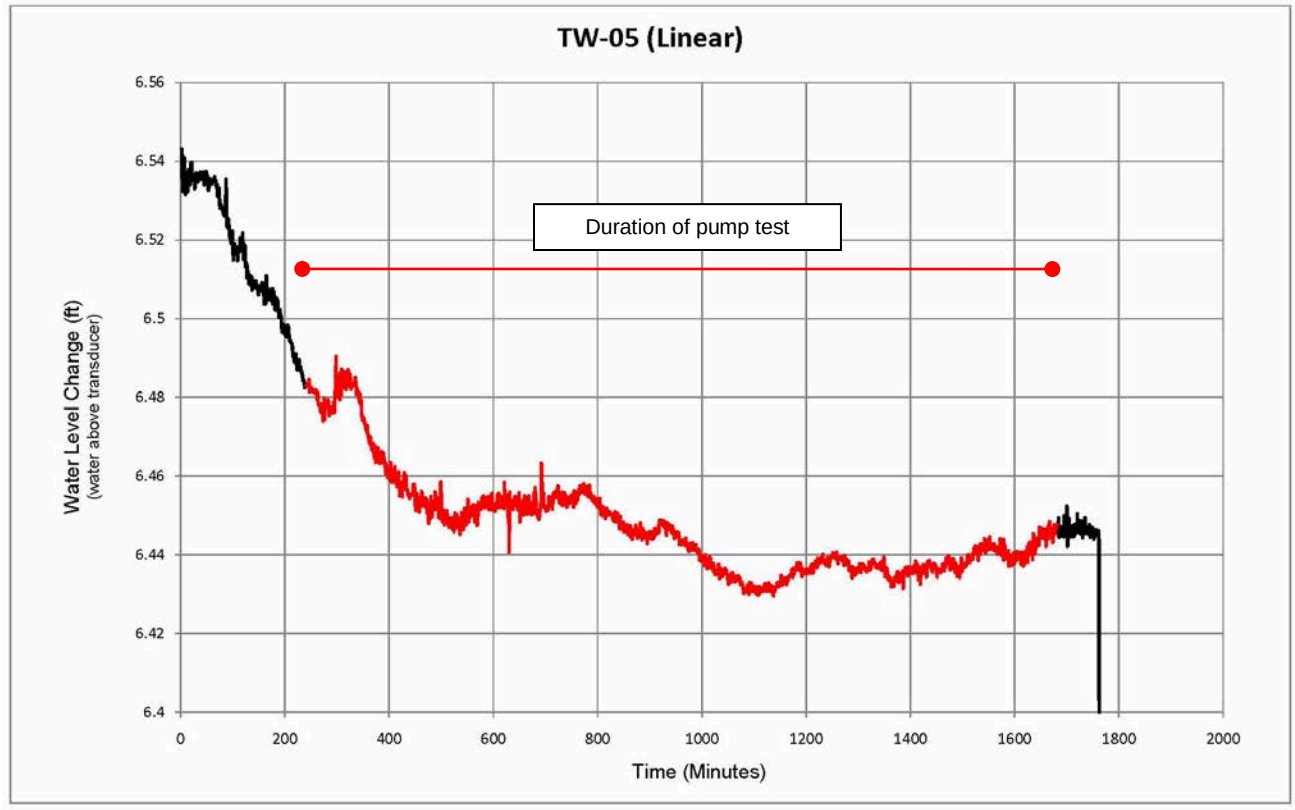

TW-04 (Logarithmic)
Two distinct water drainage characteristics:
More of a confined aquifer
Less of a confined aquifer
Water Level Change (ft)
(water above transducer)
5.3
5.25
5.2
5.15
5.1
5.05
5
(+) 240 minutes
1
10
100
1000
10000
Time (Minutes)

Figure 7d


TW-05 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
6.56
6.54
6.52
6.5
6.48
6.46
6.44
6.42
6.4
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (Minutes)

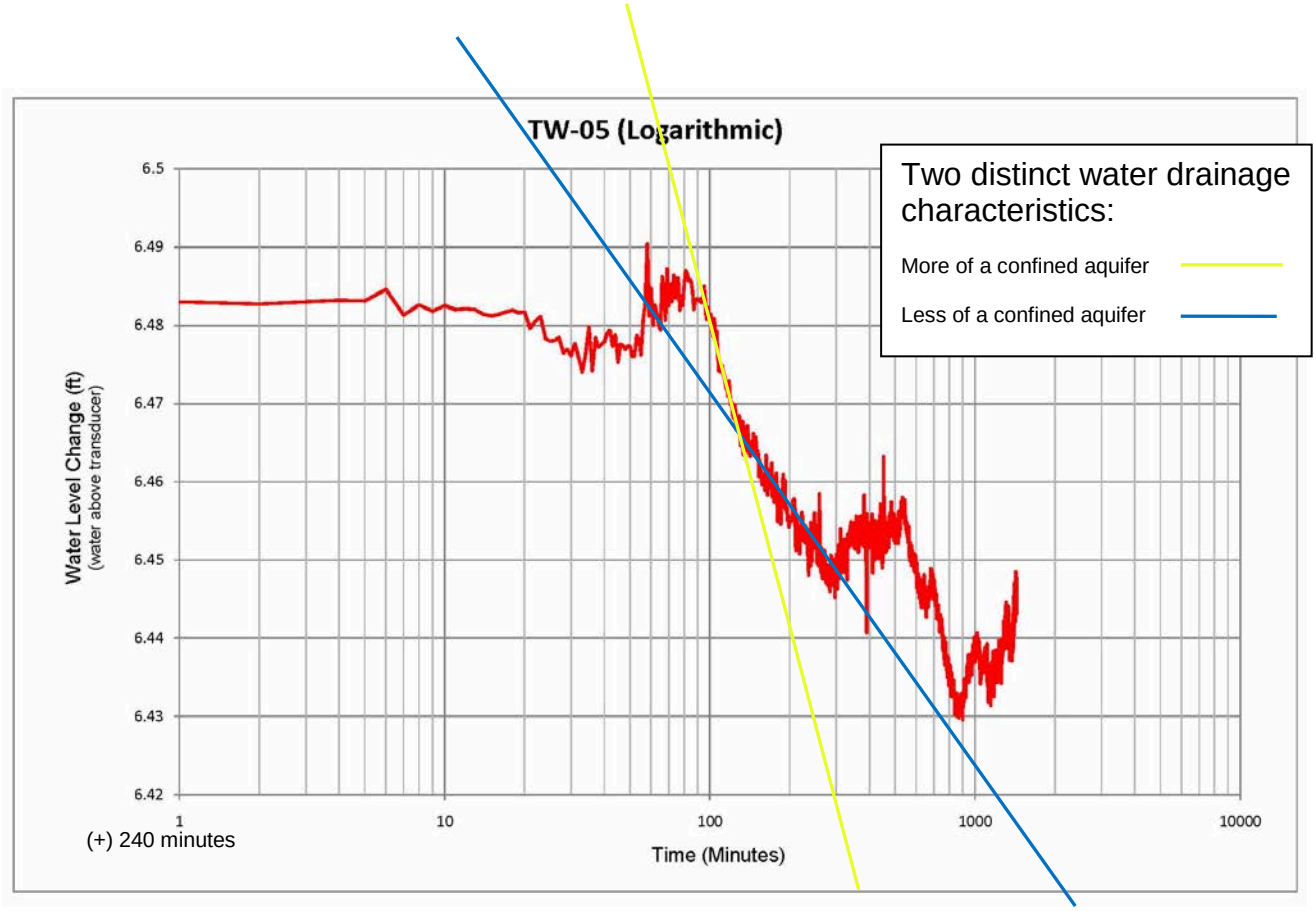
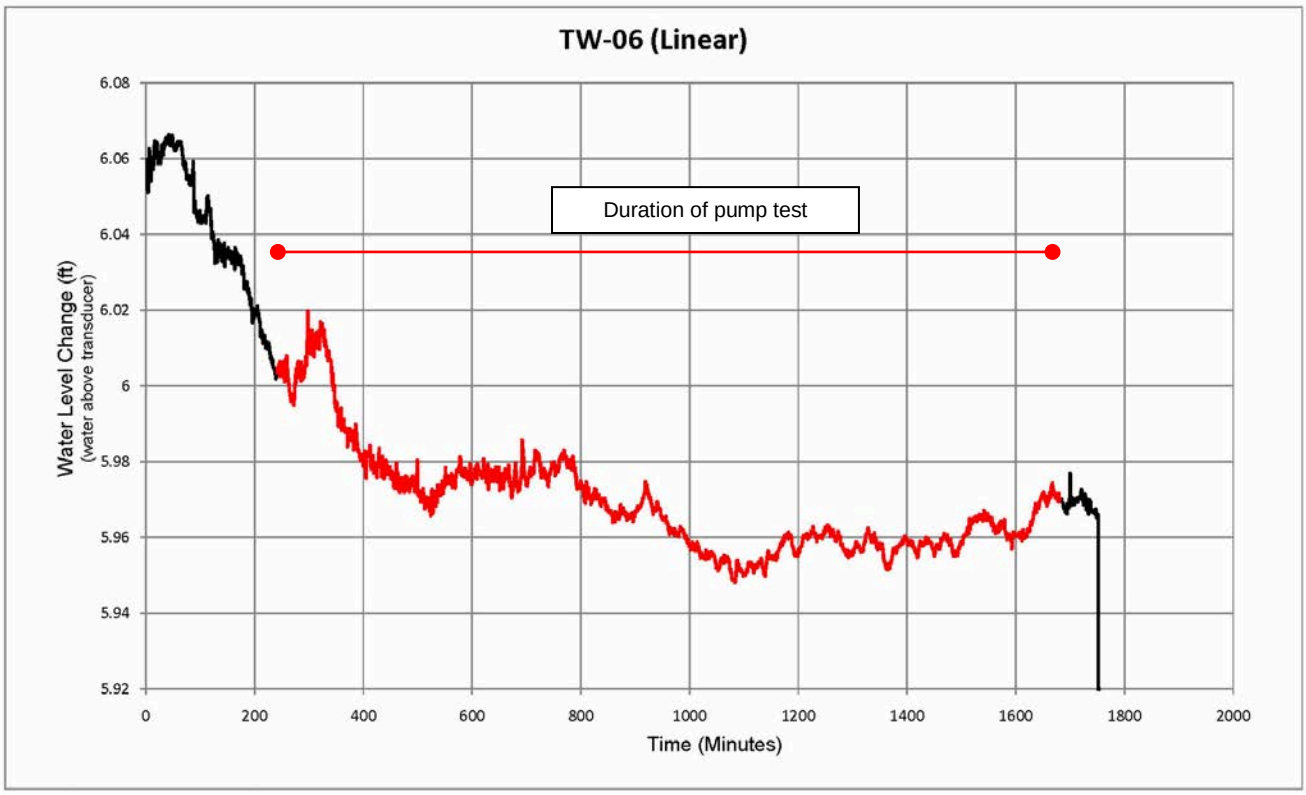

