

**HYDROGEOLOGIC INVESTIGATION REPORT  
WATER SOURCE DEVELOPMENT  
AT THE  
SPRINGDALE 16 CPF  
SPRINGDALE TOWNSHIP  
MANISTEE COUNTY, MICHIGAN**

**JANUARY 2011**

**Prepared for:**

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**Job No.: 2010563.01**

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## **ATTACHMENTS**

- ATTACHMENT 1: Site Location Maps (Topographic and Aerial Image)
- ATTACHMENT 2: Site Plan
- ATTACHMENT 3: Water Well Location Map
- ATTACHMENT 4: Water Well Records
- ATTACHMENT 5: Well Logs
- ATTACHMENT 6: Background Water Levels over Time
- ATTACHMENT 7: Drawdown over Time
- ATTACHMENT 8: Recharge over Time
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- ATTACHMENT 10: Groundwater Elevation Contour Map
- ATTACHMENT 11: Physical Aquifer Properties Summary
- ATTACHMENT 12: Drawdown Projection Spreadsheets

## 1.0 INTRODUCTION

This report presents the findings of the hydrogeologic investigation conducted for the Jordan Development Company, L.L.C. (Jordan Development) Springdale 16 Central Production Facility (CPF). The purpose of the investigation is to develop a water supply capable of yielding 90 gallons per minute (3,000 barrels per day) for use in a secondary oil recovery (water flood) project.

The investigation included 1) review of area hydrogeological information; 2) installation of a water supply well and two observation wells; 3) the performance of a 24-hour aquifer test and analysis; and 4) completion of this hydrogeological report that presents aquifer test data and potential impacts on area water supplies and/or surface water bodies.

### 1.1 Site Location and Features

The Springdale 16 CPF is located in Section 16, T24N, R14W, Springdale Township, Manistee County, Michigan. More specifically, the site is located about 800 feet north and 0.5-miles west of the intersection of Glovers Lake Road and Healy Lake Road. The site location relative to area features, contour elevations of ground surface topography, location of nearby surface water bodies and surface water elevations are shown on the Site Location Map in Attachment 1.

Existing site features are shown on the Site Plan presented in Attachment 2. As shown on the Site Plan, site features include the oil and gas well Consumers Energy 1-16A and associated processing facility equipment. Two groundwater monitoring wells exist onsite for the purpose of Supervisor of Wells Instruction S.I 1-89 compliance. The wells, identified by TB-W and TB-E for the purpose of this evaluation, are located off the southeast corners of each tank battery and are shown on Attachment 2. Well logs for the existing wells were not provided to GCES. However, based on field measurements,



the wells are likely screened across the water table with total depths of approximately 25 feet below top of casing (bTOC)

## **1.2 General Site Characteristics**

### **1.2.1 Topography**

The Springdale 16 CPF is located on generally flat terrain at approximately 776 feet above mean sea level (msl). The nearest surface water to site is Bear Creek located, approximately 0.8 miles southwest, at an elevation of 747 feet above msl. The Betsie River is located approximately 1.25 mile north of the site, at an elevation of 707 feet above msl

### **1.2.2 Surrounding Land Usage**

The Springdale 16 CPF is located in a sparsely populated area with residential and recreational land use. Surrounding properties consist of large parcel (10-acres or greater) residences to the north, south east and west.

### **1.2.3 Nearby Water Wells and Wellhead Protection Areas**

A search of documented water wells was completed by reviewing databases available online through the Groundwater Mapping Project, WELLOGIC, and scanned historical records, which are maintained by the MDNRE and the Michigan State University Center for Remote Sensing. A map of the area showing documented water wells is included in Attachment 3. As shown in Attachment 3, the nearest documented water wells were approximately 0.25 to 0.5-mile north the Springdale 16 CPF along Woods Trail. Water well logs reviewed from Section 16 generally show sand and/or gravel to approximately 17 to 30 feet, where intervals of sand, clay and sand/clay mixtures are encountered to total depth. The water wells along Wood Trail are most often screened in sand and gravel from 60 to 70 feet. Attachment 4 contains well logs identified within two miles of the site during the review of public water well record databases



A 2009 aerial photograph was reviewed to evaluate for the potential presence of undocumented water wells in the area. Based on review of the aerial photograph (Attachment 3), the nearest potential for undocumented water wells appears to be at residences located along the north side of Glover's Lake Road, about 700 feet south of the site. Observations during December 2010 aquifer testing could not identify water well type or specific locations. However, it is assumed these residences (full or part time) are served by shallow private water wells.

The nearest wellhead protection area to the site is located 6.6-miles south for the City of Kaleva.

## **2.0 INVESTIGATION METHODS AND PROCEDURES**

The scope of field work related to this investigation included the installation of one, 8-inch groundwater supply well, installation of two groundwater observation wells, completion of a aquifer (stress) test of the supply well and aquifer test analyses and calculations.

### **2.1 Supply Well Installation**

Water well PW-1 was installed to a depth of 68 feet via mud rotary techniques using a truck-mounted rotary rig. The borehole diameter was 12 25 inches. The supply well was constructed of 6-inch by 10 feet (long), 20-slot, stainless steel, wire-wound screen (set 57.5 – 67.5 feet bgs) and 8-inch, PVC casing. Annulus between the borehole and well screen was backfilled with filter sand. Above the filter sand, the annular space between the well casing and the borehole was sealed with a bentonite slurry grout.

### **2.2 Observation Well Installations**

Observation wells OW-1 and OW-2 were installed with 4¼-inch I.D. hollow-stem augers using a truck mounted, Mobile Drill B-57. Wells OW-1 and OW-2 were installed 97 feet and 74 feet, respectively, from the recovery well PW-1. The wells are constructed of



threaded, 2-inch diameter polyvinyl chloride (PVC) riser (casing) and a 5-foot long, 10-slot PVC screen. The observation wells were installed to screen 63 to 68 feet bgs, a similar interval as the water source well, PW-1. Annulus between the borehole and well screen was backfilled with filter sand. Above the filter sand, the annular space between the well casing and the borehole was sealed with a bentonite slurry grout.

A locking, above ground protective steel casing was concreted in place at each observation well. Each observation well was developed by over pumping and surging following installation. The well logs included in Attachment 5 present the details of well completion.

### **2.3 Aquifer Testing**

During December 14 – 17, 2010, a drawdown (pumping) test was performed at PW-1. The purpose of the aquifer test was to calculate aquifer parameters and estimate the aquifer drawdown due to pumping during water flood activities.

A temporary submersible pump, capable of producing in excess of 60 gallons per minute (gpm), was set in the 8-inch fresh water supply well and was flow tested prior to conducting the pump test. An in-line flow meter was used to measure the rate of discharge. Produced water from the pump test was piped from the recovery well to a gang of five, 500 barrel capacity mobile (frac) tanks.

Water level measurements were collected during three consecutive phases of the test: 1) the background, pre-test period (24-hours); 2) the drawdown test (24 hours); and 3) the recovery period (23 hours). Water level readings were collected from the pumping well (PW-1), OW-1, located approximately 97 feet east of the pumping well, OW-2, located approximately 74 feet south-southwest of PW-1. Existing onsite monitoring wells, TB-E and TB-W were also used for observation wells for aquifer testing. Water levels at OW-1, OW-2 and TB-E were recorded with Solinst Levellogger pressure-reading transducers (absolute gauge). Depth-to-water measurements were collected



manually from PW-1 and TB-W using an electronic water level meter. A barometric pressure logging instrument was placed onsite (TB-E) to record barometric pressure throughout the test for data correction. All data recorded by the water level logging equipment was compensated for changes in barometric pressure using the manufacturer's (Solinst) software and recommended procedures. Due to the volume of data collected during the test, lists of individual measurements are not included in this report. Data sets are available in spreadsheet upon request

### **2.3.1 Pretest Period**

The background/pre-test water level data shows approximately 0.01 feet of fluctuation in water level measurement during the 24-hour pre-test period, with the exception of the short pumping rate test prior to the beginning of the background period. Water level data collected during the pretest period was plotted against time and is included in Attachment 6.

### **2.3.2 Drawdown Test Period**

The drawdown test was performed by pumping PW-1 at an average rate of 57 gallons per minute (gpm) for 24-hours (December 15 – 16, 2010) while measuring drawdown at each available observation well. After 24 hours of pumping, data shows maximum drawdowns of 0.02 feet at TB-W, 0.05 feet at TB-E, 1.59 feet at OW-1, and 1.76 feet at OW-2. Water level data collected during the drawdown period was plotted against time and is included in Attachment 7.

### **2.3.3 Recovery Test Period**

Following 24 hours of continuous pumping, the pump was stopped and water level recovery measurements were collected with the dataloggers to monitor the groundwater recovery. Recovery data collected for 23 hours following the termination of pumping shows recovery to within 0.02 and 0.03 feet of background water levels at the



observation wells. Water level data collected during the recovery period was plotted against time and included in is Attachment 8.

### 2.3.4 Aquifer Test Analysis

The overall objective of the aquifer-test data analysis was to 1) obtain aquifer parameters useful for design of a permanent water source well capable of yielding 90 gpm of fresh water, and 2) evaluate for potential negative effects of pumping (if any) from the water table aquifer on nearby water wells and surface water bodies.

The following assumptions were made in interpreting the aquifer test data:

- The aquifer has an "apparent infinite extent".
- The aquifer material is assumed homogeneous and isotropic, and of uniform thickness over the area influenced by pumping.
- The piezometric surface was horizontal prior to pumping.
- The well is fully penetrating and pumped at a constant rate.
- Water removed from storage is discharged instantaneously with a decline in head.
- The well diameter is small, so well storage is negligible.

Drawdown and recovery test data from observation wells were evaluated using four methods: Theis<sup>1</sup> Method for Drawdown and Recovery, and the Cooper-Jacob<sup>2</sup> Methods applied to Time – Drawdown and Distance - Drawdown. The graphical analysis for transmissivity (T) and storativity (S) used for these methods was completed with the aid of Aquifer Test, Version 3.5 software by Waterloo Hydrogeologic. Test parameters and graphical analyses of the aquifer test data are included in Attachment 9.

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<sup>1</sup> Theis, C.V., 1935 The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage *Transactions, American Geophysical Union*, Washington, D C., pp 518-524

<sup>2</sup> Cooper, H H. and Jacob, C E , 1946 A generalized graphical method for evaluating formation constants and summarizing well field history *Transactions, American Geophysical Union*, Vol 27, No. 4



## 3.0 RESULTS

### 3.1 Hydrogeologic Conditions

The follow sections present results of research of regional and site hydrogeologic conditions that govern groundwater availability at the Springdale 16 CPF and surrounding area.

#### 3.1.1 Site Geology

Surficial geology of Manistee County is composed of Wisconsin glacial period and post-glacial deposits. The subject site is situated on a lacustrine sand and gravel system located between the Manistee and Port Huron Moraines. Based on review of the oil well log for the Consumers Power 1-16A, the thickness of the glacial deposits at the site is approximately 600 feet. Underlying the drift is early Devonian age Antrim Shale, picked with 134 feet in thickness, but is of little importance to this evaluation, due to the viability of the drift aquifer.

Near-surface site soils were evaluated during supply and observation well installation activities. Site soils encountered during drilling were classified as follows (from shallow to deep:

1. fine to medium sand with silt,
2. sand and gravel,
3. fine to medium sand with occasional clay layers and medium sand to 68 feet, and
4. at about 68 feet, a clay layer was encountered, below which exists alternating intervals of silty sand and clay to at least 180 feet.



### 3.1.2 Site Hydrogeology

Based on groundwater flow direction and area topographic features, the Springdale 16 CPF is located within the political boundary of the Bear Creek Watershed. However, due to the permeable vadose zone soils, infiltration to groundwater is the principal pathway by which precipitation is removed from the area. Recharge in the area is approximately 12 – 13 inches per year, according to the USGS estimates made by base flow analyses<sup>3</sup>.

Groundwater near the Springdale 16 occurs under water table conditions at approximately 15 feet bgs. Due to clay layers encountered during the test hole for PW-1, the supply well was set to screen a medium sand layer above the intervals of lacustrine deposits. Based on limited drawdown observed in aquifer test data, the shallower wells TB-E and TB-W, are not in direct connection with the medium sand screened by water source well PW-1. Therefore, the aquifer developed for the water flood source appears to be leaky confined due to the presence of siltier sand and clay between 42 and 54 feet bgs. The vertical extent of the produced aquifer identified during drilling activities was 41 feet of saturated thickness between the water table and lacustrine clay at 68 feet.

Groundwater elevation contouring data from the end of the background test is shown on Attachment 10, and indicates that groundwater in the leaky confined aquifer appears to flow toward the southwest. The horizontal gradient as determined from the groundwater contour map is approximately 0.0001 ft/ft, measured between PW-1 and the 761.79 foot contour. It should be noted, the calculated gradient of 0.0001 may be outside of the accuracy of the electronic water level meter used to collect the data. Due to the near-horizontal hydraulic gradient, groundwater flow direction determined by this evaluation, using closely spaced data points, should be used with caution.

<sup>3</sup> USGS and MDEQ Groundwater Mapping Project (online, maintained by MDEQ)



### **3.2 Aquifer Test Analysis**

Pumping well data from PW-1 was evaluated for specific capacity and well efficiency. Maximum measured drawdown in the recovery well was 12 feet at 58 gpm. Therefore, the specific capacity of recovery well PW-1 was 4.8 gpm/ft.

Well losses are defined as that part of the total drawdown attributable to partial penetration of the well, design deficiency, incomplete development, and/or a poor distribution of grain sizes within the formation that creates blockage near the screen. The measured drawdown in the recovery well was 12.0 ft. The theoretical drawdown, determined from the distance-drawdown plot, was approximately 5.6 feet. Therefore, approximately 6.4 feet of drawdown can be attributed to well losses. From these values the well efficiency was calculated as 47 percent.

As shown in Attachment 9, a recharge boundary was apparent by both Theis and Time-Drawdown curves for OW-1 and OW-2 after approximately 100 minutes of pumping. The recharge boundary was not apparent by TW-E data. This recharge boundary is likely leakage from the overlying clay layer, which TB-E was screened above. The time-drawdown curve for TB-E shows no discernible drawdown until after 100 minutes of pumping.

Results for transmissivity, storativity and hydraulic conductivity are summarized in Attachment 11. For data showing the recharge boundary, analyses were applied prior to leakage and after casing storage to estimate aquifer properties of the formation in which the supply well is screened. As shown in Attachment 11, transmissivity values from OW-1 and OW-2 data ranged from 2,460 to 5,420 ft<sup>2</sup>/day, with a geometric mean of 4,040 ft<sup>2</sup>/day.



Storativity coefficient results for OW-1 and OW-2 averaged  $10^{-4}$ , which is within in the range of published values<sup>4</sup> for confined aquifers of  $10^{-3}$  to  $10^{-5}$ . For comparison, the storativity coefficient result for OW-1 was  $10^{-1}$ .

Hydraulic conductivity values, calculated from transmissivity estimates and a saturated thickness of 41 feet, ranged from 60 to 132 ft/day. The aquifer material was generally classified as medium sand. Published values<sup>5</sup> of hydraulic conductivity for this type of aquifer are between 50 and 400 ft/day. The hydraulic conductivities determined by the analyses in this report produced estimates within the published range of values.

The Cooper-Jacob distance- drawdown curve of the aquifer test was included in Attachment 9. Based on the distance of the observations wells in relation to the pumping well and the recorded drawdown in the wells, the calculated radius of influence of the pumping well (at 57 gpm) is approximately 900 feet after 24 hours of pumping

### **3.3 Drawdown Projections**

Using transmissivity and storage coefficient results from the aquifer test analysis, drawdown over time was predicted using Jacob's formula for determining drawdown at any point. The Jacob formula was calculated using a spreadsheet, and three iterations of data are included in Attachment 12. The highest, lowest and average transmissivity results were used with corresponding storage coefficients to calculate drawdown over time while pumping continuously at 90 gpm, while assuming zero recharge (precipitation) to area influenced by pumping. The highest transmissivity result, from TB-E, should predict drawdown in the shallow saturated interval, logged as sand and gravel. The average transmissivity result (from OW-1 and OW-2) should predict drawdown in the interval developed for the water source, and the lowest transmissivity result (distance – drawdown) may show a worst case sensitivity.

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<sup>4</sup> "Groundwater and Wells", Fletcher G Driscoll, 1986

<sup>5</sup> "Groundwater", R. Allen Freeze, John A. Cherry, 1979



As shown in Attachment 12, projected drawdown in the upper saturated interval is less than 0.1 feet at 1-mile from the pumping well. The projected drawdown in the developed interval using the average transmissivity is approximately 1.3 feet at a distance of 1-mile. The "worst case" drawdown projection is approximately 2.3 feet at 1-mile, after one year of pumping with no precipitation.

#### **4.0 CONCLUSIONS**

A hydrogeologic investigation was conducted to assist in the development of a water source well for secondary oil recovery. Conclusions from this investigation are presented below.

- The nearest surface waters to site are Bear Creek, approximately 0.8 miles southwest, at an elevation of 747 feet above msl. The Betsie River is located approximately 1.25 mile north of the site, at an elevation of 707 feet above msl. Based on data collected to date, sustained pumping at 90 gpm will have no measureable effect on the nearest surface waters.
- The Springdale 16 CPF is located in a rural area with recreational and residential land use. The nearest documented water wells were approximately 0.25 to 0.5-mile north the Springdale 16 CPF along Woods Trail. Based on data obtained to date, sustained pumping at a rate of 90 gpm will have no discernable effect on identified documented water wells. The nearest potential for undocumented water wells appears to be at residences located along the north side of Glover's Lake Road, about 700 feet south of the site. Although construction details of the (assumed) undocumented wells are not known, negative effects on the undocumented water wells are not likely due to the estimated limited drawdown of the shallow saturated interval



- Site soils consist of sand, sand and gravel, and alternating intervals of sand and clay at the maximum explored depth of 180 feet below ground surface (bgs)  
Groundwater near the Springdale 16 occurs under water table conditions at 15 feet bgs.
- During an 24-hour aquifer test, a maximum drawdown of approximately 12.0 feet was observed in the pumping well at a discharge rate of 57 gpm. After 24 hours of pumping, data shows maximum drawdowns of 0.02 feet at TB-W, 0.05 feet at TB-E, 1.59 feet at OW-1, and 1.76 feet at OW-2.
- Recovery data collected for 23 hours following the termination of pumping shows recovery to within 0.02 and 0.03 feet of background water levels at the observation wells.
- Distance-Drawdown analysis shows that the radius of influence of the recovery well at a pumping rate of 57 gpm is approximately 900 feet after 24 hours.
- Transmissivity values from OW-1 and OW-2 data ranged from 2,460 to 5,420 ft<sup>2</sup>/day, with a geometric mean of 4,040 ft<sup>2</sup>/day. Storativity coefficient results for OW-1 and OW-2 averaged 10<sup>-4</sup>.
- The projected drawdown in the developed interval using the average transmissivity is approximately 1.3 feet at a distance of 1-mile, assuming zero recharge via precipitation.

