

PROCEDURE MANUAL

Community-based Groundwater Monitoring Project

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Chapter 1: Overview

1.1 Specific aims

The aim of this procedure manual is to provide information regarding the set-up, implementation and maintenance of a community-based groundwater monitoring project for a municipality.

This manual provides instructions on:

- How to recruit community members (Chapter 2),
- What information to collect (Chapter 3),
- Data collection techniques (recommendations) (Chapter 6),
- The legalities of obtaining consent (Chapter 5),
- The process of managing data and ensuring quality control (Chapters 7 and 8),
- Lessons learned from similar projects.

The specific aim of a community-based groundwater monitoring project is to engage local residents in a long-term data collection initiative, which provides information on groundwater resources within a municipality using a low cost method. The data should then be analyzed to assist in making water resources and land-use decisions at a policy level. The information can be used to educate the public about groundwater issues, in particular threats to fresh water in the local municipality.

1.2 Significance

A groundwater monitoring project will allow water-resource managers, land-use planners, developers and community members to understand pressures being placed on groundwater reserves within a municipality. The significance of this project is to determine trends in groundwater recharge, depletion and seasonal fluctuations. With a study occurring over a number of years, researchers can begin to understand the natural processes of the system. The importance of long-term monitoring is to determine seasonal and inter-annual variations, which can provide insight into changes occurring due to external factors, such as alterations in land-use practices or increases in water extraction.

In Alberta the increase pressure on water resources led to the development of the *Water for Life Strategy*. With the increases in population and the uncertainty in the effects of climate change, the issue of water availability has become important. The significance of a groundwater monitoring project is to provide baseline information on groundwater levels, which can be used to assess the potential effects of changes in water extraction, land-use, and climate

1.3 Study Plan Overview

1.3.1 Study design

The study requires local residents, with a well in good condition, to take water level readings. It also requires the selected wells to fulfill particular requirements (see Section 4.2) and be monitored at a regular interval (for example, bi-monthly) by the residents. The selected wells will provide information on the geology of the aquifer through lithology logs on the driller's report. The well network should include shallow and deep wells throughout the municipality, with varying land-use practices. Once the wells have been selected, the resident is trained on how to measure the water level accurately and provided with all the necessary equipment. The collected data are then compiled and reviewed by the project team to ensure quality control is maintained. A useful resource for a community-based groundwater monitoring project is the paper – *Establishing a Rural Groundwater Monitoring Network Using Existing Wells: West Nose Creek Pilot Study, Alberta* published by Grief and Hayashi in 2007 (see Section 11.1 on page 37 for the full reference).

1.3.2 Rationale

There are two main reasons behind implementing a community-based monitoring program. The first reason is to keep the cost reasonable for the municipality. Using community volunteers allows for a large scale groundwater monitoring project to be implemented in any municipality interested in monitoring and/or protecting water resources. The second reason is to use the program for education; to engage the community in water resource issues and teach local students about groundwater sustainability. The collected data can be used by community outreach groups, local watershed protection groups, schools and educational conservation groups.

1.3.3 Study objectives

Some sample objectives for a community-based groundwater monitoring project are:

- To develop a cost-effective methodology for groundwater management for the municipality.
- To create a database of monitoring records that would be made available to the public.
- To provide scientific knowledge to water-resource managers, land-use planners and policy developers.
- To support community education, including youth and children, to aid in the understanding of the sources and uses of fresh water in their community.

1.3.4 Population

The population included in the study would be any resident in the municipality willing to participate in a long-term groundwater monitoring project. In addition, the well must also meet the study requirements, which may include such factors as; being in good condition, having a driller's report, being a certain depth and easily accessible. Details about well inclusion criteria are provided in Chapter 4.

1.3.5 Recruitment goals

The primary goal is to recruit members of the community who are prepared to participate in a long-term project. The project should begin with a determined number of wells that will allow the municipality to maintain a good working relationship with residents and not become overwhelmed with the data.

1.3.6 Informed consent

It is important that the municipality obtains informed consent from each participating member and updates it as necessary (see Chapter 5).

1.4 Data to be collected

There are various stages to the research project, which require the collection of data. The initial phase of research is the recruitment of wells (Chapter 4). Once a well has been selected the initial site visit should include collection of water chemistry and a questionnaire about the well and springs located on the property. The water level measurement should be taken at this initial visit to demonstrate proper technique.

1.5 Data analysis

The data analysis for the project should include the initial water quality data for each participating well as a baseline. The water level should be reviewed for consistencies as the data are submitted and any unexpected readings verified with the residents. The data should be compiled at least once a year and reviewed in its entirety to observe any general trends or noticeable changes.

1.6 Study organization

Data being acquired for the duration of the long-term project requires management and organization (Chapter 7). The amount of data being collected will vary depending on the number of residents and the frequency of their data collection. It is recommended correspondence and data be kept organized for each participating resident.

1.7 Timeline

The timeline for setting up a community-based monitoring project will depend on a number of factors including; having a dedicated person to work on the project, the availability of volunteer residents, the scheduling of meetings with residents and the weather. Some of these can be controlled by the municipality, however others are beyond control and therefore a flexible schedule should be maintained.

Chapter 2: Recruitment

2.1 Recruitment of cohort

The success of the project relies on the quality of participants recruited. Therefore, the initial recruitment effort should attempt to reach as many residents as possible by; (1) contacting people specifically based on well location, (2) informing the community and let residents contact the municipality.

In the first recruitment method, the municipality determines which wells would be ideal for groundwater monitoring and contacts the selected residents. The contact could be a phone call or letter to the resident depending on the available information. There are some difficulties with this method, in particular determining the current resident; therefore, selecting particular wells is not always possible.

The second method requires an advertising campaign to inform and recruit a number of residents and engage the community using, for example, the municipality website, publications – such as newsletters, posters in municipal buildings and community events. The limitation of this method is determining how to broadcast the message to obtain a representative sample of participating residents.

Once the project has been started, recruitment of additional volunteers can occur through the same methods. In addition, information can be distributed through project specific newsletters and open house/information sessions. There should be some type of continual or expansion recruitment planned for the project.

2.2 Initial contact

The initial contact with potential residents can be over the phone to complete a pre-screening and eligibility questionnaire prior to a site visit. As part of the eligibility, the resident should be asked if they have a copy of the driller's report (see Section 3.1) for their well. This first discussion should be about the mutual agreement between the resident and the municipality. By providing the expectations at the beginning of the process, it will allow people to make an informed decision about the commitment.

2.3 Pre-screening and Eligibility

Once a resident has been selected, a site visit should be scheduled to make certain the well is accessible and in good conditions. If a well is located in well pits, it should be discarded due to the potential danger of the site. Additional requirements that should be confirmed during either the initial contact or site visit are outlined in Chapter 4 – Participant Eligibility.

Chapter 3: Collecting Information

3.1 Water well data

The water well data can be collected prior to deciding whether to include a well in the project.