TW-05 (Logarithmic)
Two distinct water drainage characteristics:
More of a confined aquifer
Less of a confined aquifer
Water Level Change (ft)
(water above transducer)
6.5
6.49
6.48
6.47
6.46
6.45
6.44
6.43
6.42
1
10
100
1000
10000
(+) 240 minutes
Time (Minutes)

Figure 7e


TW-06 (Linear)
Duration of pump test
Water Level Change (ft)
(water above transducer)
6.08
6.06
6.04
6.02
6
5.98
5.96
5.94
5.92
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (Minutes)

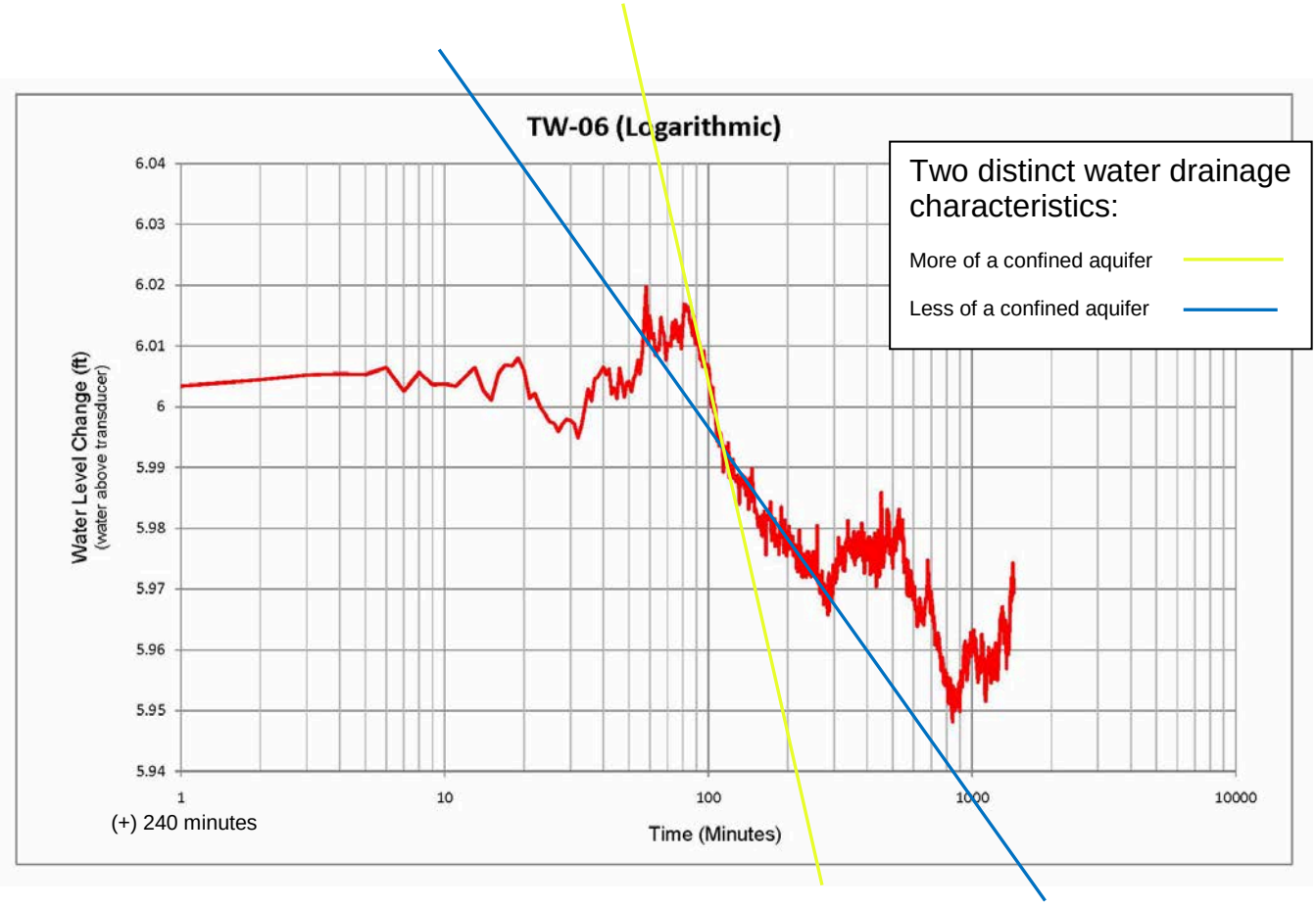
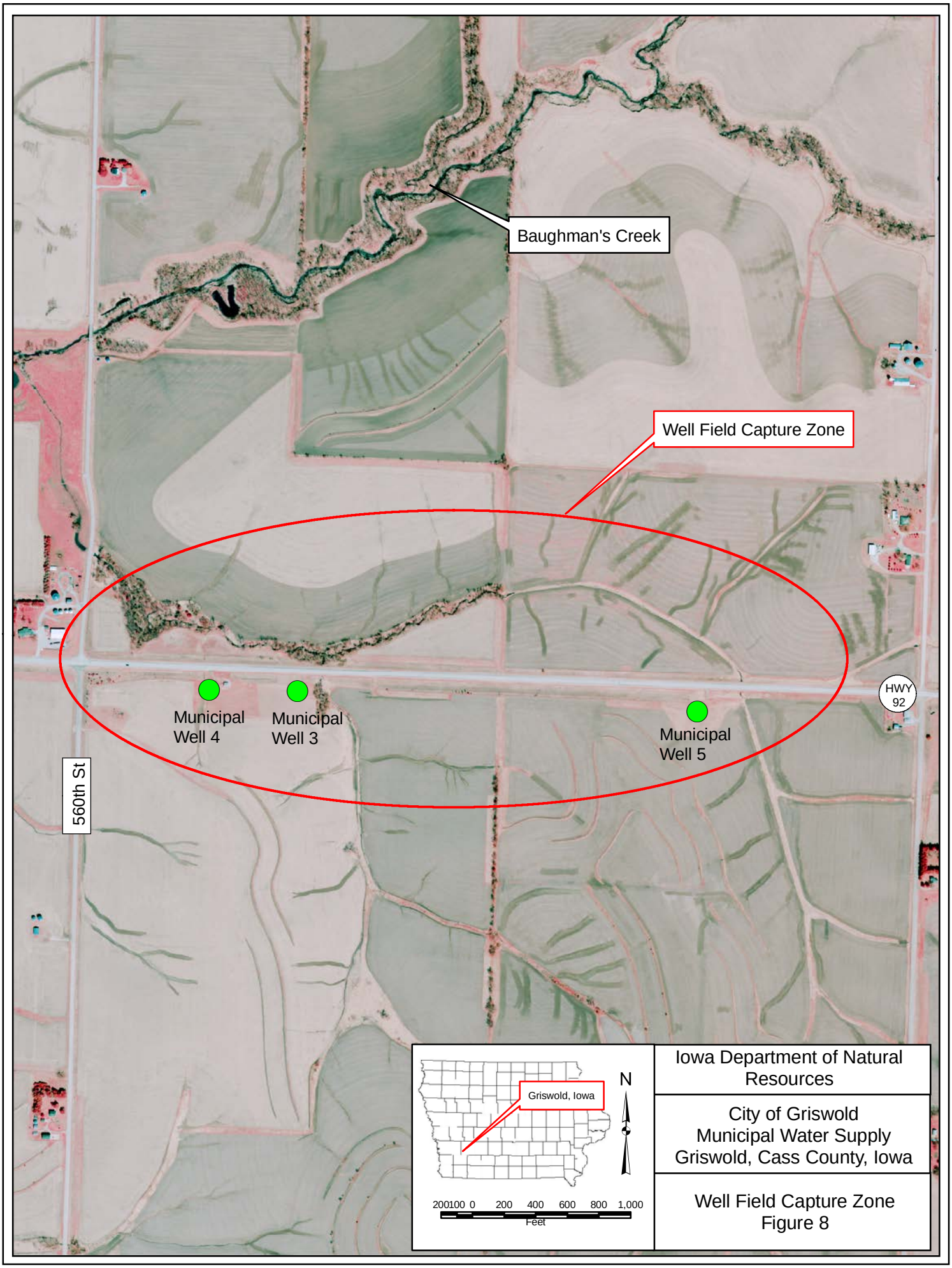

TW-06 (Logarithmic)
Two distinct water drainage characteristics:
More of a confined aquifer
Less of a confined aquifer
Water Level Change (ft)
(water above transducer)
6.04
6.03
6.02
6.01
6
5.99
5.98
5.97
5.96
5.95
5.94
1
10
100
1000
10000
(+) 240 minutes
Time (Minutes)

