Guide to Conducting Well Pumping Tests

Water Stewardship Information Series

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

The BRITISH COLUMBIA GROUND WATER ASSOCIATION

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Further information and resources on pumping tests

Reference Books and Reports

Sterrett R. J., 2007. Groundwater and Wells, 3rd edition. New Brighton: Johnson Screens

Allen, D.M., 1999. An assessment of the methodologies used for analyzing hydraulic test data in British Columbia. Queen's Press.

Internet Resources

Ministry of Environment Pumping Test Report form - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/brochures_forms.html

Guidance document on conducting pumping tests for wells requiring a Certificate of Public Convenience and Necessity (CPCN) - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/eval_well/index.html

Checklist for Pumping Test Reports in Support of Certificate of Public Convenience and Necessity - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/eval_well/well-07.htm

Listing of Groundwater Consultants in BC - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/consultants.html

Provincial registry of qualified well drillers - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/applications/well_drillers_reg.pdf

Provincial registry of qualified well pump installers - www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/applications/pump_install_reg.pdf

BC Water Resource Atlas for information on aquifers and wells - www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html

setting, pumping rates, method of flow measurement, observations made during the pumping test, duration of the test, available drawdown, specific capacity, method of water level measurements and water levels/times recorded during the pumping test and recovery period;

- analysis and assessment of the pumping test data including an assessment of the long-term sustainable yield and potential impacts to neighbouring wells and/or streams;
- the qualified professional's opinion on the short and long-term capacity of the well and its ability to meet the applicable production criteria (e.g., subdivision by-law for private sources, projected demand for water systems);
- assessment of the water quality results, including copies of laboratory results; and
- signature and professional seal of the qualified professional responsible for the report.

Table of Contents

This guide provides general information and guidance on best pumping test practices for qualified well drillers and qualified well pump installers. In addition, the guide offers general information to developers and local governments on the pumping test requirements for proving up water supplies (i.e., to determine if sufficient ground water is available for residential developments) and an explanation of the benefits of a properly conducted pumping test. This guide is not meant to be a substitute for professional guidance and the appropriate standards of care.

What is the difference between a well yield test and a pumping test?

A **well yield test** is a short (approximately one hour) flow test, usually done by a qualified well driller once the well is completed to provide a rough estimate of the well's yield. It is generally recorded in the well construction report by the driller. Well yield tests are done using bailing[1] or air lifting[2] methods. Well yield tests are not as reliable as a pumping test in the following situations.

- when well yield is low (e.g. typical bedrock well);
- where maximum yield from the well is required;
- when reliable estimates of aquifer properties are needed; and
- when assessing impacts of proposed pumping on neighbouring wells.

A **pumping test** is a practical, reliable method of estimating well performance, well yield, the zone of influence of the well and aquifer characteristics (i.e., the aquifer's ability to store and transmit water, aquifer extent, presence of boundary conditions and possible hydraulic connection to surface water). A pumping test consists of pumping groundwater from a well, usually at a constant rate, and measuring water levels in the pumped well and any nearby wells (observation wells) or surface water bodies during and after pumping (see Figure 1). These data are used to plot drawdown and recovery as shown on Figure 2. Pumping tests can last from hours to days or even weeks in duration, depending on the purpose of the pumping test, but traditional pumping tests typically last for 24 to 72 hours.

[1] Water is removed from the well in a cylindrical bailer lowered from the drilling rig mast.

[2] Compressed air is injected into the well to blow air and water out of the well.