3.1.1 Drillers report

It is recommended, only wells with driller's reports are selected for the groundwater monitoring project. The well reports will need to be obtained or verified by the resident to ensure the report is correct. Wells drilled after the mid-1970s should have their well reports available online on the Alberta Government *Water Well Information Database* website (<http://www.envinfo.gov.ab.ca/GroundWater/>); however, verification from the resident will be required.

There are some potential problems with obtaining a driller's report.

- 1. The well was drilled prior to the mid-1970s**

If the well report is not available online, the solution would be to obtain a copy from the resident. The resident may have the original driller's report, or a newer driller's report due to work being done on the well.

- 2. There are a number of driller's reports for the same location.**

Well locations are often given as the centre of the quarter section, not actual coordinates. If there are a number wells assigned to a selected quarter section, it can be difficult to determine which driller's report belongs to the chosen well. The resident should be contacted to determine if they can verify the correct report.

- 3. Information provided on the driller's report**

There is no standardization of the detail of information required on the driller's report. However, the report should provide some information about the geology, depth of the well, when it was drilled and the pumping test performed.

3.1.2 Well depth

The depth of the well will be recorded on the driller's report. If there is no report that can be verified, the well depth needs to be determined by direct measurement. It is recommended that an experienced technician be hired to determine the depth of the well as they are aware of the potential hazards and trained to not disturb the sediment settled at the bottom of the well.

The selected wells should include a range of shallow and deep wells within the study area. It is recommended that some wells be located in relatively close proximity to allow for investigation of both

horizontal and vertical groundwater flow. This will provide information on sensitivity of groundwater levels to environmental changes in different aquifers.

3.2 Location

The location of wells would ideally extend throughout the municipality and represent the diversity of land-use practices. The extent of area covered by participating wells will also provide information about different watersheds. Although watersheds are based on surface water divides, they can assist with understanding groundwater–surface water interactions.

The location and accessibility of the well must be assessed prior to selecting it for participation in the program. The well should be in a safe location and easily accessible by not only the resident, but any potential technician who may need to access the well. This will ensure that any future work, such as the installation of a water meter, will not be restricted by accessibility of the well.

3.3 Privacy and Confidentiality

It is important to consider the risks involved in a community project, and steps should be taken to protect both the municipality and participating residents. Prior to agreeing to participate, residents should be informed of what information is being collected and the intended distribution of the information. Caution must be taken to protect the privacy of residents and if any information specific to the location of the well or name is to be used, informed consent should be documented. It is recommended that wells be renamed, for example with a numeric value in the order the well was added to the project. Be sure to address any concerns with residents over privacy and confidentiality.

Chapter 4: Participant Eligibility

4.1 Introduction

This chapter provides a brief description of the ideal criteria for selecting wells and residents. A summary checklist of the criteria is located at the end of this chapter.

4.2 Eligibility criteria

The eligibility criterion for a well includes its location, depth and the informed consent of the resident. The location of the participating wells will be determined by the municipalities' objectives for the project. A balance should be achieved between clustering some wells at different depths and spreading the selected wells out over the municipality. The paper by mentioned in Section 1.3.1 is a useful resource for spacing wells.

4.2.1 Participant requirements

The participant requirements may differ between municipalities and studies. However, participating residents should commit to a set time period for the study as outlined by the municipality. In addition, the willingness to consent to researchers and/or municipal employees accessing the well will likely be required. By ensuring that the resident is aware of their time commitment, the length of the proposed study and any additional requirements prior to committing, the number of residents withdrawing after the project has started will be reduced. The study requirements can be included in the informed consent document, which the resident must sign (Chapter 5).

The final step is for the resident to participate in a training session. This generally involves a trained technician meeting with a resident on their property to go through the proper monitoring procedure (Chapter 6). The training session is critical for the monitoring procedure to be completed properly and reduce the risks involved with the process.

4.3 Checklist of participant eligibility

Below is a basic checklist that can be used to determine a potential resident's eligibility. Depending on the objective of the study, other requirements may be necessary.

Checklist

- Driller's report
- Resident willing to participate in long-term study
- Able to access well during all seasonal variations (snow, heavy rainfalls)
- Willing to release data to the municipality and researcher(s)
- Well location fits with the objectives of the study (e.g. within the defined boundary of the study)
- Well depth fits with the objectives of the study
- Resident has time to meet and be trained on the equipment

Chapter 5: Informed Consent

5.1 Introduction

The municipal department responsible for handling all the legalities will know the type of consent and legal requirements necessary for the proposed project. Therefore, it is recommended any type of informed consent be compiled or approved by the legal department prior to field work being completed. This chapter provides a foundation of information that should be included in the consent forms. The final part of this chapter includes a sample of an informed consent letter constructed for a rural Alberta monitoring program (Grief & Hayashi, 2007).

5.2 Basic elements of informed consent

The basic elements of informed consent include, but are not limited to:

- Purpose of the study
- The length of the study, possibility of extensions and estimated time commitment
- Foreseeable benefits involved in participating
- Foreseeable risks involved in participating
- Details of what will be done at the well
- Details of what could be done with the data collected (and who would have access to the data)
- Contact information for the project coordinator and/or other team member(s).
- Procedure to withdraw from the project (including a request for a departing questionnaire to be completed)

There should be at least two (2) copies of the informed consent form completed. One copy should remain with the resident and one hardcopy should be filed at the municipal office. This will ensure the resident can reference what they agreed to and have the contact information for the project coordinator if necessary.

5.3 Process to obtain consent

Once the residents are selected and the consent letter has been approved by the municipal legal department, the resident should be contacted to obtain written consent. The consent can be obtained by a face-to-face meeting with the resident. During this initial meeting the resident can review the letter, ask any questions and upon agreeing to the document, they can sign it. This first meeting can also be used to collect the preliminary data about typical well use, springs or creeks on the land and sketch the well location. In addition, this can be used for the training session on how to take a water level reading with the supplied equipment.

For some residents, it may be best to send a copy of the informed consent letter prior to meeting. This will allow the resident time to review the consent form and then during the meeting with a member of the municipal team, they can ask questions and/or have their concerns addressed. This reduces the pressure on the resident to read and sign the document quickly.

If anything changes throughout the duration of the project, ensure a revised copy of the consent form, or additional document(s) are signed by the resident before proceeding. This will allow the resident to be aware of the change and decide if they wish to continue their participation.

5.3.1 Sample Consent Form

Below is a sample consent form based on the one used for a pilot project in Rocky View County (southern Alberta). The form below has **bolded and/or highlighted text** to indicate areas where information should be inserted for the specific project and municipality.

Memorandum of Understanding (MOU)

Name of the Project Coordinator, Position

Department, County, Telephone, Fax & Email

INSERT THE ABOVE INFORMATION

Supervisor:

INSERT – Name, Position Title, Department, Municipality/County Name, Phone Number, Email

Title of the Project:

Voluntary Groundwater Monitoring Program for Sustainable Management of Agricultural Water Supplies

Sponsor:

INSERT – Any sponsor’s name here

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The (***Insert MUNICIPALITY Name here***) council has approved this project.