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Project Manager

Reviewed by:



Kevin D. Ringwelski, P.G., C.P.G.  
Director of Environmental Services



# Site Location Map



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Client: Sheet 1 of 1  
**Springdale 16 CPF: Waterflood**  
**Jordan Development Co., LLC**  
 PART OF SECTION 16, T 24 N, R 14 W,  
 SPRINGDALE TOWNSHIP,  
 MANISTEE COUNTY, MICHIGAN

Job No.: 2010563.01  
 Date: 12/01/2010  
 Scale: 1" = 2000'  
 Drawn: jrl  
 Chk'd.: ARB  
 Rev.:



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# Site Aerial - 2009 Imagery



Client:

Sheet 1 of 1

**Springdale 16 CPF: Waterflood**  
**Jordan Development Co., LLC**  
PART OF SECTION 16, T 24 N, R 14 W,  
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MANISTEE COUNTY, MICHIGAN

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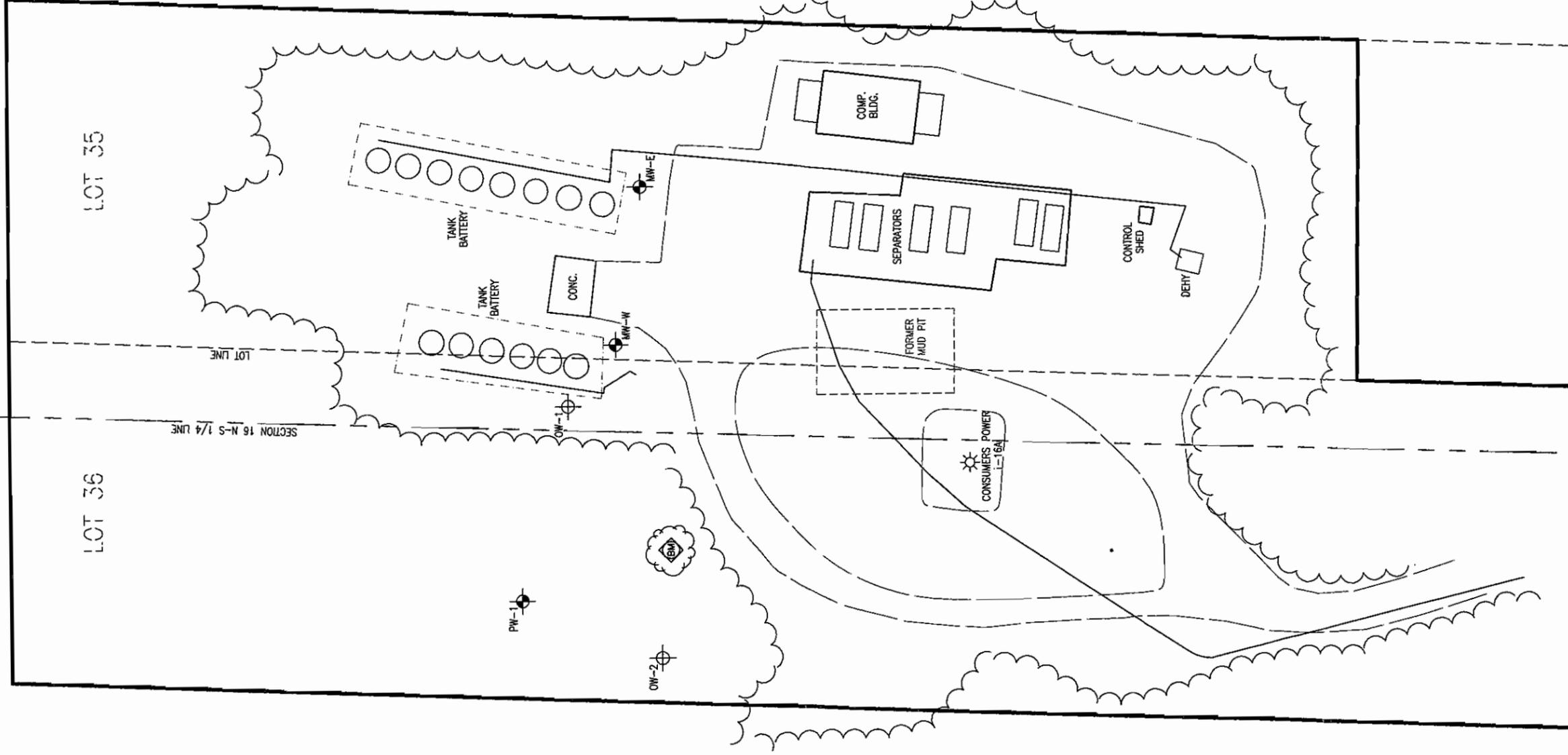


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SCALE  
0' 60' 120'  
1" = 60'

SITE PLAN BASED ON "SPRINGDALE 16 CPF SITE PLAN" PREPARED FOR JORDAN DEVELOPMENT CO., LLC BY GOURDIE-FRASER, DATED 10/06/2010 AND 2009 AERIAL IMAGERY. A PARTIAL SITE SURVEY WAS COMPLETED 12/14/2010 AND WELL LOCATIONS ARE ACCURATE. SOME FEATURE LOCATIONS ARE APPROXIMATE.

Location:  
PART OF SECTION 16,  
T 24 N, R 14 W,  
SPRINGDALE TOWNSHIP,  
MANISTEE COUNTY, MICHIGAN  
Sheet 1 of 1

**Site Plan**  
**Springdale 16 CPF: Waterflood**  
**Jordan Development Co., LLC**

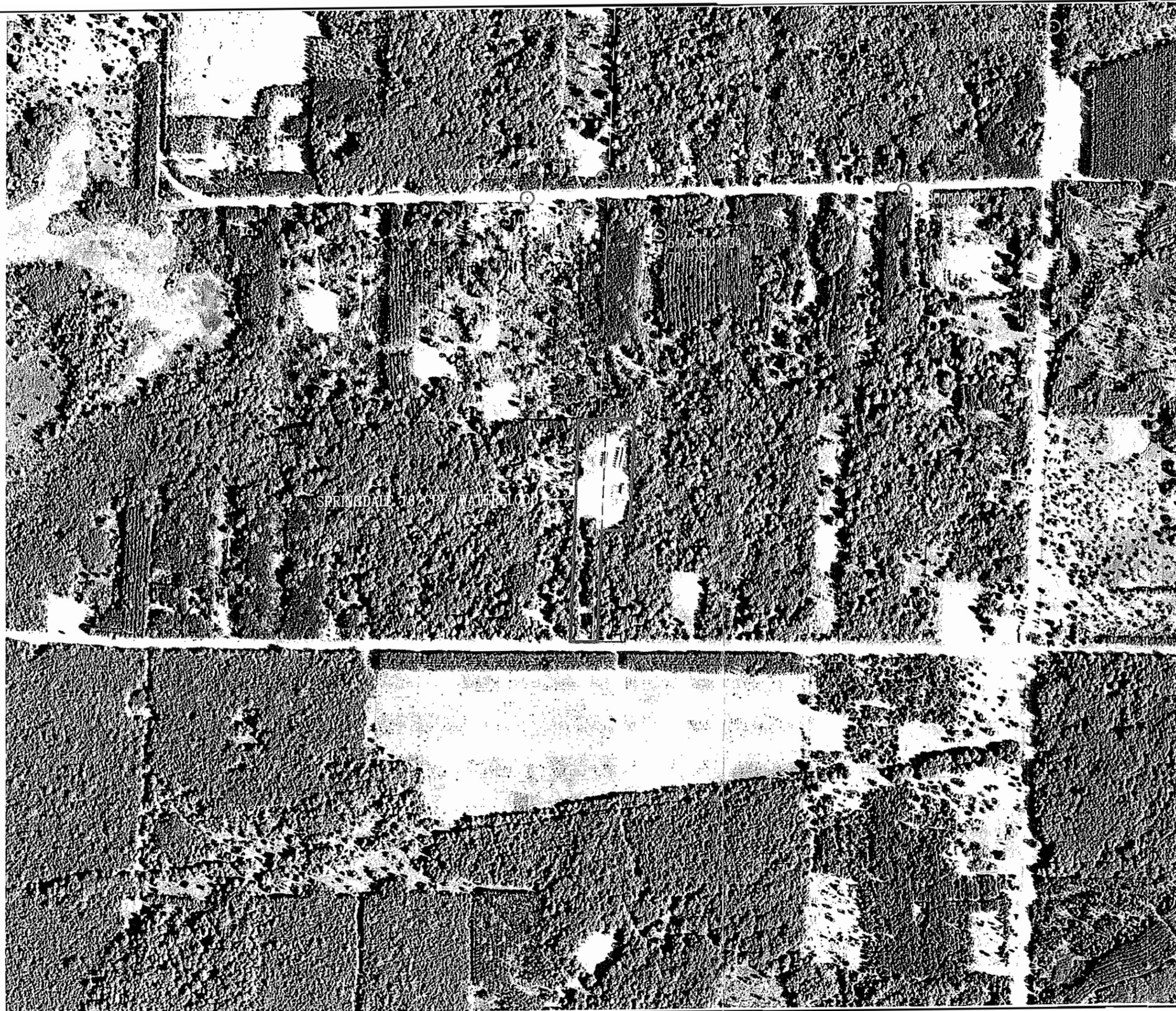
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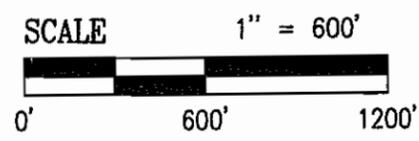
### LEGEND

○ 5100001848 WELL ID. #  
70'-75' SCREENED INTERVAL  
(B.G.S)

Well data is obtained from Wellogic, the Michigan Department of Environmental Quality Statewide Ground Water Database (SGWD). Although it represents the best available data, it cannot be considered a complete database of all the wells or well records in existence.

Beginning January 1, 2000 virtually 100% of new wells constructed are accounted for in Wellogic, however for wells older than 2000 the rate of inclusion varies from county to county, and may be considerably lower.

The locational information provided has varying degrees of accuracy, ranging from GPS point collection, map interpolation and digitizing, to address matching.



Location:  
PART OF SECTION 16,  
T 24 N, R 14 W,  
SPRINGDALE TOWNSHIP,  
MANISTEE COUNTY, MICHIGAN

Sheet 1 of 2

## 2009 Aerial Imagery & Water Well Location Map Springdale 16 CPF - JDC, LLC

Job No.: 2010563.01  
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Rev.:



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- Surveyors
- Environmental Services
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SPRINGDALE 16 CPT WATERFLOOD

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510000039  
05-28

510000040  
11-26

510000070  
70-73





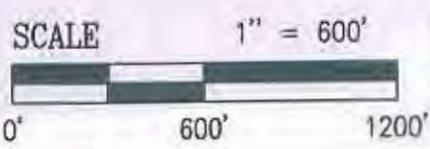
**LEGEND**

51000001848 WELL ID. #  
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Well data is obtained from Wellogic, the Michigan Department of Environmental Quality Statewide Ground Water Database (SGWD). Although it represents the best available data, it cannot be considered a complete database of all the wells or well records in existence.

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**2009 Aerial Imagery & Water Well Location Map Springdale 16 CPF - JDC, LLC**

Location: PART OF SECTION 16,  
T 24 N, R 14 W,  
SPRINGDALE TOWNSHIP,  
MANISTEE COUNTY, MICHIGAN  
Sheet 1 of 2





# Water Well And Pump Record



Completion is required under authority of Part 127 Act 368 PA 1978

Failure to comply is a misdemeanor.

Import ID:

<b>Tax No:</b> 51-13-242-713-01	<b>Permit No:</b> 51-1851	<b>County:</b> Manistee	<b>Township:</b> Springdale		
<b>Well ID: 51000003350</b>		<b>Town/Range:</b> 24N 14W	<b>Section:</b> 16	<b>Well Status:</b> Active	<b>WSSN:</b>
		<b>Source ID/Well No:</b>			
<b>Elevation:</b>					
<b>Latitude:</b> 44 4782824500					
<b>Longitude:</b> -86 0099403300					
<b>Method of Collection:</b> Interpolation-Map					
<b>Distance and Direction from Road Intersection:</b>					
<b>Well Owner:</b> WILLARD BIG JOE					
<b>Well Address:</b> 14662 WOODS TRAIL THOMPSONVILL, MI 49682			<b>Owner Address:</b> 14662 WOODS TRAIL THOMPSONVILL, MI 49682		

<b>Drilling Method:</b> Rotary	<b>Well Use:</b> Household	<b>Pump Installed:</b> Yes	<b>Pump Installation Only:</b> No
<b>Well Depth:</b> 67 00 ft	<b>Date Completed:</b> 12/4/2001	<b>Pump Installation Date:</b>	<b>HP:</b> 0 50
<b>Well Type:</b> New	<b>Height:</b>	<b>Manufacturer:</b> Flint & Walling	<b>Pump Type:</b> Submersible
<b>Casing Type:</b> PVC plastic	<b>Casing Joint:</b> Unknown	<b>Model Number:</b> 10GPM	<b>Pump Capacity:</b> 10 GPM
<b>Casing Fitting:</b> None	<b>Diameter:</b> 5 00 in to 60 00 ft. depth	<b>Drop Pipe Length:</b> 45 00 ft.	<b>Pump Voltage:</b>
<b>Borehole:</b> 8 50 in. to 67 00 ft. depth		<b>Drop Pipe Diameter:</b>	<b>Drilling Record ID:</b>
		<b>Draw Down Seal Used:</b> No	
		<b>Pressure Tank Installed:</b> Yes	
		<b>Pressure Tank Type:</b> Unknown	
		<b>Manufacturer:</b> Well-Rite-Flexcon	
		<b>Model Number:</b>	<b>Tank Capacity:</b>
		<b>Pressure Relief Valve Installed:</b> No	

<b>Static Water Level:</b> 16 00 ft Below Grade (Not Flowing)	<b>Yield Test Method:</b> Air	<b>Formation Description</b>	<b>Thickness</b>	<b>Depth to Bottom</b>
<b>Unrestricted Flow Rate:</b>		Topsoil	1.00	1.00
<b>Well Yield Test:</b>		Sand & Gravel	21.00	22.00
Pumping Level 50 00 ft. after		Sand & Clay	37.00	59.00
		Sand	8.00	67.00

<b>Screen Installed:</b> Yes	<b>Filter Packed:</b> Yes		
<b>Screen Diameter:</b> 4 00 in	<b>Blank:</b> 2 00 ft Above		
<b>Screen Material Type:</b> Unknown			
<b>Slot Length</b>	<b>Set Between</b>		
0.10	5.00 ft		60 00 ft and 67 00 ft.
<b>Fittings:</b> None			

<b>Well Grouted:</b> Yes	<b>Grouting Method:</b> Unknown	<b>Geology Remarks:</b>	
<b>Grouting Material</b>	<b>Bags</b>	<b>Additives</b>	<b>Depth</b>
Bentonite slurry	4.00	None	0.00 ft to 52.00 ft

**Wellhead Completion:** Pitless adapter, 12 inches above grade

<b>Nearest Source of Possible Contamination:</b>	<b>Drilling Machine Operator Name:</b> TONY RIVARD
<b>Type</b>	<b>Employment:</b> Employee
Septic tank	
<b>Distance</b>	<b>Contractor Type:</b> Water Well Drilling Contractor
56 ft	<b>Reg No:</b> 1981
<b>Direction</b>	<b>Business Name:</b> JIM JEFFERS W/D
Northwest	<b>Business Address:</b>

**Water Well Contractor's Certification**

This well was drilled under my supervision and this report is true to the best of my knowledge and belief

**Signature of Registered Contractor** \_\_\_\_\_ **Date** \_\_\_\_\_

**General Remarks:**

**Other Remarks:**

**ATTENTION WELL OWNER: FILE WITH DEED**



MICHIGAN DEPARTMENT OF PUBLIC HEALTH  
**WATER WELL AND PUMP RECORD**

TAX NO:

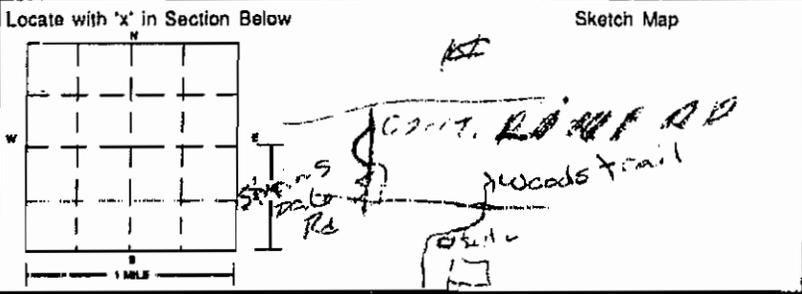
PERMIT NO:  
14093

1 LOCATION OF WELL  
 County Manistee

Township Name SPRINGDALE Fraction 1/4 1/4 1/4 Section No. 16 Town No. 24N Range No. 14W

Distance and Direction from Road Intersection  
Approx. 1 mile down Woodstrail from Springsdale Rd  
 Street Address & City of Well Location Crystal Wood Lots # 88-89

3 OWNER OF WELL Almos T. Tepherson  
 Address 14600 Woodstrail  
Thon, Muskegon Twp.  
 Address Same as Well Location  Yes  No



4 WELL DEPTH: 71 ft. Date Completed 11/19/95  
 New Well  Replacement Well

5  Cable Tool  Rotary  Driven  Dug  
 Hollow Rod  Auger/Bored  Jetted

6 USE:  Household  Type I Public  Type III Public  
 Irrigation  Type IIa Public  Heat Pump  
 Test Well  Type IIb Public

7. CASING:  Steel  Threaded  Welded  
 Plastic  Other  
 Diameter: 5 in to 66 ft depth  
7 7/8 in to 71 ft depth  
 BORE HOLE:  
 Diameter: 7 7/8 in to 71 ft depth  
 in. to \_\_\_\_\_ ft. depth

8. SCREEN:  Not Installed  Gravel-Packed  
 Type SS Diameter 3"  
 Slot/Gauze 12 Length: 5'  
 Set Between 66 ft and 71 ft.  
 FITTINGS:  K-Packer  Bremer Check  
 Blank Above Screen \_\_\_\_\_ ft. Other \_\_\_\_\_

9 STATIC WATER LEVEL:  
50 ft. Below Land Surface  Flowing

10. PUMPING LEVEL: Below Land Surface  
50 ft. After 1 1/2 hrs. Pumping at 12 GPM  
 Plunger  Bailor  Air  Test Pump

11 WELL HEAD COMPLETION:  
 Pitless Adapter  12" Above Grade  
 Basement Offset  Well House

12 WELL GROUTED?  No  Yes From 4 to 60 ft  
 Neat Cement  Bentonite  Other  
 No. of Bags 5 Additives \_\_\_\_\_

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:  
 Type septic Distance 55 ft Direction \_\_\_\_\_  
 Type \_\_\_\_\_ Distance \_\_\_\_\_ ft. Direction \_\_\_\_\_

14. PUMP:  Not Installed  Pump Installation Only  
 Manufacturer's Name Frank  
 Model Number 10BAE HP 1/2 Volts 130  
 Length of Drop Pipe 62 ft. Capacity 7 GPM  
 TYPE:  Submersible  Jet  Other  
 PRESSURE TANK:  
 Manufacturer's Name N.I.  
 Model Number \_\_\_\_\_ Capacity \_\_\_\_\_ Gallons

2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Topsoil + Sand	0	25
Sand + pea gravel	10	35
Sand + Clay Sand + gravel	15	50
Gravel + Water	21	71

**RECEIVED**  
 JUN 16 1998  
**D.H.D. #10**

15 ABANDONED WELL PLUGGED?  Yes  No  
 Casing Diameter 2" in Depth 60 ft  
 PLUGGING MATERIAL:  Neat Cement  Bentonite Slurry  
 Cement/Bentonite Slurry  Concrete Grout  Bentonite Chips  
 No. of Bags 1 Casing Removed?  Yes  No

16 REMARKS: (Elevation Source of Data etc)

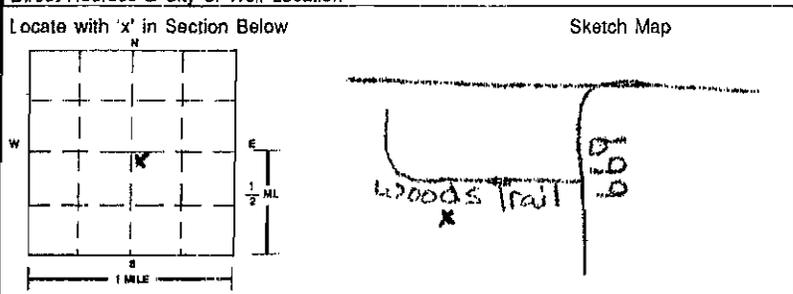
17 DRILLING MACHINE OPERATOR:  
 Employee  Subcontractor  
 Name Joe Demarcio

15 WATER WELL CONTRACTOR'S CERTIFICATION:  
 This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief  
Stanbridge Well Digs 0974  
 REGISTERED BUSINESS NAME REGISTRATION NO.  
 Address 6015 Benzyl Purse  
 Signed Ronald J. Stanbridge Date 2-19-96  
 AUTHORIZED REPRESENTATIVE



1 LOCATION OF WELL  
 County: MANISTEE Township Name: Springdale Fraction: SW 1/4 Section No: 10 Town No: T. 24 N Range No: R. 14 W

Distance and Direction from Road Intersection  
West of 669 on 14787 Woods Trail



3 OWNER OF WELL  
 Bert Hamilton  
 Address: Bert Hamilton 14787 Woods Trail Thompsonville, MI  
 Address Same as Well Location  Yes  No