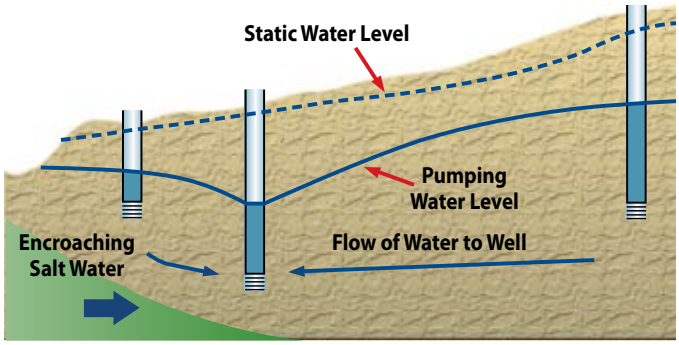

Figure 11. Pumping test of a well adjacent to the ocean.

professional, pumping should be stopped if intruding salt water could affect the water quality in the coastal aquifer.

Who can interpret pumping test data?

Interpretation of pumping test data should be done by a qualified professional with expertise in hydrogeology, especially in the following situations:

- when required by an approving agency;
- where the maximum well yield is needed;
- to assess impacts of the pumping well; or
- when estimates of aquifer properties are needed.

Where wells are tested solely to provide greater confidence in the driller's estimated yield, a qualified well driller or pump installer with competency in pumping test interpretation may be able to interpret the pumping test data.

What should be in a pumping test report?

The formal report for a pumping test should contain the following:

- information on the well (the well construction report, type of well and a diagram showing the well's location on the property, etc.);
- information on field procedures and personnel involved in the test (i.e., person responsible for the pumping test, such as a qualified well pump installer)
- information on the hydrogeologic setting, including references to mapped aquifers, when available;
- pumping test information including the date of the pumping test, all data on the pump type, depth of pump

A qualified professional hydrogeologist should be consulted if the major water-bearing fracture(s) are not known.

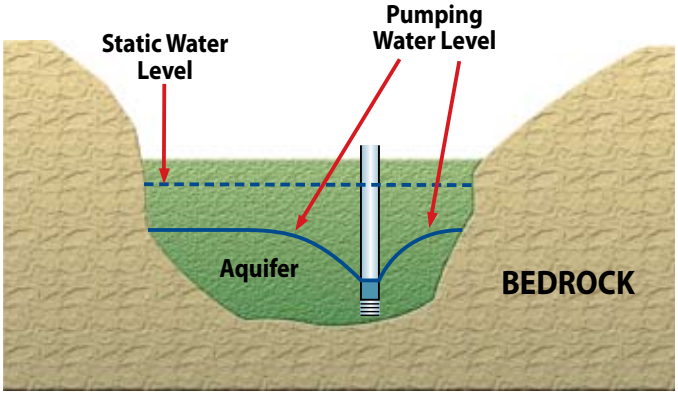

Figure 10. Drawdown behaviour in small unconsolidated unconfined aquifer bounded by bedrock.

Small unconsolidated (sand and gravel) aquifers (e.g., covering up to a few km^2 in area) have a limited storage and recharge capacity and are often bounded by low permeability deposits such as silt, clay, till or bedrock (see Figure 10). The drawdown behaviour in the early part of the pumping test may give a falsely optimistic impression of the long-term yield. The aquifer's limits are reached when the drawdown rate increases noticeably (i.e., an impermeable geologic boundary or barrier may have been reached).Wells pumped in **coastal aquifers** have the potential for salt water intrusion, particularly where pumping occurs on ocean waterfront properties (see Figure 11). In this case, a qualified professional hydrogeologist should be involved. Monitoring a parameter like specific conductance throughout the pumping test will indicate whether salt water intrusion is occurring during the test. For example, when specific conductance has risen to greater than 1,000 micro Siemens per centimetre (µS/cm) which is equivalent to ~250 mg/L of chloride, it is likely salt water intrusion is being initiated. Specific conductance can be monitored using a specific conductance probe or meter. A qualified professional should be consulted. The qualifed professional will design the pumping test and determine whether sentinel or observation wells (monitoring wells located between the foreshore and faults or fracture zones adjacent to sea water and the pumping well) should be installed or monitored, as well as the parameters to monitor where there is a reasonable concern about salt water intrusion. On the advice of a qualified