Purpose of the Project:

Insert a paragraph introducing the background and motivation for this groundwater monitoring project. It is recommended to include the scope of the project, for example the number of watersheds that will have monitoring wells. It is also important to include information about why a community-based methodology is being requested and the number of wells anticipated in the project.

What will I be asked to do?

Insert a paragraph explaining the privacy issues, initial water sampling and chemical analysis. Included in this section will be a brief description of the specific measurement devices being used, the length of study, and expectation of the resident, along with training that will be provided. There should be information explaining who will be responsible for compiling the data, where it might be available and who will be using the collected data.

What type of personal information will be collected?

Should you agree to participate, your name and the location of your well would be recorded. There are several options for you to consider if you decide to take part in this study. With respect to the use of your name, please put a check mark on the corresponding line(s):

I wish to remain anonymous: Yes ___ No ___

I wish to remain anonymous, but you may refer to me by a pseudonym: Yes ___ No ___

The pseudonym I choose for myself is: _____

You may quote me and use my name: Yes ___ No ___

Are there Risks or Benefits if I participate?

If the monitoring is being conducted on your drinking water well, the risk of introducing harmful substances will be avoided by keeping the water level meter clean and using clean rubber gloves. If analytical results of the water sample taken before researchers use your drinking water well show concentrations of dissolved substances that exceed the Canadian Drinking Water Standards, you will be notified by your local health region.

There is also a risk of volunteers or the project staff injuring them on your property or damaging something on your property. Safety meetings will be held prior to approaching your property, also, be sure to warn of any potential hazards or vulnerable things on your property.

There are a number of ways in which you will benefit by participating in this study. You will:

- Have your drinking water well sampled for major ions and bacteria concentrations;
- Gain greater understanding of the natural groundwater system in your community; and,
- Contribute to the development of sustainable water resource management strategies in your watershed.

NOW THEREFORE, FOR VALUABLE CONSIDERATION, the receipt and sufficiency of which is hereby confirmed and acknowledged by the undersigned, **the undersigned hereby covenants and agrees** to indemnify and hold harmless the **MUNICIPALITY** and its employees, agents and servants from the actions (whether whole or in part by any act or omission or negligence of the **MUNICIPALITY**, its employees or agents or any other person from whom the **MUNICIPALITY** is at law responsible), and against any and all liability, damages, loss, cost and expense what so ever, arising owned or controlled by undersigned or otherwise, or arising pursuant to any other loss, injury or death to any property or to any person or persons arising by reason of or in any way connected with water level monitoring project.

What happens to the information I provide?

The **MUNICIPALITY (and the name any other organization that might be working with the data)** will have access to the information collected at your well. You can choose to be anonymous; however, the location of your well will be plotted and presented on figures when the data are published.

The data will be retained until it is no longer required for monitoring and reporting purposes at which point it will be destroyed.

Signatures (written consent)

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this monitoring project, and 2) agree to participate as a monitoring subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature: _____ Date: _____

Project Coordinator Name: (please print) _____

Coordinator's Signature: _____ Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Name:
Position Title:
MUNICIPALITY Name (or Organization)
Phone:
Fax:
Email:

Name:
Position Title:
MUNICIPALITY Name (or Organization)
Phone:
Fax:
Email:

A copy of this consent form has been given to you to keep for your records and reference. The Project Coordinator has kept a copy of the consent form.

Chapter 6: Monitoring Procedures

6.1 Introduction

The basic procedures for monitoring groundwater levels using existing domestic wells are outlined in this chapter. Information about the type and amount of equipment along with the potential cost is provided. This chapter also contains instructions and sample worksheets for the initial data collection, the frequency of water level measurements and the step-by-step measurement methodology.

6.2 Equipment

The equipment may change as technology adapts to demands and becomes available at lower costs. If equipment is loaned to a resident, it should be documented, signed and dated by the resident and project coordinator. The signed document(s) should be kept on file. When the equipment is retrieved the resident and project coordinator should sign and date that the equipment has been returned. This will maintain inventory records throughout the project.

6.2.1 Manual Water Level Sounder

A water level sounder is a long tape measure (varying lengths are available) with a probe on the end. When the probe comes into contact with water, it completes an electric circuit illuminating the LED light and sounding the buzzer. A photo of a water level tape is presented in **Figure 1**.

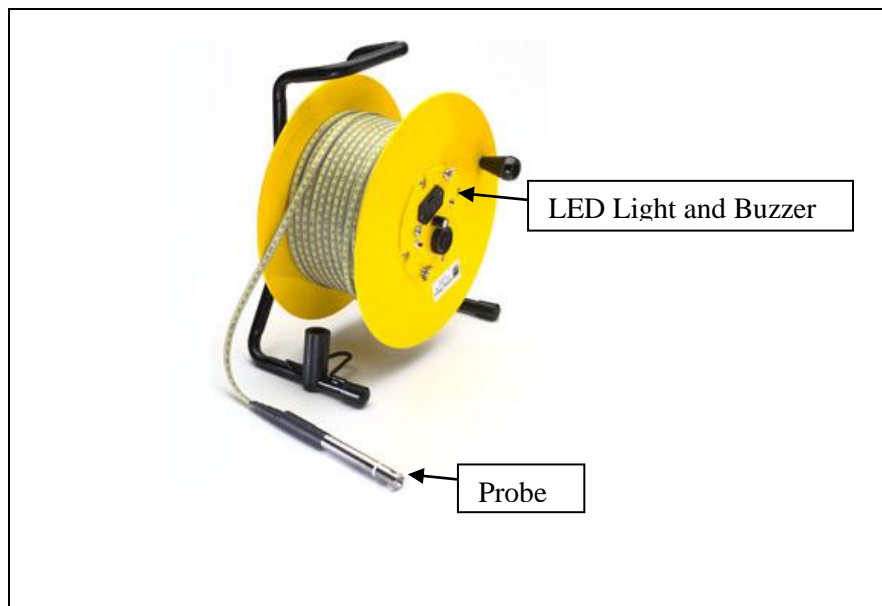


Figure 1: Water level tape (Source: www.globalw.com)

Below are the websites (as of May 2013) of companies that distribute manual water level tapes:

<http://www.solinst.com/Prod/101/water-level-meter.html>

<http://www.heroninstruments.com/dipper-t-water-level-meter.aspx>

<http://www.globalw.com/products/wl500.html>

The estimated costs for each manual water level tape can be found on the above websites; or a sales representative can be contacted to provide a more accurate quote. In addition to the water level sounder, materials for cleaning the probe (see Section 6.3.3) are also required.

6.2.2 Automatic Water Level Recorder

If a selected well cannot be monitored manually, an automatic recorder can be installed, for example for well sites that are inaccessible during winters with heavy snow cover. Since seasonal fluctuations and monthly data are required to view groundwater trends and variability, these water level data are important to obtain.