4 WELL DEPTH: 83 ft. Date Completed: 1/5/98  
 New Well  Replacement Well

5  Cable Tool  Rotary  Driven  Dug  
 Hollow Rod  Auger/Bored  Jetted

6 USE:  Household  Type I Public  Type III Public  
 Irrigation  Type IIa Public  Heat Pump  
 Test Well  Type IIb Public

7 CASING:  Steel  Threaded  Plastic  Welded  Other  
 Height: Above/Below Surface: 1 ft  
 Diameter: 5 in to 76 ft depth  
 Weight: SBR2 lbs/ft  
 BORE HOLE:  Drive Shoe  Shale Packer  
 Diameter: 8 1/2 in to 83 ft depth

8 SCREEN:  Not Installed  Gravel-Packed  
 Type: Johnson Wop Diameter: Full 4"  
 Slot/Gauze: 0.12 Length: 5  
 Set Between: 76 ft and 83 ft  
 FITTINGS:  K-Packer  Bremer Check  Blank Above Screen 2 ft. Other

9 STATIC WATER LEVEL: 16 ft. Below Land Surface  Flowing

10 PUMPING LEVEL: Below Land Surface 45 ft After \_\_\_\_\_ hrs. Pumping at \_\_\_\_\_ GPM  
 Plunger  Bailor  Air  Test Pump

11 WELL HEAD COMPLETION:  Pitless Adapter  12" Above Grade  
 Basement Offset  Well House

12 WELL GROUTED?  No  Yes From 0 to 68 ft  
 Neat Cement  Bentonite  Other  
 No. of Bags: 6 Additives: E-Z Mud

13 NEAREST SOURCE OF POSSIBLE CONTAMINATION:  
 Type: Septic Distance: 73 ft Direction: S  
 Type: \_\_\_\_\_ Distance: \_\_\_\_\_ ft. Direction: \_\_\_\_\_

14 PUMP:  Not Installed  Pump Installation Only  
 Manufacturer's Name: Flint & Walling  
 Model Number: 10 GPM HP: 1/2 Volts: 230  
 Length of Drop Pipe: 40 ft Capacity: 10 GPM  
 TYPE:  Submersible  Jet  Other  
 PRESSURE TANK:  
 Manufacturer's Name: Well Rite  
 Model Number: WR-60 Capacity: 20 Gallons

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top	1	1
Sand + some Gravel	20	21
Clay + SAND MIX	43	64
SAND	19	83

RECEIVED  
 MICH DEPT OF ENVIRONMENTAL QUALITY  
 FEB 09 1998  
 Drinking Water & Ecological Protection Division  
 Ground Water Supply Section  
 WELL CONSTRUCTION UNIT

RECEIVED  
 JAN 22 1998  
 D.H.D. #10

USE A 2ND SHEET IF NEEDED

15 ABANDONED WELL PLUGGED?  Yes  No  
 Casing Diameter: 1 1/4 in Depth: 27 ft  
 PLUGGING MATERIAL:  Neat Cement  Bentonite Slurry  
 Cement/Bentonite Slurry  Concrete Grout  Bentonite Chips  
 No. of Bags: 14 Casing Removed?  Yes  No

16 REMARKS: (Elevation, Source of Data, etc)

18 WATER WELL CONTRACTOR'S CERTIFICATION:  
 This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief  
Jim Jeffers Well Drilling 83-1981  
 REGISTERED BUSINESS NAME: \_\_\_\_\_ REGISTRATION NO. \_\_\_\_\_  
 Address: 4498 12 Road Manistee, MI 49667  
 Signed: Jim Jeffers Date: 1-7-98  
 AUTHORIZED REPRESENTATIVE





**WATER WELL AND PUMP RECORD**

PERMIT NUMBER

1 2482

**1 LOCATION OF WELL**

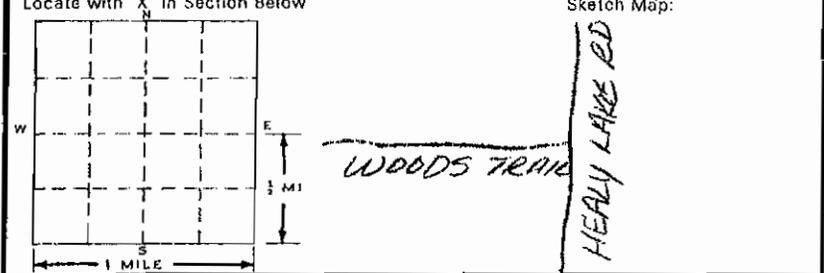
County: MANISTEE Township Name: SPRINGDALE Fraction: 1/4 Section Number: 16 Town Number: 24 Range Number: 14 NW

Distance And Direction From Road Intersection  
CRYSTAL WOODS LOT 90

Street Address & City of Well Location  
14558 WOODS TRAIL

**3 OWNER OF WELL:** MR STATWICK  
Address: 14558 WOODS TRAIL  
COPENASH MI 49625

Address Same As Wolf Location?  Yes  No



**4 WELL DEPTH:** 58 FT. Date Completed: 7-25-94

New Well  
 Replacement Well

**5**  Cable tool  Rotary  Driven  Dug  
 Hollow rod  Auger  Jetted

**6 USE:**  Domestic  Type I Public  Type III Public  
 Irrigation  Type IIa Public  Heat pump  
 Test Well  Type IIb Public

**7 CASING:** Diameter:  Steel  Threaded Height: Above/Below Surface 1 ft  
 Plastic  Welded Weight 3.75 lbs/ft

2 in to 54 ft depth  
Grouted Drill Hole Diameter: \_\_\_\_\_ in. to \_\_\_\_\_ ft depth  
Drive Shoe  Yes  No

**2 FORMATION DESCRIPTION**

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
<u>YELLOW SAND</u>	<u>15'</u>	<u>15'</u>
<u>YELLOW CLAY</u>	<u>7'</u>	<u>22'</u>
<u>YELLOW SAND &amp; CLAY</u>	<u>2'</u>	<u>24'</u>
<u>YELLOW SAND</u>	<u>8'</u>	<u>32'</u>
<u>GRAY CLAY</u>	<u>16'</u>	<u>48'</u>
<u>GRAY WATER SAND</u>	<u>10'</u>	<u>58'</u>

**8 SCREEN:**  Not Installed  
Type: STAINLESS Diameter: 1 1/4"  
Slot/Gauge: 60 Length: 4'  
Set between: 54 ft and 58 ft  
FITTINGS:  K-Packer  Lead Packer  Bremer Check  
 Blank above screen \_\_\_\_\_ ft. Other: \_\_\_\_\_

**9 STATIC WATER LEVEL:** 10 ft. below land surface  Flow

**10 PUMPING LEVEL:** below land surface  
15 ft after 2 hrs pumping at 12 GPM  
\_\_\_\_\_ ft after \_\_\_\_\_ hrs pumping at \_\_\_\_\_ GPM

**11 WELL HEAD COMPLETION:**  Pitless adapter  12" above grade  
 Basement offset  Approved pit

**12 WELL GROUTED?**  No  Yes From \_\_\_\_\_ to \_\_\_\_\_ ft  
 Neat cement  Bentonite  Other \_\_\_\_\_  
No. of bags of cement \_\_\_\_\_ Additives \_\_\_\_\_

**13 Nearest source of possible contamination**  
Type: SEPTIC Distance: 60 ft. Direction: NW  
Well disinfected upon completion?  Yes  No  
Was old well plugged?  Yes  No

**14 PUMP:**  Not Installed  Pump Installation Only  
Manufacturer's name: FLINTCO WALLING  
Model number: E-KO55 HP: 1/2 Volts: 115  
Length of Drop Pipe: 20 ft. capacity: 8 GPM  
TYPE:  Submersible  Jet  
PRESSURE TANK  
Manufacturer's name: CON AIRE  
Model number: CA15 Capacity: \_\_\_\_\_ Gallons

**15 Remarks** elevation source of data etc

**17 Rig Operator's Name:** PHIL KLUESNER

**16 WATER WELL CONTRACTOR'S CERTIFICATION:**  
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief  
PHIL KLUESNER Well Drilling 190  
REGISTERED BUSINESS NAME REGISTRATION NO  
Address: PO Box 67 BRETHREN MI 496  
Signed: \_\_\_\_\_ Date: 7-28-94  
AUTHORIZED REPRESENTATIVE

TAX NO: OK

# MICHIGAN DEPARTMENT OF PUBLIC HEALTH WATER WELL AND PUMP RECORD

PERMIT NO: 15053

1 LOCATION OF WELL  
County Manistee

Township Name Springdale

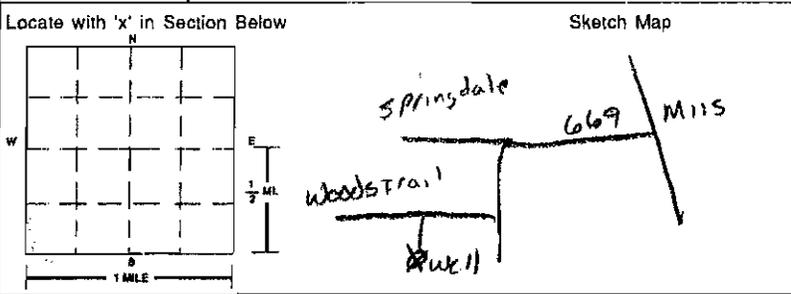
Fraction 1/4 1/4 1/4

Section No. 11

Town No. 24 N

Range No. 14 W

Distance and Direction from Road Intersection  
Woodstail 300' west of C.R. 669



3 OWNER OF WELL  
Address John & Judith Shellhass  
Woodstail,  
Thompsonville, MI 49683  
Address Same as Well Location  Yes  No

4. WELL DEPTH: 128 ft. Date Completed 11/10/97  
 New Well  
 Replacement Well

5  Cable Tool  Rotary  Driven  Dug  
 Hollow Rod  Auger/Bored  Jetted

6. USE:  Household  Type I Public  Type III Public  
 Irrigation  Type IIa Public  Heat Pump  
 Test Well  Type IIb Public

7 CASING:  Steel  Threaded  Plastic  Welded  
 Other  
Height: Above/Below Surface: 1 ft  
Diameter: 5 in to 123 ft depth  
Weight: 2 lbs/ft  
BORE HOLE:  Drive Shoe  Shale Packer  
Diameter: 7 7/8 in to 128 ft depth

8 SCREEN:  Not Installed  Gravel-Packed  
Type Full W.O.P. Diameter 4"  
Slot/Gauze 20 Length: 5'  
Set Between 123 ft and 128 ft  
FITTINGS:  K-Packer  Bremer Check  
 Blank Above Screen 2' ft, Other

9 STATIC WATER LEVEL: 12 ft. Below Land Surface  Flowing

10 PUMPING LEVEL: Below Land Surface  
18 ft. After 1 hrs. Pumping at 10 G.P.M.  
 Plunger  Bailor  Air  Test Pump

11 WELL HEAD COMPLETION:  Pitless Adapter  12" Above Grade  
 Basement Offset  Well House

12 WELL GROUTED?  No  Yes From 0 to 110 ft  
 Neat Cement  Bentonite  Other  
No. of Bags 10 Additives

13 NEAREST SOURCE OF POSSIBLE CONTAMINATION:  
Type Septic Distance 70' ft Direction E  
Type \_\_\_\_\_ Distance \_\_\_\_\_ ft. Direction \_\_\_\_\_

14 PUMP:  Not Installed  Pump Installation Only  
Manufacturer's Name SPR Rite  
Model Number 10SP4C02J HP 1/2 Volts 230  
Length of Drop Pipe 45 ft Capacity 10 G.P.M.  
TYPE:  Submersible  Jet  Other  
PRESSURE TANK:  
Manufacturer's Name Well Mate  
Model Number WML6 Capacity 30 Gallons 6

2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
<u>SAND</u>	<u>18</u>	<u>18</u>
<u>Clay (Blue)</u>	<u>86</u>	<u>104</u>
<u>SAND + Gravel</u>	<u>14</u>	<u>118</u>

RECEIVED  
MICH DEPT OF ENVIRONMENTAL QUALITY  
JAN 07 1998  
Drinking Water & Radiological Protection Division  
Ground Water Supply Section  
WELL CONSTRUCTION UNIT

RECEIVED  
JAN 18 1998  
D.H.D. #10

15. ABANDONED WELL PLUGGED?  Yes  No  
Casing Diameter \_\_\_\_\_ in Depth \_\_\_\_\_ ft  
PLUGGING MATERIAL:  Neat Cement  Bentonite Slurry  
 Cement/Bentonite Slurry  Concrete Grout  Bentonite Chips  
No. of Bags \_\_\_\_\_ Casing Removed?  Yes  No

16. REMARKS: (Elevation Source of Data, etc)

17 DRILLING MACHINE OPERATOR:  
 Employee  Subcontractor  
Name Michael MacEachern

15 WATER WELL CONTRACTOR'S CERTIFICATION:  
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief  
Kastl Well Drilling 83-2175  
REGISTERED BUSINESS NAME REGISTRATION NO.  
Address 9287 W. 30 1/2 Rd Hartsville, MI 49638  
Signed [Signature] Date 11-10-97  
AUTHORIZED REPRESENTATIVE

DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION

**WATER WELL AND PUMP RECORD**

Completion is required under authority of Part 127 Act 368 PA 1978  
Failure to comply is a misdemeanor

PERMIT NO:

14434

TAX NO:

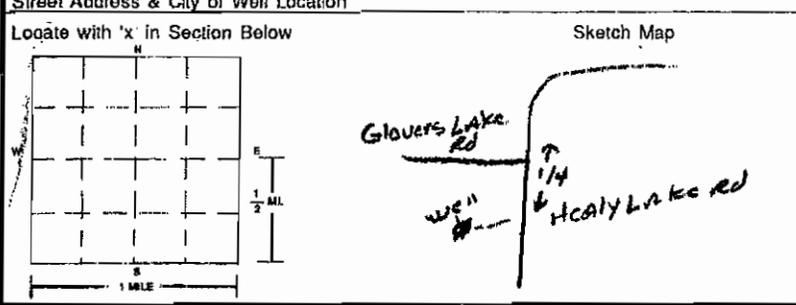
1 LOCATION OF WELL

County Manistee

Township Name Springdale Fraction 1/4 1/4 1/4 Section No. 21 Town No. 24N Range No. 14W

Distance and Direction from Road Intersection

Street Address & City of Well Location



2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	36	36
Clay @ 37'		

USE A 2ND SHEET IF NEEDED

15 ABANDONED WELL PLUGGED?  Yes  No

Casing Diameter \_\_\_\_\_ in Depth \_\_\_\_\_ ft.

PLUGGING MATERIAL:  Neat Cement  Bentonite Slurry  Cement/Bentonite Slurry  Concrete Grout  Bentonite Chips

No. of Bags \_\_\_\_\_ Casing Removed?  Yes  No

16 REMARKS: (Elevation, Source of Data, etc.)

17 DRILLING MACHINE OPERATOR:

Employee  Subcontractor

Name Michael MacEachern

3 OWNER OF WELL

Address Rick Fredericks  
10302 Eastman Ave  
Beulah MI 49617

Address Same as Well Location  Yes  No

4 WELL DEPTH: 36 ft. Date Completed 10/1/97

New Well  Replacement Well

5  Cable Tool  Rotary  Driven  Dug

Hollow Rod  Auger/Bored  Jetted

6 USE:  Household  Type I Public  Type III Public

Irrigation  Type IIa Public  Heat Pump

Test Well  Type IIb Public

7 CASING:  Steel  Threaded  Plastic  Welded

Other \_\_\_\_\_

Height: Above/Below Surface: 1 ft

Diameter: 5 in to 31 ft depth

Weight: \_\_\_\_\_ lbs/ft

BORE HOLE:  Drive Shoe  Shale Packer

Diameter: 7 7/8 in to 36 ft depth

in. to \_\_\_\_\_ ft. depth

8 SCREEN:  Not Installed  Gravel Packed

Type Stainless Steel 1 Diameter 3'

Slot/Screen 10 Length: 4'

Set Between 31 ft and 36 ft

FITTINGS:  K-Packer  Bremer Check

Blank Above Screen 2' ft. Other 1' Blank on Bottom

9 STATIC WATER LEVEL: 12 ft. Below Land Surface  Flowing

10 PUMPING LEVEL: Below Land Surface 15 ft After 3 1/2 hrs. Pumping at 10 G.P.M.

Plunger  Bailer  Air  Test Pump

11 WELL HEAD COMPLETION:  Pitless Adapter  12" Above Grade

Basement Offset  Well House

12 WELL GROUTED?  No  Yes From 0 to 30 ft

Neat Cement  Bentonite  Other \_\_\_\_\_

No. of Bags 2 Additives \_\_\_\_\_

13 NEAREST SOURCE OF POSSIBLE CONTAMINATION:

Type Septic Distance 80 ft Direction S

Type \_\_\_\_\_ Distance \_\_\_\_\_ ft. Direction \_\_\_\_\_

14. PUMP:  Not Installed  Pump Installation Only

Manufacturer's Name STA. Rite

Model Number 1054002 HP 1/2 Volts 230

Length of Drop Pipe 25 ft Capacity 10 G.P.M.

TYPE:  Submersible  Jet  Other \_\_\_\_\_

PRESSURE TANK:

Manufacturer's Name Well Mate

Model Number WML6 Capacity 20 Gallons 6

18 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief

Kastl Well Drilling 83-2175

REGISTERED BUSINESS NAME REGISTRATION NO.

Address 9287 W. 30 1/2 Rd Hartsville MI 49638

Signed Michael MacEachern Date 10-1-97

AUTHORIZED REPRESENTATIVE

RECEIVED

SEP 03 1998

D.H.D. #10

STATE OF MICHIGAN  
DEPARTMENT OF NATURAL RESOURCES  
LOG OF OIL, GAS OR MINERAL WELL WATER WELL  
SUBMIT IN TRIPLICATE WITHIN 30 DAYS AFTER WELL COMPLETION

1. LOCATION DATA

NAME(S) & ADDRESS OF OWNER(S) SHOWN ON PERMIT  
MIT

NAME & ADDRESS OF DRILLING CONTRACTOR(S)

L & R Well Drilling  
R.R. #1 Box 78  
Elmira, Mi. 49730

EASE NAME(S) & WELL NUMBER SHOWN PERMIT  
MIT - Steck 1-21

PERMIT NUMBER

COUNTY  
Manistee

TOWNSHIP  
Springdale

FRACTION  
NW 1/4 NW 1/4 SW 1/4

SECTION NO.  
21

TOWN NO  
24 N/S

RANGE NO  
14 E/W

2	FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM	3 WELL DEPTH (completed)		Date of Completion	
				50 ft		08-27-90	
	Sand	30	30	4 <input type="checkbox"/> Cable tool <input type="checkbox"/> Rotary <input type="checkbox"/> Driven <input type="checkbox"/> Don			
	Medium Sand	20	50	<input type="checkbox"/> Hollow rod <input checked="" type="checkbox"/> Auger <input type="checkbox"/> Jetted <input type="checkbox"/>			
				5. CASING		Height Above/Below	
				Diameter <input checked="" type="checkbox"/> Steel <input checked="" type="checkbox"/> Fluted <input type="checkbox"/> Welded		Surface 2 ft	
				4 <input type="checkbox"/> Base <input type="checkbox"/> 45 ft depth		Weight 11 lbs/ft	
				7 <input type="checkbox"/> 50 ft depth		Drive Shoe <input type="checkbox"/> Yes <input type="checkbox"/> No	
				6. SCREEN		<input type="checkbox"/> Not installed	
				Type Johnson S.S.	Diameter 4"		
				Slot/Gauge 12	Length 5'		
				Set between 45 ft and 50 ft			
				FITTINGS <input type="checkbox"/> K Packer <input type="checkbox"/> Lead Packer <input type="checkbox"/> Blower Check			
				<input type="checkbox"/> Blank above screen <input type="checkbox"/> Other			
				7. STATIC WATER LEVEL			
				17 ft below land surface <input type="checkbox"/> Flow			
				8. PUMPING LEVEL below land surface			
				17 ft after 1 hrs pumping at 60 GPM			
				ft after hrs pumping at GPM			
				9. WELL GROUDED? <input type="checkbox"/> No <input checked="" type="checkbox"/> Yes From 0 to 25 ft			
				<input type="checkbox"/> Near casing <input checked="" type="checkbox"/> Bottom to <input type="checkbox"/> Other			
				No. of bags of cement Archives			
				10. PUMP <input type="checkbox"/> Not installed <input type="checkbox"/> Pump installation O.K.			
				Manufacturer's name			
				Model number HP Volts			
				Length of Drop Pipe ft capacity GPM			
				TYPE <input type="checkbox"/> Submersible <input type="checkbox"/> Jet			
	11. REMARKS (ELEVATION, SOURCE OF DATA, WATER QUALITY, ETC.)						

