

# Yield Tests for High Capacity Wells

## - Recommended Practices -

The Michigan Department of Environmental Quality, Water Division, Groundwater Section recommends the following practices for conducting yield tests for new high capacity wells that are not intended as public drinking water supplies. Some examples of high capacity wells for which these practices are recommended, are agricultural irrigation wells, golf course irrigation wells, industrial process wells, and lake/pond augmentation wells.

2003 PA 177 (enacted August 28, 2003) addresses methods for resolving disputes arising from the failure of small quantity water wells due to the lowering of groundwater because of the withdrawal of groundwater from a nearby high capacity well or wells. Act 177 subjects high capacity well owners to severe financial penalties if they fail to resolve groundwater disputes caused by their wells. Understanding the potential impacts and operational limits of their water well or wells will benefit high capacity well operators and can help minimize the occurrence of groundwater withdrawal disputes.

These procedures are based on widely accepted industry practices for the estimation of potential yield from a water well, predicting the drawdown, and delineating the extent of the cone of depression surrounding an operating well. Local health department staff should consider using these yield test recommendations in their well permitting programs. High capacity well owners are advised to conduct a yield test as described below before the initial operation of new high capacity wells or when replacing pumping equipment with higher capacity equipment.

### **DEFINITIONS:**

**High Capacity Well:** 1 or more wells at the same site which, in the aggregate, are equipped to withdraw groundwater with a pump capacity of 70 gallons per minute (gpm) or greater.

**Yield Test:** a test to predict the long-term production capability of a well, determine drawdown, and estimate the dimensional properties of the cone of depression surrounding a high capacity well.

**Static Water Level** – the distance from the ground surface to the water level within a well that is not being pumped or is not under the influence of a well that is being pumped.

**Drawdown** – the difference between the water level at any time during a yield test and the static water level.

**Cone of Depression** – a conical-shaped depression in the water table (or potentiometric surface) due to the drawdown of groundwater surrounding a pumping well.

### **YIELD TEST METHODOLOGY:**

The yield test and data analysis should be conducted by a qualified hydrogeologic consultant or groundwater professional.

**OBSERVATION WELLS** – A minimum of two observation wells meeting the following criteria should be used:

1. Observation wells should be completed in the same aquifer and screened at or near the depth of the high capacity well.
2. Adjacent existing wells may be used or observation wells may be constructed for the sole purpose of obtaining drawdown measurements during the yield test. If the high capacity well terminates in the bedrock, the observation wells should terminate in the

same bedrock formation at approximately the same depth and have a similar interval of open bedrock borehole.

3. Observation wells should be located at distances from the production well one to five times the thickness of the aquifer and at right angles to each other. Locate the observation wells at different distances from the production well.
4. Avoid using observation wells that are subject to being pumped during the yield test. Pumping of the observation wells during the yield test will hinder data interpretation.

**LOCATION INFORMATION** – Accurate measurements of the distances between the high capacity well and observation wells and the location of the wells in relation to property boundaries should be obtained. Well locations (high capacity well and observation wells) can be determined by using a global positioning system. The locations should be reported as a latitude and longitude in degrees-minutes-seconds or in degrees to an accuracy of 0.00001 of a degree.

**STATIC WATER LEVEL (SWL) MEASUREMENTS** – Measure SWLs in the high capacity well and observation wells before the yield test begins. The SWL measurements should be accurate to within one inch (or within 1/10<sup>th</sup> of a foot). Measure the distance from the top-of-casing to the SWL in the well. The height of the casing above ground surface should be recorded in order to calculate a SWL elevation.

Before beginning the pumping phase of the yield test, SWL measurements should be taken at a minimum of one reading every hour for a period of time equal to at least 1/3 of the anticipated length of the yield test.

