

ETHANOL PRODUCTION PLANT MONITORS IMPACTS TO WATER SUPPLY AND STAYS IN COMPLIANCE

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ABSTRACT

Under current ethanol plant configurations, water use for ethanol production ranges from 3 to 7 gallons of water required per gallon of ethanol produced. With the average new plant producing 120 million gallons of ethanol per year, water yields in excess of 1,300 gallons per minute are required; therefore adequate water supply is essential to the operation of an ethanol production facility. Most ethanol plants in the United States use aquifer systems for their water supply, and an in-depth aquifer analysis must be completed before a plant can be constructed or expanded. Some states require 60-day aquifer yield tests, and plants must continue to monitor impacts on groundwater resources during the life of plant operation.

Environmental engineers and consultants can enhance data collection and site analysis by integrating the latest technologies. Due to regulatory requirements of aquifer impact analysis, combined with the rural location of ethanol plants, groundwater data collection and analysis can be costly with regards to travel expenses, data management, labor, and reporting costs. The use of innovative software solutions along with accurate water level monitoring equipment and telemetry systems can provide ethanol plant managers with remote access, real-time data, and results that keep them in compliance with their state regulatory agency.

INTRODUCTION

The number of ethanol plants has more than doubled, and the annual volume of ethanol produced has more than quadrupled in the United States since 1999 (RAF). The level of activity in this sector of the biofuels market has increased the amount of water production in mid-western states utilizing sand and gravel and bedrock aquifers. The design capacity of ethanol plants has increased from 55 million gallons per year (MGY) of ethanol to over 120 MGY as technology and experience with the design and construction of these facilities has grown. Depending on the process, between 3 and 7 gallons of water are used primarily in the distillation process as non-

contact cooling water to make 1 gallon of ethanol. Therefore, plants capable of producing 120 MGY can require in excess of 700 MGY of water. While river water is currently being used as a source at some plants, the majority of ethanol plants utilize groundwater for production. Ethanol plants therefore require the installation of high-capacity wells, often with redundant or backup wells, that have capacity in excess of 1,300 gallons per minute.

Permitting is generally different in each state, but many states require some form of aquifer testing. The State of Minnesota currently requires that background, or static, groundwater elevation data are collected from the proposed pumping well, from the on-site observation well, and from surrounding domestic/farm wells for a period of three days prior to the start of a 30-day aquifer pumping test. Groundwater elevation data are also required to be collected during the recovery phase of the aquifer test, which can result in a total of over 60 days of groundwater elevation monitoring. The value of continuous data collection using pressure transducers and dataloggers has been recognized by regulating agencies and is either required or strongly recommended for aquifer testing. While manual water level measurements are often required to corroborate electronic data, the continuous data collected using pressure transducers and dataloggers are far superior to the “snapshot in time” water-level readings when determining aquifer parameters and predicting long-term sustainability of aquifer systems.

Recent advancements in telecommunications are being leveraged by monitoring equipment manufacturers and distributors to result in sensing and logging capabilities with telemetric access. One company, In-Situ[®] Inc. based out of Fort Collins, Colorado, has multiple products that employ a cellular solution and that enable full access and control of remote water sensors. This paper will present the methods to deploy In-Situ Inc.’s Level TROLL[®] 700 instruments, their BaroTROLL[®] barometric pressure sensor, and their TROLL[®] Link telemetry system and to analyze groundwater data in near-real time during aquifer testing and long-term monitoring at a typical ethanol plant.

METHODS

Aquifer testing is commonly used to evaluate impacts and to optimize the design of groundwater withdrawal systems. Mathematical equations have been developed to calculate aquifer parameters including hydraulic conductivity, transmissivity, and storativity based upon aquifer response to pumping, or the amount of drawdown in the aquifer under pumping conditions. Accurate collection of groundwater elevation data and weather parameters is essential for defensible, quantitative conclusions regarding aquifer systems. Recording groundwater elevations to an accuracy of 0.01 foot is a difficult task under many field applications, yet is an important component of most aquifer studies. In-Situ Inc.’s Level TROLL[®] 300, 500 (Figure 1), and 700 instruments provide options for a pressure transducer and temperature probe with data logging capability.