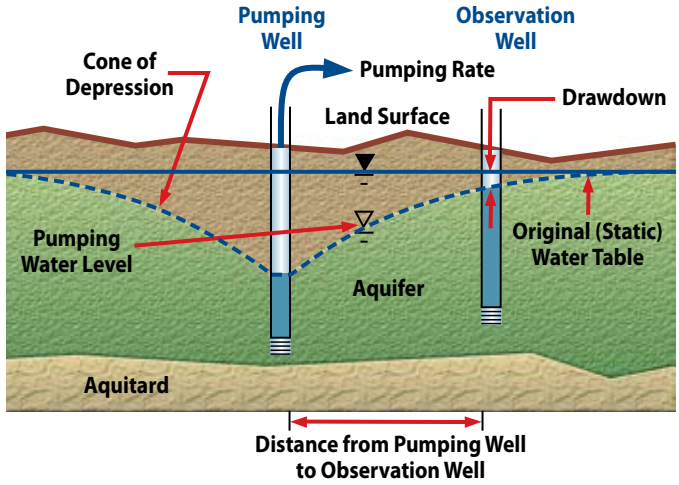

Figure 1. This figure shows the impact of a pumping well on the water level and on a neighbouring well (observation well) in an unconfined aquifer. As the water is pumped from the well, the original water level lowers, i.e., drawdown in the well. A cone of depression is formed in the aquifer around the pumping well as the water level declines due to pumping. Note that drawdown in the observation well is much less than in the pumping well.

Pumping test water level measurements should be made prior to, during and immediately following the pumping periord (see Figure 2). The information collected during the recovery period is used to verify the results of the pumping test.

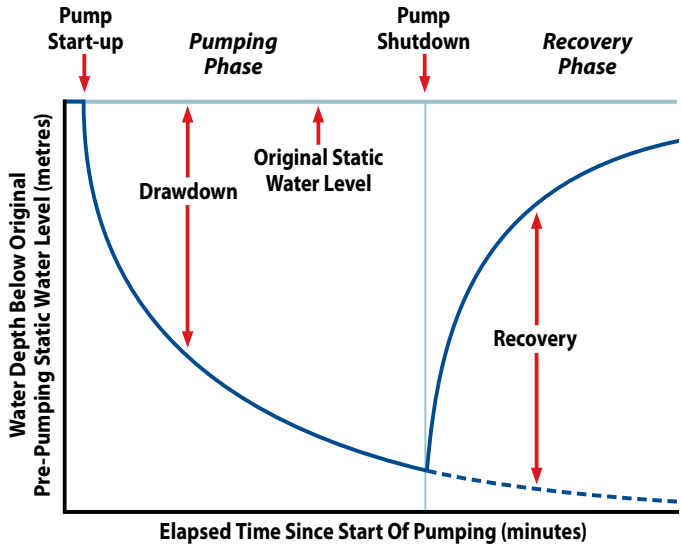

Figure 2. Graph showing the different phases of a constant rate pumping test – the pumping phase and the recovery phase.

When are pumping tests needed?

Wells can be pump tested solely to provide a greater confidence in the driller's estimated well yield. These tests are typically shorter in duration (4 to 12 hours) and are commonly done on domestic or single-residence wells.

Longer duration pumping tests are commonly required to:

- prove up water quantity under local government bylaws for new residential developments or regulatory requirements, e.g. Certificate of Public Convenience and Necessity (CPCN);
- determine the maximum sustainable well yield;
- assess impacts on neighbouring wells or water bodies such as streams from the proposed use of the well; and/or
- obtain aquifer properties such as permeability and boundary conditions.

Who can conduct a pumping test?

Under Section 70 of the *Water Act*, the following persons can conduct a pumping test:

- a qualified well driller;
- a qualified well pump installer; or
- a person working under the direct supervision of the qualified well driller, qualified pump installer or qualified professional with competency in hydrogeology.