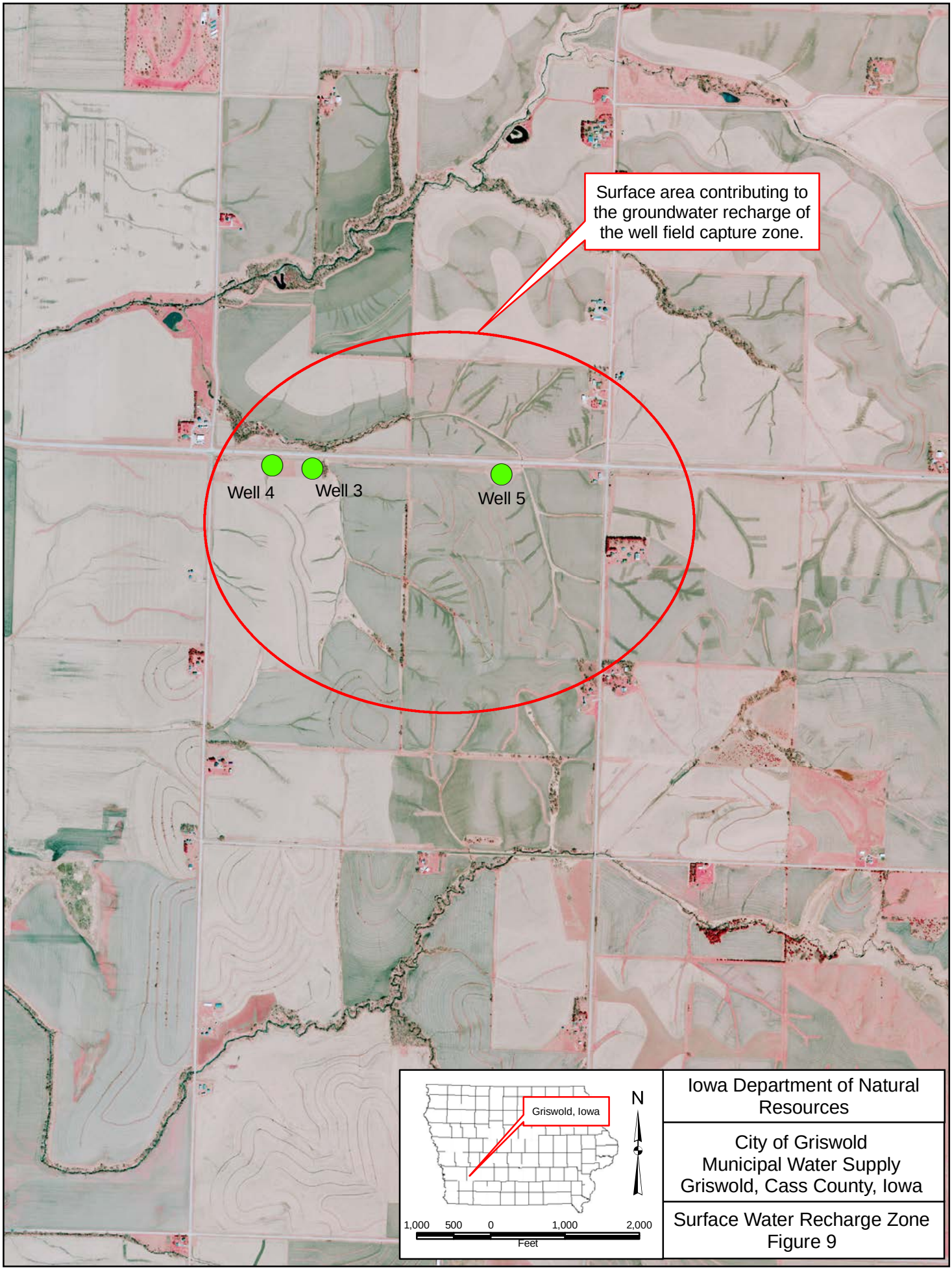
Figure 7f



Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

Well Field Capture Zone
Figure 8



Iowa Department of Natural Resources

City of Griswold
Municipal Water Supply
Griswold, Cass County, Iowa

Surface Water Recharge Zone
Figure 9

SOURCE WATER PROTECTION PROGRAM

PHASE II SITE ASSESSMENT RESULTS

for

CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

GRISWOLD, CASS COUNTY, IOWA

APPENDIX B

Municipal Well Records

Layne-Western Company

4430 Commercial Avenue - Omaha, Nebraska

TEST WELL REPORT

City and State	Griswold, Iowa	Date	February 21, 1956
Contract	City of Griswold	Driller	Donald Oseka
Test No.	6	Helpers	Louis Woitaszewski
Static Water Level	23'		Oscar Neighbors

Test Log

0	-	6'	Brown sandy clay
6	-	10'	Dakota sandstone with clay
10	-	40' 6"	Dakota sandstone, fairly coarse and loose
40' 6"	-	43' 6"	Gray clay
43' 6"	-	48'	Dakota sandstone, fine
50	-	55'	Dakota sandstone
55	-	58'	Gray clay
58	-	87' 6"	Dakota sandstone, fairly coarse and loose
87' 6"	-	88'	Gray clay
88	-	99' 6"	Dakota sandstone, coarse and loose with gravel and pebbles
99' 6"	-	103'	Rusty colored clay
103	-	104'	Blue shale

Size Mud Pit—Length 4', Width 2', Depth 3'

WATER BEARING FORMATION DATA

Depth	Wt. Mud Lbs. per Gal.	Inches Mud Taken from Pit	Drilling Time
31 to 41'	8.6	3-1/4"	
41 to 51'	8.6	4	
51 to 61'	8.6	2-3/4"	
61 to 71'	8.6	3-1/4"	
71 to 81'	8.6	4-1/2"	
81 to 91'	8.6	4-1/2"	
91 to 99' 6"	8.6	3-1/2"	

LOCATION: 500' west of new well in road ditch.

REMARKS: This hole is even better than the test hole No. 102.

W-7441

IOWA GEOLOGICAL SURVEY
In Cooperation with U. S. Geological Survey
RECORD OF WELL

Location:

Town: Griswold (N E) (S W) :County Cass

NENENW NW sec. 1 T. 74 N., R. 37 E. W. Twp.

Well name and number Griswold Town Well (1955)

Owner _____ Address _____

Tenant _____ Address _____

Contractor Thorpe Well Co. Address _____

Drillers Don Wram

Drilling dates Oct. 13-25, 1955

Well data:
Altitudes: Drilling curb _____ feet; Land surface 1138 feet

Determined by GROUP ALTIMETER RUN 8/1965

Topographic position _____

Total depth: Reported 96 or 100 feet, Measured _____ feet

Drilling method _____

Hole and casing data 78' of 8" pipe set at 76' and 20' of Everdur screen attached to 8" pipe. Gravel packed

Original depth to water 24 ft. above below Date _____

Source of data _____

Sources of water: Principal _____

Others _____

Production Data

Date				
Static water level	24			
Measuring point				
Pumping water level				
Yield (g. p. m.)	280			
Duration of pumping				
Specific capacity				

Pump Data

Type pump _____ Column diameter and length _____

Cylinder or bowls diameter and length _____

Suction pipe _____ Airline _____

Power _____ Production _____ g. p. m. for _____ hours per day

Use of water _____

Dissolved constituents and properties (in parts per million except as indicated)

Date sampled				
Sampled by				
Silica (SiO_2)				
Iron (Fe)				
Manganese (Mn)				
Calcium (Ca)				
Magnesium (Mg)				
Potassium (K)				
Sodium (Na)				
Carbonate (CO_3)				
Bicarbonate (HCO_3)				
Sulfate (SO_4)				
Chloride (Cl)				
Fluoride (F)				
Nitrate (NO_3)				
Dissolved solids				
Hardness (as $CaCO_3$)				
Total				
Grains per gallon				
Noncarbonate				
Alkalinity (as $CaCO_3$)				
pH				
Specific conductance (micromhos at 25°C)				
Temperature (°F)	53			
Analysis No.				

Laboratory Data

EH10-8

Well No. W-7441 Sample range 0-100 No. of samples 20

No. of dupls. and cond. 20 GOOD Washed range _____

Samples prepared by CAMPBELL Date 2-10-55

Logged by NORTHUP Date 3/5/56

Correlations by NORTHUP Date 3/5/56

074-37W-09BBAA

WRD Exp. (GW)
Aug. 1964

Punched EBC

U. S. DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY

Water Resources Division Well Schedule Form

MASTER CARD

Record by: D. AARONSON — Source of data: FILE — Date: 4/26/66 — Map: COUNTY HWY. 1:63,360

State: IOWA (16) — County (or town): CASS (15)

Latitude: 41 13 55 N (dg min sec) — Longitude: 095 06 52 (degrees min sec) — Sequential number: 1

Lat-long accuracy: 2 — T. 74 N, R. 37 W — Sec. 9 — NENE, NW ¼, NW ¼ 5

Local well number: 074 37 W 09 B B A A — Other number: W-7441 (B & M)

Local use: 074 41 SSCITY — Owner or name: GRINWOLD TOWN WELL

Owner or name: GRISWOLD TOWN — Address: GRISWOLD, IA.

Ownership: (C) County, (F) Fed Gov't, (M) City, (N) Corp or Co, (P) Private, (S) State Agency, (W) Water Dist — M

Use of water: (A) Air cond, (C) Comm, (D) Dewatering, (F) Fire, (H) Dom, (I) Irr, (N) Ind, (P) PS, (S) Stock, (T) Instit, (U) Unused — P

Use of well: (A) Aerat, (D) Drain, (G) Geotec, (O) Obs, (O) Oilfield, (R) Recharge, (S) Spring, (T) Test, (U) Unused, (W) Withdraw, (X) Waste, (Z) Destroyed — W

DATA AVAILABLE: Well data 2 — Freq. W/L meas.: INVENTORY Ø — Field aquifer char.

