CONTROLLED PUMPING TEST

SOP#: 2045
DATE: 10/04/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The most reliable and commonly used method of determining aquifer characteristics is by controlled aquifer pumping tests. Groundwater flow varies in space and time and depends on the hydraulic properties of the rocks and the boundary conditions imposed on the groundwater system. Pumping tests provide results that are more representative of aquifer characteristics than those predicted by slug or bailer tests. Pumping tests require a greater degree of activity and expense, however, and are not always justified for all levels of investigation. As an example, slug tests may be acceptable at the reconnaissance level whereas pumping tests are usually performed as part of a feasibility study in support of designs for aquifer remediation.

Aquifer characteristics which may be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers. These parameters can be determined by graphical solutions and computerized programs. The purpose of this standard operating procedure (SOP) is to outline the protocol for conducting controlled pumping test.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

It is desirable to monitor pre-test water levels at the test site for about one week prior to performance of the pump test. This information allows for the determination of the barometric efficiency of the aquifer, as well as noting changes in head, due to recharging or pumping in the area adjacent to the well. Prior to initiating the long term pump test, a step test is conducted to estimate the greatest flow rate that may be sustained by the pump well.

After the pumping well has recovered from the step test, the long term pumping test begins. At the beginning of the test, the discharge rate is set as quickly and accurately as possible. The water levels in the pumping well and observation wells are recorded accordingly with a set schedule. Data is entered on the Pump/Recovery Test Data Sheet (Appendix A). The duration of the test is determinated by project needs and aquifer properties, but rarely goes beyond three days or until water levels become constant.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Interferences and potential problems include atmospheric conditions, impact of local potable wells, and compression of the aquifer due to trains, heavy traffic, etc.

5.0 EQUIPMENT/APPARATUS

The following equipment is required to perform a pump test:

- Tape measure (subdivided into tenths of feet)
- Submersible pump

- Water pressure transducer
- Electric water level indicator
- Weighted tapes
- Steel tape (subdivided into tenths of feet)
- Generator
- Electronic data-logger (if transducer method is used)
- Watch or stopwatch with second hand
- Semi-log graph paper (if required)
- Water proof ink pen and logbook
- Thermometer
- Appropriate references and calculator
- A barometer or recording barograph (for tests conducted in confined aquifers)
- Heat shrinks
- Electrical tape
- Flashlights and lanterns
- pH meter
- Conductivity meter
- Discharge pipe
- Flow meter

6.0 REAGENTS

No chemical reagents are used for this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required, refer to the SOP for Sampling Equipment Decontamination and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan.

6. Identify and mark all sampling locations.

7.2 Field Preparation

1. Review the site work plan and become familiar with information on the wells to be tested.

2. Check and ensure the proper operation of all field equipment. Ensure that the electronic data-logger is fully charged, if appropriate. Test the electronic data-logger using a container of water. Always bring additional transducers in case of malfunctions.

3. Assemble a sufficient number of field data forms to complete the field assignment.

4. The pumping well should be properly developed prior to testing, following the guidelines outlined in the Well Development SOP.

5. An orifice, weir, flow meter, container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well shall be provided.

6. Sufficient pipe to transport the discharge from the pumping well to an area beyond the expected cone of depression is needed. Conducting a pumping test in contaminated groundwater may require treatment, special handling, or a discharge permit before the water can be discharged.

7. The discharge pipe must have a gate valve to control the pumping rate.

8. Determine if there is an outlet near the well head for water quality determination and sampling.

7.3 Pre-Test Monitoring

It is desirable to monitor pretest water levels at the test site for about one week prior to performance of the test. This can be accomplished by using a continuous-recording device such as a Stevens Recorder. This information allows the determination of the barometric efficiency of the aquifer when

barometric records are available. It also helps determine if the aquifer is experiencing an increase or decrease in head with time due to recharge or pumping in the nearby area, or diurnal effects of evapotranspiration. Changes in barometric pressure are recorded during the test (preferably with an on-site barograph) in order to correct water levels for any possible fluctuations which may occur due to changing atmospheric conditions. Pretest water level trends are projected for the duration of the test. These trends and/or barometric changes are used to "correct" water levels during the test so they are representative of the hydraulic response of the aquifer due to pumping of the test well.

7.4 Step Test

Prior to initiating a long term pumping test, a step test shall be conducted. The purpose of a step test is to estimate the greatest flow rate that may be sustained during a long term test. The test shall be performed by progressively increasing the flow rate on one hour intervals. The generated drawdown versus time data is plotted on semilogarithmic graph paper, and the discharge rate is determined from this graph.

