

H₂O Chelsea Static Level Program



Implementation Manual

The static level of a well is the measurement of the height of water in the well when the aquifer reaches equilibrium (when the pump has not been used for an extended period of time and the water level returns to its natural level).

By monitoring the static level of wells throughout the year, you can detect fluctuations in groundwater levels in local aquifers (Figure 1). By tracking the water levels over a longer period of time (multiple years), you can determine whether the water tables in your community are rising, falling, or staying at a constant level. A long-term pattern of lowering water tables may be an indication that groundwater is being overdrawn (groundwater is not being used sustainably and well water shortages could eventually occur).

The program was designed for three main reasons:

1. Give municipal planners information about annual and long-term water level fluctuations of the wells in their community;
2. Educate residents about groundwater and conservation options;
3. Verify and/or follow up on information received through other water quantity monitoring initiatives (e.g. the H₂O Chelsea Water Questionnaire and Water Census).

All Static Level Program tools and resources (protocols, datasheets, database etc.) as well as other H₂O Chelsea monitoring program resources mentioned in this document can be obtained free of charge via the H₂O Chelsea website. Direct links to these tools and resources are given in the footnotes of this document and are listed in the Appendices of this manual. We encourage communities to read these resources and to contact us with any questions.

Static Level Monitoring

Are the water tables in your community rising, falling, or staying at the same level?

What?

Residents and/or project employees measure the static water level in local wells using inexpensive equipment.

Why?

Long term measurements of the static water level of the aquifers feeding your community can help you infer trends in groundwater levels, thus, helping you identify and protect areas where water levels may be decreasing.

Stat-ic wa-ter lev-el (stáitic wéter lévəl) height of water naturally occurring in the aquifer, as measured in an observation well or piezometer, when this level reaches equilibrium

Impact on Municipal Decision Making

The monitoring of the static level of local wells over several years can help municipal planners understand the effects of climate and water consumption patterns on local groundwater levels. Trends can be identified and potential water shortages (due to lowering water tables) could be avoided by taking appropriate action.

A wide variety of options to better manage groundwater resources are available to municipal governments. For example, in areas where the static levels of wells are shown to be lowering (i.e. decreasing trend over several years) the municipality might choose to:

- ✓ Implement lawn watering by-laws in late summer well water levels are typically at their lowest and water usage is at its highest
- ✓ Develop regulations requiring a minimum well depth to ensure that new wells in these areas are accessing the more water abundant regional aquifers
- ✓ Minimize the density of homes to be built on surrounding lands
- ✓ Develop a subsidized program to encourage the retrofitting of homes with water-efficient devices (low flush toilets, low flow shower heads etc.).

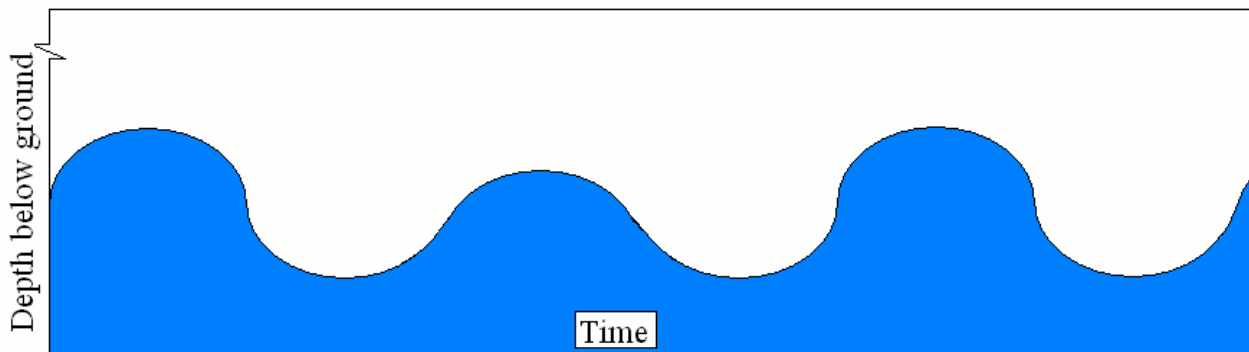


Figure 1. Illustration of the oscillatory behavior of static water level throughout the year

Each municipality will have a unique set of options available to them, based on economic, environmental and political factors.