Hyd. lab. data:

Qual. water data; type: COMPLETE — C

Freq. sampling: ORIG. SAMPLE. Ø — Pumpage inventory: yes no; period:

Aperture cards: yes

Log data: GEOLOGIST LOG - DRILLER'S LOG — G D

WELL-DESCRIPTION CARD

SAME AS ON MASTER CARD — Depth well: 100 ft (100 Meas. Est.) — 6

Depth cased (first perf.): 76 ft (76) — Casing type: STEEL; Diam.: 8 in (accuracy) — 8

Finish: (C) porous concrete, (F) gravel w. (perf.), (G) gravel w. (screen), (H) horiz. gallery, (O) open end, (P) perf., screen, sd. pt., (S) shored, (T) open hole, (W), (X), (Z) other — G

Method Drilled: (A) air rot, (B) bored, (C) cable, (D) dug, (H) hyd rot., (J) jetted, (P) air percussion, (R) reverse rotary, (T) trenching, (V) driven, (W) drive wash, (Z) other

Date Drilled: OCT. 1955 (955) — Pump intake setting: ft

Driller: THORPE WELL CO., DES MOINES, IA. (name, address)

Lift (type): (A) air, (B) bucket, (C) cent, (J) jet, (L) multiple (cent.), (M) multiple (turb.), (N) rod, (F) piston, (R) rot, (S) submerg, (T) turb, (Z) other — Deep / Shallow

Power (type): diesel, elec, nat gas, gasoline, hand, LPG gas, wind; H.P. — Trans. or meter no.

Descrip. MP: LSD ft above/below lsd, Alt. MP: 1138

Alt. LSD: 1138 (1138) — Accuracy (source): ALTIMETER — 7

Water Level: 24 ft above/below MP; ft above/below lsd (24) — Accuracy: DRILLER'S LOG — D

Date meas.: OCT. 1955 (Ø55) — Yield: 280 gpm (280) — Method determined

Drawdown: ft — Accuracy: — Pumping period: hrs

QUALITY OF WATER DATA: Iron < 0.05 ppm (0) — Sulfate 11 ppm (1) — Chloride 3.0 ppm (0) — Hard. 164 ppm — 5

Sp. Conduct. 337 x 10⁶ (3) — Temp. °F (57) — Date sampled 11/22/55 — N S

Taste, color, etc.

Well Number 41 13 55 S 095 06 52 (d m s d m s)

HYDROGEOLOGIC CARD

SAME AS ON MASTER CARD — Physiographic Province: CENTRAL LOWLAND (12) — Section: DISSECTED

TILL PLAIN (E) — Drainage Basin: NISHNABOTNA (3 S D) — Subbasin:

Topo of well site: (D) local depression, (F) flat surface, (H) hilltop, (S) hillside, (T) terrace, (V) valley flat,

MAJOR AQUIFER: CRETACEOUS (system), LOWER (series) (K1), DAKOTA FM. (aquifer, formation, group) — D

Lithology: COARSE SANDSTONE (4V) — Origin: MARINE (6) — Aquifer Thickness: ft

Length of well open to: 20 ft (20) — Depth to top of: 25 ft (25)

MINOR AQUIFER: system, series, aquifer, formation, group

Lithology: — Origin: — Aquifer Thickness: ft

Length of well open to: ft — Depth to top of: ft

Intervals Screened: 76'-96'

Depth to consolidated rock: 25 ft (25) — Source of data: WELL CUTTINGS — C

Depth to basement: ft — Source of data:

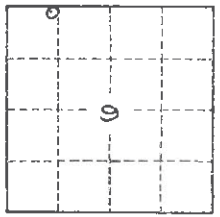
Surficial material: LOESS (Q) — Infiltration characteristics: GOOD — 2

Coefficient Trans: gpd/ft — Coefficient Storage:

Coefficient Perm: gpd/ft² — Spec cap: gpm/ft — Number of geologic cards:

CASING:
78' OF 8" PIPE SET AT 76'.
20' OF SCREEN 76'-96'.

WELL IS GRAVEL PACKED.



GPO 844-275

FORM NO. 79—In stock and for sale by Ross-Martin Co., Tulsa. W-7441

STATE IOWA	GRISWOLD (CASS)
NE NE NW NW	GRISWOLD TOWN WELL
SEC. 9	(1955)
TWP. 74N RGE. 37W	COMMENCED COMPLETED OCT. 13-25, 1955
	THORPE WELL CO.- DON WRAM
	CASING RECORD 78' OF 8" PIPE SET @ 76' AND
	20' OF 8" Everlast SCREEN ATTACHED
	LOGGED MARCH 6, 1956 BY NORTHUP
EL 1138	REMARKS
TD 100'	WELL IS GRAVEL PACKED
	SWL 24'
3/14/56	YIELD 280 GPM.
EH10-8	

SOURCE WATER PROTECTION PROGRAM

PHASE II SITE ASSESSMENT RESULTS

for

CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

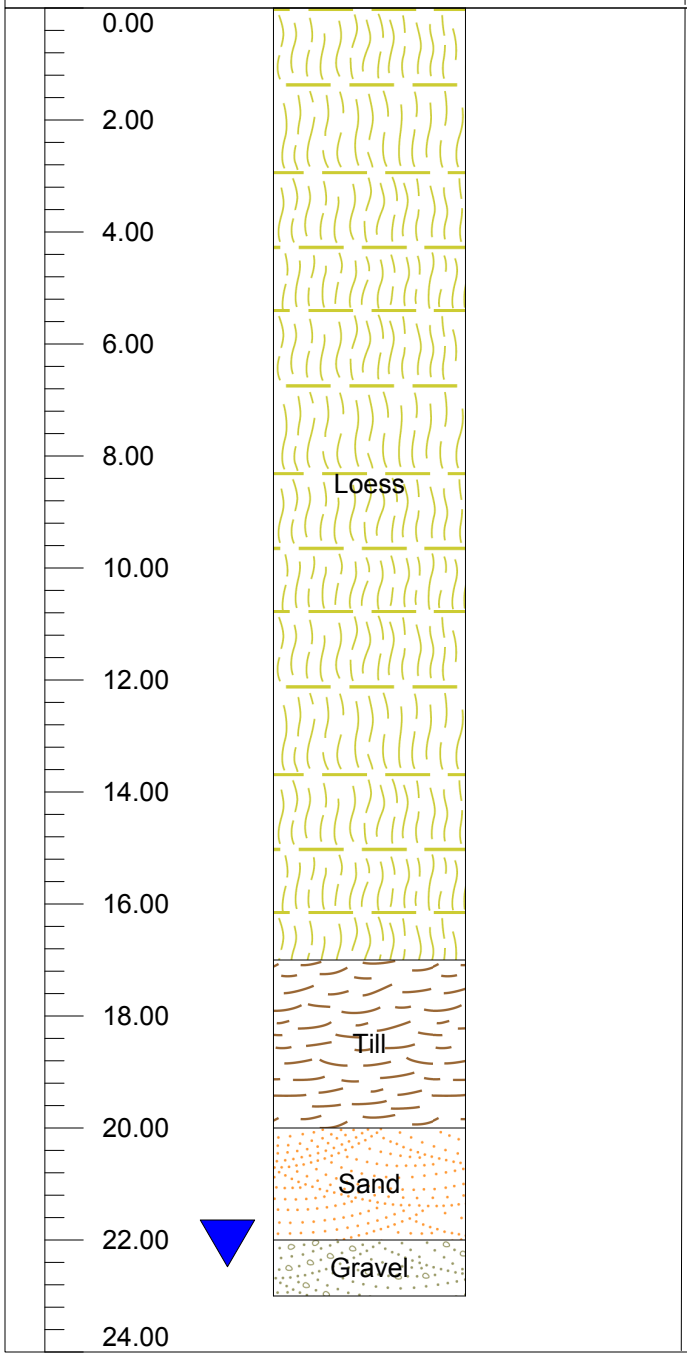
GRISWOLD, CASS COUNTY, IOWA

APPENDIX C

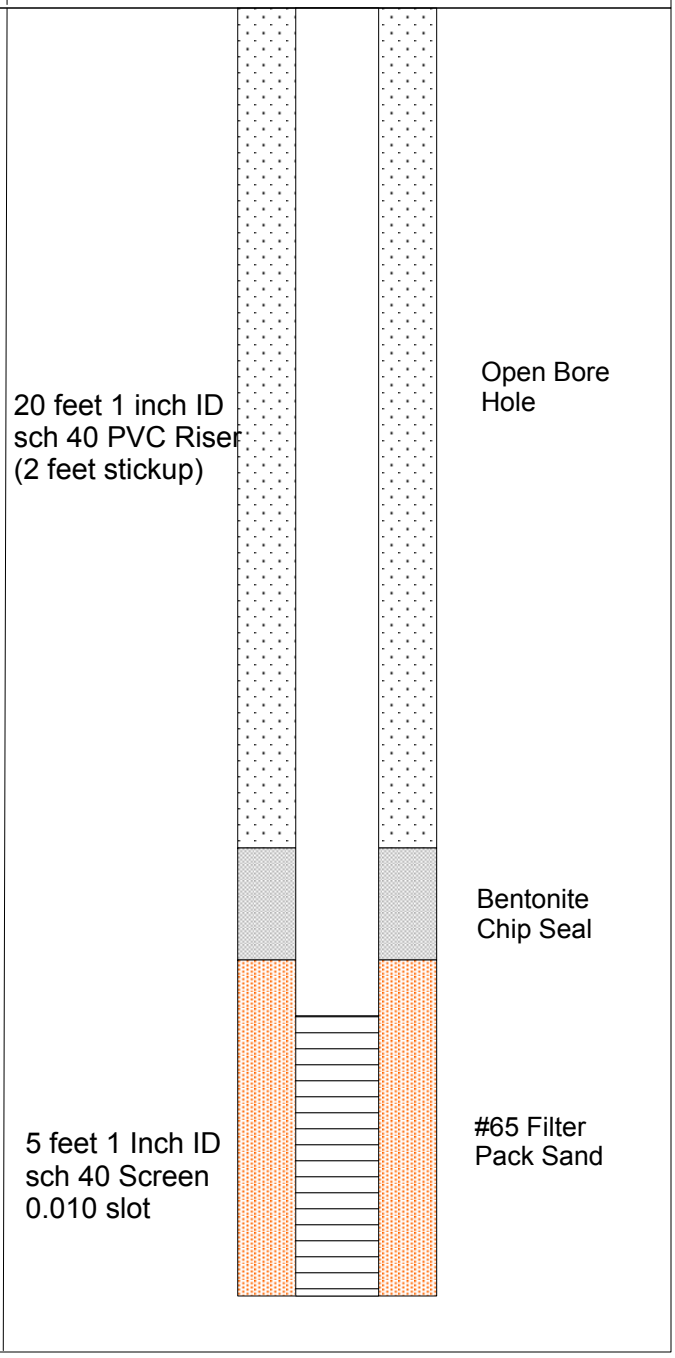
Test Well Boring Data

Project: City of Griswold SWP Phase II	Location: Test Well 01	Elevation/Datum: 1156 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 23 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 21.5 Feet	Screen Interval: 18 to 23 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description