This method provides continuous data at set intervals, and reduces the possibility of contamination and/or the entanglement of manual water-level probe in the pump assembly. It is important to note, the installation of an automatic recorder should *only* be completed by a trained technician. Although this procedure allows for a continuous supply of data there are limitations, primarily the software required to download and analyze the data. In addition, this method requires a person from the municipality to go to the well and download the data throughout the year. The other noticeable limitation is the cost associated with these types of devices.

A number of different water level recorders available, for example:

<http://www.heroninstruments.com/tap-n-tell.aspx>

<http://www.solinst.com/Prod/3001/3001.html>

Cost estimates can be found on the company website, or a sales representative can be contacted for an accurate quote. There are typically additional costs for automatic recorders, such as devices and cables for data download.

6.2.3 Estimated Costs

Table 1 illustrates an example of cost estimate for a monitoring program consisting of 17 participating wells, based on prices obtained in March 2013.

Table 1: Estimated cost of a manual groundwater level monitoring network with 17 wells

Type of Equipment	Number Required	Cost Breakdown	Total Estimate
Manual Sounder (60m*)	15** tapes to start	\$700	\$10,500
9V Battery	15** to start	\$3.00	\$45
Bleach and Squirt Bottles	1 – ~2.5L bottle of bleach 15** squirt bottles	\$6	\$90
SUB-TOTAL			\$10,512.50
Automatic Recorder	2**	\$1,200	\$2,400
SUB-TOTAL			\$2,400
EQUIPMENT TOTAL			\$12,912.50
Project Coordinator	1 person – P/T	Wage	Varied

*Note: The length and number of tapes selected is arbitrary. The length of tape selected will depend on the groundwater properties of the municipality.

**Note: The number will depend on the scope of the project and the number of volunteers.

6.3 Data Collection

6.3.1 Initial data of site location

During the initial site visit, it is recommended that the project coordinator completes an inventory of the well and local water features, as well as collect a water sample for water quality testing. The inventory of the well will allow both the municipality and the resident to be aware of any potential problems and the initial condition of the well. If a well is not in good condition, it should not be included in the study. The water sample collected will provide information on the geochemistry in the selected well and can provide additional incentive to attract well owners. A photograph of the well should be taken and kept on file, which is useful for both publications and as an inventory of the well condition.

An initial questionnaire should be completed during this first visit to obtain basic well information (age, screen type, drilling method), the usage of the well, the location and accessibility, the land-use surrounding the area and location of any surface water and its flow rate/presences. Since groundwater and surface water interact, the coordinator should note any surface water, including springs, sloughs, creeks or dugouts. The information from this meeting, including a sketch of the area, should be kept on file at the municipal office. A sample initial questionnaire has been provided at the end of this chapter, which can be used as a template.

This initial site visit will allow for the documents to be signed (if not previously completed), the resident to be trained on the equipment and/or installation of equipment. In addition, this in-person meeting can provide an opportunity to address any possible concerns or questions. This will be the foundation of a

working relationship and the public perception of the project, which are important for the program's success.

6.3.2 Frequency

The recommended frequency of data collection would be once every two weeks (bi-monthly); for example, water level readings taken on the 1st and 15th of each month. The resident should be encouraged to maintain the bi-monthly water level readings as much as possible. However, it is important to inform residents that the municipality understands it is not always possible to take a scheduled reading. Both the municipality and the residents should be aware that even monthly readings will provide useful information on groundwater changes.

6.3.3 Methodology

When completing a well reading using a water level sounder, it is recommended every precaution is taken to ensure the tape is clean and will not introduce any contaminant into the well. The best method is to clean the water level tape with a 50 mg/L bleach solution followed by clean water (Wilde, 2004) after a measurement is taken (see Section 11.1 for the full reference). Below are the step-by-step procedures for mixing the disinfectant bleach solution and taking a manual measurement. It is important to remember to wear gloves while cleaning the water level tape.

Mixing Disinfectant Procedure:

If using bleach, prepare a dilute 50mg/L (0.005 percent) solution of common household chlorine bleach. It is important to not use bleach that has any scent added to it. This solution can be mixed right into a spray bottle that has measurement notation on the side or transferred after being prepared.

1. Measure 1mL of bleach into 900mL of water.
2. Stir the mixture to ensure the bleach is diluted
3. Add water to bring the total volume up to 1,000mL (1L)
4. If the mixture was not mixed in a spray bottle, transfer the diluted bleach solution
5. Label spray bottle as "Well-Tape Disinfectant" and record the date of preparation using a permanent marker

Manual Measurement Procedure:

It is recommended a trained technician assists the resident with the first water level reading in order to go through the procedure and answer questions. The resident should also be provided with a methodology handout, which includes; the manual reading procedure, common problems and solutions, safety precautions and a data sheet for recording.

The procedure for taking a water level readings manually is outlined below:

1. Remove the cap from the top of the well
2. Listen for the pump – the well should be quiet, this indicates no pumping is occurring
3. Clean the probe with bleach solution and clean water, if this has not already been completed.
 - a. Spray the tape with the diluted bleach solution

- b. Rinse the tape with the clean water
4. Slowly lower the probe attached to the tape into the well along the edge of the internal casing. It is important to go slow and straight down to avoid getting the probe or tape caught on the pit-less adaptor. For the first few measurements, use a flash light to inspect the well (see below).
 - a. *NOTE:* Make sure the buzzer volume is on and loud enough for you to hear
5. When the probe touches the water, the circuit is completed and the buzzer will sound. It is recommended the tape be reeled in slightly and slowly lowered to determine the most precise depth to water. If necessary, adjust the sensitivity dial of the probe.
6. The reading should be taken from the **top of casing**. (See **Figure 2**)
7. The probe should be lifted out of the water high enough to break the electric circuit and discontinue the buzzer.
8. The probe is then lowered again to connect the circuit, sounding the buzzer. The measurement on the tape should again be recorded.
9. Once the readings are recorded, slowly wind the tape up to bring the probe to the surface of the well.
10. It is recommended that the tape be cleaned again with the bleach and clean water, using the same procedure outlined in step 3.

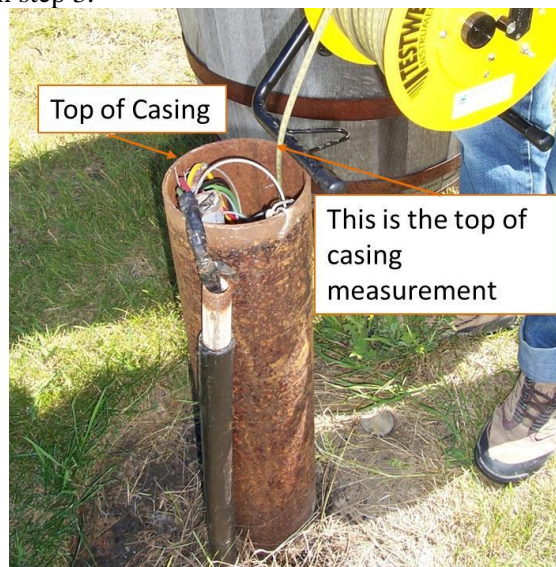


Figure 2: Illustration of a top of casing well measurement

6.3.4 Basic problems and solutions

Although not common, there are a few basic problems that may be encountered when collecting water level measurements. It is important to be aware of these problems and make residents aware of some possible solutions.