A qualified professional[3] with competency in hydrogeology should be responsible to plan, design, implement and interpret the pumping test in the following situations:

- where a pumping test for a well is required by an approving agency; or
- where the yield of the well needs to be maximized; or
- when data needs to be interpreted, for example:
  - when there is a need to assess the impact of the pumping well on nearby surface and ground water resources; and
  - when estimates of an aquifer's properties are required.

[3] Qualified professionals who are registered with the Association of Professional Engineers and Geoscientists of British Columbia

Figure 9. Conveyance channel constructed to reduce erosion from discharged pumped water.

to analyze. Consult a qualified professional if field measurements are required (e.g. pH, temperature, conductivity, alkalinity, dissolved oxygen and turbidity). Consult the laboratory for sampling procedures, sampling bottles, coolers and holding times for delivery of water quality samples to the laboratory.

Are there special conditions to be aware of when conducting or interpreting the pumping test?

If **hydrofracturing** (fracking) has been used to increase the productivity of the well, it may advisable to wait up to a week before conducting the pumping test. Hydrofracturing uses large volumes of water (up to 2,000 U.S. gallons or 7.6 m^3/min) that either need to be pumped out or dissipate into the surrounding rock before the pumping test is done. Dissipation effects of hydrofracturing can be checked by measuring the water level immediately after the hydrofracturing has occurred and over subsequent hours or days.

In **fractured bedrock aquifers** it is important to know the depth of any major water-bearing fracture(s) (usually found in the driller's well construction report) to:

- ensure the water level is not drawn down below the fracture during the pumping test; and
- enable meaningful interpretation of the pumping test and the well's sustainable yield.

Figure 8. Discharge pipe for a large volume pumping test in Merritt.

In an urban setting, the pumped water may be discharged to a storm sewer but local government approval may be required if the pumping rate is above a certain threshold.

For large production wells, where disposal will be to an adjacent water body or wetland, the local Ministry of Environment and Department of Fisheries and Oceans (DFO) offices must be advised as an approval may be required. Even if the well water is potable, discharging the water to an adjacent water body could mobilize sediment and impact fish habitat. To eliminate or minimize this, a proper conveyance channel should be used. Ensure the channel is either rock-lined or vegetated to prevent erosion (see Figure 9) and that the outlet to the receiving water body does not harm fish habitat by destabilizing stream banks or eroding instream habitat such as riparian vegetation, river banks or beds.

Is a water sample required for analysis?

A pumping test is a good time to collect water quality samples to assess the chemical, physical and bacterial properties of the water. Water samples should be collected when conditions have stabilized (usually near the end of the pumping test). Sanitize the sampling port or bib with isopropyl alcohol or a dilute chlorine solution before collecting a sample, taking care not to introduce the sanitization fluid to the water sample. Consult with the qualified professional responsible for the test or the approving authority (regional health authority or local government) to determine what water quality parameters

What are the key things to consider when designing and planning a pumping test?

Designing and planning a pumping test is critical prior to testing. Lack of planning can result in delays, increased costs, technical difficulties and poor or unusable data.

Some things to consider in the pre-planning stage are:

- ✔ time of year the pumping test should be done
- ✔ natural variations in the groundwater levels that occur during the test that needs to be accounted for
- ✔ informing others who may be affected
- ✔ depth of pump setting and type of pump
- ✔ pumping duration
- ✔ pumping rate
- ✔ control and measurement of the pumping rate
- ✔ frequency of measurements of the water levels
- ✔ measuring water levels in neighbouring wells and/or streams
- ✔ discharge of pumped water
- ✔ collection of water samples for water quality analysis
- ✔ special conditions to be aware of, e.g. salt water intrusion in coastal aquifers

What time of year should a pumping test be done?

An approving agency may require a pumping test to be conducted during a low recharge period (e.g. dry period) or other time of the year. For fractured bedrock and other low-yielding wells, a pumping test should be done during a dry period when water tables are at their lowest levels to allow for a conservative estimate of long-term yield. Optimal times for testing in B.C. are summer and fall in coastal areas and fall and winter in the Interior.