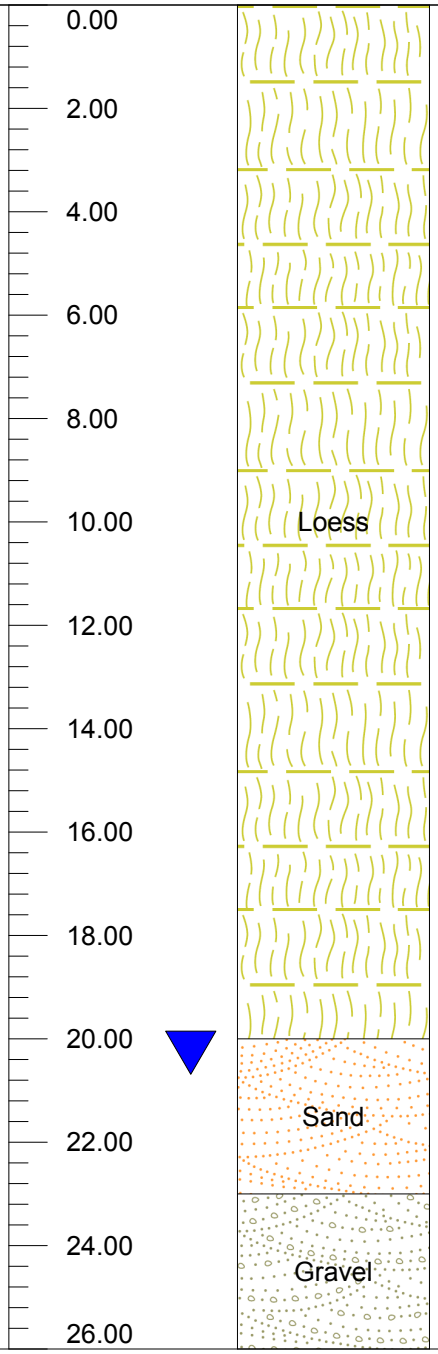


Well Construction

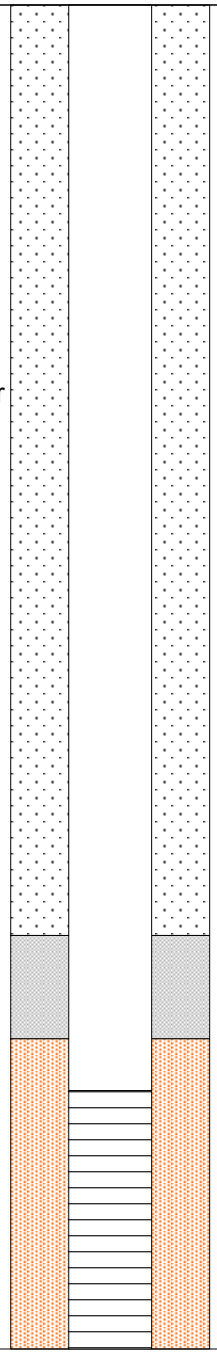


Project: City of Griswold SWP Phase II	Location: Test Well 02	Elevation/Datum: 1151 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 26 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 19.8 Feet	Screen Interval: 21 to 26 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description

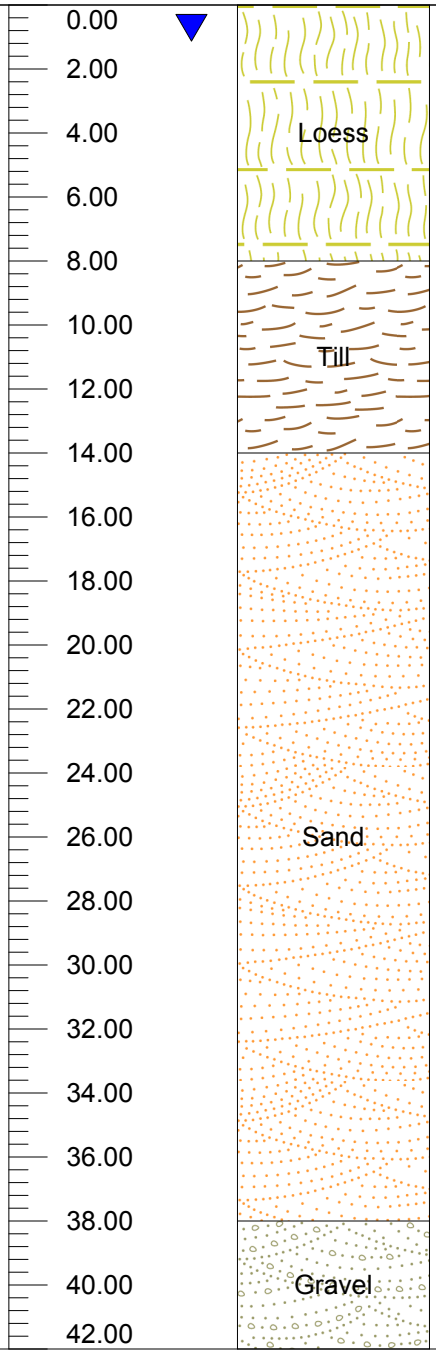


Well Construction

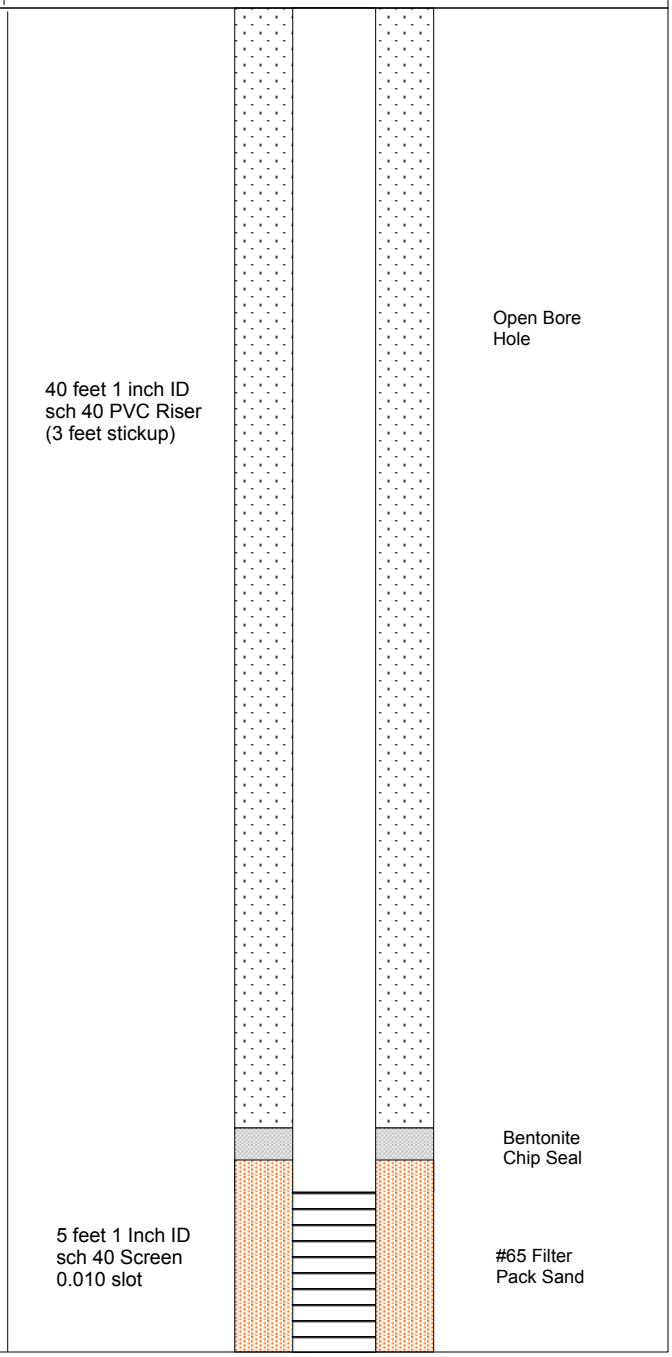


Project: City of Griswold SWP Phase II	Location: Test Well 03	Elevation/Datum: 1133 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 42 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 0.5 Feet	Screen Interval: 37 to 42 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description