Water level tape stuck

The resident's water level tape may become stuck in either 1) the pit-less adaptor or 2) jammed in between electric cables. This can occur even with being cautious and the training provided by the technician. As a preventative measure, it is recommended that a procedure guide be left with each resident in the well monitoring tape bag.

There are ways to reduce the risk of getting the probe stuck. Prior to taking a manual measurement, the person taking the reading should visually examine the well with a flashlight and identify the configuration of the pit-less adapter to determine the best place to lower the water level tape. The typical structure of a well can be viewed online on the *Water Wells That Last* website in Figure 1 of Module 3 “Design and Construction of Water Wells” ([http://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/wwg408](http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/wwg408)). When lowering the water level tape, do not allow it to have slack and lower it slowly. The majority of cases where the tape gets stuck are due to the tape being lowered too quickly. Finally, ensure that the water level tape is in good working condition, including the battery. This will ensure that when the probe hits the water, it will beep, which prevents it from being lowered too deep and getting stuck in the pump assembly.

Solution: It appears that when the pump is turned on, its vibration loosens the cables and releases the probe. Therefore, some of residents have found if they leave the tape alone, it will become unstuck within a week. This is one possible solution, however it means the well tape is sitting next to the well and the cap may not secure. Another method is to release the tension on the tape, wiggle it around gently and then try to wind it up again. It is important not to forcefully pull the tape, as it can cause damage to the well and the tape.

An unexplained extreme value is recorded

Unexplained extreme values are generally noticed by residents once they get an understanding of their well fluctuations. Most residents have a good understanding of their water level and possible reasons for fluctuations in the data. If the reading does not appear to be within the expected variability it could be the sensitivity setting on the water level tape is not appropriately set.

Solution: There is a simple solution to this problem, however, the most difficult part is determining if it is the sensitivity of the device or an extreme reading. If the sensitivity is too high or too low, the knob on the side of the water tape can be adjusted to either decrease or increase the sensitivity. Once the sensitivity has been adjusted a second reading can be completed. It is important when a person is trained to use the tape this is pointed out and an acceptable level of sensitivity is determined.

If there does not seem to appear to be an issue with the equipment, a second reading should be completed after removing the water level tape from the well. By removing the probe, the resident can see if there is anything wrong with the probe and then take the second reading to determine the water level.

Constantly changing water level

The constant change of water level during the recording process is usually associated with pumping. If the water level is increasing, the well is likely recovering from being pumped; whereas if the level is decreasing, it is likely attributed to pumping.

Solutions: There are a couple solutions to this problem. First, since the resident knows the water use behavior of the occupants, it is recommended the water level be taken when the pump is not in use. One way to verify the pump is not active during the water level measurement is to listen and make sure the well is silent. The other solution is to determine a good time to take the well measurement, for example

in the morning, prior to the pump being activated for the day. Each resident will be able to determine a time that works best for their schedule when the water level is static.

6.4 Well Monitoring Worksheet

Every participating resident should be provided with a copy of a well monitoring worksheet, which is designed to ensure all information required for analysis is recorded. In addition, the worksheet allows for organization of the data and consistency between residents. The important columns to include on the worksheet are: the date, time and average water level reading. It is highly recommended a comments/remarks column be added for residents to provide information related to the water level. For example, comments may be related to the weather, precipitation, well activity for the day and/or information about livestock and well usage.

6.4.1 Sample worksheet – Template

A sample worksheet has been provided in **Figure 3** as a template of a recommended format. The sample worksheet was used previously and improved based on participating resident's feedback. The document was set up in Microsoft Excel as it was determined to be user-friendly and easily accessible to all participating residents. The worksheet will need to be adapted for individual monitoring projects depending on the objectives of the study and required data.

Figure 3: Sample data collection template

Site Location		Legal Land Description		Height of Casing Above Ground			###.## m	
							Casing Diameter: ##.## cm	
Well # ##							Elevation #####.## m asl	
Owner: NAME								
Owner ID: ##								
Number	Date	Time	Reading 1	Reading 2	Reading 3	Average Reading	Remarks	Sent
1	yyyy-mm-dd	hh:mm	#.###	#.###	#.###	#.###	Text	<input checked="" type="checkbox"/>
2	yyyy-mm-dd	hh:mm	#.###	#.###	#.###	#.###	Text	Y
3								
4								
5								
6								
7								
8								
9								
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Sample – Introductory Questionnaire

Questionnaire for Perspective Water Wells to be used for monitoring in the **INSERT MUNICIPALITY NAME HERE** Watersheds:

Interviewer:	Date:
Well owner:	Legal land location:
Phone:	Watershed quadrant:
Well ID #:	Owner ID #:
Mailing address:	
1. Verify that the well described in the record exists and that its depth, age, and construction details, corresponds with those listed in the record.	
Depth: _____ Drilling method: _____ Approximate age: _____ Screen type: _____ Casing type and diameter: _____	
2. Water-use frequency and purpose? i.e., drinking water, domestic, stock, one.....	
Withdrawals generally occur at what time of the day?	
3. If used for stock, what type of animals and how many?	
Also, is it used all year long?	
Are grazing reserved used?	
If used for domestic, how many people in the household?	
4. Location of well? i.e. well pit, basement, yard, pasture	
5. Location of tap(s)? i.e. outside, inside, corral	
6. Accessibility? i.e. bolted lid, fence, roads, lock	

Well ID:	PAGE 2
<p>7. System Design? i.e., tanks between well and taps, pump, generator</p>	
<p>8. History of well or other related comments/concerns/instructions?</p>	
<p>9. Land-use (type of farm operation) and surface hydrology (ponds, depressions, streams... direction of flow, topography) in the area of the well?</p>	
<p>10. Any springs on the property? Where?</p> <p>What is the age, flow rate, periodically (i.e., seasonal, decadal)</p>	
<p>11. Special directions? Sketch a map to show how to get to the house, well, and springs.</p>	
<p>12. Any other wells on the property? Purpose and frequency of use? Withdrawals occur at what time of the day?</p>	

Chapter 7: Data Management

7.1 Introduction

The data set collected will depend on the number of people participating and the frequency of water level measurements. This chapter will address data management and the mechanisms of collecting and storing data from community volunteers. The system should be simple and allow for flexibility to adapt to changing technology and improved ideas of efficiency.

7.2 General data collection

The most important aspect of the project will be finding an efficient manner to collect data from residents. The collection of data from volunteers can be difficult, therefore, some possible solutions are recommended for the initial stages of the project. These are only guidelines; the best approach is to work with the participating residents to develop a program that will function for them.

7.2.1 Mechanisms of collecting data

There are typically two methods of data collection for a groundwater monitoring project; (1) manual readings and (2) automatic data logger readings. For manual readings, the data will be collected and recorded by the resident at the frequency requested in the letter of consent and training procedure sheet provided. The process for submitting the data collected by residents can be done in one of three ways; electronic, fax or phone.