H₂O Chelsea, with funding from the Walter and Duncan Gordon Foundation has developed a resource manual titled *Municipal Approaches to Groundwater Quantity Monitoring and Management*¹, a comprehensive account of groundwater monitoring options, education initiatives, and municipal regulations and by-laws developed to conserve groundwater resources in Chelsea and other communities across North America.

¹ Municipal Approaches to Groundwater Quantity Monitoring and Management
http://www.h2ochelsea.ca/PDFs/Quantity_Manual_Oct25_3.pdf

Aquifer and Geological Considerations

Aquifer behaviour

Static water levels in an aquifer depend on the density of homes, water consumption patterns, rate of groundwater recharge, and the ability of the geologic material to store water (Figure 2). Tracking the water levels of the aquifers over a long period provides information on whether the regional water tables are rising, falling or staying at the same level.

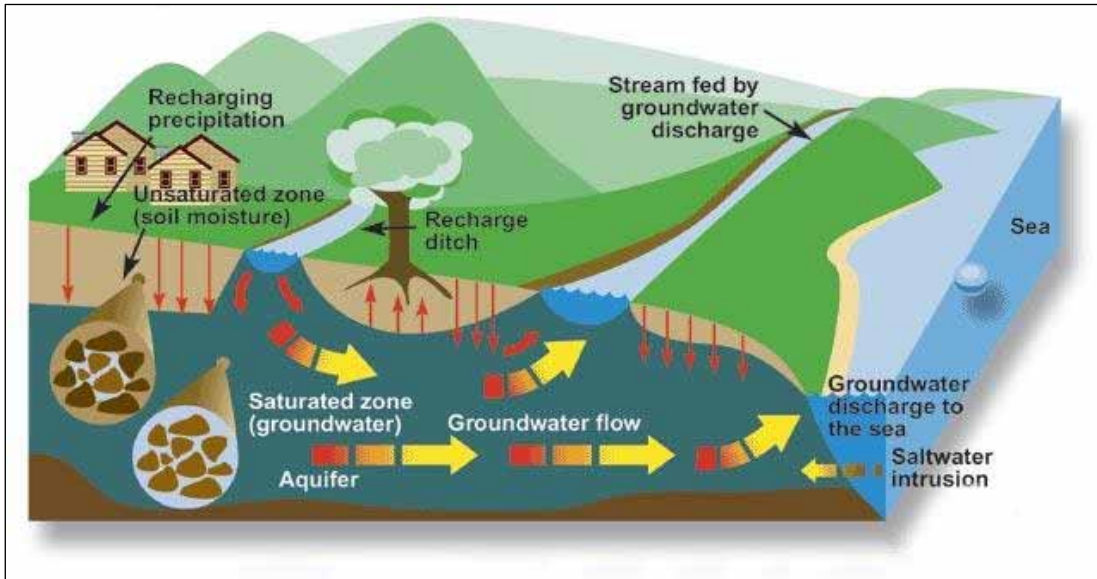


Figure 2. Illustration of natural groundwater discharge and recharge with surface water

Source: Groundwater Flow, <http://www.ec.gc.ca/water/images/nature/grdwtr/a5f2e.htm>, Environment Canada, 2004.

Extracting water from a well will cause the water table to lower. Water is extracted radially around the well forming a cone of depression (Figure 3). When the aquifer is allowed to recover, the water level returns to equilibrium; this is referred to as the static water level.