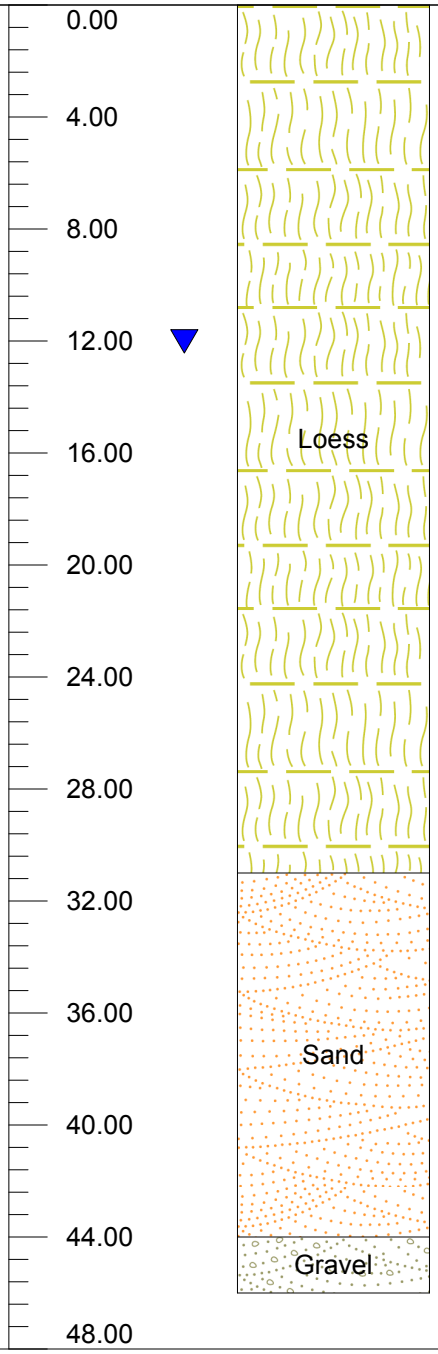


Well Construction

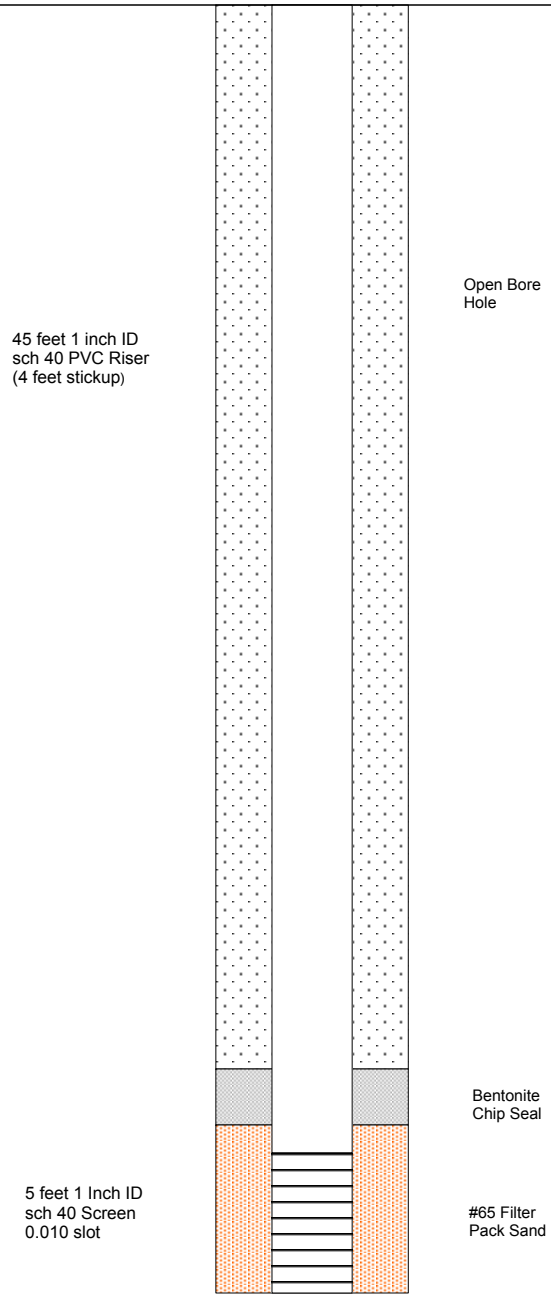


Project: City of Griswold SWP Phase II	Location: Test Well 04	Elevation/Datum: 1129 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 46 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 11.4 Feet	Screen Interval: 41 to 46 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description

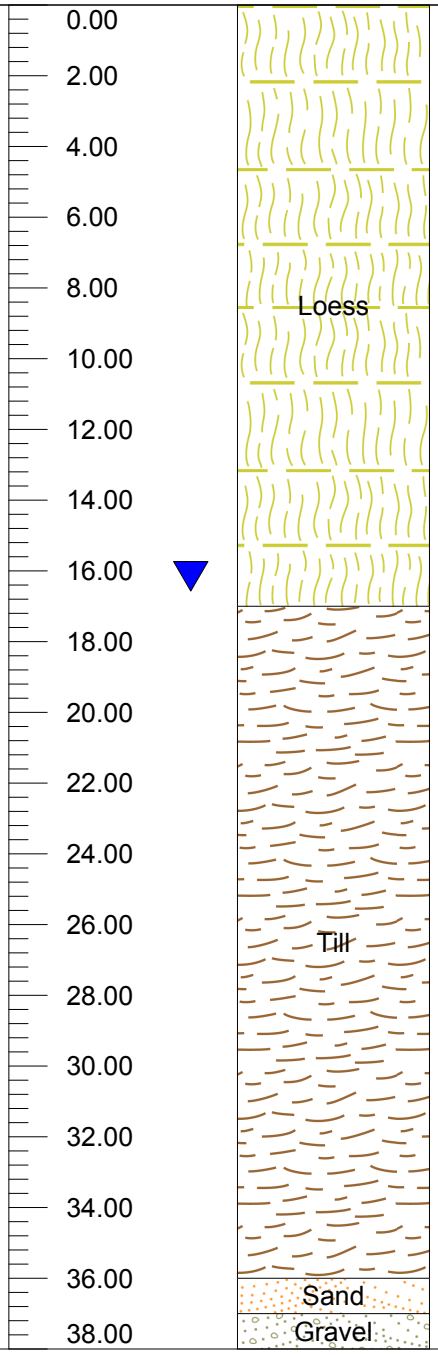


Well Construction

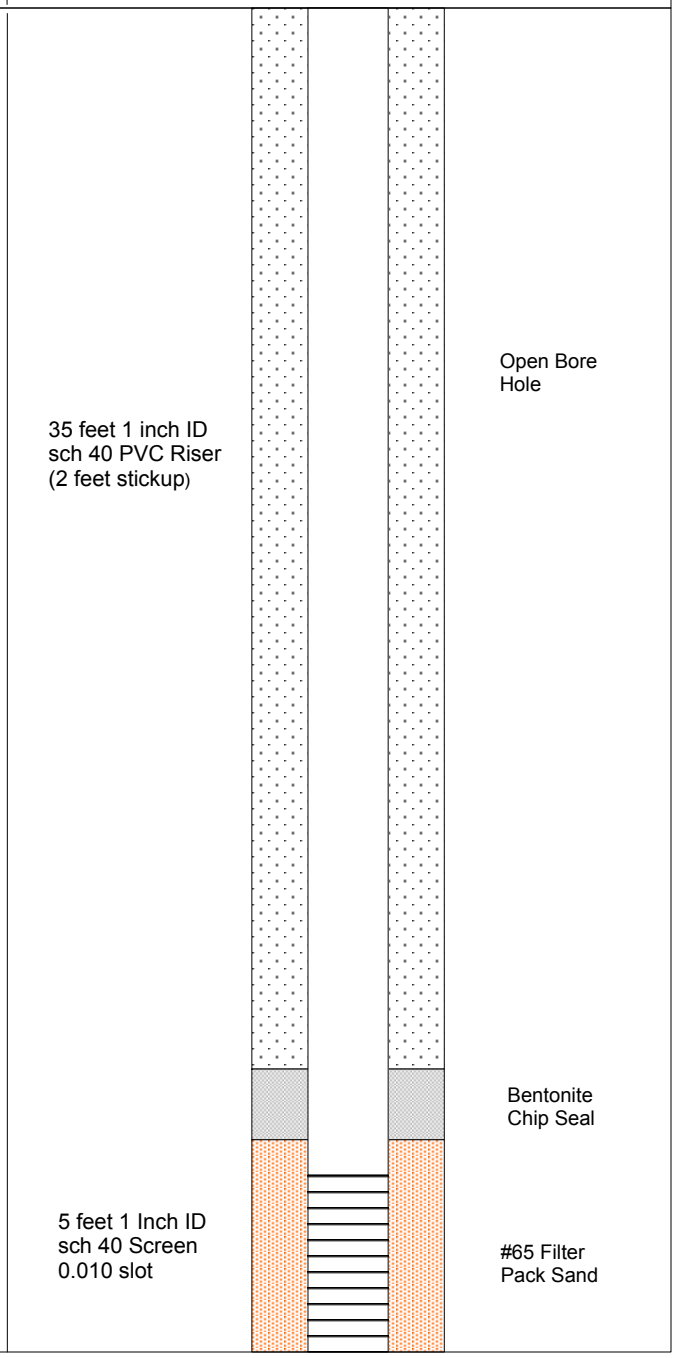


Project: City of Griswold SWP Phase II	Location: Test Well 05	Elevation/Datum: 1121 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 38 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 15.9 Feet	Screen Interval: 33 to 38 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description