7.5 Pump Test

7.5.1 Time Intervals

After the pumping well has fully recovered from the step test, the long term pumping test may start. At the beginning of the test, the discharge rate should be set as quickly and accurately as possible. The water levels in the pumping well and observation wells will be recorded according to the following schedule:

TABLE 1. Time Intervals for Measuring Drawdown in the Pumped Well

Elapsed Time Since Start or Stop of Test (Minutes)	Interval Between Measurements (Minutes)
0-10	.5-1
10-15	1
15-60	5
60-300	30
300-1440	60
1440-termination	480

TABLE 2. Time Intervals for Measuring Drawdown in an Observation Well

Elapsed Time Since Start or Stop of Test (Minutes)	Interval Between Measurements (Minutes)
0-60	2
60-120	5
120-240	10
240-360	30
360-1440	60
1440-termination	480

7.5.2 Water Level Measurements

Water levels will be measured as specified in the Well Level Measurement SOP. During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well. After the first two hours, two people are usually sufficient to continue the test. It is not necessary that readings at the wells be taken simultaneously. It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured. Alternately, individual pressure transducers and electronic data-loggers may be used to reduce the number of field personnel hours required to complete the pumping test. A typical aquifer pump test form is shown in Appendix A.

During a pumping test, the following data must be recorded accurately on the aquifer test data form.

1. Site ID - A number assigned to identify a specific site.

2. Location - The location of the well in which water level measurements are being taken.

3. Distance from Pumped Well - Distance the observation well is from the pumping well in feet.

4. Logger - The company conducting the pumping test.

5. Test Start Date - The date when the pumping test began.

6. Test Start Time - Start time, using a 24-hour clock.

7. Static Water Level (Test Start) - Depth to water, in feet and tenths of feet, in the observation well at the beginning of the pumping test.

8. Test End Date - The date when the pumping test was completed.

9. Test End Time - End time, using a 24-hour clock.

10. Static Water Level (Test End) - Depth to water, in feet and tenths of feet, in the observation well at the end of the pumping test.

11. Average Pumping Rate - Summation of all entries recorded in the Pumping Rate (gal/min) column divided by the total number of Pumping Rate (gal/min) readings.

12. Measurement Methods - Type of instrument used to measure depth-to-water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers).

13. Comments - Appropriate observations or information which has not been recorded elsewhere, including notes on sampling.

14. Elapsed Time (min) - Time of measurement record continuously from time 0.00 (start of test) recorded in minutes.

15. Depth to Water (ft) - Depth to water, in feet and tenths of feet, in the observation well at the time of the water level measurement.

16. Pumping Rate (gal/min) - Flow rate of pump measured from an orifice, weir, flow meter, container or other type of water measuring device.

7.5.3 Test Duration

The duration of the test is determined by the needs of the project and properties of the aquifer. One simple test for determining adequacy of data is when the log-time versus drawdown for the most distant observation well begins to plot as a straight line on the semi-log graph paper. There are several exceptions to this simple rule of thumb; therefore, it should be considered a minimum criteria. Different hydrogeologic conditions can produce straight line trends on log-time versus drawdown plots. In general, longer tests produce more definitive results. A duration of one to three days is desirable, followed by a similar period of monitoring the recovery of the water level. Unconfined aquifers and partially penetrating wells may have shorter test durations. Knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives is necessary in interpreting just how long the test should be conducted. There is no need to continue the test if the water level becomes constant with time. This normally indicates that a hydrogeologic source has been intercepted and that additional useful information will not be collected by continued pumping.

7.6 Post Operation

The following activities shall be performed after completion of water level recovery measurements.

1. Decontaminate and/or dispose of equipment as per the Sampling Equipment Decontamination SOP.

2. When using an electronic data-logger, use the following procedures.

   - Stop logging sequence.
   - Print data, or save memory and disconnect battery at the end of the day's activities.

3. Replace testing equipment in storage containers.

4. Check sampling equipment and supplies. Repair or replace all broken or damaged equipment.

5. Review field forms for completeness.

6. Interpret pumping/recovery test field results.

8.0 CALCULATIONS

There are several accepted methods for determining

aquifer properties such as transmissivity, storativity, and conductivity. However, the method to use is dependent on the characteristics of the aquifer being tested (confined, unconfined, leaky confining layer etc.). When reviewing pump test data the following texts may be used to determine the method most appropriate to your case.

- Applied Hydrogeology (Fetter, 1980).
- Groundwater and Wells (Driscoll, 1986).
- Groundwater (Freeze & Cherry, 1979).

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

All gauges, transducers, flow meters, and other equipment used in conducting pumping tests shall be calibrated before use at the site. Copies of the documentation of instrumentation calibration should be obtained and filed with the test data records. The calibration records will consist of laboratory measurements and, if necessary, any on-site zero adjustment and/or calibration will be performed. Where possible, all flow and measurement meters will be checked on-site using a container of measured volume and stopwatch; the accuracy of the meters must be verified before testing proceeds.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, following U.S. EPA, OSHA, and corporate health and safety practices.

12.0 REFERENCES

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APPENDIX A

Pump/Recovery Test Data Sheet

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PUMP/RECOVERY TEST DATA SHEET

SITE ID: DISTANCE FROM PUMPED WELL (FT):

LOCATION: LOGGER:

TEST START TEST END

DATE: DATE:

TIME: TIME:

STATIC WATER LEVEL (FT): __ STATIC WATER LEVEL (FT): __

AVERAGE PUMPING RATE (GAL/MIN):

MEASUREMENT METHODS:

COMMENTS:

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)
0.00			0.00	

APPENDIX A (Cont'd)

Pump/Recovery Test Data Sheet

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PUMP/RECOVERY TEST DATA

SITE:

LOCATION ID: DATE:

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)
0.00			0.00	