Division of Drinking and Ground Waters

Policy on When The Constant Rate Pumping Test Should Exceed 24 Hours

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I. Purpose:

The purpose of this document is to provide clarification to public water systems (PWSs) and staff on determining appropriate pumping rate test duration.

II. Background:

Rule 3745-9-09(B) of the Administrative Code (OAC) requires that after developing a new PWS well, a constant rate pumping test shall be conducted to demonstrate that the well can supply water at the anticipated permanent design pumping rate. The rule states that the duration of the constant rate test can vary from normal hours of operation to at least 24 hours. The rule does not elaborate on the hydrogeologic conditions that would indicate tests exceeding 24 hours should be used because it would be difficult to capture all scenarios. The policy is intended to provide a basis for when longer pump tests may be needed.

III. Policy:

OAC rule 3745-9-09(B) requires low use community system wells and low to medium use noncommunity system wells to be tested at least for the period of normal operation either at the peak hourly demand, or at least at 1.5 times the pump design rate if the well cannot sustain peak hourly flow. For standard operation of most low use and medium use noncommunity wells, the wells are typically pumped during many brief intervals over the course of the day, whenever water is needed. However, the total collective duration of pumping per day is relatively short. The volume of water produced from pumping at the peak hourly flow for the normal hours of operation usually exceeds the volume of water these systems will ever use on a daily basis. Based on these considerations, the constant rate testing for these wells does not need to exceed 24 hours.

According to OAC rule 3745-9-09(B), constant rate pumping tests for community system wells and high use noncommunity system wells need to last at least 24 hours. However, this rule does not provide any upper limit to the duration requirement. This policy is aimed to provide clarification on when constant rate pumping test should be continued longer than 24 hours (see recommendations in Table 1) and when it may be stopped.

Table 1. Regulatory requirements on the minimum duration of constant rate pumping tests and technical recommendations on extending the duration of the test.

Public Water System	**Well use** [3745-9-09(B)]	**Minimum duration of constant rate pumping test** [3745-9-09(B)]	**Maximum duration**
Non-community	Low - medium	Normal operation period	24 hours
Non-community	High	24 hours	72 hours
Community	Low to high	24 hours	72 hours

Conceptual model for constant rate pumping test:

Pumping releases water from the aquifer and lowers hydraulic head (e.g., water table in unconfined aquifers, piezometric surface in confined aquifers), at the pumping well and in the aquifer surrounding the well. The area of lowered head expands outward as the drawdown at the pumping well increases. These changes are monitored in the pumping well and observation wells. Pumping is continued until the ground water flow conditions reach a stabilized condition, which becomes evident in the drawdown data or plot of drawdown versus time. For the purpose of the requirements of OAC rule 3745-9-09(B), the drawdown is considered "stabilized" when changes in drawdown with time become negligible. Under this condition, drawdown may be considered at a dynamic equilibrium between the volume of water pumped (i.e., yield of the well) and the volume of water that recharges back into the well from the surrounding aquifer.

The time-drawdown curve during some tests flattens (i.e., changes in drawdown with time become negligible). Although, there may be slight variations in individual data points, these variations appear random and do not show any discernible pattern of increase in drawdown with time. In other situations, the change in drawdown progressively slows down with time, but the time-drawdown curve may not become flat (i.e., not visually obvious), even if the pump test is run for several days. For the purpose of reviewing reports on pumping tests submitted for approval of new public water system wells, it is assumed that a stabilized drawdown condition is reached when, after 24 hours of pumping, the following conditions are met*:*

1) The time-drawdown data in the latest part of the constant rate pumping test indicate an average change in drawdown of no more than 0.2 feet per hour, and

2) The estimated average rate of change in drawdown is based on at least four consecutive water level data points that are collected at intervals in accordance with OAC rule 3745-9-09(B).

While running the test, it is recommended that the driller/hydrogeologist make preliminary plots of the raw data points to see how and whether the drawdown is approaching stabilization and how much longer the test may need to continue. If the conditions of stabilized drawdown are not met within 24 hours, the constant rate pumping test for community system wells and high use non-community system wells should be continued for duration up to 72 hours. The constant rate pumping test may be ended between 24 and 72 hours when drillers/hydrogeologists determine that data is adequate to demonstrate that drawdown is stabilized and the well can supply water at the anticipated permanent design pumping rate [OAC rule 3745-9-09(B)].

The determination of the yield of a well [OAC rule 3745-9-09(B)] is based on pumping the well for an extended period of time to reach a point when the drawdown changes become minimal. Upon reaching this "stabilized" drawdown condition, it can be reasonably assumed that under existing hydrogeologic conditions the tested well, when ready for production, can supply water at the anticipated permanent design pumping rate. The Water Well Standards require a minimum pumping duration of normal operation or 24 hours. In reality, it may be necessary to continue pumping longer than the regulatory minimum.

Scope of the constant rate test required by theWater Well Standards :

The yield of the well when drawdown is "stabilized" may not be the same as the "safe yield", "perennial yield" (Todd, 1980) or "sustainable yield," which is used in more recently published literatures. Kalf and Wooley (2005) provided a chronological overview of these concepts, published between 1915 and 2004. It is evident that these concepts are complex, mostly used on an aquifer wide or basin wide basis to manage ground water resources. This is in contrast to the well by well approach of yield determination in OAC rule 3745-9-09. Furthermore, these concepts are to be tied to some specified conditions that may need monitoring. Some examples of these specified conditions are reduced discharge of ground water to surface water features, well interference, impact on the availability and quality of ground water, ecological impacts, etc. (For more details, see Kalf and Wooley, 2005; Sophocleous, 2000.)