(USE A 2ND SHEET IF NEEDED)

12. AUTHORIZED REPRESENTATIVE CERTIFICATION (THIS WELL WAS DRILLED UNDER MY AUTHORITY AND THIS REPORT IS TRUE TO THE BEST OF MY KNOWLEDGE AND BELIEF)

NAME L & R Well Drilling

PRINT OR TYPE

ADDRESS Rt. 1 Elmira, Mich. 49730

Tom Skryock

DATE 10/14/10

(USE A 2ND SHEET ON ATTACH SHEETMENTS IF NEEDED)

**WATER WELL AND PUMP RECORD**

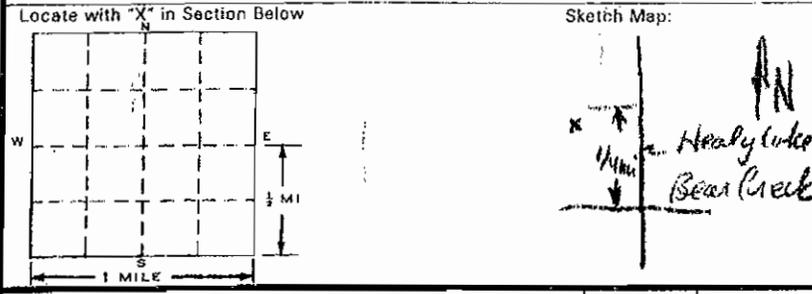
PERMIT NUMBER

1 LOCATION OF WELL

County <i>Manistee</i>	Township Name <i>Springdale</i>	Fraction <i>NE 1/4 SE 1/4</i>	Section Number <i>121</i>	Town Number <i>24 N</i>	Range Number <i>14 E</i>
---------------------------	------------------------------------	----------------------------------	------------------------------	----------------------------	-----------------------------

Distance And Direction From Road Intersection  
*1/4 mi N of Bear Creek on W side of Healy Lake Rd*

Street Address & City of Well Location



3 OWNER OF WELL:  
*Mr Harold Nearhood*

Address  
*15266 Healy Lake Rd. Bear Lake, Mich 49614*

Address Same As Well Location?  Yes  No

4 WELL DEPTH: *50* FT. Date Completed MO. *6* DAY *20* YEAR *92*

New Well  Replacement Well

5  Cable tool  Rotary  Driven  Dug  
 Hollow rod  Auger  Jetted

USE:  Domestic  Type I Public  Type III Public  
 Irrigation  Type IIa Public  Heat pump  
 Test Well  Type IIb Public

7 CASING: Diameter  Steel  Threaded  Plastic  Weided

*4* in to *44* ft depth Height:  Above  Below  
 Surface *1* ft  
 Weight *11.8* lbs/ft

GROUTED DRILL HOLE DIAMETER  
 \_\_\_\_\_ in. to \_\_\_\_\_ ft. depth  
 Drive Shoe  Yes  No

2 FORMATION DESCRIPTION

THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
----------------------	----------------------------

<i>Top Soil</i>	<i>1</i>	<i>1</i>
<i>Red Sand</i>	<i>2</i>	<i>3</i>
<i>Sand</i>	<i>13</i>	<i>16</i>
<i>Sand &amp; Water</i>	_____	

8 SCREEN:  Not Installed

Type *WOP* Diameter *4"*  
 Gauze *7* Length *7'*  
 Set between \_\_\_\_\_ ft and \_\_\_\_\_ ft

FITTINGS:  K-Packer  Lead Packer  Bremer Check  
 Blank above screen *2* ft. Other \_\_\_\_\_

9 STATIC WATER LEVEL: *16* ft. below land surface  Flow

10 PUMPING LEVEL: below land surface

\_\_\_\_\_ ft after *1* hrs pumping at *30* GPM  
 \_\_\_\_\_ ft after \_\_\_\_\_ hrs pumping at \_\_\_\_\_ GPM

11 WELL HEAD COMPLETION:  Pitless adapter  12" above grade  
 Basement offset  Approved pit

12 WELL GROUTED?  No  Yes From *0* to *all* ft

Neat cement  Bentonite  Other \_\_\_\_\_

No. of bags of cement *5* Additives \_\_\_\_\_

13 Nearest source of possible contamination

Type *Septic* Distance *60* ft. Direction *W*

Well disinfected upon completion?  Yes  No  
 Was old well plugged?  Yes  No

14 PUMP:  Not Installed  Pump Installation Only

Manufacturer's name *Banks*  
 Model number *55HB* HP *1/2* Volts *115*  
 Length of Drop Pipe *35* ft. capacity *10* GPM  
 TYPE:  Submersible  Jet

PRESSURE TANK: Manufacturer's name *Amiral*  
 Model number *202* Capacity *20* Gallons

**RECEIVED**  
 Mich. Dept. of Public Health  
 OCT 8 1992

BUREAU OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH-GWQS  
 USE A 2ND SHEET IF NEEDED

15 Remarks elevation source of data, etc.

17 Rig Operator's Name:  
*Ed Benson*

16 WATER WELL CONTRACTOR'S CERTIFICATION:  
 This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief

*Ed Benson Well Drilling* *51-1603*  
 REGISTERED BUSINESS NAME REGISTRATION NO  
 Address *14645 Kanges Rd Kalamazoo, Mich*  
 Signed *Ed Benson* Date *6-21-92*  
 AUTHORIZED REPRESENTATIVE

Authority: Act 368 PA 1978  
 Completion: Required  
 Penalty: Conviction of a violation of any provision is a misdemeanor

WATER WELL RECORD  
ACT 294 PA 1965

MICHIGAN DEPARTMENT  
OF  
PUBLIC HEALTH

1 LOCATION OF WELL		County <i>Manistee</i>		Twp. <i>Springdale</i>		Fraction <i>NW 1/4 SE 1/4</i>		Section No. <i>21</i>		Town <i>24 NA</i>		Range <i>14 W.</i>	
Distance And Direction from Road Intersections <i>1/2 mi W. of Peony Station</i>				OWNER No. _____		3 OWNER OF WELL: Address <i>State 7 n.s.l. 1st chert Harrietta, Mich</i>							
Street address & City of Well Location				2 FORMATION		THICKNESS OF STRATUM		DEPTH TO BOTTOM OF STRATUM		4 WELL DEPTH: (completed) Date of Completion <i>175 ft. Aug. 7, 1967</i>			
<i>Surface dirt &amp; fill</i>				<i>10'</i>		<i>10'</i>		5 <input type="checkbox"/> Cable tool <input type="checkbox"/> Rotary <input type="checkbox"/> Driven <input type="checkbox"/> Dug <input checked="" type="checkbox"/> Hollow rod <input type="checkbox"/> Jetted <input type="checkbox"/> Bored <input type="checkbox"/> _____					
<i>Coarse Sand yellow &amp; brown</i>				<i>10'</i>		<i>29'</i>		6 USE: <input checked="" type="checkbox"/> Domestic <input type="checkbox"/> Public Supply <input type="checkbox"/> Industry <input type="checkbox"/> Irrigation <input type="checkbox"/> Air Conditioning <input type="checkbox"/> Commercial <input type="checkbox"/> Test Well					
<i>Clay, red &amp; brown</i>				<i>76'</i>		<i>96'</i>		7 CASING: Diam. Threaded <input checked="" type="checkbox"/> Welded <input type="checkbox"/> <i>2 in. to 171 ft. Depth</i> Height: Above/Below surface <i>1</i> ft. Weight <i>3.75</i> lbs./ft. Drive Shoe? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>					
<i>Sand, yellow coarse &amp; fine</i>				<i>89'</i>		<i>185'</i>		8 SCREEN: Type: <i>Open end</i> Dia.: <i>1 1/4"</i> Slot/Gauze <i>60</i> Length <i>4'</i> Set between <i>171</i> ft and <i>175</i> ft. Fittings: <i>K packer 5' Tail &amp; fore piece Beemer check</i>					
<i>Layered gravel, coarse with rocks, small - Clay, brown -</i>								9 STATIC WATER LEVEL <i>0</i> ft. below land surface					
<i>Sand, yellow, coarse &amp; fine</i>				<i>22'</i>		<i>207'</i>		10 PUMPING LEVEL below land surface _____ ft. after _____ hrs pumping _____ g p m _____ ft. after _____ hrs pumping _____ g p m					
								11 WATER QUALITY in Parts Per Million: Iron (Fe) _____ Chlorides (Cl) _____ Hardness _____					
								12 WELL HEAD COMPLETION: <input type="checkbox"/> In Approved Pit <input type="checkbox"/> Pitless Adapter <input checked="" type="checkbox"/> 12" Above Grade					
								13 GROUTING: Well Grouted? <input type="checkbox"/> Yes <input type="checkbox"/> No Material: <input type="checkbox"/> Neat Cement <input type="checkbox"/> _____ Depth: From _____ ft. to _____ ft.					
								14 SANITARY: Nearest Source of possible contamination _____ feet _____ Direction _____ Type Well disinfected upon completion <input type="checkbox"/> Yes <input type="checkbox"/> No					
								15 PUMP: Manufacturer's Name _____ Model Number _____ HP _____ Length of Drop Pipe _____ ft. capacity _____ G P M Type: <input type="checkbox"/> Submersible <input type="checkbox"/> _____ <input type="checkbox"/> Jet <input type="checkbox"/> Reciprocating					

Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER. ITEM NO. \_\_\_\_\_

CORRECTED BY: \_\_\_\_\_

\*\*ADDITION BY: \_\_\_\_\_

17 WATER WELL CONTRACTOR'S CERTIFICATION:  
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

*Country Line Company* *0539*  
REGISTERED BUSINESS NAME REGISTRATION NO.

Address *15000 Michigan*

Signed *Wm. Peterson* Date *Oct 7 68*  
AUTHORIZED REPRESENTATIVE



Project Name: Springdale 16: Source Well HGI  
Location: Springdale Twp., Manistee Co., Michigan  
Project Number: 2010563.01  
Client: Jordan Development

Page 1 **BORING NO: Test Hole**

Contractor: Shepler Well Drilling  
Crew Chief: D. Kropp  
Drill Method: Mud Rotary  
Boring Dia. (in ): 4  
Boring Depth (ft ): 180 Date Drilled: 12-6-2010  
Logged By: A. Biteman

**Borehole Completion Notes:**

Test hole near future PW-1 location 4-inch borehole was abandoned with Benseal/EZ-mud bentonite slurry placed via tremmie methods

Groundwater Encountered While Drilling at: 17 ft bgs  
Ground Elevation: 779 Static Water 17 ft bgs

Graphic Log	Soil Classification (Color, Texture, Structure)	Depth (ft)	Sample	Blow Counts	Undefined	Undefined
	Fine to medium SAND - some silt - trace gravel					
	Fine to coarse SAND and GRAVEL - occasional cobble	25				
	Fine to medium SAND - little silt - occasional clay layers	50				
	Medium SAND					
	Clay Silty SAND - frequent clay seams	75				
	Clay SAND and CLAY (alternating, 2 to 5 ft thick layers)	100				
		125				
		150				
	CLAY - hard	175				
	End of boring at 180 feet					

Cutting Samples

P:\2010563\_01\Well Logs.wfp



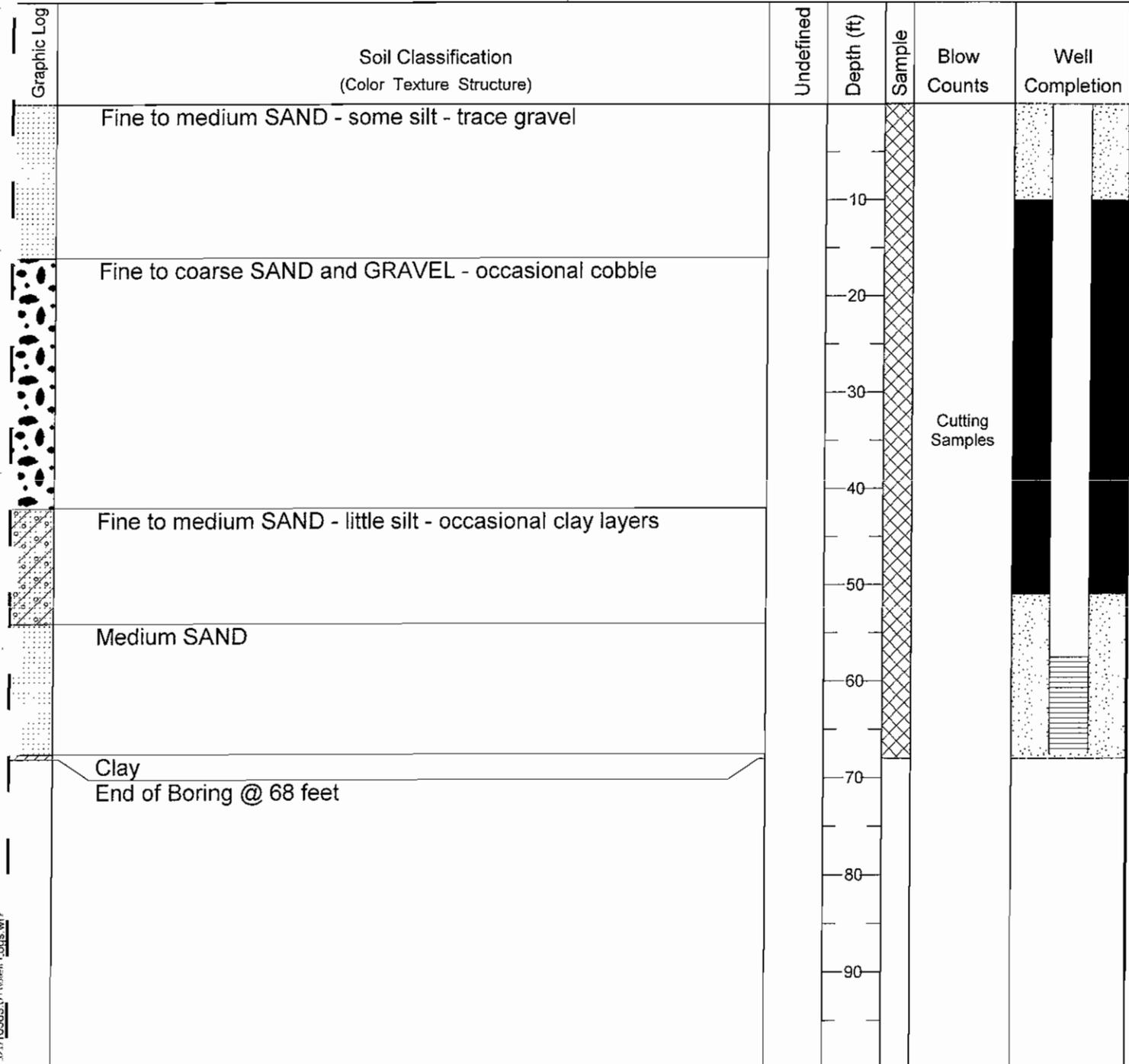
Project Name: Springdale 16: Source Well HGI  
Location: Springdale Twp., Manistee Co., Michigan  
Project Number: 2010563.01  
Client: Jordan Development

Well Completion Notes (casing/screen dia , type,length):  
PW-1 was constructed of 8-inch SDR 21 casing and a 6-inch by 10 foot 20 slot stainless steel telescope screen Well screen annulus was filter packed to 51 feet Casing annulus was tremmie grouted with Benseal/EZ-mud bentonite slurry

Page 1 **WELL NO:** **PW-1**

Contractor: Shepler Well Drilling  
Crew Chief: D. Kropp  
Drill Method: Mud Rotary  
Boring Dia. (in.): 12.25  
Boring Depth (ft.): 68 Date Drilled: 12-7-2010  
Logged By: E. Vincke

TOC Elevation: 780.96 Static Water 19.26 ft bgs/~~XOX~~  
Ground Elevation: 779.2



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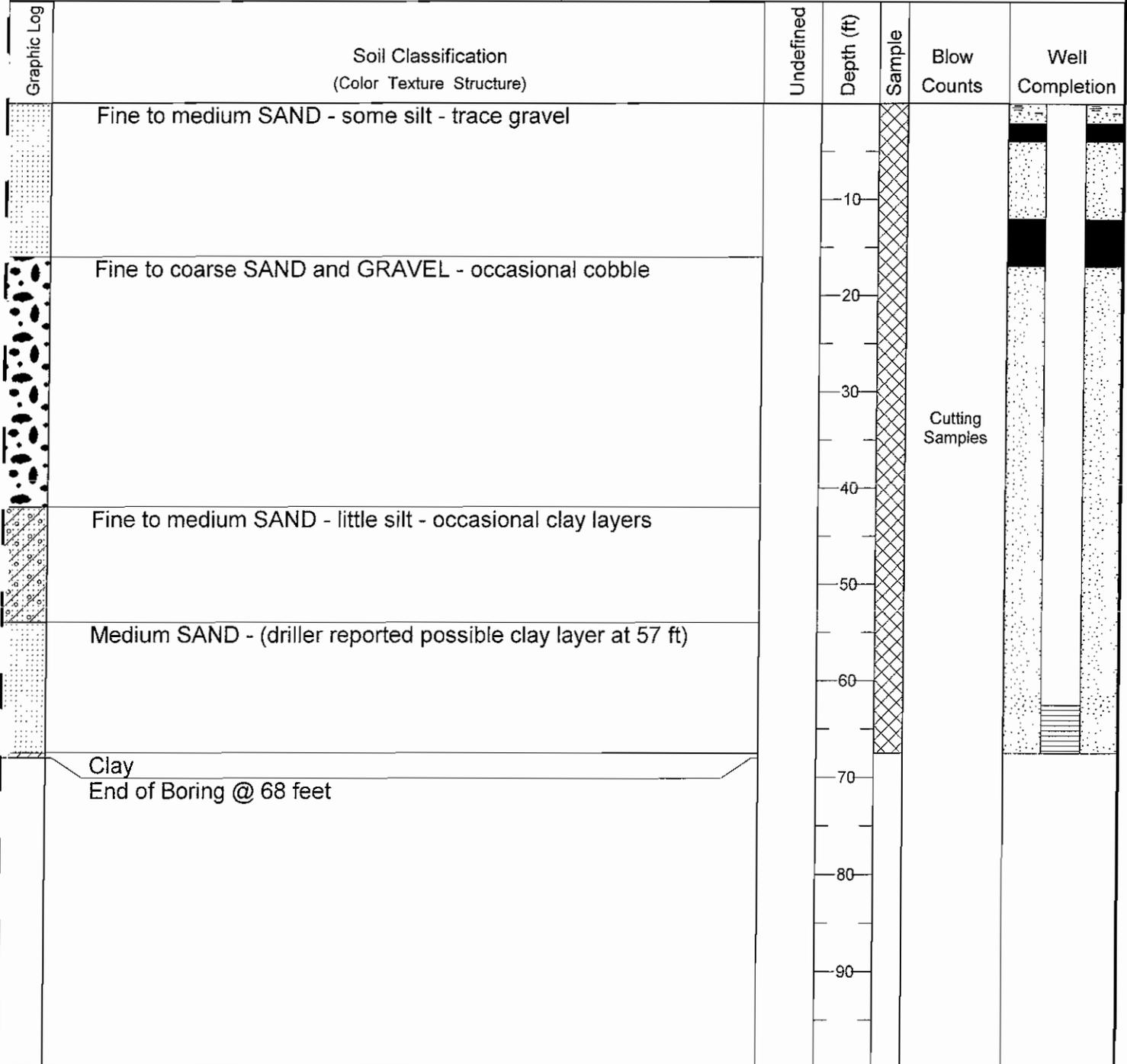
Project Name: Springdale 16: Source Well HGI  
Location: Springdale Twp., Manistee Co., Michigan  
Project Number: 2010563.01  
Client: Jordan Development