Are there natural variations in the groundwater levels?

Natural variations in water levels caused by tidal, river and barometric changes can influence water levels during pumping and recovery. Even diurnal variation can occur in shallow water

tables due to the great difference between night and day evapotranspiration. Pre-pumping and post-pumping (recovery) water level measurements in the pumping well and any observation well(s), can be used by the qualified professional hydrogeologist to filter out natural fluctuations.

Should other well owners be notified about the pumping test?

If the pumping test involves pumping a large volume of water for a long duration (e.g., 24 to 72 hours), owners of neighbouring wells (i.e., any well within 300 feet or 100 meters of the pumping well) should be notified. Pumping of these neighbouring wells during the pumping test could affect the results of the test, especially if the neighbouring wells are to be used as observation wells.

What type of pump should be used and at what depth should it be placed?

The pump is normally placed above the well screen to maximize the amount of drawdown for the pumping test. The intake of the pump should not be placed within the well screen as this may cause increased velocities resulting in sanding and potential casing deteriorization, along with screen plugging. For bedrock wells the pump is set at or just above the uppermost major water-bearing fracture (refer to the driller's well construction report).

There are several factors to consider when determining the type of pump to use and the depth at which it should be set, including:

- well diameter;
- desired pumping rate;
- total dynamic head including the pumping water level, the above ground head (if applicable) and all friction losses in the casing, pipes, fittings, etc.;
- reliability of power source; and
- horsepower requirements.

As well, consider whether the pump is submersible and has variable speeds. Power needs to be continuously available to the pump during the test. If power is interrupted, it may be necessary to terminate the test, allow the well to recover and run a new test.

- presence of sediments in the pumped water;
- presence of any smell from the discharged water e.g., rotten egg (H_2S); and
- evidence of cascading water inside the well.

When should neighbouring wells and/or stream levels be measured?

Monitoring of water levels in neighbouring wells (observation wells) and/or streams to assess the impact of the pumping well should be specified by the qualified professional, especially where:

- the pumping rate is high;
- there are regulatory requirements; and/or
- neighbouring wells or stream levels could be impacted by the pumping.

Existing wells may be used if they are within the same aquifer formation and the well owner has provided consent. Water levels in at least one observation well need to be monitored if an aquifer storativity value is required. The observation well should not be pumped during the pumping test. If this is unavoidable, the times and pumping rates should be recorded. Often, water levels may not vary as much in observation wells as they will in the pumping well, therefore it is important to establish reliable background conditions prior to the pumping test.

How is the pumped water discharged?

Proper discharge of the pumped water is important to ensure there is no damage due to erosion, flooding or sediment deposits in streams (see Figure 3). It is important to assess the volume of pumped water, if storage or treatment are needed, and disposal alternatives early in the planning process. For land disposal, direct the water from the pumping well in a down-hill direction at a sufficient distance from the pumping well. This will prevent re-circulation of the pumped water into the well or aquifer and will preserve both the pumping water level and the integrity of the pumping test. Several hundred feet or more of discharge line may be needed (see Figure 8). If the aquifer is confined (refer to the lithology section of the driller's well construction report), the water can generally be conveyed a shorter distance away from the pumping well without affecting the pumping water level.

OBSERVATION WELL*
DURING PUMPING:
• Every 10 minutes for the first 100 minutes**
• Every 50 minutes from 100 minutes to 500 minutes**
• Every 100 minutes from 500 minutes to 1000 minutes**
• Every 500 minutes from 1000 minutes to 5000 minutes**
• Every 24 hours from 5000 minutes onward**
• Final water level measurement just prior to end of pumping
DURING RECOVERY:
• Every 10 minutes for the first 100 minutes after end of pumping***
• Every 50 minutes from 100 minutes to 500 minutes after end of pumping***
• Every 100 minutes from 500 minutes to 1000 minutes after end of pumping***
• Every 500 minutes from 1000 minutes to 5000 minutes after end of pumping***
• Every 24 hours from 5000 minutes onward***