Figure 1. In-Situ Level TROLL 500 sensor/datalogger

In-Situ Inc. is recognized as an industry leader in the development and sales in remote sensing instruments and has made many improvements over the past 10 years to increase memory storage, extend battery life, and increase the durability of their equipment. A relatively recent addition to their product line is the TROLL Link telemetry system (Figure 2).



Figure 2. In-Situ TROLL Link telemetry system

The TROLL Link system includes a cellular modem with an Internet protocol (IP) address, a battery, solar panel, and rugged enclosure. The cable for the Level TROLL can be connected directly into a proprietary weather-tight locking system on the bottom of the enclosure.

When deploying the Level TROLL sensor, several standard operating procedures (SOPs) should be used. First, it is highly recommended that relative elevations of the well reference points be obtained and be accurate to 0.01 foot. The well reference point is often the top of the well casing and is used as a reference for obtaining “manual” depth-to-water measurements using an

electronic interface probe. The calculation of accurate groundwater gradients and velocities is only possible if the elevations of the reference points are reported in feet above sea level or are surveyed to an arbitrary datum. Second, experience indicates that sensors connected to cables should be deployed at least 48 hours prior to obtaining accurate water level data; the coil “memory” of the cables often results in a downward “settling-in” period within the well as the cable stretches and uncoils. Third, an accurate sensor depth should be determined after the sensor has stabilized. This step enables the rapid analysis of data as described later in this paper and is accomplished by collecting a manual water level measurement and by reading the depth of water above the transducer on the “home” screen of the Win-Situ[®] Plus software (Figure 3).



Figure 3. Win-Situ Plus “Home” screen

The sensor depth is then calculated as:

$$\text{Sensor depth (feet)} = \text{Depth to water (feet)} + \text{Sensor reading (feet above sensor)}$$

The next step is to install and set up the TROLL Link hardware and software. Communication between a laptop PC is accomplished through Win-Situ TROLL Link software (Figure 4).