Well Completion Notes (casing/screen dia , type,length):  
OW-1 was constructed of 2-inch PVC casing and a 2-inch by 5 foot, 10 slot (milled) PVC screen Well screen annulus was filter packed to 60 feet Casing annulus was sealed with bentonite chips

Page 1 **WELL NO: OW-1**

Contractor: Shepler Well Drilling  
Crew Chief: E. Shepler  
Drill Method: 4.25-inch H.S.A.  
Boring Dia. (in ): 8  
Boring Depth (ft ): 68 Date Drilled: 12-8-2010  
Logged By: E. Vincke

TOC Elevation: 780.93 Static Water 19.13 ft bgs/~~X00X~~  
Ground Elevation: 778.6



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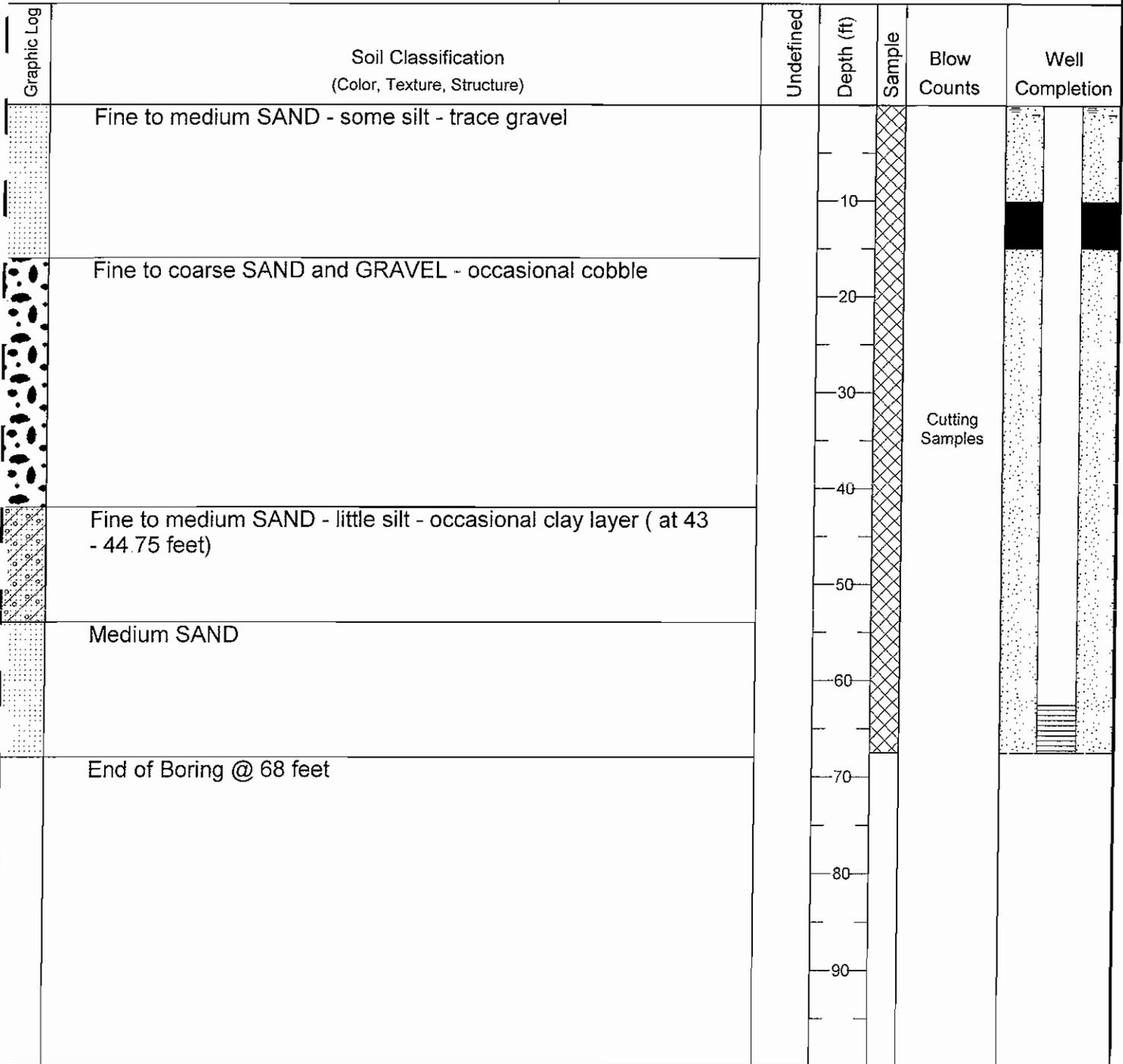
Project Name: Springdale 16: Source Well HGI  
Location: Springdale Twp., Manistee Co., Michigan  
Project Number: 2010563.01  
Client: Jordan Development

Well Completion Notes (casing/screen dia ,type,length):  
OW-2 was constructed of 2-inch PVC casing and a 2-inch by 5 foot, 10 slot (milled) PVC screen Well screen annulus was filter packed to 60 feet Casing annulus was sealed with bentonite chips

Page 1 **WELL NO:** **OW-2**

Contractor: Shepler Well Drilling  
Crew Chief: E. Shepler  
Drill Method: 4.25-inch H.S.A.  
Boring Dia (in ): 8  
Boring Depth (ft ): 68 Date Drilled: 12-8-2010  
Logged By: E. Vincke

TOC Elevation: 780.93 Static Water 19.13 ft. bgs/~~XXX~~  
Ground Elevation: 778.6



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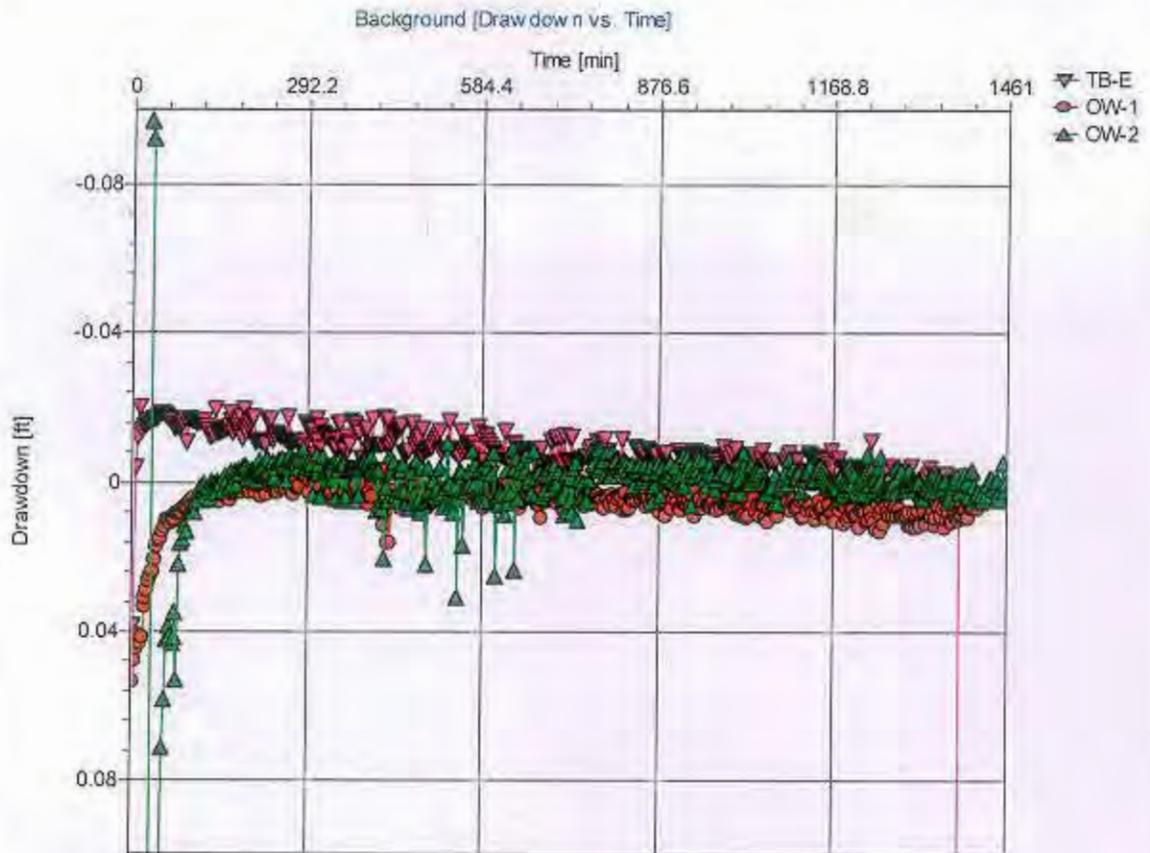
**Gosling Czubak**  
Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Background

Analysis Method: Drawdown vs. Time

Analysis Results:

<u>Test parameters:</u>	Pumping Well:	PW-1	Aquifer Thickness:	41 [ft]
	Casing radius:	0.25 [ft]		
	Screen length:	10 [ft]		
	Boring radius:	0.51 [ft]		
	Discharge Rate:			

Comments:

Evaluated by: GCES

Evaluation Date: 12/20/2010



### Gosling Czubak

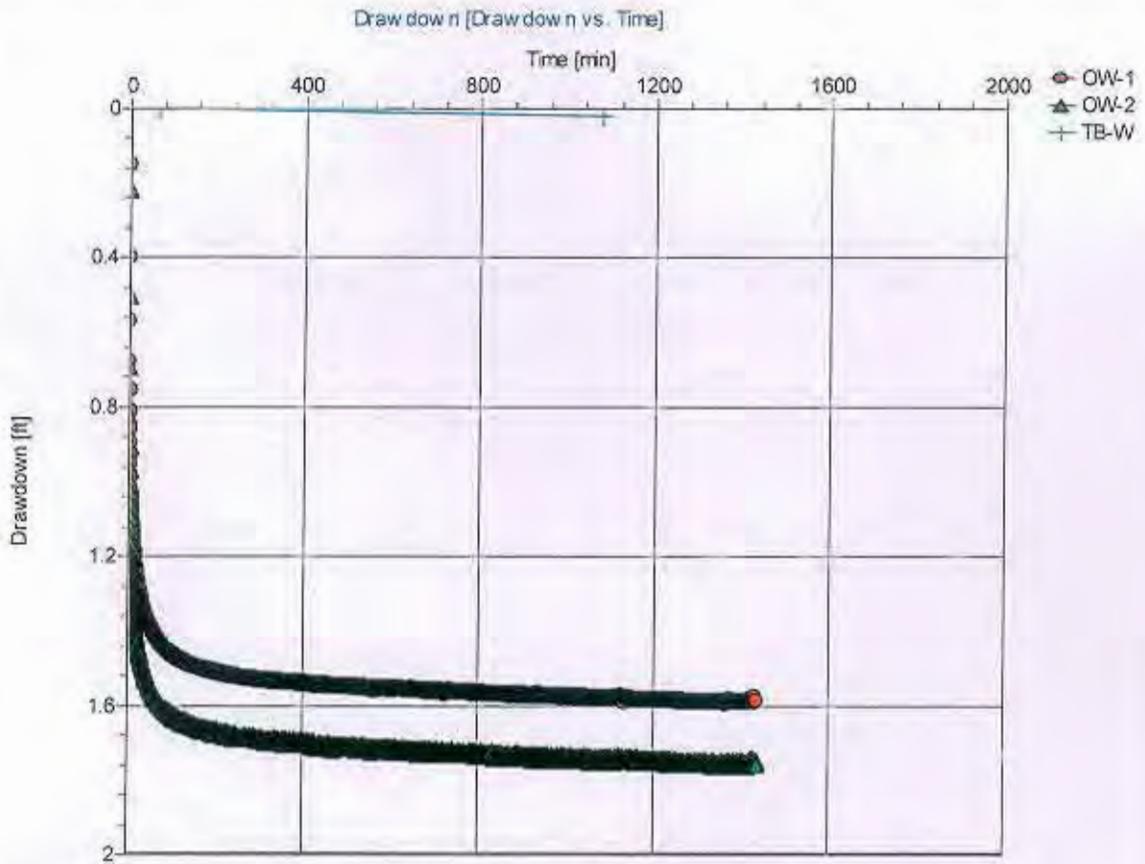
Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

### Pumping Test Analysis Report

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Drawdown vs. Time

Analysis Results:

<u>Test parameters:</u>	Pumping Well:	PW-1	Aquifer Thickness:	41 [ft]
	Casing radius:	0.25 [ft]		
	Screen length:	10 [ft]		
	Boring radius:	0.51 [ft]		
	Discharge Rate:	56.8 [U.S. gal/min]		

Comments:

Evaluated by: GCES

Evaluation Date: 12/21/2010



**Gosling Czubak**  
Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Recovery  
Analysis Method: Drawdown vs. Time

Analysis Results:

<u>Test parameters:</u>	Pumping Well:	PW-1	Aquifer Thickness:	41 [ft]
	Casing radius:	0.25 [ft]		
	Screen length:	10 [ft]		
	Boring radius:	0.51 [ft]		
	Discharge Rate:	56.8 [U.S. gal/min]		

Comments:

Evaluated by: GCES  
Evaluation Date: 12/29/2010



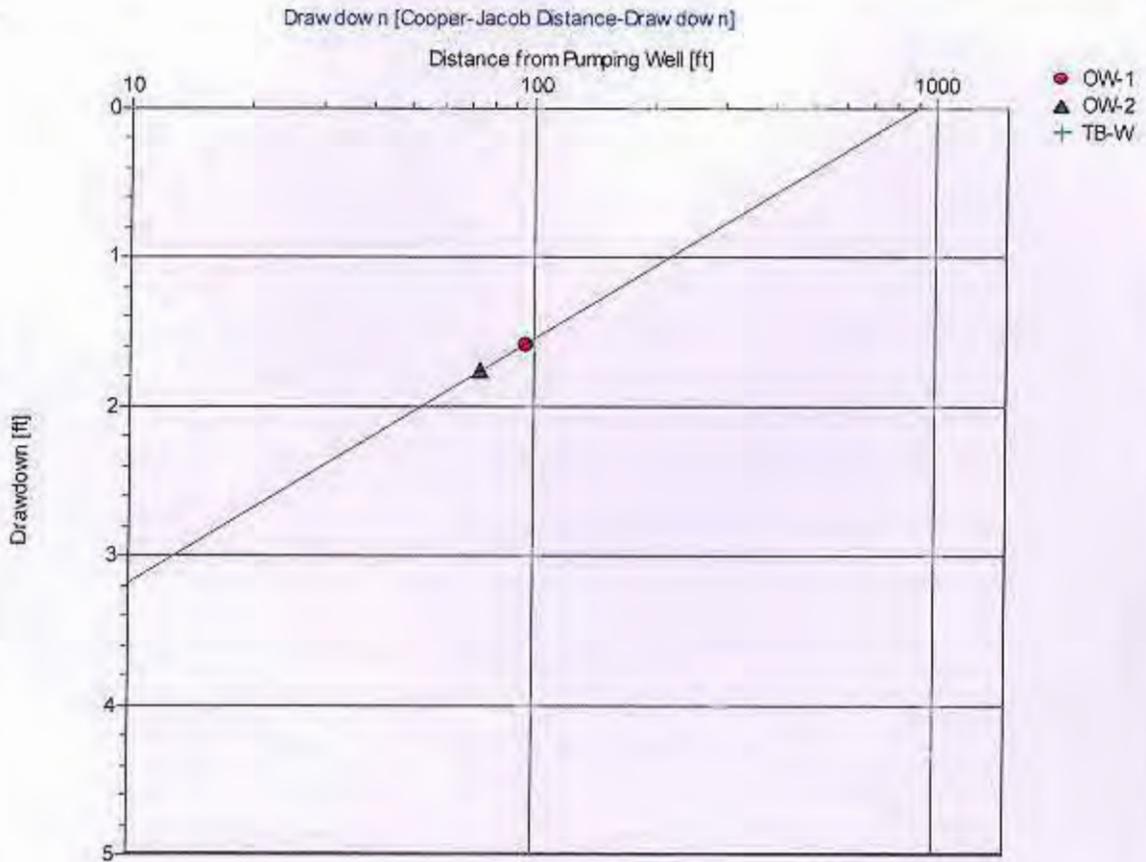
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Cooper-Jacob Distance-Drawdown

<u>Analysis Results:</u>	Transmissivity:	2.48E+3 [ft <sup>2</sup> /d]	Conductivity:	6.00E+1 [ft/d]
	Storativity:	6.92E-3		

<u>Test parameters:</u>	Pumping Well:	PW-1	Aquifer Thickness:	41 [ft]
	Casing radius:	0.25 [ft]	Confined Aquifer	
	Screen length:	10 [ft]		
	Boring radius:	0.51 [ft]		
	Discharge Rate:	56.8 [U.S. gal/min]		
	Calculation Time:	1435 [min]		

Comments:

Evaluated by: GCES

Evaluation Date: 12/21/2010



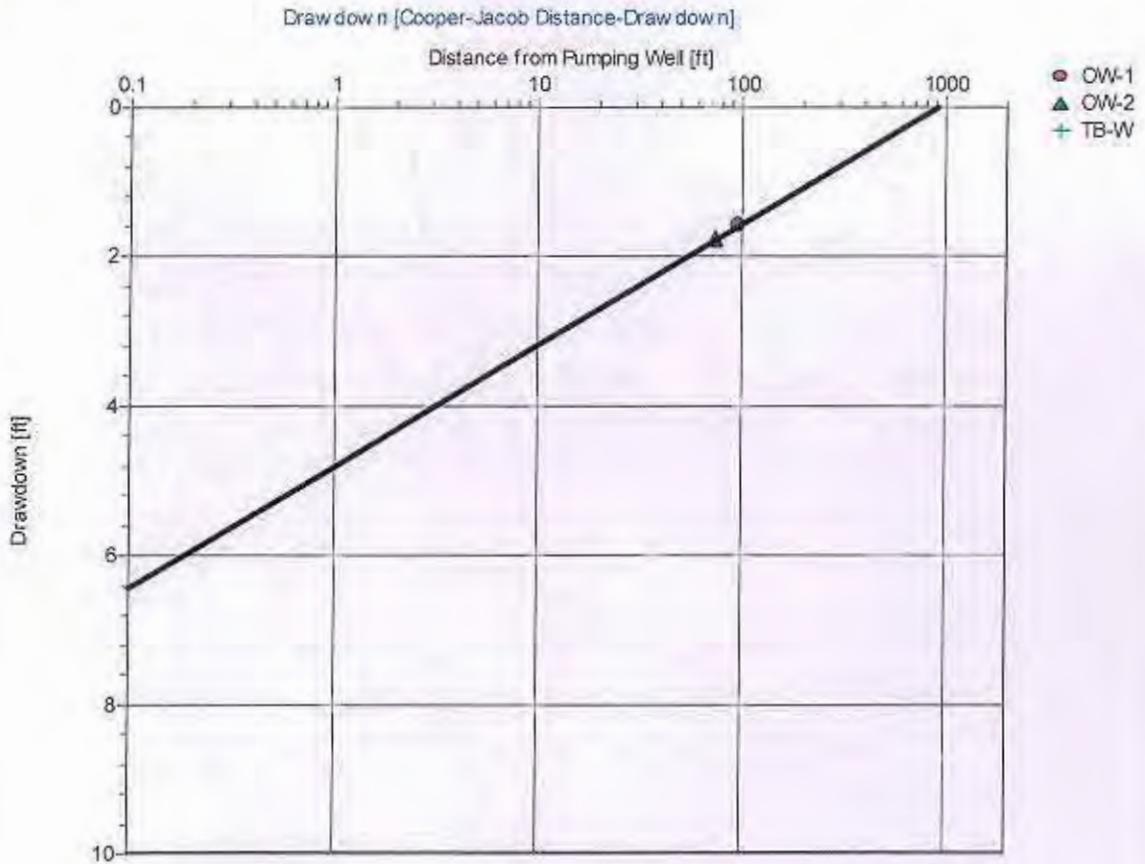
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown  
Analysis Method: Cooper-Jacob Distance-Drawdown

Analysis Results: Transmissivity: 2.46E+3 [ft<sup>2</sup>/d]      Conductivity: 6.01E+1 [ft/d]  
 Storativity: 6.50E-3