** If the observation well is located in close proximity to the pumping well it may be possible to take more frequent measurements*

*** Time since the real start time of the pumping or time immediately after a step change in pumping*

**** Not required if time is beyond the specified duration of recovery measurements*

loading of the aquifer due to heavy equipment (trains, for example). It is important to accurately note down data and to record events that occur during the pumping test. Key points to note are as follows:

- changes in the pumping rate;
- any periodic cycling on and off of well pumps in the area;
- staff changes during the pumping and recovery tests;
- if and when equipment (e.g., sounding probe) was changed during the test;
- if the pumping test was conducted in a well field, or when other wells were pumping;
- when the pump was pulled out;
- times and pumping rates of any observations wells;
- precipitation that occurred during the test;

How much time will the pumping test take?

The duration of the pumping test depends on the purpose of the well, the type of aquifer and any potential boundary conditions. Aquifer types and potential boundary conditions can be obtained from:

- well construction reports for the pumping well and any neighbouring well(s);
- information on the aquifer and surface water bodies, such as lakes or rivers in the vicinity of the well; and
- qualified well drillers and professional hydrogeologists.

Minimum durations of traditional pumping tests are 24 to 72 hours unless stabilization occurs. Local by-laws, regulatory requirements or a qualified professional can stipulate minimum pumping durations. Duration is generally longer, e.g. 72 hours, for bedrock wells due to uncertainties associated with bedrock aquifers, and 48 hours for wells completed in unconfined aquifers due to the delayed release of water as the water level goes down or "delayed yield" effect.

How is the pumping rate selected?

The well should be pumped at or above the required yield and the well should not be rated above the pumping rate used during the test.

Other considerations for setting the pumping rate are:

- wells should not be pumped at a rate higher than the manufacturer's recommended transmitting capacity for the well screen to avoid damage to the well and aquifer near the well (check the well screen details in the driller's construction report and refer to the section on entrance velocities in Groundwater and Wells);
- wells completed in unconsolidated aquifers (e.g., sands and gravels) with an open bottom (e.g., no well screen) should not be pumped at a rate which could cause the heaving of aquifer materials into the well and locking up the pump; and
- bedrock wells should not be overpumped (i.e., water levels should not be drawn down past the uppermost water bearing fracture) because turbulence at the borehole/well interface could damage the aquifer formation and result in excessive turbidity in the water

A qualified professional involved in the design of a pumping test may determine a step drawdown test is needed before the constant rate pumping test is conducted. If a step drawdown test is done, the well should be "rested" between the step test and the constant-rate pumping test to allow for the water level to recover. A qualified professional should determine the optimum pumping rate for traditional pumping and step drawdown tests.

Another consideration when selecting the pumping rate is borehole storage (water stored in the well casing). In most cases, for a short period after pumping begins, all the pumped water comes from borehole storage. However, in some cases, where the well is deep and the rate of intended use is low, the borehole storage may never be pumped out. In these instances, the pumping rate can be initially set higher than the rate of intended use to remove the borehole storage and then the pumping rate is cut back to match the rate of intended use.

How is the pumping rate controlled and measured?

Control of the pumping rate during the test is important as it allows for reliable drawdown data to be collected to determine the yield of the well and aquifer properties. Controlling the pumping rate by adjusting the pump speed is generally not satisfactory. It is better to use a gate valve to adjust the pumping rate to keep it constant. The discharge pipe and the valve should be sized so that the valve will be from ½ to ¾ open when pumping at the desired rate. The valve should be installed at a sufficient distance from the flow measurement device to avoid any impacts from turbulence. Measuring the discharge of pumped water accurately is also important and common methods of measuring discharge include the use of an orifice plate and manometer (see Figure 3), an inline flow meter (see

Figure 3. Water discharge during a pumping test

TABLE 1

Recommended minimum intervals for water level measurements for pumping tests.