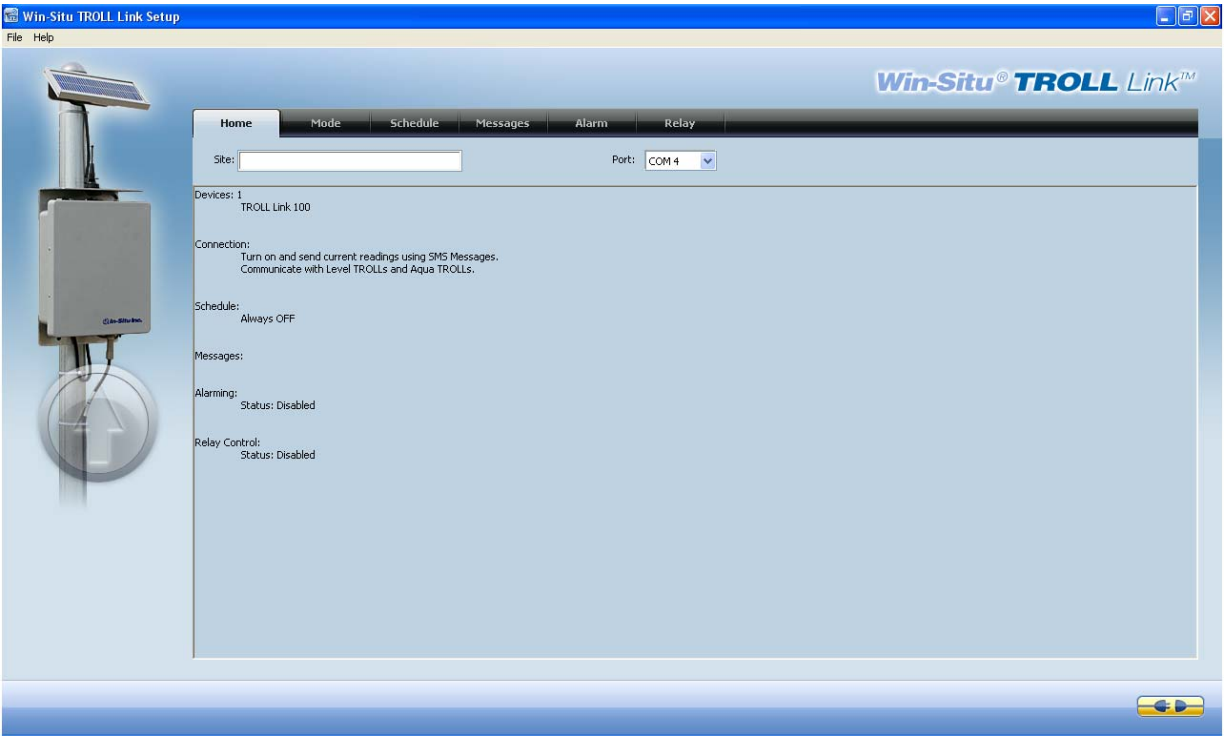


Figure 4. Win-Situ TROLL Link

Communication settings and alarms are established using this software. Additional settings and sensor programming are accomplished remotely using Win-Situ Plus software (Figure 5).

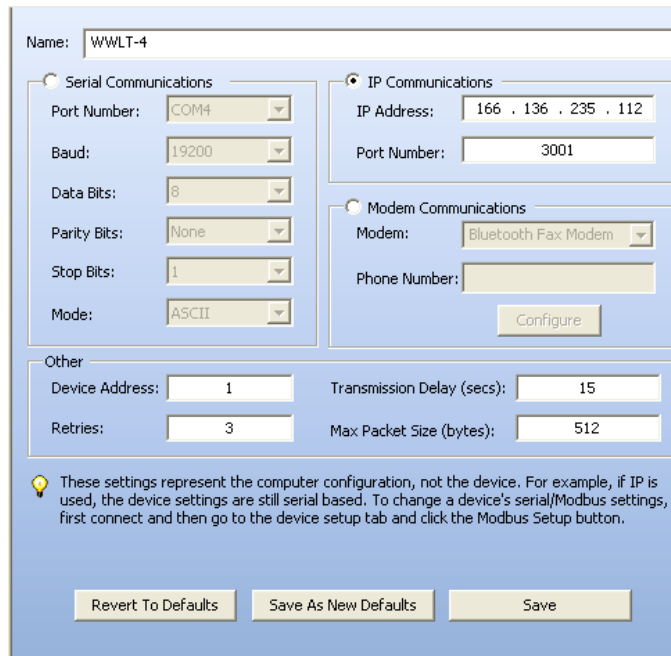


Figure 5. Win-Situ Plus telemetric setup

Once the equipment is properly installed and programmed, remote acquisition of data can begin. The sensors can be programmed to record water levels at linear, fast linear, event, timed, or logarithmic intervals. The timed events are particularly useful for step-drawdown testing, where the pumping rate is increased in a step-wise fashion to evaluate the specific capacity of the well at various pumping rates. Given the importance of the aquifer response shortly after turning on or off groundwater pumps, the fast-linear capability can be used to collect water levels at sub-second intervals. The amount of data can multiply very quickly, and, if using traditional methods, data collection can become cumbersome. However, increasing computer speeds and memory capacity are enabling large amounts of groundwater data to be collected and processed. In addition, software applications can process real-time data and large historic data sets; these applications will be presented below.

Individual wells with telemetric sensors can be accessed in real time or the dataloggers can be downloaded at routine intervals. Once downloaded, a .csv file is created by a file export from the Win-Situ Plus software. Summit Envirosolutions' Transducer Fast Lane™ can be used to import the sensor data into Aquifer Resource Management's AQUA TRUEVUE™ software, which is a graphical user interface (GUI) that enables scientists and engineers to query and visualize data stored in a database. Transducer Fast Lane uses the well name embedded in the datalogger file or file name to automatically call the well reference elevation and sensor depth from a Microsoft Access®, SQLServer®, or MySQL database. The tool saves considerable time converting the data to feet above sea level for relative analysis. Figure 6 shows a typical import screen.