Test parameters: Pumping Well: PW-1      Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft]      Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]  
 Calculation Time: 1435 [min]

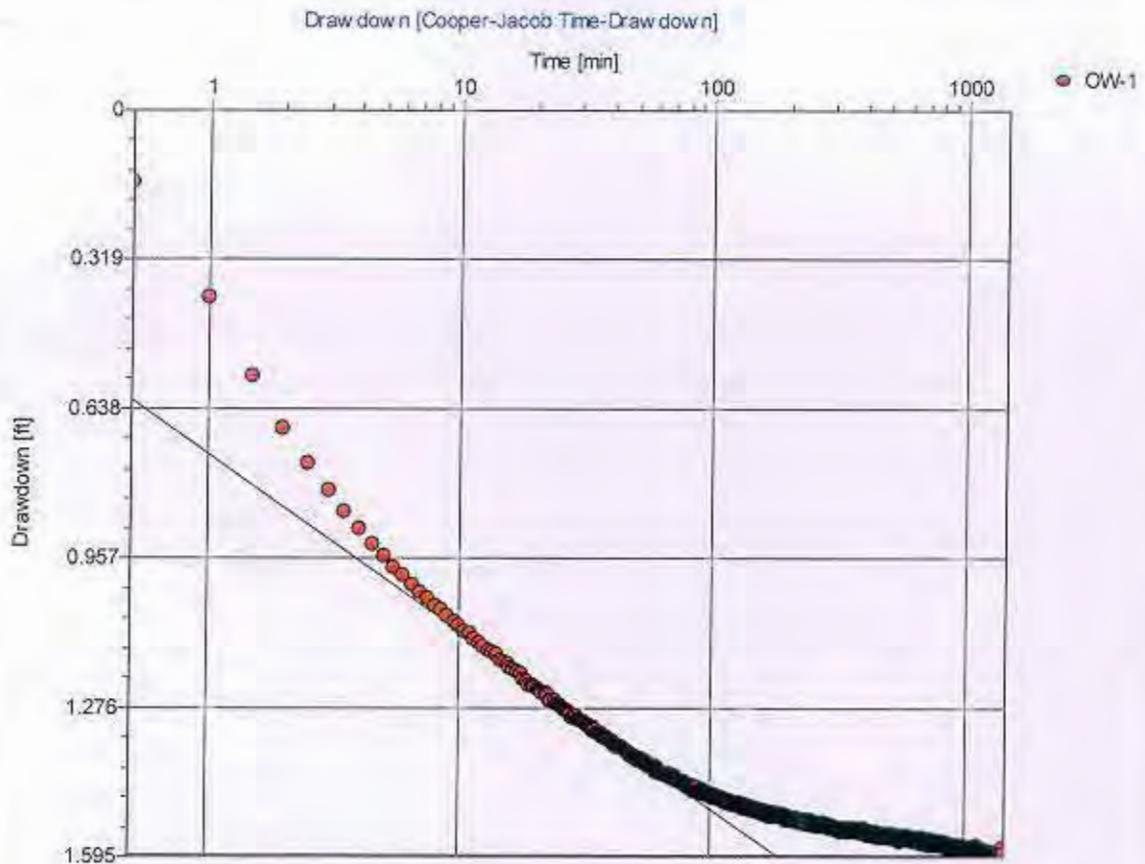
Comments:

Evaluated by: GCES  
 Evaluation Date: 12/22/2010



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Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

**Pumping Test Analysis Report**  
Project: December 2010 Testing  
Number: 2010563.01  
Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results: Transmissivity: 5.26E+3 [ft<sup>2</sup>/d] Conductivity: 1.28E+2 [ft/d]  
Storativity: 1.05E-5

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
Casing radius: 0.25 [ft] Confined Aquifer  
Screen length: 10 [ft]  
Boring radius: 0.51 [ft]  
Discharge Rate: 56.8 [U.S. gal/min]

Comments:

Evaluated by: GCES  
Evaluation Date: 12/20/2010



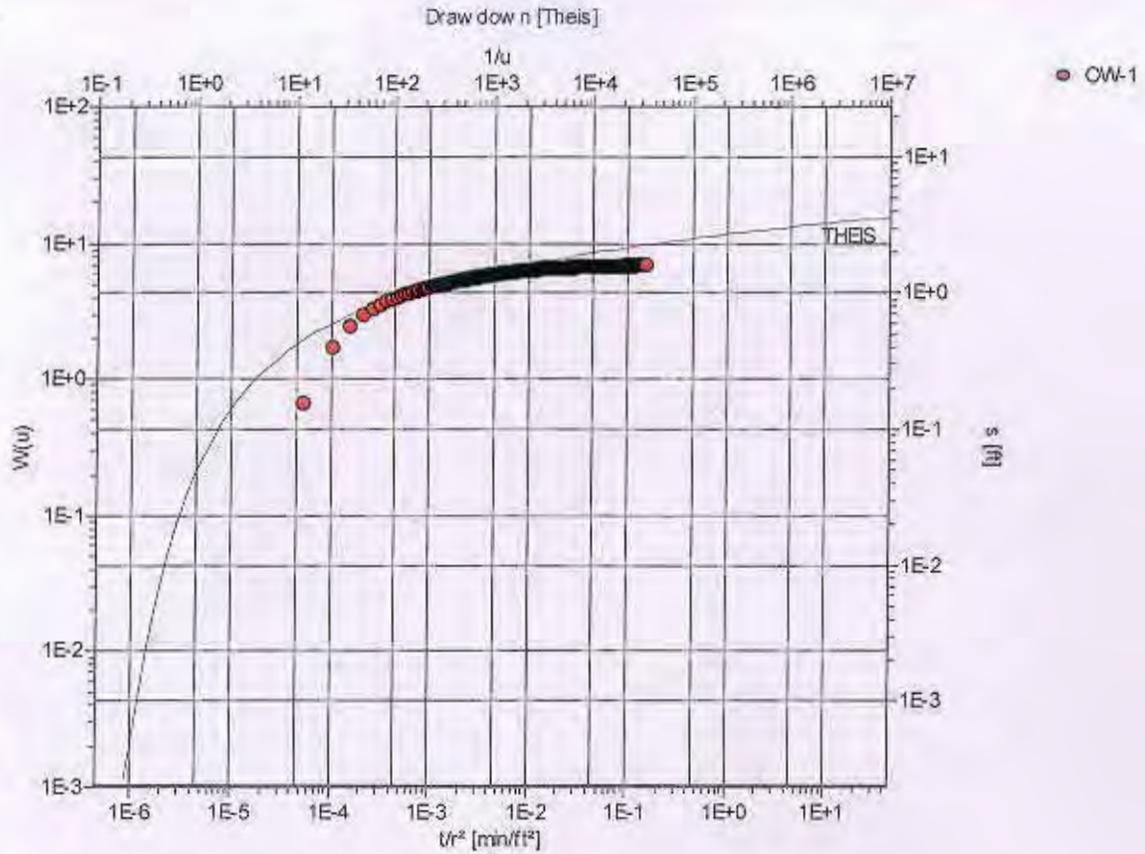
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Theis

Analysis Results: Transmissivity: 3.75E+3 [ft<sup>2</sup>/d] Conductivity: 9.14E+1 [ft/d]  
 Storativity: 4.76E-5

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]

Comments:

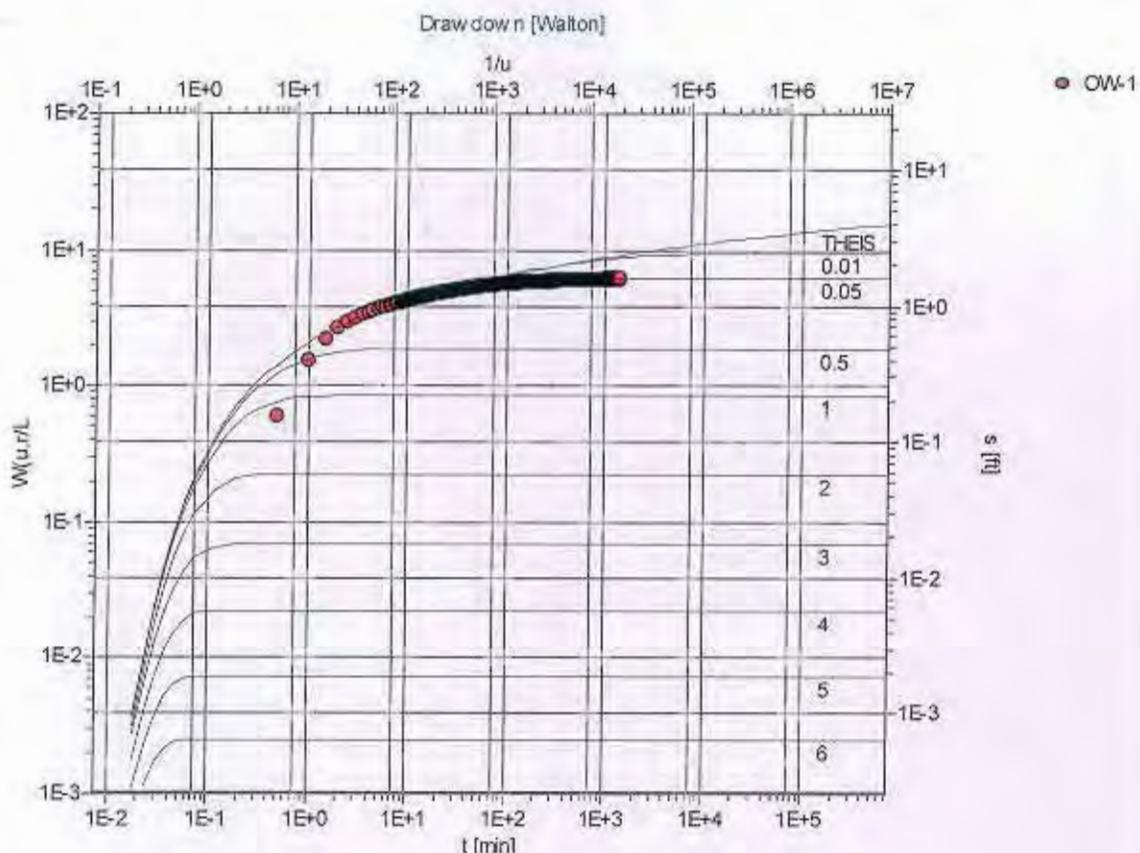
Evaluated by: GCS

Evaluation Date: 12/20/2010



**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**  
 Project: December 2010 Testing  
 Number: 2010563.01  
 Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Walton

Analysis Results: Transmissivity: 3.39E+3 [ft<sup>2</sup>/d] Conductivity: 8.26E+1 [ft/d]  
 Storativity: 7.48E-5 c: 3.96E+7 [min]

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] r/L: 0.01  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]

Comments:

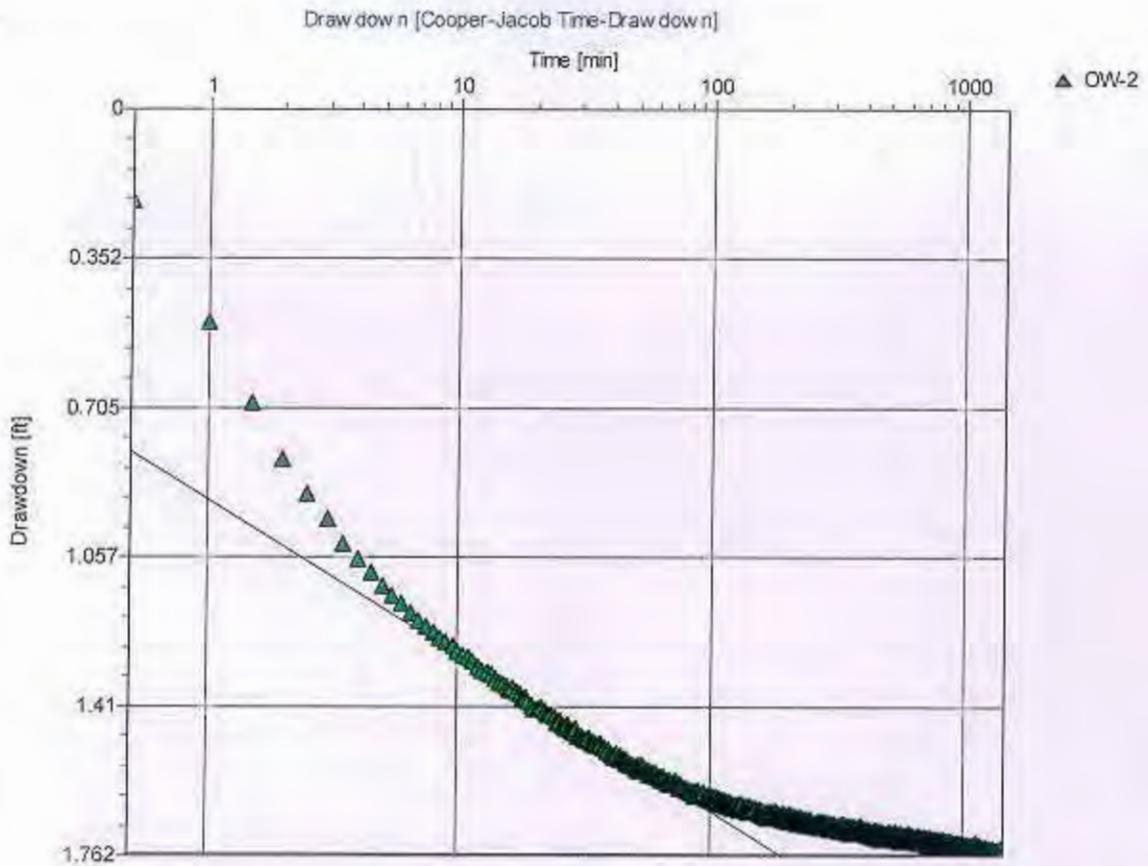
Evaluated by:

Evaluation Date: 12/21/2010



**Gosling Czubak**  
Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

**Pumping Test Analysis Report**  
Project: December 2010 Testing  
Number: 2010563.01  
Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results: Transmissivity: 5.42E+3 [ft<sup>2</sup>/d] Conductivity: 1.32E+2 [ft/d]

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
Casing radius: 0.25 [ft] Confined Aquifer  
Screen length: 10 [ft]  
Boring radius: 0.51 [ft]  
Discharge Rate: 56.8 [U.S. gal/min]

Comments:

Evaluated by: GCES  
Evaluation Date: 12/29/2010



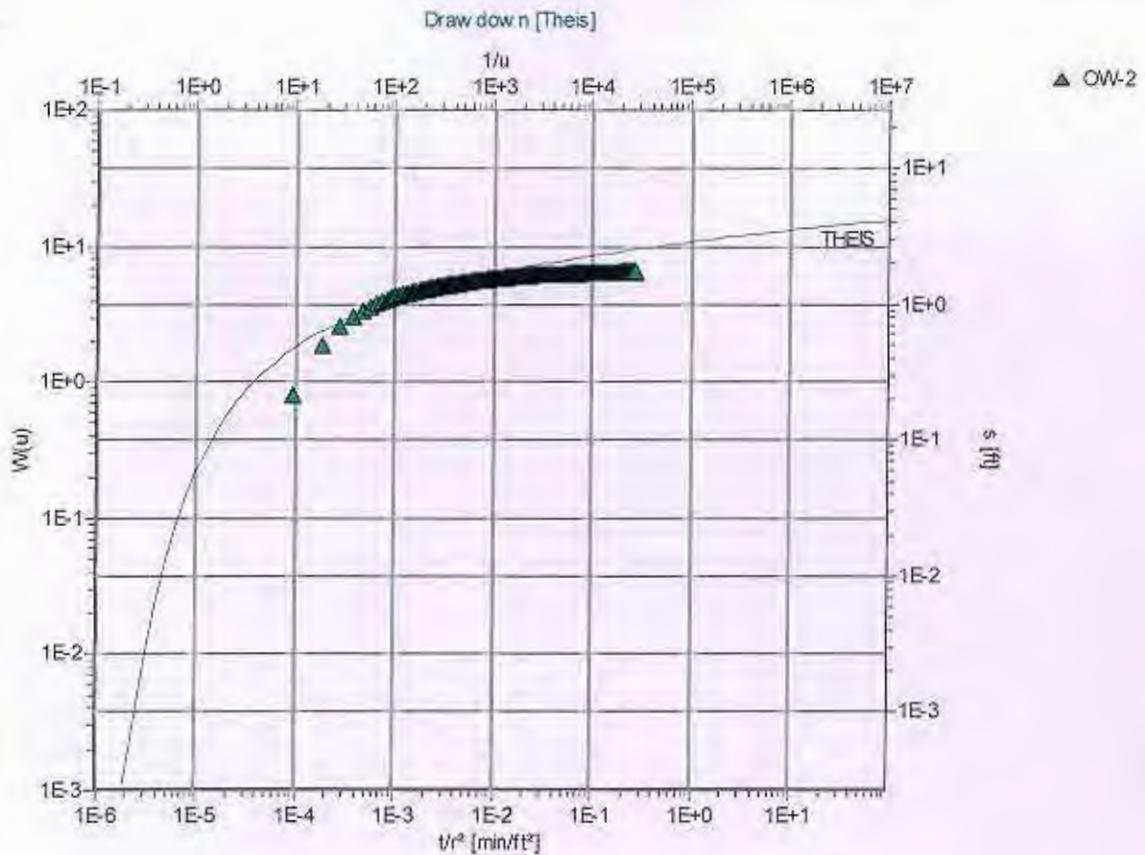
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Theis

Analysis Results: Transmissivity: 3.27E+3 [ft<sup>2</sup>/d] Conductivity: 7.96E+1 [ft/d]  
 Storativity: 8.86E-5

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]

Comments:

Evaluated by: GCES  
 Evaluation Date: 1/10/2011



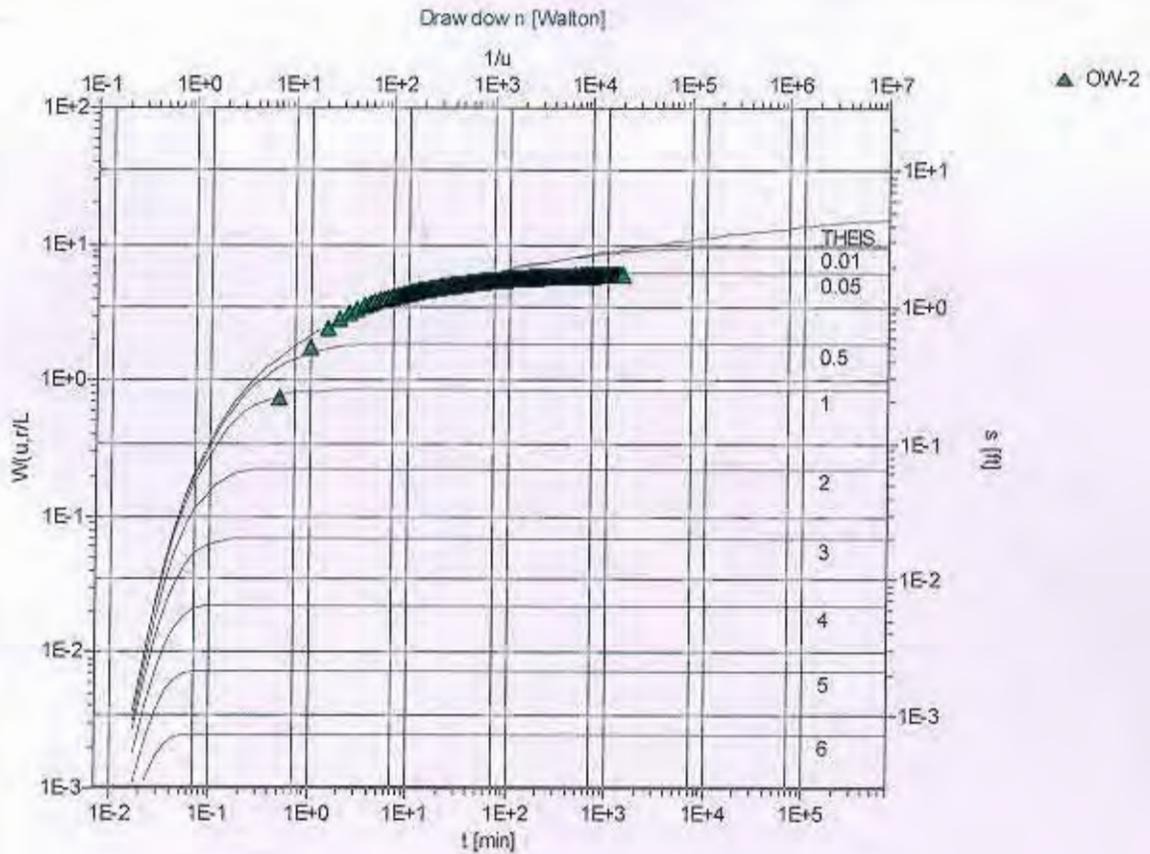
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Walton