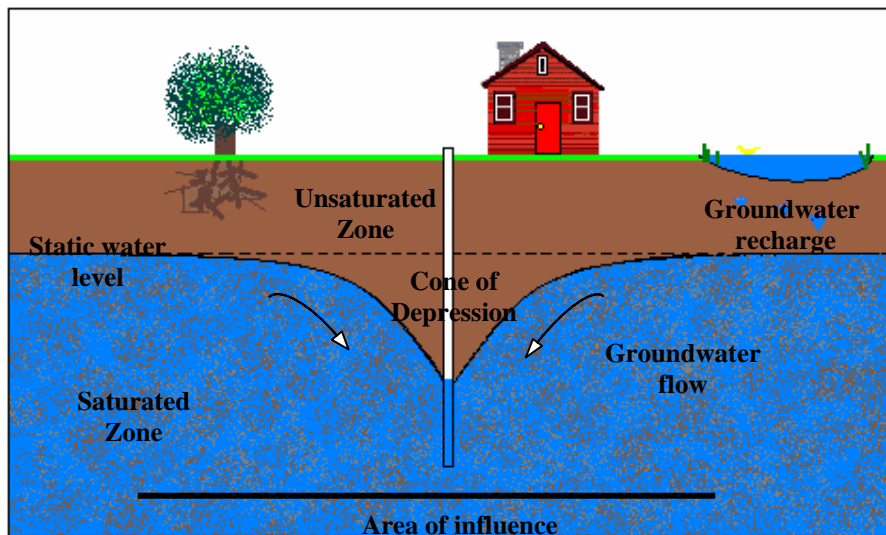


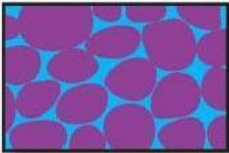

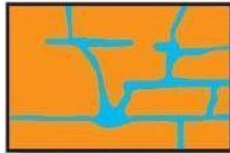
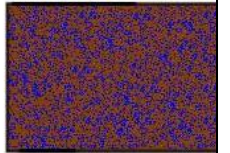
Figure 3. Cone of depression (as would occur in homogeneous², isotropic³ conditions)

² Uniform structure, compositions, and nature of the geologic formation throughout the aquifer

Geologic Data

In order to properly develop a Static Level Program, information about the geology in the municipality should be obtained. Baseline information can be obtained using existing topographic, geologic, and hydrostratigraphic maps⁴, as well as well driller's reports. Information on the geology of the municipality will help determine the geologic formations water storage and transmission capacities, flow patterns, as well as the sampling density required.

Common geologic formations and sediments

	 Sand and gravel Intergranular	 Igneous rocks Crevices	 Limestone * Solution	 Clay Pores
Porosity	20-60% sand only \cong 33% glacial till 20%	1-2% (massif) 3-7% (fractured) 30-60% (weathered)	3-30% (generally \cong 10%)	50-75%,
Hydraulic Conductivity (m/s)	Gravel: 10^{-3} to 1 Sand: 10^{-5} to 10^{-2} Glacial till: 10^{-6} to 10^{-12}	Unfractured: 10^{-13} to 10^{-9} Fractured: 10^{-8} to 10^{-4}	Limestone: 10^{-9} to 10^{-5} Sandstone: 10^{-10} to 10^{-6}	Marine 10^{-9} to 10^{-12}
Water Storage Capacity	High	Medium-High	Medium	High
Water Transmission Capacity	High	Medium (depends on degree of fracturing & weathering)	Medium (depends on degree of alteration)	Low (water is chemically bound to sediment)

* Sedimentary geologic materials

Data Source: Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Englewood Cliffs: Prentice-Hall.

Image Source: Main types of porosity, <http://www.ec.gc.ca/water/images/nature/grdwtr/a5fle.htm>, Environment

Implementing the Static Level Program in your Community

The H₂O Chelsea Static Level Program was designed by professors at the University of Ottawa to be a community-based project that could be easily implemented by local volunteers.

Please note however that each community will need to modify the program based on their information needs, the hydrogeological characteristics of their local aquifers, as well your program's financial and human resources.

³ Geologic formation exhibiting the same aquifer properties and therefore the flow behaviour is the same when measured along any axes in all directions

⁴ Natural Resources Canada, Geoscience Data Repository
http://gdr.nrcan.gc.ca/index_e.php (last updated 2006-05-10)

To provide an example of how the Static Level Program could be implemented in your community, we will describe how the program was developed in Chelsea.

We encourage communities to collaborate with groundwater specialists to modify H₂O Chelsea's sampling protocols for their Static Level Program (in order to determine: minimum density and ideal location of sampled wells, adequate sample size, frequency of monitoring etc.) Factors such as geology, aquifer characteristics and population densities will affect the type of program you will develop and how you interpret the data.

The Chelsea Experience

In early spring, information is sent out to residents to request the participation of local residents. Volunteers receive training regarding the Static Level sampling protocols⁵ and use of the monitoring equipment⁶. Participants measure the static level of their well once a month, from May to November, and input their results directly to the H₂O Chelsea database through an online form⁷.

The H₂O Chelsea Static Level Program is divided into the Intensive Static and the Volunteer Static programs.