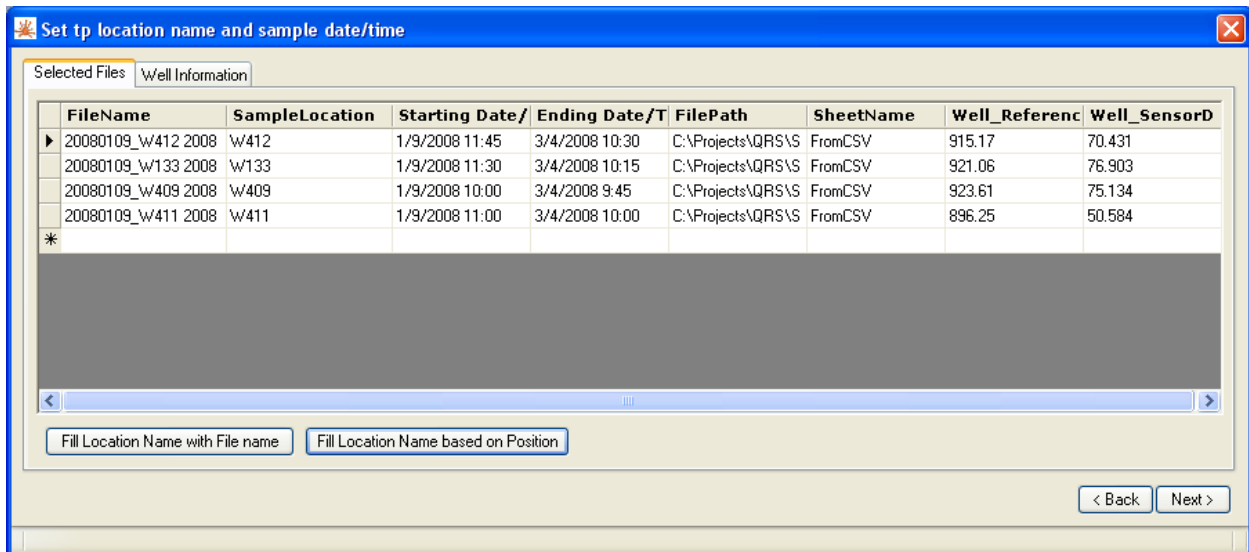


Figure 6. Transducer Fast Lane data import

AQUA TRUEVUE is a combination of Visual Basic and .NET programming that provides for automated mining and analysis of groundwater data. Weather data (e.g., barometric pressure and precipitation) are obtained from In-Situ Inc.'s BaroTROLL sensor, on-site weather stations, or Internet sources and imported into the database, which allows comparison of water elevations, barometric pressure, and precipitation in graphical format. Figures 7 and 8 and show these capabilities.

Data Query Form

Define Search

* Required Search Criteria Advanced Search Options 3-D Visualization

Select Location(s): PR1 *

Select Parameter(s): Groundwater Elevation *
Media: Water

Select a Sort Order

ASC	Sort Order	DESC
<input type="checkbox"/>	Location	<input type="checkbox"/>
<input type="checkbox"/>	Sample DateTime	<input type="checkbox"/>
<input type="checkbox"/>	Parameter	<input type="checkbox"/>
<input type="checkbox"/>	Numeric Result	<input type="checkbox"/>
<input type="checkbox"/>	Log Date/Time	<input type="checkbox"/>

Month: June Year: 2007

[Select Current Month]
[Select Current Quarter]
[Select Current Year]
[Select All]

Start Date: 6/1/2007 *
End Date: 6/30/2007 *

Auto time on

HELPFUL HINTS

You can select a date in several ways. The "Select All" button is the fastest. Another convenient way is to select a Month and Year, then choose from the "Current" buttons. You can also use the calendar (usually best for data for individual days). Dates may be specified that include times. The format for a date time is 06/07/02 1:15 p.m.

Once you have filled in the Required Search Criteria (Location, Parameter, and Date Period), click on "Search Results" for a table of your results.

To reset/refresh individual search criteria, please double click on the blue header bars.