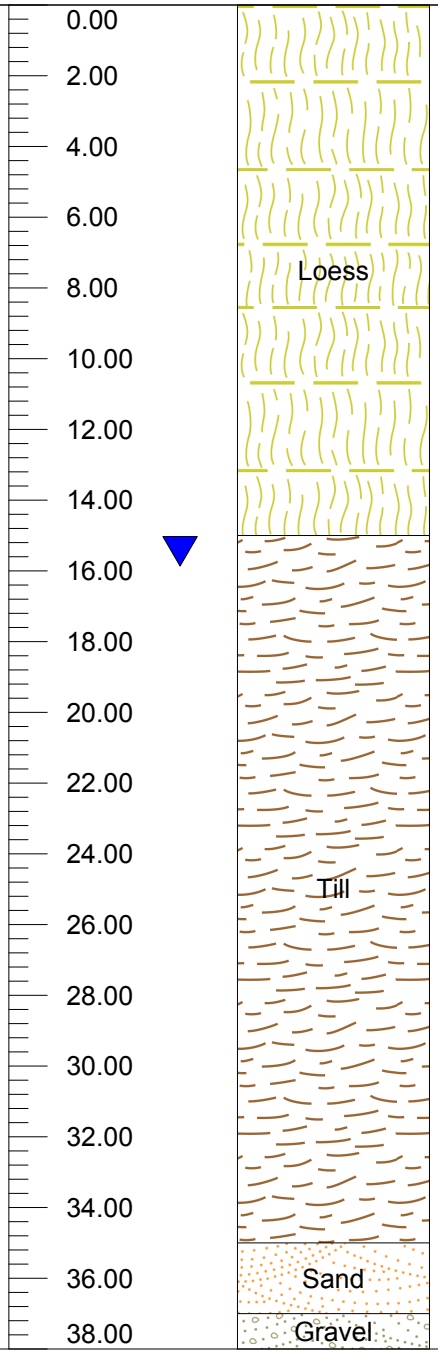


Well Construction

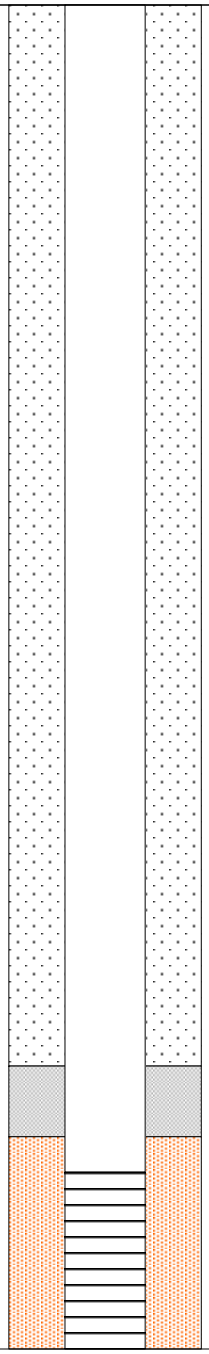


Project: City of Griswold SWP Phase II	Location: Test Well 06	Elevation/Datum: 1120 Feet/IDNR LIDAR
Drilling Contractor: Iowa Department of Natural Resources	Date: April 5, 2011	Total Depth: 38 Feet
Drilling Method: Geoprobe Direct Push	Depth to Water: 14.8 Feet	Screen Interval: 33 to 38 feet
Sampling Method: Geoprobe Conductivity Probe	Responsible Professional: Dan Cook	Reg. No. 9501

Boring Description



Well Construction



SOURCE WATER PROTECTION PROGRAM

PHASE II SITE ASSESSMENT RESULTS

for

CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

GRISWOLD, CASS COUNTY, IOWA

APPENDIX D

Solinst Levelogger Gold

Levelogger Gold

Model 3001

The Levelogger® Gold is completely designed, developed and manufactured in-house, in the tradition of all Solinst high quality products. Due to the Solinst commitment to providing leading-edge instruments designed for repeatable accuracy, the Levelogger Gold is always advancing.

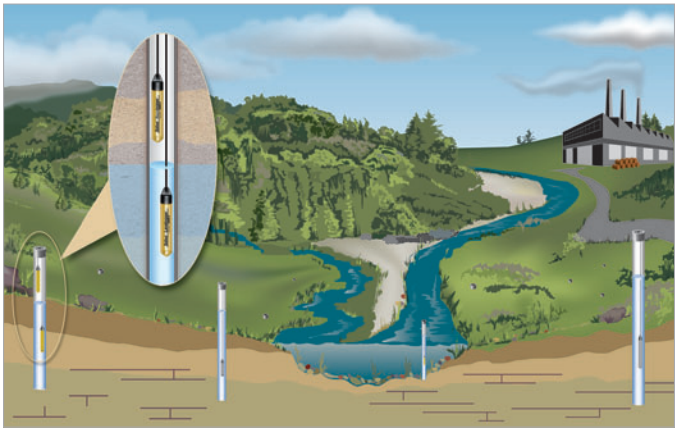
The Levelogger Gold is a water level and temperature recording device. It combines a datalogger, 10-year battery, pressure transducer and temperature sensor, in a small, minimal maintenance, 7/8" x 6" (22 mm x 154 mm) stainless steel housing. The sealed Faraday cage design greatly simplifies maintenance and provides protection against electrical spikes caused by lightning. A Zirconium Nitride coating resists corrosion.

The Levelogger Gold offers high resolution and reliability with an accuracy of 0.05%. The Levelogger Gold has excellent transducer, temperature and clock accuracies. Altitude, water density, temperature and barometric compensations also add to the accuracy and instrument stability.

High accuracy, long-term stability and an internal battery that lasts for 10 years when reading every minute, make Leveloggers the ideal devices for recording water levels. A Barologger provides the easiest and most accurate method of barometric compensation.

Applications

- Pumping and slug tests
- Watershed, drainage basin and recharge monitoring
- Stream gauging, lake and reservoir measurement
- Harbor and tidal fluctuation monitoring
- Wetlands and stormwater run-off monitoring
- Tank level monitoring
- Input water level data to SCADA/PLC systems
- Long-term water level monitoring in wells, surface water bodies and seawater environments



Get Quote | More Info

Features

- Self-test capability
- Maintenance-free, waterproof design
- Protected from power surges, such as lightning
- Real-time viewing; data can be exported
- Radio, satellite or cellular telemetry
- SDI-12 compatible, up to 1500 ft (450 m)
- User-selectable, 30 line sampling schedule

Robust Memory

The Levelogger Gold memory allows a maximum of 40,000 readings of level and temperature, set up in individual logs. The user has a choice of slate or continuous logging when operating in linear mode. In event-based and schedule sampling, memory is a form of circular slate, which starts logging from the end of the last log and wraps around to eventually overwrite older logs, but which will stop at the start of the current log. A separate redundant memory provides backup of the last 1200 readings, which can be accessed by a Diagnostic Utility program.

Downloading Options

The Levelogger Gold offers 4 download options: 'All Data' downloads the complete log, or the user can save time by selecting 'Append Data', when only new data is desired. A selected period of time prior to the last date stamp can be downloaded using 'Partial Download'. 'Recover Previous Log' is a safeguard in case the Levelogger has been restarted without downloading data. A complete data dump is also available as a feature of the Diagnostic Utility, which downloads all available memory in the Levelogger Gold.

High Accuracy

The Levelogger Gold has an accuracy of at least 0.05% net FS, a resolution of 0.0006 to 0.002% depending on range, a Barologger with algorithms based on air not water, enhanced altitude, density, temperature and barometric compensation, as well as a very accurate clock.

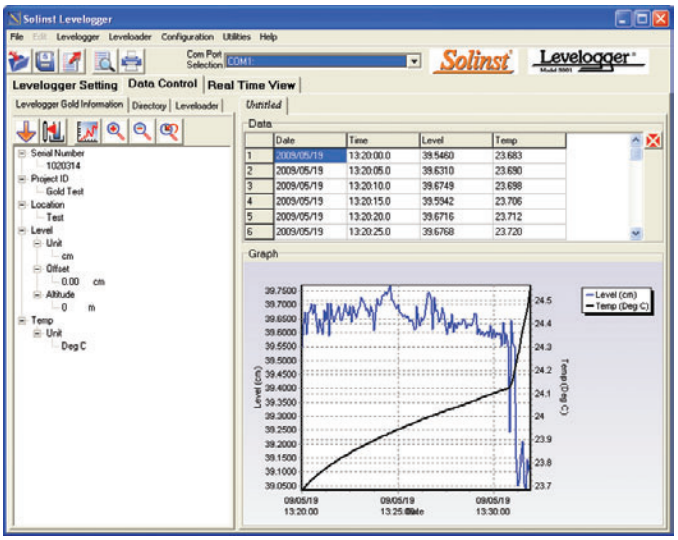
® *Solinst and Levelogger are registered trademarks of Solinst Canada Ltd.*

Levelogger Operation

Solinst has made programming the Levelogger Series extremely intuitive. Simply place the Levelogger in the optical reader or connect to the direct read cable. All in one screen, fill in the information fields for location, project ID, sample mode and rate, altitude, density adjustment and any desired offset.

Levelogger time may be synchronized to the computer clock, or the Leveloader Gold clock, or it can be user defined. There are options for immediate start or a future start time. The percentage battery life remaining and the amount of free memory are indicated on the settings screen.

A manual measurement of the initial water depth is usually taken at each location, and noted as a base line measurement. When a Barologger is used for barometric pressure measurement, it is set above high water level in one location on site. If direct read cables are being used, data can also be viewed, logged on demand and retrieved from the Levelogger at any time using a Leveloader or a portable computer.



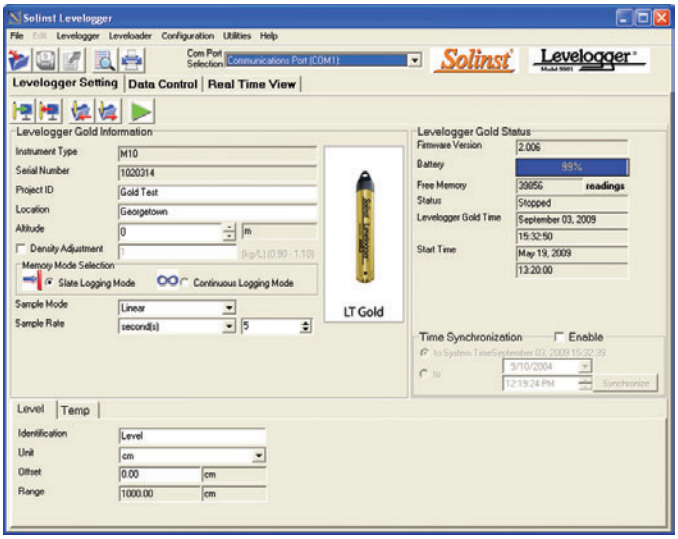
Real Time View Window

Convenient Sampling Options

Solinst includes a very flexible, user-selectable sampling schedule, as well as the standard linear and event-based sampling options. Linear sampling can be anywhere from 0.5 seconds to 99 hours.