Intensive Static Program

The Intensive Static Program was developed to monitor well-water levels (static level) in neighbourhoods which reported a greater incidence (above the municipal average) of water shortages in the 2004 Water Questionnaire⁸. Over 70 households in two neighbourhoods of Chelsea participated in this program providing excellent coverage for the small study areas. The Intensive Static Program required the hiring of a summer student to ensure that the wells involved in the study were guaranteed to be monitored monthly.

Volunteer Static Program

The Volunteer Static Program has the same goals as the Intensive Static Program but differs slightly in that:

1. Residents volunteer to measure the static level of their own wells.
2. The program involves monitoring throughout the municipality, not solely in neighbourhoods that reported a higher incidence of water shortages in the Water Questionnaire.

⁵ Static Level Program Protocols

http://www.h2ochelsea.ca/PDFs/StaticLevel_2006_Protocol_en.pdf

⁶ Static Level Monitoring Equipment Utilized by H2O Chelsea

http://www.h2ochelsea.ca/adopt_programs.htm

⁷ Static Level Datasheet

http://www.h2ochelsea.ca/PDFs/StaticLevel_2006_startupDataSheet_bi.pdf

⁸ H2O Chelsea Water Questionnaire

http://chelsea.ca/english/environment/h2o_chelsea.asp

Interpretation of Data

A municipality considering starting a Static Level Program must be aware that in order to make conclusions about the aquifer, several years of sampling will be required. Further, to properly analyse data compiled from the Static Level Program, the depth of the well, the elevation above sea level of the top of the well casing, and knowledge regarding the geologic formation in which the well is located should also be collected. We recommend that you consult a groundwater specialist to develop your monitoring programs and interpret your monitoring data.

To review some of the analysis strategies of H₂O Chelsea's Static Program, please see our *H₂O Chelsea Year 2 (2004)* report⁹.

Below, we explain the three primary approaches to interpreting your program's static level data: comparison to the static level recorded in your well driller's report, annual trends and long-term trends.

Comparison to the well driller's report

The current static level can be compared to the static level in the well when it was first drilled; this information will be given in the well driller's report. When making this comparison, ensure that you consider the time of year at which both measurements were taken; the seasonal variations in water levels can be misleading. Furthermore, if the water level indicated in the driller's report was approximated, caution should be taken when using this value in any analysis.

Annual trends

One year of sampling (year round or 6 months) will illustrate the trend of annual water fluctuations in the aquifers. A few years (3-5 years) of monthly static water sampling should confirm this trend with a higher degree of confidence (Figure 4). Monthly static water level measurements should show periodic oscillation: in the spring and fall, recharge usually exceeds discharge (water level is high); in summer and winter, discharge usually exceeds recharge (water level gradually lowers throughout these seasons).

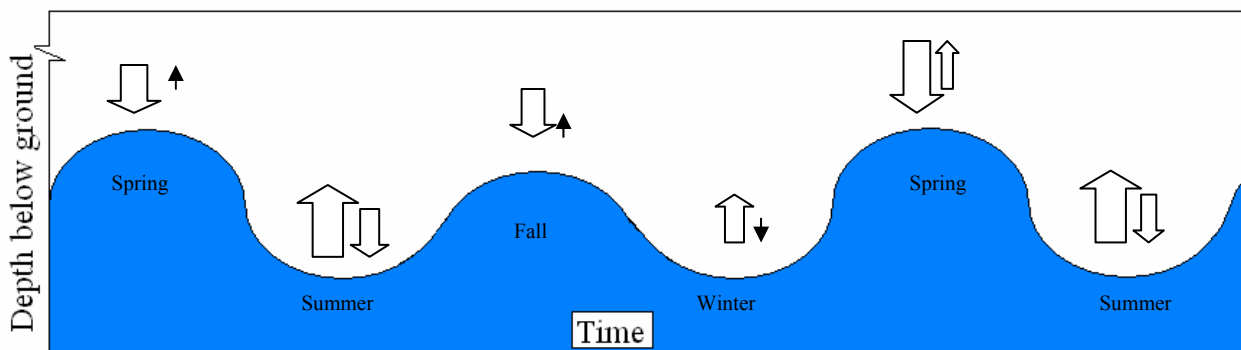


Figure 4. Illustration of normal annual fluctuations of water level due to aquifer discharge (↑) and recharge (↓).