Change Data Set
Define Search
Search Results
Graph
Data Export
Data Import
Location Groups
Parameter Groups
Database Utilities
Help
Exit

Figure 7. AQUA TRUEVUE query screen

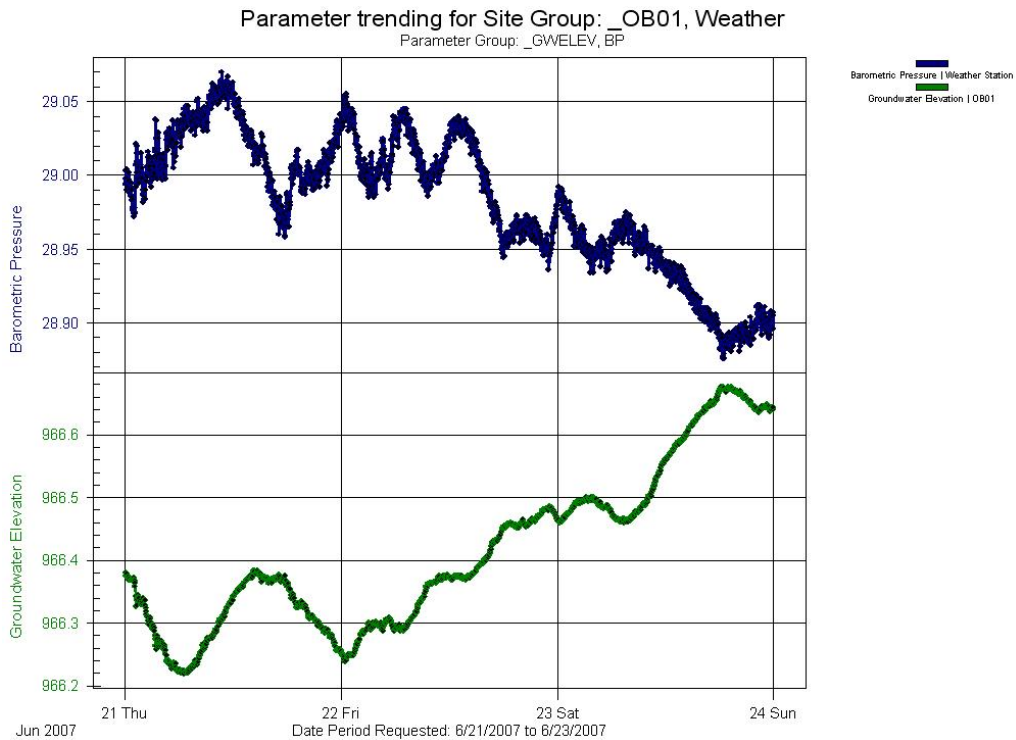


Figure 8. On-the-fly graph showing groundwater/barometric pressure relationship

Time-specific sensor data for well groups and parameter groups can be queried and exported using the AQUA TRUEVUE tool as a shapefile to ESRI's ArcMap® application. The Spatial Analyst® extension can then be used to interpolate a contour map or colored grid.

AQUA TRUEVUE can also be used to perform standard hydrogeologic analyses on the data. Well efficiencies, specific capacity, entrance velocities, capture zones, hydraulic conductivity, and potentiometric surfaces can be calculated relatively quickly. The potentiometric surface can be interpolated using spline, inverse difference weighting, or a linear-log kriging algorithm developed specifically for groundwater data. Figures 9 through 11 depict some of these capabilities. The end result of this process is an ongoing data collection and analysis tool.