Event-based sampling can be set to record when the level changes anywhere from 0.1% up to 25% of the full range of the logger. Readings will be checked at the selected time interval, but only recorded in memory if the condition has been matched or exceeded.

The Schedule option allows up to 30 schedule items, each with its own sampling rate of seconds, minutes or hours, and a duration of seconds, minutes, hours, days or weeks. A running total of sample time and number of readings available are indicated and updated. Templates of these Schedules, and Levelogger Settings, can be saved for easy re-use.



Levelogger Settings Window

Data Download, Viewing and Export

Data is downloaded to a PC with the click of a screen icon or with the push of a button on the Leveloader. Collected data is retained in the Levelogger until it has been written over. The level data downloaded from a Levelogger has already been automatically compensated for temperature and altitude and the temperature data is also downloaded.

Barometric compensation of the Levelogger data is performed by a Wizard that can be used to input elevation offsets and adjust for Barometric efficiency. The software allows immediate viewing of the data in graph or table format using the 'Real Time View' option. It also allows easy export into a spreadsheet or database for further processing

Use of Direct Read Cables

When it is desired to get real-time data and communicate with Leveloggers without removal from the water, they can be deployed using direct read cables.

The lower end of the direct read cable has a miniaturized infra-red optical reader. The top cap of the Levelogger is removed and the direct read cable is threaded in its place. In turn, the upper end of the cable is attached to a portable computer or Leveloader, via a USB or RS232 PC Interface Cable. This allows viewing of the data, downloading and/or programming in the field.

Leveloggers can also be connected to an SDI-12 datalogger using the Solinst SDI-12 Interface Cable attached to a direct read cable.

The full benefits of a sealed Levelogger with no vent tube or electrical cable connection are also maintained. The logger is still sealed from all electrical interference through a Faraday cage design. Cable handling problems are minimized.

A Direct Read Cable with a Levelogger connected, attaches to a PC Interface Cable at a 2" Well Cap

PC Interface Cable connected to the Direct Read Cable

Enviro Cap™ lockable cap and key used with Wireline and Hooks

Helpful Utilities

The 'Self-Test Diagnostic Utility' can be used in case of an unexpected problem. It checks the functioning of the program, calibration, backup and logging memories, the pressure transducer, temperature sensor and battery voltage, as well as enabling a complete Memory Dump, if required. A Firmware Upgrade will be available from time to time, to allow upgrading of the Levelogger Gold, as new features are added.

Direct Read Cable Specifications

Direct read cables are available for attachment to any Levelogger, new or old, in standard lengths of: 15', 50', 100', 200', 250', 300' and 5 m, 15 m, 30 m, 60 m, 80 m, 100 m. Custom cable lengths up to 1500 ft (450 m) are also available to fit particular monitoring situations, as required. Cable markings are available upon request.

The 1/10" dia. (3 mm) coaxial cable has an outer polyethylene jacket for strength and durability. A stranded stainless steel braided conductor gives non-stretch accuracy.

The upper end of the direct read cable is fitted with a connector that can act as a well cap for a 1" well. This connector fits Solinst Levelogger well caps designed for 2" or 4" wells, and can easily be tethered at surface in other situations.

Use of Suspension Wireline and Kevlar Cord

Leveloggers may also be suspended in the water on a stainless steel wireline or Kevlar® cord. This is a very inexpensive method of deployment, and if in a well, allows the Levelogger to be easily locked, out of sight and inaccessible to anyone without a special key.

Solinst has adapted the Enviro Cap™ by adding a vent hole in the cap to allow for the equalization of barometric pressure in the well. The well cap has a convenient eyelet from which to suspend the Levelogger. It slips into the casing and is locked in place with the tamper-proof key, as shown.

The Enviro Caps are available sized for 2" and 4" wells. Well caps for other sizes of well can also be used.

Accurate Barometric Compensation

Leveloggers measure absolute pressure (water pressure + atmospheric pressure) expressed in feet, meters or centimeters of water column.

The most accurate method of obtaining changes in water level is to compensate for atmospheric pressure fluctuations using a Barologger. This avoids any time lag in the compensation calculation and any errors introduced due to moisture buildup, kinking or damage to vented cable. The Barologger Gold uses algorithms based on air rather than water pressure, which gives superior accuracy. The recorded barometric information can also be very useful to help determine barometric lag and/or barometric efficiency of the monitored aquifer.

The Data Compensation Wizard in the Levelogger software greatly simplifies the barometric adjustment of the water level measurements by using the synchronized data from one on-site Barologger with all the Leveloggers.

The overall results give more reliable, highly accurate level data than that obtained when using high maintenance and expensive vented cable.

® Kevlar is a registered trademark of DuPont Corp.

Levelogger Gold Specifications

Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Accuracy (Typical):	0.05% FS
Stability of Readings:	Superior, low noise
Resolution:	0.002 to 0.0006% FS
Normalization:	Automatic Temp Compensation
Temperature Sensor:	Platinum Resistance Temperature Detector
Temp. Sensor Accuracy:	± 0.05°C
Temp. Sensor Resolution:	0.003°C
Temp. Comp. Range:	-10 to +40°C
Battery Life:	10 Years - based on one reading/min
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20°C to 80°C
Maximum # Readings:	40,000 of level and temperature
Memory:	Superior reliability EEPROM (Slate or Continuous) plus redundant backup of last 1200 readings
Communication:	Optical Infra-Red Interface, Serial at 9600 Baud, Conversion to RS232 or USB Computer Connection
Size:	7/8" x 6" (22 mm x 154 mm)
Weight:	6.3 oz (179 grams)
Backwards Compatibility:	Full
Corrosion Resistance:	Zirconium Nitride (ZrN) Coating
Other Wetted Materials:	316-L Stainless Steel, Delrin®, Viton®
Sampling Modes:	Linear, Event and User-Selectable with 30 separate line items
Measurement Rates:	0.5 sec to 99 hrs
Barometric Compensation:	Software Wizard and one Barologger in local area (approx. 20 miles/30 km) radius

Models	Full Scale (FS)	Accuracy (typical)	Resolution
Barologger	4.92 ft., 1.5 m	± 0.003 ft., 0.1 cm	0.002% FS
F15, M5	16.4 ft., 5 m	± 0.010 ft., 0.3 cm	0.001% FS
F30, M10	32.8 ft., 10 m	± 0.016 ft., 0.5 cm	0.0006% FS
F65, M20	65.6 ft., 20 m	± 0.032 ft., 1 cm	0.0006% FS
F100, M30	98.4 ft., 30 m	± 0.064 ft., 1.5 cm	0.0006% FS
F300, M100	328.1 ft., 100 m	± 0.164 ft., 5 cm	0.0006% FS

Levelogger Junior: See Model 3001 Junior Data Sheet for details
Conductivity: See Model 3001 LTC Levelogger Junior Data Sheet

Leveloader Gold

The Leveloader Gold is a data transfer unit designed for use with all versions of the Solinst Levelogger, Barologger and Rainlogger. It is used to download and store multiple data files.

The 8 Mb FLASH memory stores up to 1,390,000 LT readings, 930,000 LTC readings, or 34 full Levelogger downloads. It can also be used to display data in real-time, and has optional password protection.

Simply use the connector cables for attachment to a Levelogger, or to a direct read cable, to allow downloading or reprogramming of the Levelogger settings in the field. It comes with cables for USB and RS232 connection to a PC for data transfer. (See Model 3001 Leveloader Gold Data Sheet.)

STS Telemetry

The STS Gold Telemetry System provides an economical and efficient method to access remote data instantly. Built for the Levelogger Series, the system combines high quality dataloggers, intuitive software and a variety of wireless communication options to create a remote monitoring solution.

CDMA and GSM digital cellular, satellite and radio wireless communication options give the flexibility to suit any project. Systems are suitable for both small to large networks. The STS Gold is designed to save costs by enabling the self-management of data, as well as remote collection of the data. Alarm notification, remote firmware upgrades and diagnostic reporting make system maintenance simple. (See Model 9100 Data Sheet.)

RRL Telemetry

The inexpensive RRL Gold Radio Telemetry is ideal for short range applications up to 1000 ft (300 m) or more. Distances can be increased by using some radios as 'repeater' stations. (See Model 9200 Data Sheet.)

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Printed in Canada
May 31, 2010

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SOURCE WATER PROTECTION PROGRAM

PHASE II SITE ASSESSMENT RESULTS

for

CITY OF GRISWOLD MUNICIPAL WATER SUPPLY

GRISWOLD, CASS COUNTY, IOWA

APPENDIX E

Photographic Log

Griswold SWP Phase II
Photographic Log

(Both photos) Installation of Test Well 02 between Municipal Well 3 and 4

Griswold SWP Phase II
Photographic Log

(Both photos) Installation of Test Well 01

Griswold SWP Phase II
Photographic Log

Installation of Test Well 05

Installation of Test Well 06

Griswold SWP Phase II
Photographic Log

Solinst Levelogger programming

Manual Water level measuring Test Well 03

Griswold SWP Phase II
Photographic Log

(Both Photos) Municipal Well 4 during pumping

Griswold SWP Phase II
Photographic Log

Removal of Test Well 03 after the pump test

Griswold SWP Phase II
Photographic Log
Baughman's Creek at 560th Street