Analysis Results:

Conductivity: 7.36E+1 [ft/d]

Test parameters:

Pumping Well:	PW-1	Aquifer Thickness:	41 [ft]
Casing radius:	0.25 [ft]	r/L:	0.01
Screen length:	10 [ft]		
Boring radius:	0.51 [ft]		
Discharge Rate:	56.8 [U.S. gal/min]		

Comments:

Evaluated by: GCES

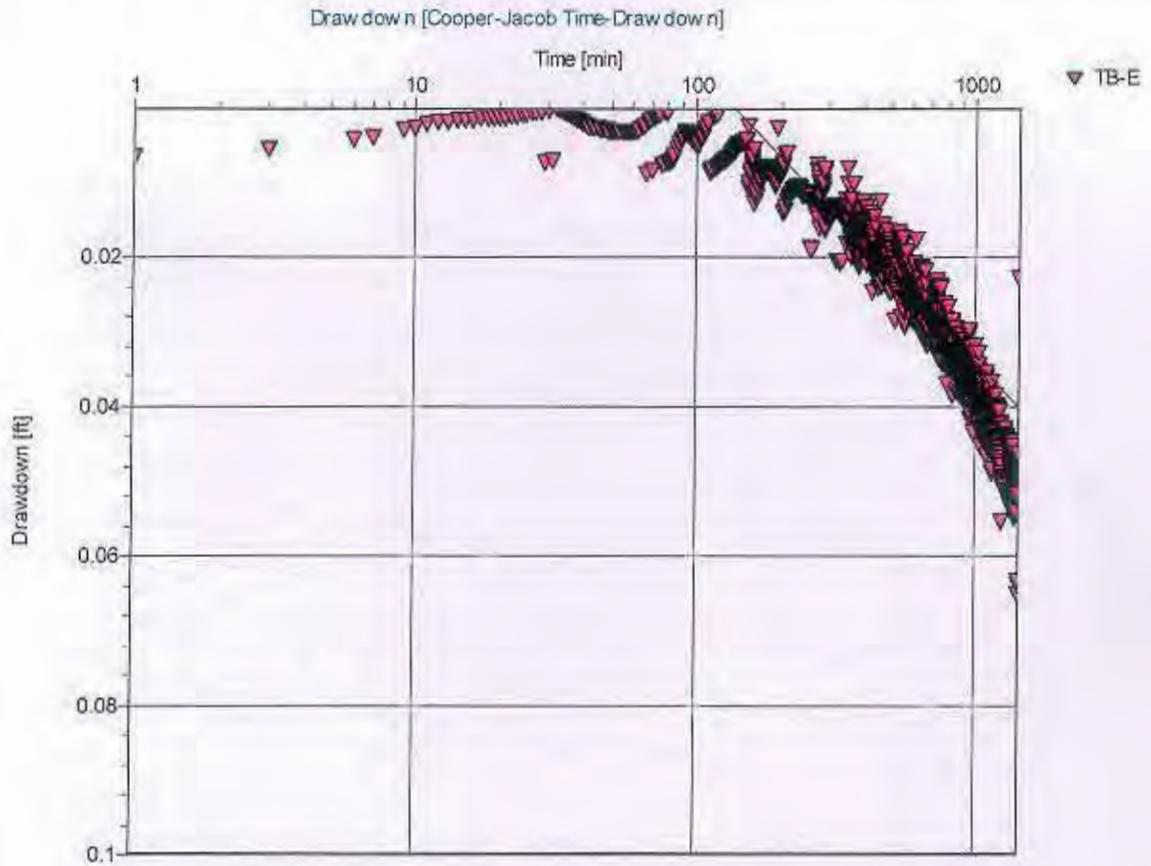
Evaluation Date: 12/29/2010



**Gosling Czubak**  
Engineering Sciences, Inc.  
1280 Business Park Drive  
Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing  
Number: 2010563.01  
Client: Jordan Development Company



Pumping Test: Drawdown  
Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results: Transmissivity: 5.11E+4 [ft<sup>2</sup>/d] Conductivity: 1.25E+3 [ft/d]  
Storativity: 2.41E-1

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
Casing radius: 0.25 [ft] Confined Aquifer  
Screen length: 10 [ft]  
Boring radius: 0.51 [ft]  
Discharge Rate: 56.8 [U.S. gal/min]

Comments:

Evaluated by: GCES  
Evaluation Date: 12/21/2010



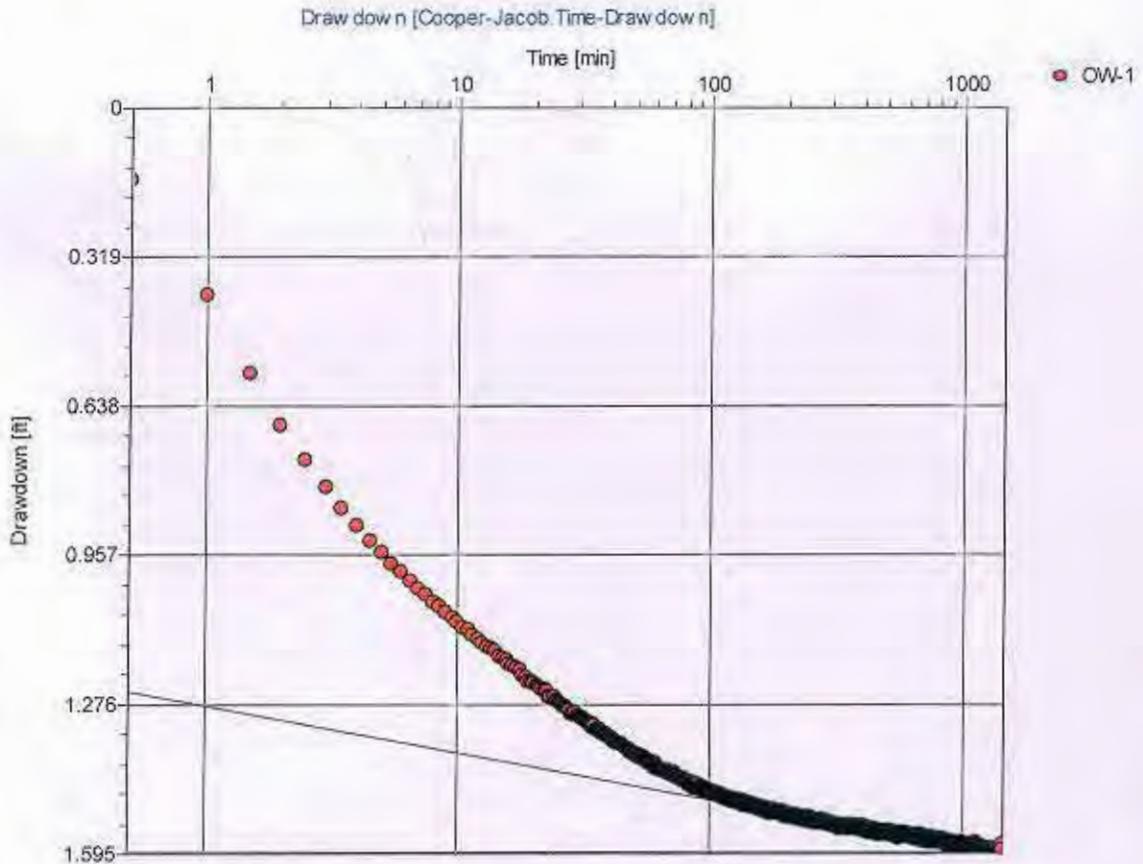
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results: Transmissivity: 2.02E+4 [ft<sup>2</sup>/d] Conductivity: 4.93E+2 [ft/d]  
 Storativity: 4.02E-16

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]

Comments: (For drawdown projections)

Evaluated by: GCES  
 Evaluation Date: 1/3/2011



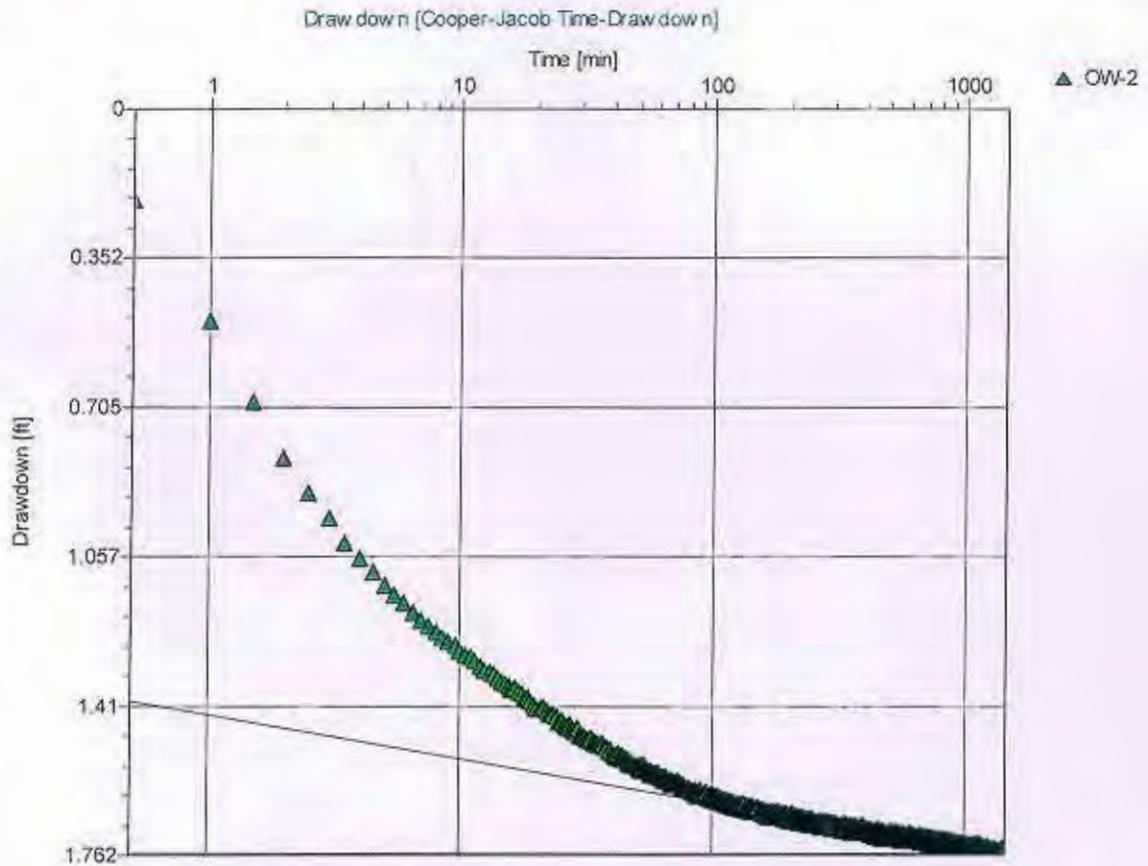
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



Pumping Test: Drawdown

Analysis Method: Cooper-Jacob Time-Drawdown

Analysis Results: Transmissivity: 1.90E+4 [ft<sup>2</sup>/d] Conductivity: 4.65E+2 [ft/d]

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]

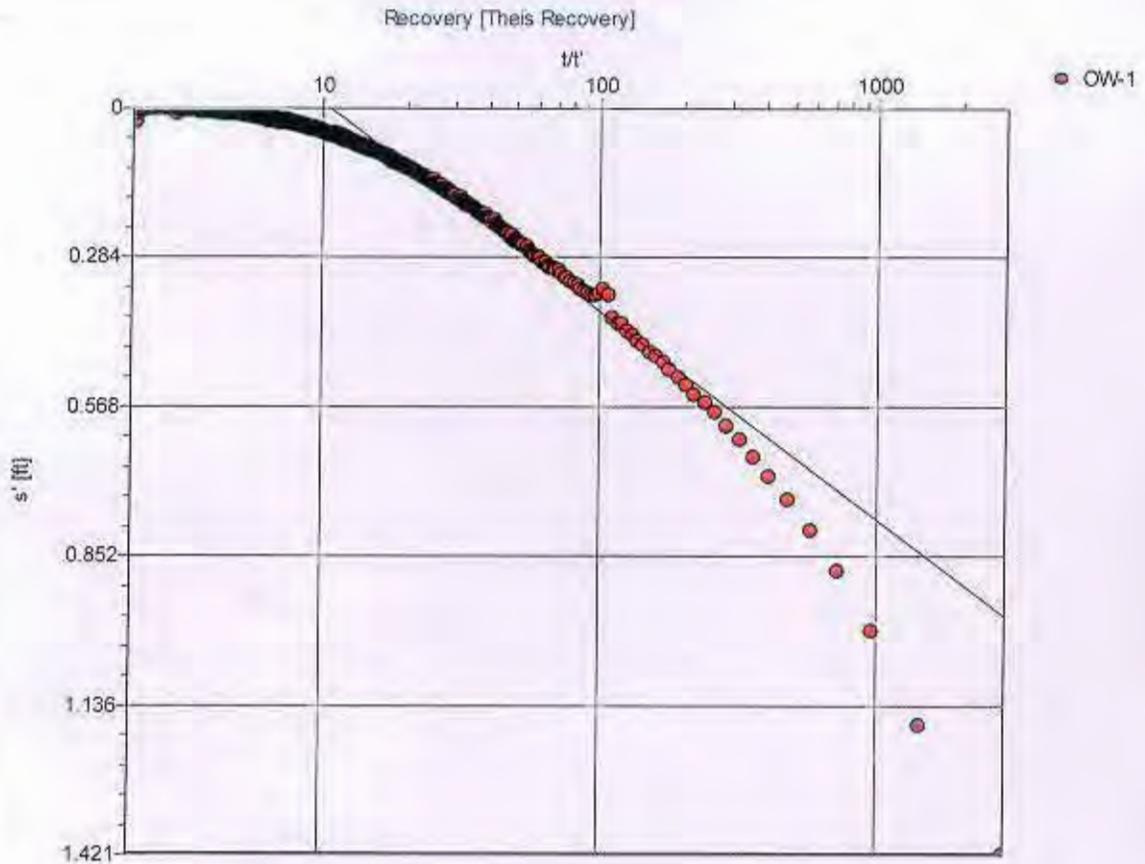
Comments: (For drawdown projections)

Evaluated by: GCES  
 Evaluation Date: 1/3/2011



**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**  
 Project: December 2010 Testing  
 Number: 2010563.01  
 Client: Jordan Development Company



Pumping Test: **Recovery**

Analysis Method: **This Recovery**

Analysis Results: Transmissivity: 5.04E+3 [ft<sup>2</sup>/d] Conductivity: 1.23E+2 [ft/d]

Test parameters: Pumping Well: PW-1 Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft] Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]  
 Pumping Time: 1440 [min]

Comments:

Evaluated by: GCES  
 Evaluation Date: 12/20/2010



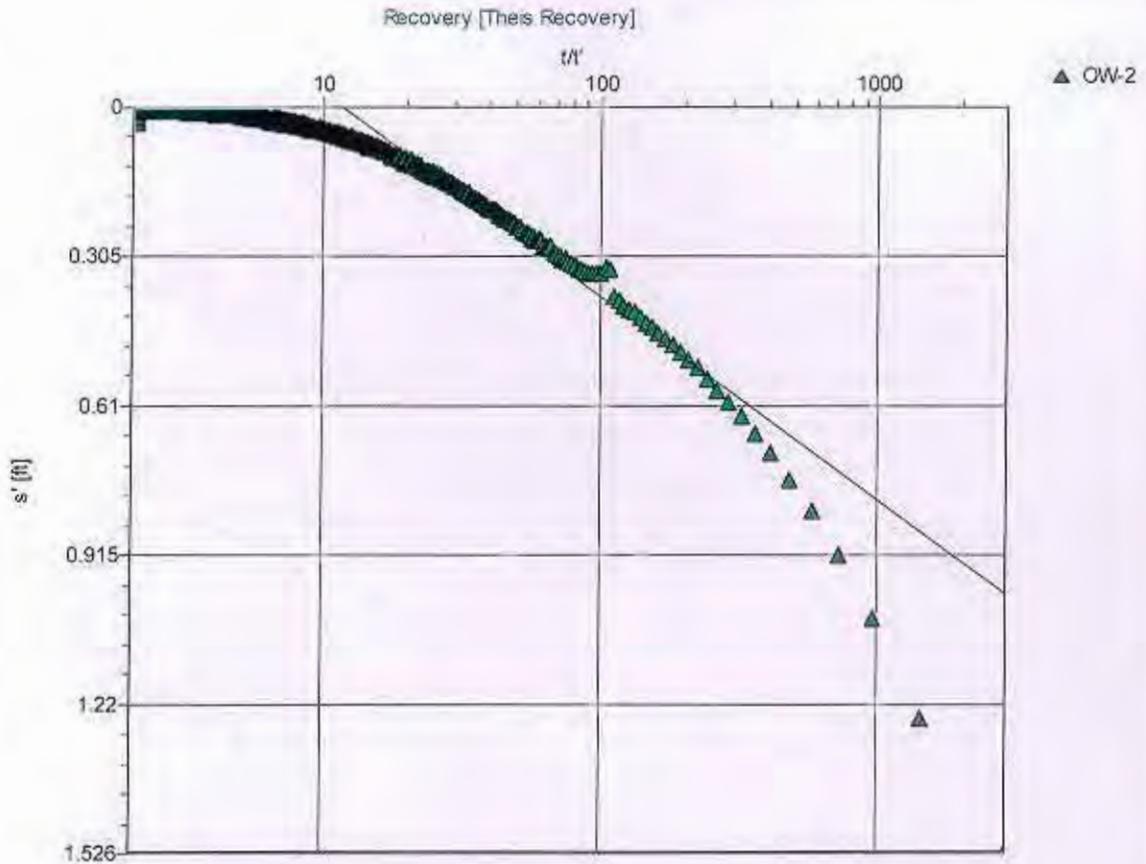
**Gosling Czubak**  
 Engineering Sciences, Inc.  
 1280 Business Park Drive  
 Traverse City, Michigan

**Pumping Test Analysis Report**

Project: December 2010 Testing

Number: 2010563.01

Client: Jordan Development Company



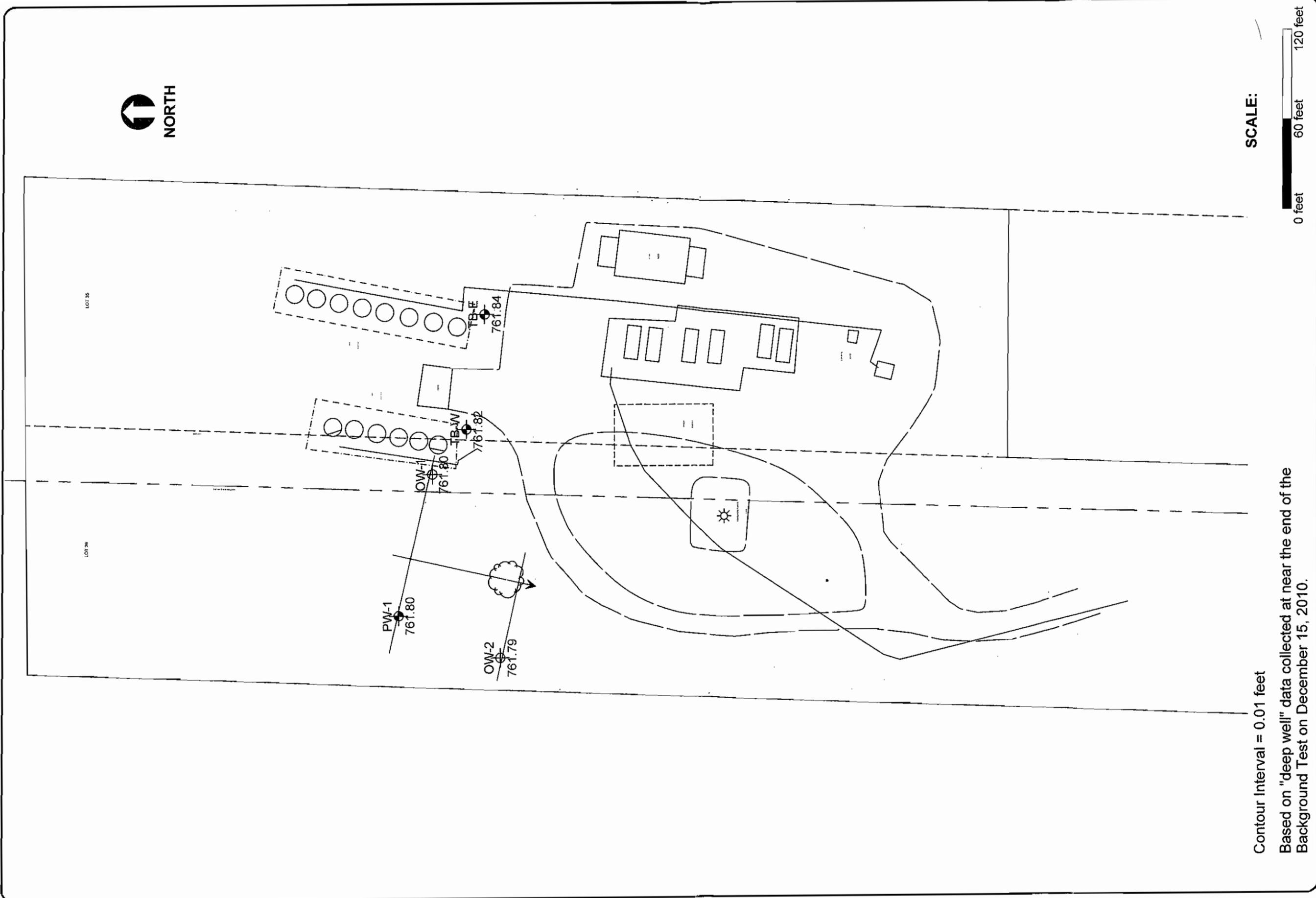
Pumping Test: Recovery  
Analysis Method: Theis Recovery

Analysis Results: Transmissivity: 4.83E+3 [ft<sup>2</sup>/d]      Conductivity: 1.18E+2 [ft/d]

Test parameters: Pumping Well: PW-1      Aquifer Thickness: 41 [ft]  
 Casing radius: 0.25 [ft]      Confined Aquifer  
 Screen length: 10 [ft]  
 Boring radius: 0.51 [ft]  
 Discharge Rate: 56.8 [U.S. gal/min]  
 Pumping Time: 1440 [min]

Comments:

Evaluated by: GCES  
 Evaluation Date: 12/20/2010



Contour Interval = 0.01 feet

Based on "deep well" data collected at near the end of the Background Test on December 15, 2010.