The scope of OAC rule 3745-9-09(B) does not include a determination of the safe yield/perennial yield/sustainable yield for ground water resource management. It simply focuses on the yield of the tested well under existing hydrogeologic conditions. It is assumed that reaching a "stabilized" drawdown condition, during an appropriately conducted constant rate pumping test, is a major piece of evidence to demonstrate that the well can supply water at the anticipated permanent design pumping rate.

Conduct and duration of constant rate pumping tests:

In some tests, drawdown may achieve stabilization before the regulatory minimum requirement of 24 hour pumping is met. In those situations, pumping may be discontinued after 24 hours, provided that adequate drawdown data is collected to demonstrate that the well can supply water at the anticipated permanent design pumping rate. Other constant rate tests should continue beyond 24 hours and strive for achieving a stabilized drawdown condition.

Besides meeting the regulatory requirements, there are other benefits of achieving stabilized drawdown during pumping tests. This approach allows using simpler equations for data analysis, can provide more and better quality data on the aquifer, and may reveal aquifer boundary conditions. (For more details see, Todd, 1980; Krusemann and de Ridder, 1990.)

It is difficult to generalize how many hours it may take to reach this apparent "stabilized" condition. In reality, it may vary from hours to days to weeks, or in some cases the test may never "stabilize." Drawdown stabilization depends on multiple factors including the type of aquifer, aquifer storage and transmissive properties, pumping rate, desired data accuracy, aquifer boundary conditions, etc. Ohio EPA is aware that the details and the accuracy of information available on the aquifer, in which the new well is to be installed, may be a limiting factor in planning and designing the constant rate pumping test. The nature of the aquifer, whether it is confined, unconfined, or leaky may be unknown. It is possible that an aquifer may

appear confined prior to the test, but may transition into an unconfined aquifer during or after the test. Also, there could be seasonal changes. For example, an aquifer may appear confined during the wet season but during the dry season, it may appear unconfined. Therefore, in some cases, the duration of the constant rate pumping test should not be predetermined on the basis of very limited information before the test.

When reliable information on the aquifer is available (e.g., for other wells nearby in the same aquifer, along with driller's/hydrogeologist's professional experience and judgment), this information can be considered in planning and designing the test. Arbitrarily selecting a high pumping rate, compared to what is known from other wells in the same aquifer in the area, can yield data that may be inconclusive. In the case of high use wells, the results of the step drawdown pumping test need to be properly evaluated, interpreted and considered in selecting the pumping rate for the constant rate test.

When an unconfined aquifer is pumped, water drains out (i.e., dewatering) of the aquifer. In confined aquifers, water comes from the compaction of the aquifer, expansion of water within the aquifer, and leakage into the aquifer. Because of this difference, unconfined and confined aquifers respond differently to pumping. In general, a greater and quicker drawdown is expected in confined aquifers than in unconfined aquifers. When pumping tests are conducted at similar rates and durations, the effects of pumping stress are generally noticeable over a larger area in confined aquifers than in unconfined aquifers.

Krusemann and de Ridder (1990) noted that, under average conditions, stabilized conditions may be achieved after 15 to 20 hours in leaky aquifers and it is a good practice to pump for 24 hours in confined aquifers, and a longer test period such as three days for unconfined aquifers. It is common for pumping tests in unconsolidated or cavernous formations to take more than 24 hours to reach stabilized drawdown. Ohio EPA has conducted some research on regulatory requirements from other states and local agencies regarding the duration of constant rate pumping test. These requirements vary depending on the type of the system, nature of the aquifer (i.e., confined, unconfined, unconsolidated, bedrock), desired pumping rate, etc. For example, the required duration varies from at least 24 hours (e.g., Ohio, Indiana, West Virginia) to up to 10 days (wells in bedrock, >100,000 gpd, Massachusetts).

Based on a consideration of the information in published literature, and regulatory requirements of Ohio and some other states, Ohio EPA recommends that the constant rate pumping test for community system wells and high use non-community system wells be run for a duration varying from 24 to 72 hours, unless under special circumstances a longer duration is needed.

The constant rate pumping test may be ended between 24 and 72 hours when the driller/hydrogeologist determines that adequate data have been collected to demonstrate that drawdown is "stabilized" and the well can supply water at the anticipated permanent design pumping rate [OAC rule 3745-9-09(B)]. It needs to be considered that the cost of running the test for few additional hours to make test results conclusive is low compared to the total cost of the test. (For more details, see Krusemann and de Ridder, 1990; Osborne, 1993.)

Determining the yield of a well

The determination of the yield of a well [OAC rule 3745-9-09(B)] is based on pumping the well for an extended period of time to reach a point when the drawdown changes become minimal. Upon reaching this "stabilized" drawdown condition, it can be reasonably assumed that under

existing hydrogeologic conditions the tested well, when ready for production, can supply water at the anticipated permanent design pumping rate. The Water Well Standards require a minimum pumping duration of normal operation or 24 hours. In reality, it may be necessary to continue pumping longer than the regulatory minimum.

IV. References:

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