7.2.1.1 *Electronic*

The electronic submission of well data is ideal. This allows for an electronic copy of the original data to be maintained on file, which can be consulted if there are discrepancies improving quality control within the data set. If the data is emailed, either the attachment or the body of the email should be saved. Once the data is saved and entered into the resident spreadsheet, the information should be transferred into the electronic database.

7.2.1.2 *Fax*

If the resident prefers to maintain a hard copy of the well readings instead of an electronic copy, the data can be faxed into the municipal office. An example fax sheet should be provided as a template to ensure all the necessary information will be provided. Once the fax is received and the data are entered into the spreadsheet, the hard copy should be filed. Once the data are saved, the information should be transferred into the electronic database.

7.2.1.3 Phone

For residents that do not have access to a computer, or have slow internet service, their water levels can be called into the project coordinator. This option should be the last recommended method for submitting water level measurements, as no original copy of the data can be filed. However, the use of phone submissions allows any resident to be eligible to participate in the monitoring program.

For phone submissions the data should be recorded right into the spreadsheet with a comment stating when the resident called. It is recommended that the spreadsheet be opened while the resident is on the phone to compare the data to previous readings. Once the data is saved, the information should be transferred into the electronic database.

7.2.1.4 Downloading

For wells with an automatic recorder, a technician will need to be responsible for downloading the data. This should be done at regular intervals to ensure the data are being collected and check that the equipment is working properly. The data should be saved and checked for quality by the technician. Once the data are saved, the information can be transferred into the electronic database.

7.2.2 Possible problems and solutions

A long-term monitoring project provides data for scientists and decision makers about the groundwater levels within a particular municipality; however, there can be some challenges associated with data collection and organization. Below are some of the potential problems a municipality may encounter and possible solutions.

1. Changing personnel

Due to the duration of the project, there is a possibility of employee turnover within the project team. It is recommended a procedure for the municipal project and records of correspondence are easily accessible to new staff as they provide background information and important contacts. The maintenance of an organized file system with previous correspondence and outreach publications will allow new employees easy access to important material. In addition, a good filing system will decrease the loss of data during transitional periods.

2. Data entry errors

Errors in data entry can occur, but if consistency is maintained and procedures are clearly outlined, the problem can be reduced. The first recommendation is to simplify the data and the procedure for entering information into the database or individual resident spreadsheets. The second recommendation is to maintain a consistent format for the date and time of water level measurements in all documents.

The second challenge with data entry is typing errors. It is important that a quality control procedure is in place and the original data is kept on file. This allows the original water level measurement to be accessed if there are any questions or concerns about the data. Additionally, if a submitted water

level does not seem correct based on previous readings, the resident should be contacted to confirm the measurement.

3. Lost/missing data

Although missing or lost data is not a major concern for most groundwater monitoring project, it can occur. It is recommended the resident includes the reading number along with the water level measurement, as it allows the municipal staff to check the number of readings already accounted for in the resident's file.

4. Quality control responsibility

The quality of the collected data is critical for it to be useful for researchers and decision makers. Therefore a quality control procedure should be developed to reduce mistakes within the database. A training program focusing on the database will assist in maintaining the quality of the data (see Chapter 8). In addition, it is recommended that there is a place for employees to enter comments or their initials after entering or changing information in the spreadsheets or database. It is recommended that the database is checked every six months to ensure no errors are present.

7.3 Data Storage

The storage and maintenance of a filing system will allow for original documents to be kept and organized and for information to be easily found for review when necessary. It is recommended the filing system already applied by the municipality be used (or adapted) for the groundwater monitoring project.

7.3.1 Hardcopy filing system

It is recommended a hardcopy filing system be put in place for the duration of the project. This will allow information to be maintained with a system not reliant on technology. The best method is to use the conventions already used by the municipality. It is recommended that each participating resident and partnership group have a file for correspondence and signed agreements. A map and directions for each location should be available in hardcopy, so if site visits are necessary the information is easily accessible. The confidentiality of these files should be maintained using the process outlined by the municipal policy.

7.3.2 Electronic filing system

An electronic filing system is useful for organizing information about each well and partnership group. Each participating resident should have an electronic folder with the following information; driller's report (if available), water level measurements and copies of correspondence. It is recommended an electronic copy of a map and directions to each location be saved for easy access. For partnership groups, the file should contain meeting minutes, agreements and correspondence. In addition, outreach materials such as newsletters and presentations should be kept for future reference.

7.4 Creating a Database

The individual spreadsheets are a good way to organize individual residents' well information. These spreadsheets can be used to graph water levels for individual wells and provide feedback to residents to keep them engaged. For organizing all the data it is recommended a database be created. This database can be used to organize the data collected for the entire well network and generate reports about the wells and water level measurements for analysis.

Chapter 8: Quality Control

8.1 Introduction

The quality of the data collected will determine the analysis that can be completed and its ability to provide information related to the project's objectives and goals. The continuous quality control of equipment, data, and management systems should be maintained throughout the project.

8.2 Continuous quality control

Once the monitoring program is organized and implemented quality control will need to be maintained for the project. This is a continuous effort necessary to ensure the equipment is working, the data are correctly entered, the necessary information is available for each participating well, such as the driller's report and well location, and any changes that occur throughout the duration of the project are accounted for.

8.2.1 Equipment

When providing the equipment to residents, they should be provided with information about how to care for the equipment to minimize potential problems. For the duration of the project, residents should be encouraged to check their water tapes for wear and tear. If there are any problems, the project coordinator/technician should be contacted so the equipment can be fixed or replaced.

Automatic water level recorder and other monitoring equipment should be checked during each site visit to ensure it is working correctly and has enough memory and power.

8.2.2 Data quality

The quality of the data should be checked as it is received. This should involve checking the current water level measurements against previously documented levels. The data should be confirmed prior to it being entered into the data management system or being made publicly accessible. If there is a discrepancy, the resident should be contacted to determine if the data was entered correctly. This also provides a chance to discover possible explanations for the water level change; for example, the drilling of a new well or large amounts of precipitation. Once the data is confirmed by the well owner, it is recommended a note be added to the comment section, stating that the reading was verified. This will ensure that anyone handling or analyzing the data is aware the data have been confirmed for quality control.

For wells being monitored using an automatic recorder, a manual measurement should be recorded when the device is downloaded. This will allow a comparison between the manual and recorded measurements. If there is a discrepancy, the manual measurement can serve as a correction factor to be applied to the

recorded water level measurements. The difference between the manual and the automatic recorder can also provide information about possible equipment problems and/or calibration issues.

8.2.3 Data management system

It is important to use a system that maintains a standard of accuracy and clarity of the monitoring network data. Once the data has been checked for quality it can be entered into the data management system. It is recommended the data management system be checked approximately every six months for errors. This management system check also ensures the necessary data is present in the resident's file and accessible to researchers if necessary. Ensuring the data is correct and up-to-date will allow for accurate analysis and provide useful information to residents and decision makers. The release of information must be based on the permission outlined in the informed consent letter signed by the resident (Chapter 5).