WELL BEING PUMPED
DURING PUMPING:
• Every minute for the first 10 minutes**
• Every 2 minutes from 10 minutes to 20 minutes**
• Every 5 minutes from 20 minutes to 50 minutes**
• Every 10 minutes from 50 minutes to 100 minutes**
• Every 20 minutes from 100 minutes to 200 minutes**
• Every 50 minutes from 200 minutes to 500 minutes**
• Every 100 minutes from 500 minutes to 1000 minutes**
• Every 200 minutes from 1000 minutes to 2000**
• Every 500 minutes from 2000 minutes to 5000 minutes**
• Every 24 hours from 5000 minutes onward**
• Final water level measurement just prior to end of pumping
DURING RECOVERY:
• Every minute for the first 10 minutes after end of pumping***
• Every 2 minutes from 10 minutes to 20 minutes after end of pumping***
• Every 5 minutes from 20 minutes to 50 minutes after end of pumping***
• Every 10 minutes from 50 minutes to 100 minutes after end of pumping***
• Every 20 minutes from 100 minutes to 200 minutes after end of pumping***
• Every 50 minutes from 200 minutes to 500 minutes after end of pumping***
• Every 100 minutes from 500 minutes to 1000 minutes after end of pumping***
• Every 200 minutes from 1000 minutes to 2000 minutes after end of pumping***
• Every 500 minutes from 2000 minutes to 5000 minutes after end of pumping***
• Every 24 hours from 5000 minutes onward***

Good record keeping is key to interpreting the data collected from a pumping test. Occasionally, fluctuations in the water level will occur, due to nearby pumping of another well, sudden rainfall events, tidal variations or changes in surface

The Ministry of Environment has developed a Pumping Test Report form to record information and data collected from the pumping and recovery test – www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/brochures_forms.htm. An Excel spreadsheet has also been developed to record the test drawdown and recovery data. The recommended minimum intervals for water level measurements in both the pumping and observation well(s) during the pumping and recovery phases is shown in Table 1 as well as on the back of the Pumping Test Report form. Data collection at the minimum specified intervals will establish conditions that affect groundwater flow to the well. It may not always be possible to take the drawdown measurements at the specified intervals. In these cases, water level readings would be recorded with the actual time the drawdown was recorded.

Monitoring water level recovery after the pump has stopped is very important because it aids the interpretation of the pumping test. Recovery data also tend to smooth out variations in the pumping rate, should variations occur. To obtain accurate recovery data, a check valve should be installed at the bottom of the pump discharge pipe to eliminate backflow of water into the well.

Typically, the duration of the recovery test is directed by the qualified professional. At a minimum, recovery water levels in the well should be monitored for the same duration of the pumping test or at least until 90 per cent recovery has been achieved. The pump should not be removed from the well until the water level has returned to 85-90 per cent of the pre-pumping or static water level or until the supervising qualified professional indicates the pump can be removed. However, generally for a 24-hour pumping test, 90 per cent recovery occurs within two to three hours after the pump is stopped and the pump can then be removed (this event should be recorded on the data sheet). If the water does not recover within the same time duration of the pumping test (e.g., 24 hours) the water level should be monitored daily for an additional week.

If the water does not return to 90-95 per cent of the starting water level after a week, the test pumping rate is likely higher than the aquifer's capacity to sustain this rate and further testing (i.e., longer pumping time and lower pumping rate) may be required. If this happens, a qualified professional should interpret the pumping test and recovery data and recommend a course of action.

Figure 4. In-line flow meter.

Figure 5. A five gallon bucket (~20 liters) and a stop watch can be used to estimate low pumping rates.

Figure 4), an inline calibrated pitot tube, a calibrated weir or flume, or observing the length of time taken for the pumped water to fill a container of known volume (see Figure 5).The flow measurement device should be compatible with the expected pumping rate. Calibrated in-line flow meters and orifice weirs are used to measure pumping rates for high production wells. If an orifice weir is used, the discharge pipe should be straight and level for a distance of at least six feet (1.8 meters) before the water reaches the orifice plate. For relatively low pumping rates (e.g. <10 USgpm or <0.6 L/s), a five gallon (19 L) bucket or graduated cylinder and a stop watch is practical for measuring flow (see Figure 5).