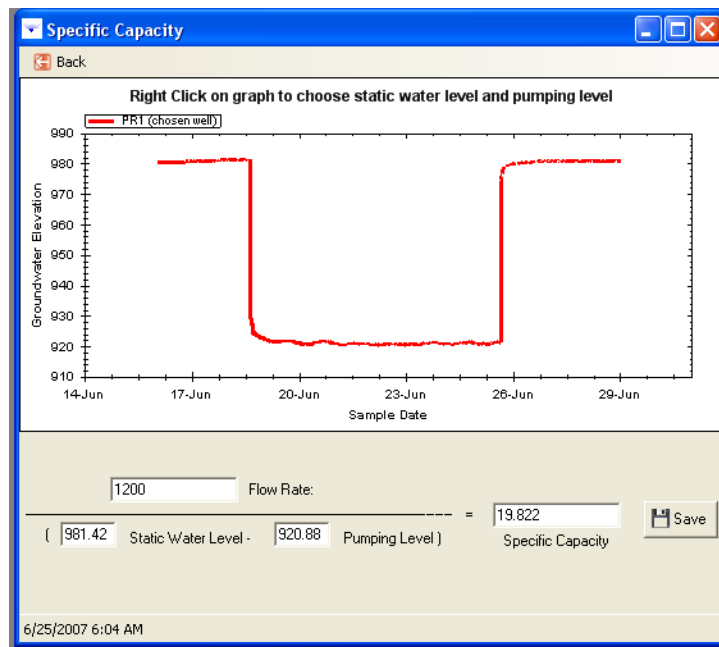


Figure 9. Specific capacity calculated from pumping data

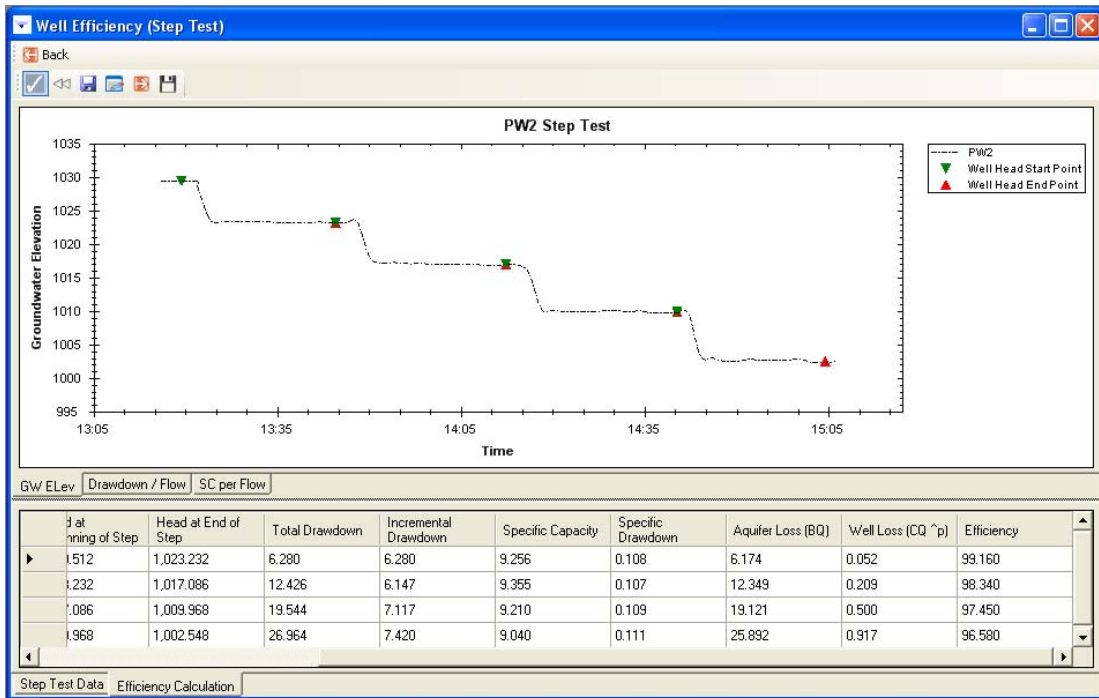


Figure 10. Well efficiency calculations from step-drawdown data

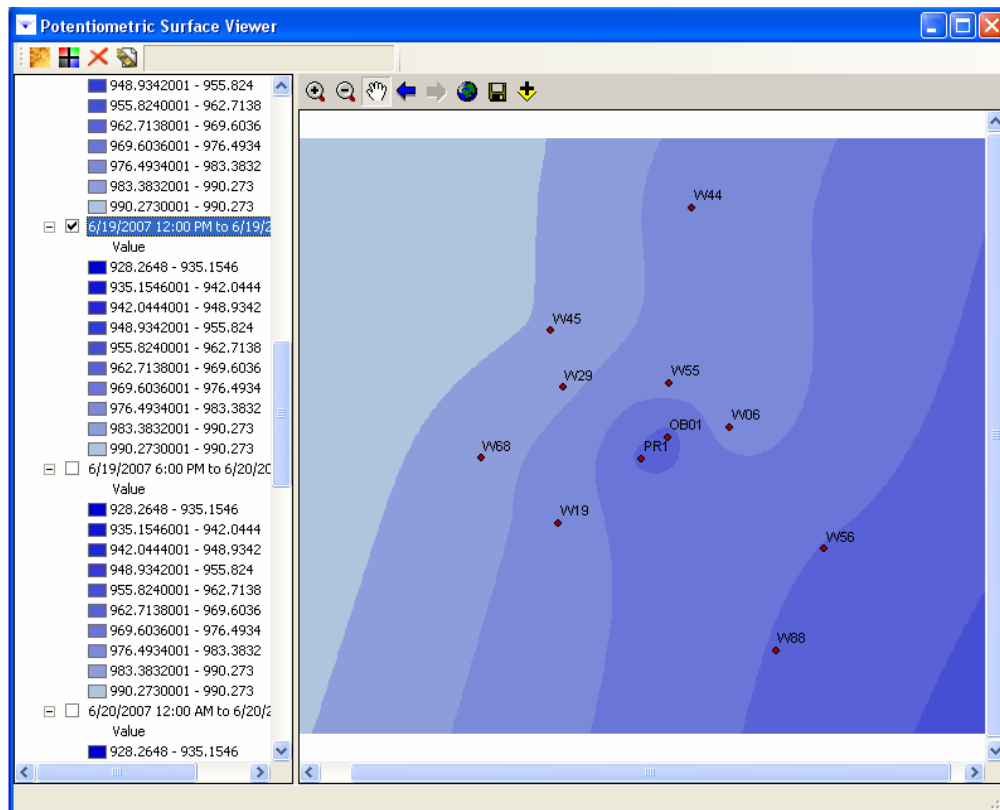


Figure 11. Groundwater contour map showing static conditions in real time

CONCLUSIONS

Ethanol production requires a reliable water supply. Most ethanol plants are located where surface water supplies are not adequate and rely on groundwater supplies. Due to regulatory requirements of aquifer impact analysis, combined with the rural location of ethanol plants, groundwater data collection and analysis can be costly with regards to travel expenses, data management, labor, and reporting costs. The use of datalogging instruments, telemetry systems, and advanced software can provide ethanol plants with remote access, near real-time data, and results that can keep an ethanol plant in compliance with their state regulatory agency. In addition, the total cost of remote data acquisition and automated data analysis can provide ethanol plants with significant savings on hydrogeological services.

With technological advances, aquifer testing can be performed at relatively low cost as pumps are turned on and off for operational purposes. By managing drawdown and by reducing the lift required to pump water, a plant can reduce electrical expenses. Furthermore, a database will be developed over time that represents a continuous record of aquifer response to recharge, barometric pressure, and pumping stress. Defensible groundwater velocities, flow directions, aquifer parameters, and groundwater models can be calculated and developed. Changes in pumping rates and optimal pumping schemes can be automatically sent to a PLC or SCADA system.

The data can be ported in near real time to the Internet for access by the company, by consultants, and by regulating agencies. For the ethanol industry, these technologies have been successfully employed at several sites throughout the permitting process and through plant operation. The capabilities increase regulator confidence, decrease costs relative to conventional data collection and analysis, increase the knowledge and protection of the aquifer resource, decrease liability of the groundwater user, and expand the knowledge base for groundwater scientists and engineers. Permit compliance can be automated by granting data access to the state regulating authority or, more conventionally, by automating the reporting requirement common to most permits. Real-time monitoring can help a plant stay in compliance and keep groundwater pumps operating at optimal efficiency.

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