8.2.4 Changes in procedure

When procedural changes are required in either data collection or management, an effort should be made to minimize confusion and lost data. This will require documentation of the changes made and should only include those people affected by the change. The original method may need to be slowly phased out to maintain data control and a smooth transition to the new system.

If changes in procedures involve residents submitting data the following steps should allow for a smooth transition. An informative notice should be sent out prior to the change; then training if necessary during the transition; followed by reminders of the change after implementation. It is recommended the previous system be phased out to ensure no data is lost during the transitional period and maintain a quality relationship with participating residents.

8.3 Site visits

It is recommended that a site visit be arranged every year or every other year to confirm the condition of the well and equipment used. This site visit also provides an opportunity for a face-to-face meeting between the coordinator and the resident. These visits can be used to check over the data submitted and have the resident take a water level reading to confirm proper technique is maintained.

Chapter 9: Communication

9.1 Introduction

This chapter discusses open communication and how to recruit and retain volunteer residents in a groundwater monitoring project. This chapter presents information on inter-municipal and watershed group communication and coordination. Open communication allows for all stakeholders to become involved and informed with the same information in order to work together to protect and sustainably use local groundwater resources.

9.2 Open Communication

A community-based groundwater monitoring project requires open communication between coordinators, technicians, community groups and residents. The information collected through long-term monitoring projects should be shared where appropriate. If open communication is initiated with the project and maintained carefully throughout, it will provide a positive experience for residents and the municipality.

The foundation of open communication begins with the recruitment of residents. It is important that members of the community are aware of the reasons the project is being implemented, as well as the benefits and risks (Chapter 5). If people understand the required commitment prior to volunteering for the project, it should decrease the number of individuals withdrawing from the program.

For the project to be a success feedback to participating residents such as; information on the data collected, what it is being used for and what the researchers have found (see Section 9.2 for more detail) is essential. It is also important to ask for feedback from residents, whether during site visits, mailed out questionnaires (sample at the end of the chapter) or online surveys. This feedback provides information to the municipality on the resident's perspectives of the project, which could allow for problems/concerns to be addressed prior to someone wanting to leave. When residents feel they are contributing to something important, they are more likely to continue with the program. If a resident wishes to withdraw from the project, an exit questionnaire would be beneficial to understand their reason(s) for leaving.

9.2.1 Email Reminders

Email or phone call reminders sent from the project coordinator to residents twice a month can increase the success in data collection. The email reminder is particularly a good idea at the beginning of the project when residents are forming the habit of taking water level measurements. However, reminders for the duration of the project maintain communication with residents and may increase the response rate. In theory, the email provides not only a reminder, but a simple way of responding with the measurement. It is important when sending emails to residents that confidentiality is maintained.

9.3 Outreach Communication

A volunteer monitoring project is unique as it engages members of the community to participate and acquire the data. The purpose of outreach communication is twofold; (1) to engage the community while promoting the project and (2) to thank the residents actively participating in the program. The same publication can be used to satisfy both objectives. The information contained in the outreach communication should cover topics about the development of the project, the scope and goals of the project and the analysis of data so far.

Engaging the Community

Although the monthly time commitment might seem minimal, it should be recognized that due to the long-term structure of this type of monitoring project, participation requires a significant commitment from volunteers in order to acquire a comprehensive data set. The process of engaging the community will not only recruit willing residents, but also encourage pride in the project. The recruitment of residents might vary for each municipality; however, there are some common techniques (see section 2.1 for more information). This project is about getting the community involved, so recruitment publications might be beneficial in community meeting spots, such as sports arenas, community centers/halls, and local restaurants.

The project can be used to educate the entire community about groundwater topics including sustainability and conservation. Some examples of methods used to engage the communities as a whole are; open houses, websites and community events can be used to build excitement around groundwater monitoring. Community events might include farmer's markets, annual festivals, summer camps and educational programs in schools.

Active participant communication

For outreach communication, the use of information packages can provide the feedback residents need. A simple information package could include a summary of the water level data collected, water quality results and a quick summary of the data provided. It is recommended a graph be used to illustrate the fluctuations in water level. Lastly, a yearly review of the project is recommended to give residents the opportunity to request changes or address challenges encountered. This annual questionnaire/survey will provide feedback to the municipality about how to improve the project.

Newsletters

To maintain community engagement and inform residents of their contribution, a newsletter should be published at least once a year. This communication can help to maintain the momentum of the project and can be used to promote relevant events. Information about the study and interesting results and/or simplified information on the watersheds, hydrogeology and groundwater should be included. In addition adding photos and activities such as a word search or trivia can make the newsletter more fun. It is important to ensure the contact information for the Project Coordinator is clearly displayed on the newsletter.

The newsletter should be sent to the participating residents, community groups and watershed groups within the municipal boundary. In addition, it is recommended that copies of the newsletter be available for the general public at places where people can access them, including the municipality's website.

Thank-you notes

The purpose of a thank-you note is to acknowledge the residents who take bi-monthly readings and allow the monitoring project to be successful. Many people today have busy schedules and various organizations requesting volunteer hours, therefore it is important to appreciate the residents who volunteer their time for the project. Two examples are a simple card or a letter expressing gratitude.

Open Houses

An open house can provide an opportunity to market the project to additional residents and increase awareness about the project. This type of event can also provide an opportunity to share the educational component of the project. The face-to-face connection can allow for more effective communication and provides residents with a chance to ask questions and engage in discussion, while providing feedback.

Website

A website can be used as a communication tool to interact with the community, while promoting the project to a larger audience. The design and properties of the website can be determined for the purpose and objective of the project. The website can be used as an educational tool for the community, to provide a context of the research and as a foundation of hydrologic knowledge. By providing information on the project objectives and documenting findings, it allows the groundwater monitoring project to reach an international audience. Chapter 11 provides some examples and resources for creating a project website.

9.4 Partnership communication

As additional municipalities begin to participate in groundwater monitoring projects, it is recommended communications occur between these jurisdictions. This is particularly important in bordering municipalities, as there may be greater insight into groundwater levels, and flow patterns if cooperation between municipalities exists. Another potential partnership is with watershed groups who focus on watershed boundaries not municipal boundaries. The partnership between municipalities and watershed groups could provide a more comprehensive understanding of surface water, groundwater and their connection. Therefore, open communication and sharing of resources and data would allow for the collected data to be efficiently used.

Sample – Feedback Questionnaire

Participant Feedback Questionnaire for **INSERT MUNICIPALITY NAME** **HERE** Monitoring Project:

Your feedback is very important for the continuation and improvement of community-based monitoring programs. Please fill out this survey and mail it back to us in the return envelope provided.