SCALE:



Location:  
 PART OF SECTION 16,  
 T24N, R14W  
 SPRINGDALE TOWNSHIP,  
 MANISTEE COUNTY, MICHIGAN

**GROUNDWATER FLOW MAP  
 SPRINGDALE 16 CPF  
 JORDAN DEVELOPMENT COMPANY**

Job No.: 2010563.01  
 Date: Jan 2011  
 Scale: 1" = 40'  
 Drawn: ARB  
 Chk'd: KDR  
 Rev'd:



**Gosling Engineering Sciences, Inc.**  
 1280 Business Park Drive  
 Traverse City, MI 49686-8807  
 231-946-9191 800-968-1062  
 Fax: 231-941-4803

- Engineers
- Surveyors
- Environmental Services
- Landscape Architecture

Client: Jordan Development Company  
 Project: Springdale 16 CPF: Source Well Evaluation  
 Project No.: 2010563.01

**Physical Aquifer Properties Summary - Aquifer Testing at PW-1**

Test	Analysis Method	Transmissivity (feet <sup>2</sup> /day)	Conductivity (feet/day)	Storativity	Radius of Influence (feet)
Drawdown (at 57 gpm)	Cooper-Jacob Distance-Drawdown	2 460	60	6 92E-03	900
Drawdown at OW-1	Theis	3 750	91 4	4 76E-05	N/A
Drawdown at OW-2	Theis	3 270	79 6	8 86E-05	N/A
Drawdown at OW-1	Cooper-Jacob Time-Drawdown	5 260	128	1 05E-05	N/A
Drawdown at OW-2	Cooper-Jacob Time-Drawdown	5 420	132		N/A
Drawdown at TB-E	Cooper-Jacob Time-Drawdown	1 100	125	2 4 3E-01	N/A
Drawdown at OW-1	Walton	3 390	82 6	7 48E-05	
Drawdown at OW-2	Walton		73 6		
Recovery at OW-1	Theis Recovery	5 040	123		N/A
Recovery at OW-2	Theis Recovery	4,830	118		N/A

**Geometric Mean:** 4,040 95 1.18E-04

**Arithmetic Mean:** 4,178 99 1.43E-03

\* Results of analyses from TB-E were not included in mean calculations

**Notes and Significant Assumptions**

**Notes:**

- 1) Results presented were calculated using Waterloo Hydrologic's Aquifer Test Software Applications
- 2) Results are based on data collected during a 24-hour aquifer pumping test completed in December 2010

**Significant Assumptions:**

- 1) The aquifer is assumed to be isotropic and infinite in extent.
- 2) The aquifer is assumed to be confined (leaky) based on drilling data
- 3) The saturated aquifer thickness is assumed to be 41 feet

JORDAN DEVELOPMENT COMPANY  
 SPRINGDALE 16 CPF  
 SOURCE WELL EVALUATION  
 2010563.01

Estimated Well Drawdown

Approx. Plume Width	N/A	ft
Hydraulic Conductivity		99 ft/day
Estimated Aquifer Thickness		41 ft
Estimated Transmissivity		4,040 sq ft/day
		30,219 gpd/sq ft

JACOB'S FORMULA FOR DETERMINING DRAWDOWN AT ANY POINT

$$s = (264 * Q / I) * @LOG(.3 * T * t / (r^2 * S))$$

where

s= Drawdown in feet	Value Selected
Q= Pumping rate in gpm	90
T= Transmissivity in gpd/ft	30219.296
t= Time since pump started in days	
r= Distance from pumping well in feet	
S= Storage coefficient (dimensionless)	0.0001

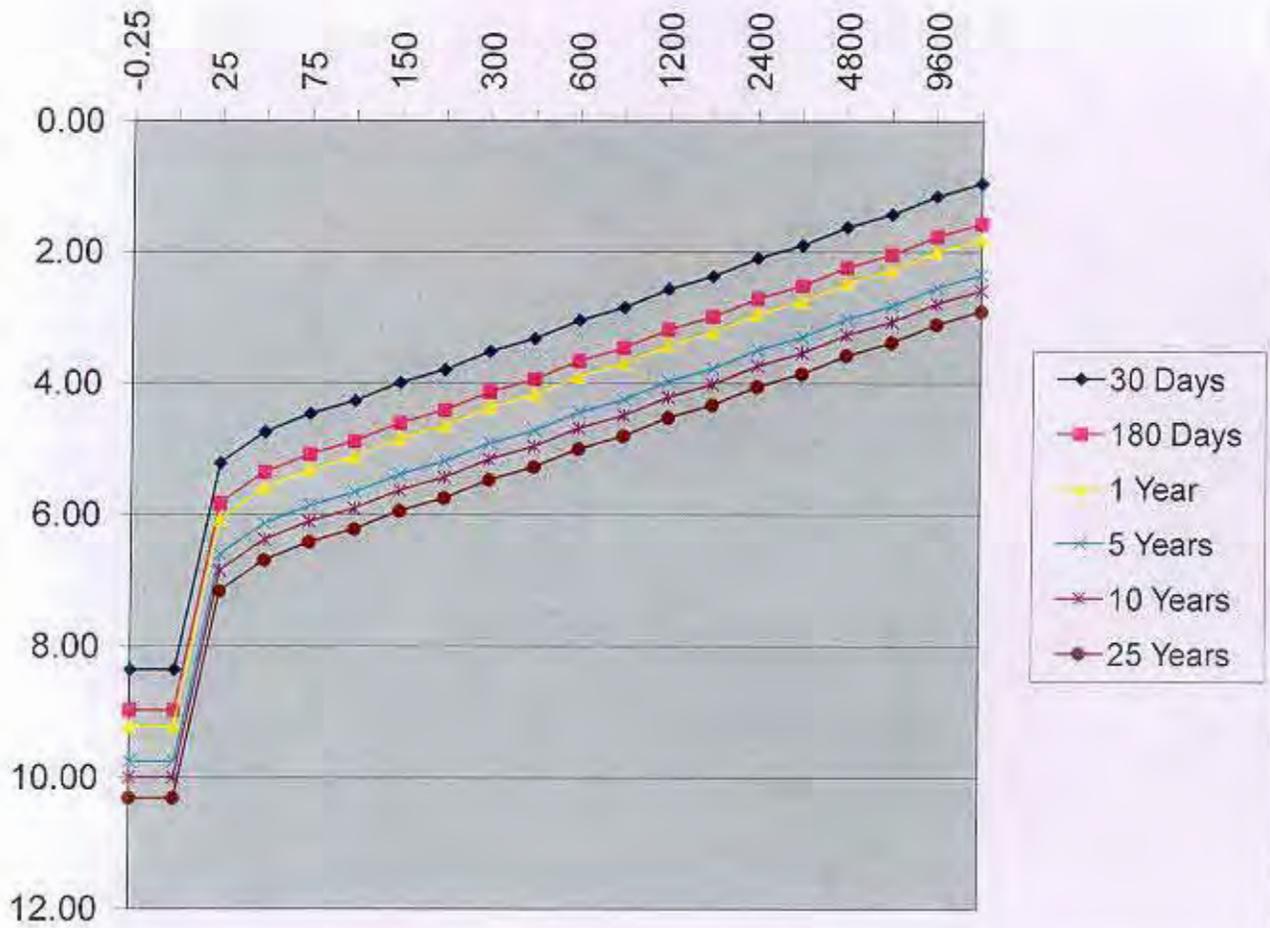
Drawdown

r(ft)	Pumping Time (Days)					
	30	180	365	1825	3650	9125
-0.25	8.36	8.98	9.22	9.77	10.00	10.32
0.25	8.36	8.98	9.22	9.77	10.00	10.32
25	5.22	5.83	6.07	6.62	6.86	7.17
50	4.75	5.36	5.60	6.15	6.39	6.70
75	4.47	5.08	5.32	5.87	6.11	6.42
100	4.27	4.88	5.13	5.68	5.91	6.23
150	4.00	4.61	4.85	5.40	5.64	5.95
200	3.80	4.41	4.65	5.20	5.44	5.75
300	3.52	4.13	4.38	4.93	5.16	5.47
400	3.33	3.94	4.18	4.73	4.97	5.28
600	3.05	3.66	3.90	4.45	4.69	5.00
800	2.85	3.46	3.71	4.26	4.49	4.81
1200	2.58	3.19	3.43	3.98	4.22	4.53
1600	2.38	2.99	3.23	3.78	4.02	4.33
2400	2.10	2.71	2.96	3.51	3.74	4.05
3200	1.91	2.52	2.76	3.31	3.55	3.86
4800	1.63	2.24	2.48	3.03	3.27	3.58
6400	1.43	2.04	2.29	2.84	3.07	3.39
9600	1.16	1.77	2.01	2.56	2.80	3.11
12800	0.96	1.57	1.81	2.36	2.60	2.91
1	7.42	8.03	8.27	8.82	9.06	9.37

\* Indicates that  $u > .05$  and Jacob formula is not valid.

### Drawdown vs. Distance from Pumping Well

$K=99 \text{ ft/day}$ ,  $Q = 90 \text{ gpm}$ ,  $S = 1.00\text{E-}04$



JORDAN DEVELOPMENT COMPANY  
 SPRINGDALE 16 CPF  
 SOURCE WELL EVALUATION  
 2010563.01

Estimated Well Drawdown

Approx. Plume Width	N/A	ft
Hydraulic Conductivity		60 ft/day
Estimated Aquifer Thickness		41 ft
Estimated Transmissivity		2,460 sq ft/day
		18,401 gpd/sq ft

JACOB'S FORMULA FOR DETERMINING DRAWDOWN AT ANY POINT

$$s = (264 * Q / I) * @LOG(.3 * I * t / (r^2 * S))$$

where

s= Drawdown in feet	
Q= Pumping rate in gpm	90
T= Transmissivity in gpd/ft	18400.8
t= Time since pump started in days	
r= Distance from pumping well in feet	
S= Storage coefficient (dimensionless)	7.00E-03

Value Selected

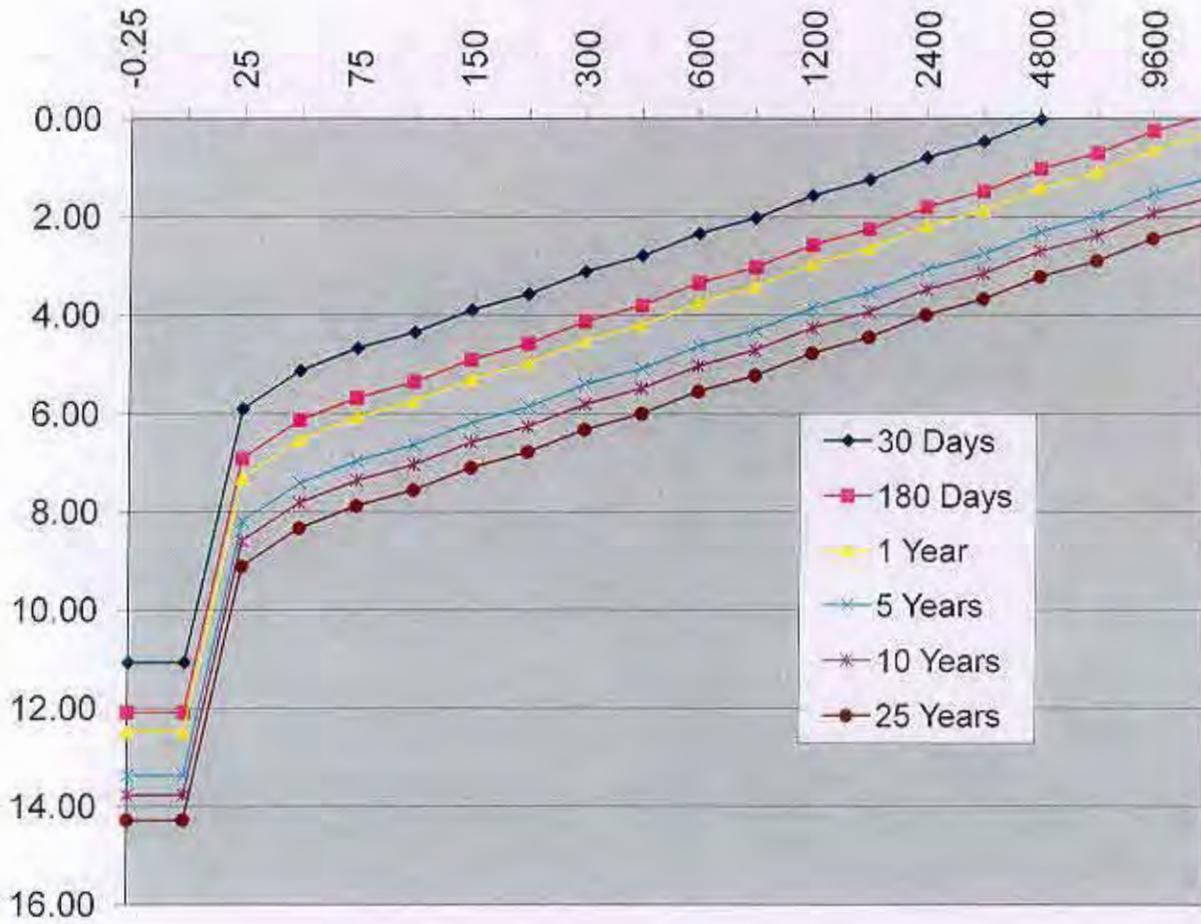
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Drawdown

r (ft)	Pumping Time (Days)					
	30	180	365	1825	3650	9125
-0.25	11.08	12.08	12.48	13.38	13.77	14.28
0.25	11.08	12.08	12.48	13.38	13.77	14.28
25	5.91	6.92	7.31	8.22	8.60	9.12
50	5.13	6.14	6.54	7.44	7.83	8.34
75	4.68	5.68	6.08	6.98	7.37	7.89
100	4.36	5.36	5.76	6.66	7.05	7.56
150	3.90	4.91	5.30	6.21	6.59	7.11
200	3.58	4.58	4.98	5.88	6.27	6.79
300	3.12	4.13	4.53	5.43	5.82	6.33
400	2.80	3.81	4.20	5.11	5.49	6.01
600	2.35	3.35	3.75	4.65	5.04	5.55
800	2.02	3.03	3.43	4.33	4.72	5.23
1200	1.57	2.57	2.97	3.87	4.26	4.78
1600	1.25	2.25	2.65	3.55	3.94	4.45
2400	0.79	1.80	2.19	3.10	3.48	4.00
3200	0.47	1.47	1.87	2.77	3.16	3.68
4800	0.01	1.02	1.42	2.32	2.71	3.22
6400	-0.31	0.70	1.09	2.00	2.38	2.90
9600	-0.76	0.24	0.64	1.54	1.93	2.44
12800	-1.09	-0.08	0.32	1.22	1.61	2.12
1	9.52	10.53	10.92	11.83	12.21	12.73

### Drawdown vs. Distance from Pumping Well

$K=60$  ft/day,  $Q = 90$  gpm,  $S = 7.00E-03$



JORDAN DEVELOPMENT COMPANY  
 SPRINGDALE 16 CPF  
 SOURCE WELL EVALUATION  
 2010563.01

Estimated Well Drawdown

Approx. Plume Width N/A ft  
 Hydraulic Conductivity 1,250 ft/day  
 Estimated Aquifer Thickness 41 ft  
 Estimated Transmissivity 51,250 sq ft/day  
 383,350 gpd/sq ft

JACOB'S FORMULA FOR DETERMINING DRAWDOWN AT ANY POINT

$$s = (264 * Q / I) * @LOG((.3 * I * t / (r^2 * S)))$$

where

s= Drawdown in feet  
 Q= Pumping rate in gpm 90  
 I= Transmissivity in gpd/ft 383350  
 t= Time since pump started in days  
 r= Distance from pumping well in feet  
 S= Storage coefficient (dimensionless) 2.41E-01

Value Selected  
 -----

Drawdown

r (ft)	Pumping Time (Days)					
	30	180	365	1825	3650	9125
-0.25	0.52	0.57	0.59	0.63	0.65	0.67
0.25	0.52	0.57	0.59	0.63	0.65	0.67
25	0.27	0.32	0.34	0.38	0.40	0.42
50	0.23	0.28	0.30	0.34	0.36	0.39
75	0.21	0.26	0.28	0.32	0.34	0.36
100	0.20	0.24	0.26	0.31	0.32	0.35
150	0.17	0.22	0.24	0.28	0.30	0.33
200	0.16	0.21	0.23	0.27	0.29	0.31
300	0.14	0.18	0.20	0.25	0.27	0.29
400	0.12	0.17	0.19	0.23	0.25	0.27
600	0.10	0.15	0.17	0.21	0.23	0.25
800	0.08	0.13	0.15	0.19	0.21	0.24
1200	0.06	0.11	0.13	0.17	0.19	0.22
1600	0.05	0.09	0.11	0.16	0.18	0.20
2400	0.02	0.07	0.09	0.14	0.15	0.18
3200	0.01	0.06	0.08	0.12	0.14	0.16
4800	-0.01	0.04	0.05	0.10	0.12	0.14
6400	-0.03	0.02	0.04	0.08	0.10	0.13
9600	-0.05	0.00	0.02	0.06	0.08	0.10
12800	-0.07	-0.02	0.00	0.04	0.06	0.09
1	0.44	0.49	0.51	0.55	0.57	0.60

### Drawdown vs. Distance from Pumping Well

$K=1250 \text{ ft/day}$ ,  $Q = 90 \text{ gpm}$ ,  $S = 2.41E-01$