During a constant-rate pumping test the pumping rate must be measured correctly and recorded regularly. In general, the lower the pumping rate, the more accurate and careful the flow measurement must be. An unrecorded change of as little as two per cent in the pumping rate can affect the interpretation of the data, i.e., indicate a false stabilization or a boundary condition. At the beginning of the test the pumping rate should be set as quickly and accurately as possible and should remain constant for the duration of the test. For example, the pumping rate should not vary by more than five per cent and should generally be within two to three per cent for higher pumping rates. It is good practice to measure and record pumping rates frequently at the beginning of the test (every 15 minutes for the first hour) and hourly thereafter for tests of one to three days. Checking the pumping rate allows for adjustments to be made if the rate has drifted, and confirms the selected pumping rate has been maintained. Adjustments to the pumping rate should be recorded along with the measured rate and water levels during the pumping test. Good record keeping is key to interpreting the pumping test results.

How and at what intervals will changes in water levels be measured?

Prior to the test, all water monitoring instruments should be checked to be sure they are working properly. Fresh replacement batteries should be available for all manual sounding probes. Before the test begins, synchronize the watches of all observers and data logger's "time-of-day" settings. All stop watches should be started at the time the pump starts pumping water (or stopped if doing a recovery test).

Establish initial conditions by measuring static water levels in the well and any observation well(s) for a period of time before starting the pumping test.. As a general rule, the period of observation before the start of the test should be at least one week. All observers should use the same measuring point on the top of the well casing for each well. If static water levels in the aquifer are changing due to recharge or other factors, a qualified professional should be consulted on establishing the water level prior to the test.

A sounding tube or access tube, typically a ¾" to 1" (19 to 25 mm) diameter PVC pipe that extends from the top of the casing down to 3 to 4 feet (0.9 to 1.2 meters) above the pump, can

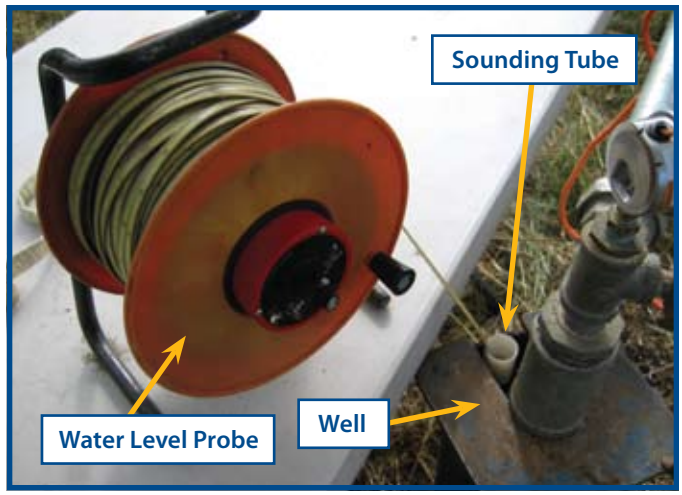

Figure 6. Water level measurement using water level probe and sounding tube.

be used to take water level measurements without the probe getting tangled in the pump wiring. Water levels can be measured using water level probes (see Figure 6) or pressure transducers (see Figure 7). If pressure transducers are used, select types that cover the range of drawdown anticipated. Pressure transducers should be calibrated before and after the test. Take manual readings of the water level prior to and following the test and periodically throughout the test to confirm the water level measurements by the transducer. Measurements should be taken to the nearest ⅛" or ¼" (0.3 to 0.6 cm).

Figure 7. A pressure transducer can be used for automatic measurement and recording of water level and temperature, specific conductance or other parameters during the pumping test.