**PUMPING RATE** – During the pumping phase, the high capacity well should be equipped to discharge at or above the desired final well production rate. The pumping rate should be constant over the course of the yield test. Periodically measure the pumping rate (using a flow meter) to ensure a constant rate throughout the test. Water from the high capacity well should be discarded in a manner that will not impact water levels in the aquifer or the outcome of the yield test. This is especially important if the high capacity well is in a shallow unconfined aquifer. Be sure there are provisions to control or precisely know the timing and amount of ground water withdrawals from the aquifer as a result of other high capacity wells in the vicinity that are producing from the same aquifer.

**PUMPING DURATION** – The suggested minimum length of the yield test depends on the type of the aquifer in which the high capacity well is completed, as follows:

<u>Aquifer Type</u>	<u>Minimum Pumping Duration</u>
Confined	24 hours
Unconfined	72 hours

**DRAWDOWN AND RECOVERY MEASUREMENTS** – During the yield test, record the drawdown measurements in the high capacity well and observation wells to an accuracy of within 1 inch (or 1/10<sup>th</sup> of a foot). Measure the drawdown, at a minimum, in accordance with the following schedule:

<u>ELAPSED TIME</u>	<u>MEASUREMENT FREQUENCY</u>
0 to 10 minutes	1 per minute
10 to 20 minutes	Every 2 minutes
20 to 60 minutes	Every 5 minutes
60 to 180 minutes	Every 15 minutes

ELAPSED TME (cont'd)

MEASUREMENT FREQUENCY (cont'd)

180 to 360 minutes  
360 to completion

Every 30 minutes  
Every 60 minutes

Upon completion of pumping, measure the water level recovery for a period of time not less than 1/3 the length of the yield test. During recovery, the water level measurements should be made in accordance with the above schedule.

**ANALYSIS OF DATA** – Analyze the yield test data using a suitable mathematical groundwater model to:

1. Predict the effects of pumping at the intended final operational pumping rate, duration, and timing of the high capacity well and
2. To estimate a safe groundwater withdrawal rate.

At a minimum, the transmissivity and storage coefficient of the aquifer should be determined employing the methods of Cooper and Jacob (1946), or Theis (1935). More complex methods of analysis, including but not limited to the following, are recommended where appropriate to the area hydrogeology and response of the aquifer to the withdrawal of ground water:

Hantush and Jacob, 1955 – leaky-confined conditions  
Hantush, 1960 – leaky-confined conditions  
Neuman, 1972 – unconfined conditions and/or delayed yield  
Neuman, 1974 – unconfined conditions and partial penetration  
Hantush, 1961 – partial penetration  
Ferris, et al., 1962 – the presence of boundaries

The analysis of the yield test data should include the following:

1. A prediction of the effects of the maximum projected continual operation of the high capacity well on the closest water well on adjacent property and a depiction of the radial extent of the cone of depression caused by the high capacity well.
2. A determination of the maximum safe withdrawal rate for the high capacity well without exceeding 10 feet of drawdown at the property boundary if the high capacity well terminates in a sand or gravel aquifer.
3. A determination of the maximum safe withdrawal rate for the high capacity well without exceeding 25 feet of drawdown at the property boundary if the high capacity well terminates in a bedrock aquifer.
4. The projected drawdown after 100 days of continuous operation of the high capacity well to predict long-term impacts.

**RECOMMENDED ACTION**

If analysis of the yield test data shows significant drawdown of the groundwater level at the property line or at the closest water well on adjacent property, the high capacity well owner should do the following: 1) modify the pumping rate, duration, or timing of the groundwater withdrawal to eliminate or minimize impacts, and /or 2) enter into an agreement with adjacent well owners to make modifications to their wells to prevent well failure due to groundwater lowering.

**FOR FURTHER INFORMATION**

Contact the Michigan Department of Environmental Quality, Water Division, Groundwater Section, 525 W. Allegan Street, P.O. Box 30630, Lansing, MI 48909-8130, phone 517-241-1300, fax 517-241-1328.

## **References:**

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