For the questions, please circle the word that **best** describes your position on each statement:

1. Right now there is a need for sustainable management of water resources in my area: Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
2. I believe my contribution to the study was useful Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
3. Water resource management should involve community members like me: Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
4. I felt ownership and connected to the project for which I was monitoring Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
5. I see a need for research into water resources in my area: Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
6. I foresee a need for sustainable management of water resources in my area in the future: Strongly Agree - Agree - Neither - Disagree - Strongly Disagree
7. I believe there needed to be greater feedback about the data I was collecting. Strongly Agree - Agree - Neither - Disagree - Strongly Disagree

What first got you interested in the volunteer monitoring program and why did/do you continue to participate?

What aspects of the volunteer monitoring program did you like?

What aspects of the volunteer monitoring program did you dislike?

From your perspective, what should remain the same in the volunteer monitoring program?

From your perspective, what could be improved in the volunteer monitoring program?

What are the reason(s) for leaving the volunteer monitoring program?

Chapter 10: Hydrologic Definitions

Aquiclude: Same as *Aquitard* (see below).

Aquifer: A geological formation that bears a useful quantity of water – it has the ability to store and/or transmit water.

Aquifer, confined: An *aquifer* that is overlain by a confining layer, causing the saturated zone to be under pressure. The confining layer has a much lower *hydraulic conductivity* compared to the aquifer.

Aquifer, unconfined: An *aquifer* that has no confining layer between the *zone of saturation* and the ground surface. The top of an unconfined aquifer is the *water table*.

Aquitard: A geological formation that has low *hydraulic conductivity*, which stores ground water and transmits it slowly from one *aquifer* to another, but cannot transmit a useful amount of water readily.

Artesian: The condition of groundwater that is under pressure within a *confined aquifer* that when tapped by a well, it rises to a level above the top of the aquifer. (Also see *flowing well*)

Drawdown: The lowering of the groundwater level caused by pumping.

Flowing well: A well that is drilled into an *artesian* aquifer, with enough pressure to raise the water above the ground surface without pumping

Groundwater: Water held beneath the ground surface in the pores and crevices of soils and rocks under the water table.

Hydraulic Head: The static elevation of water in a well at a given point in an *aquifer*.

Hydraulic Conductivity: A coefficient used to describe the rate at which a fluid can move through a permeable medium. Hydraulic conductivity considers the properties of both the medium (see *permeability*) and the liquid (water) flowing through it.

Hydraulic Gradient: The rate of change in *hydraulic head* per distance. Hydraulic gradient is used to represent the magnitude and direction of force that drives flow.

Hydrogeology: The study of the groundwater and its relationship with geology.

Permeability: The ability of a material to allow the passage of a liquid (such as water, gas, oil) to pass through. This takes into consideration the size and connectivity of pore spaces. For example gravels and sands allow water to move quickly through them; whereas clay does not allow water to flow freely.

Porosity: The ratio of pore volume to total volume of sediment and rocks. Higher porosity material can store more water. Pores can be open, interconnected, closed and/or isolated.

Pumping: Extraction of groundwater from a well

Recharge: Replenishment of an *aquifer* by rainfall and snowmelt that seeps into the ground and eventually reaches the *aquifer*.

Saturated zone: The zone where all pore spaces are filled with water. The *water table* is usually considered the top of the saturated zone.

Surface water: Water that is found on the Earth's surface, for example streams, rivers, lakes or reservoirs.

Unsaturated zone: The zone immediately below the land surface where pores contain both water and air, therefore it is not totally saturated with water.

Water table: The top of an *unconfined aquifer*, defined by the presences of standing water in a hole dug into the ground.

Watershed: The area of land that is drained by a stream, river or lake (relates to *surface water* boundaries). It is also called a catchment or drainage basin.

Chapter 11: Recommended Resources

11.1 Cited References

Grieff, L.A. and Hayashi, M. 2007. Establishing a rural groundwater-monitoring network using existing wells: West Nose Creek pilot study, Alberta. *Canadian Water Resources Journal* 32: 303-314.

Wilde, F.D., ed., 2004, Cleaning of Equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, April 2004, accessed June 2013, at <http://water.usgs.gov/owq/FieldManual/chapter3/final508Chap3book.pdf>.

11.2 Rocky View Well Watch web portal

Description:

The University of Calgary, Geomatics Engineering Department partnered with the Geoscience Department to create a web portal for the Rocky View community-based groundwater monitoring project. This web portal allows residents of Rocky View County to create an account and submit their water level readings directly into the online database. A moderator checks the quality of the data before they are posted for public viewing through the browser side of the portal.

Link: <http://rockyview.geocens.ca>

11.3 Groundwater Connections web site

Description:

The University of Calgary, Geoscience Department in partnership with the Biogeoscience Institute has developed an integrated website called Groundwater Connections. The website was created as part of the community-based groundwater monitoring pilot project in Rocky View County. This website provides information on the research, community monitoring and educational resources. The purpose of the site is to provide awareness about the use of scientific information in groundwater management.

This website includes scientific information on groundwater hydrology in the Alberta prairie region in an accessible manner. The site also includes topics on geology, hydrological processes, groundwater-surface water interactions and the importance of long-term monitoring of water resources. In addition there is educational material for students, teachers and members of the general public. There are also resources available for municipalities interested in implementing a local community-based groundwater monitoring project.

Link: www.ucalgary.ca/groundwaterconnections

11.4 Alberta Environment and Sustainable Resource Development

Description:

Alberta Water Well Information Database

Since the mid-1970s, legislation requires water well drillers to submit drilling reports to Alberta Environment and Sustainable Resource Development. These reports are made available through the online database and can be searched using the map, legal land description, owner name, well ID or municipal boundary. If using the map, the orange dots depicting well locations will only appear as the user zooms into the location. To obtain the report, a user must hover the mouse arrow over the orange dot and select the well report for that section. More information about the database can be found online.

Link: <http://www.envinfo.gov.ab.ca/GroundWater/>

Groundwater Observation Well Network (GOWN)

Alberta Environment and Sustainable Resource Development Department owns a network of groundwater monitoring wells throughout the province. Most of these wells continuously record groundwater levels and have some type of water quality analysis completed. On the GOWN website there is historical groundwater level information for the active wells within the network. The work is completed by regional technologists that maintain and sample the wells, as well as collect and archive the data.

Link: <http://environment.alberta.ca/apps/GOWN/Default.aspx>

Water for Life

The Water for Life web page provides information on the original strategy for obtaining a healthy, secure and sustainable water supply for communities, the environment and the economy. In addition the site includes information on the renewed strategy, updates of what is new, a calendar of events, related achievements, and news releases. The development of a community-based groundwater monitoring program is consistent with the three main goals outlined in the strategy.

Links: <http://www.waterforlife.alberta.ca/>

11.5 Alberta Agriculture and Rural Development

Water Wells that Last

The Water Wells that Last for Generations contains 12 modules in a workbook, which are available online. The first module – “Understanding groundwater” will provide a better understanding of the complexities of groundwater and discusses protection of groundwater for future generations. In module 10 the concept of groundwater management is discussed. This website provides valuable information about groundwater and domestic wells.

Link: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/wwg404](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/wwg404)