⁹ Stow, N. Findlay, S. (2004) *H₂O Chelsea Year 2 (2004): Summary of Water Monitoring Results*
<http://www.h2ochelsea.ca/PDFs/H2O%20Chelsea%20year%20%20report-%20Jan%202026.pdf>

Long- term trends

A few years of sampling (3-5 years) can start to show long-term aquifer level trends. Comparing water levels at the same time of year for several years will show if the trend is of a generally lowering, increasing or stable water level. This will strongly be affected by the amount of precipitation the region receives all year. A long term project (10-15 years) should confirm assumptions about aquifer water levels. However, as illustrated in Figure 5 we can clearly see that trends may change over time.

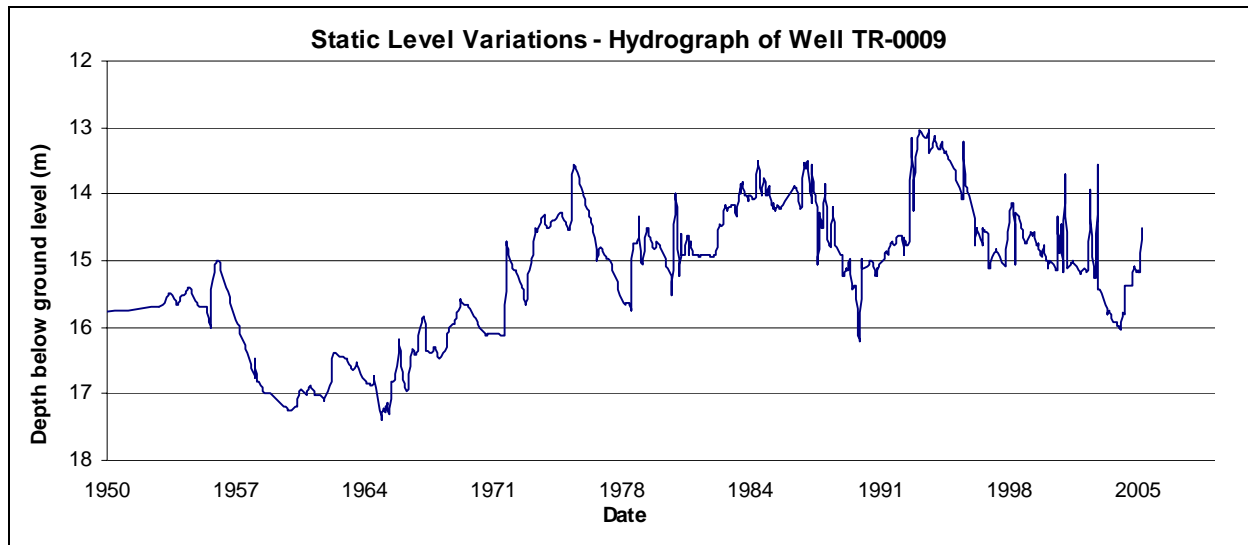


Figure 5. Observation from long term monthly sampling of static water level in one monitoring well (TR-009) in Trempealeau County, Wisconsin (1953 to 2005).

Source data: Hydrograph of Well TR-009, <http://wi.water.usgs.gov/public/gw/HISTORICAL/TR-0009.html>, U.S. Geological Survey, Wisconsin Water Science Center, 2006.

Short-term and long-term trends identified with the static water level program can help municipal planners review existing rates of water consumption and water conservation practices to ensure sustainable use of the resource. If the municipality is presently overdrawing water (long-term trends indicate a lowering water table), it is advised that water conservation initiatives be implemented. For example, the municipality could choose to limit the density of homes to be built in neighbourhoods (and surrounding regions) whose water tables are lowering (Figure 6).

Precautionary Principle

Municipalities need not wait several years while they conduct extensive studies before deciding to take actions to protect their groundwater resources. The precautionary principle states that it is best to act preventatively, even in the absence of supporting data.

Sampling Density

The density of wells to be sampled will vary depending on the geologic formation of the study area. Although there are no strict density requirements for the program, maximizing the number of participating homes in a given area will increase the accuracy and analytical potential of the data. Careful analysis of geologic data will help interpret the effects of aquifer characteristics on your static level data. This analysis is very important because movement and storage capacity is restricted by the porosity of the sediment in which the water flows. Also, be aware that water use in one well may impact the water level in another well, as per the superposition principle¹⁰. Understanding the geologic formation will help the project scientists to choose an appropriate sampling density. Note also that in order to compare measurements between wells, the different wells must penetrate the same aquifer.

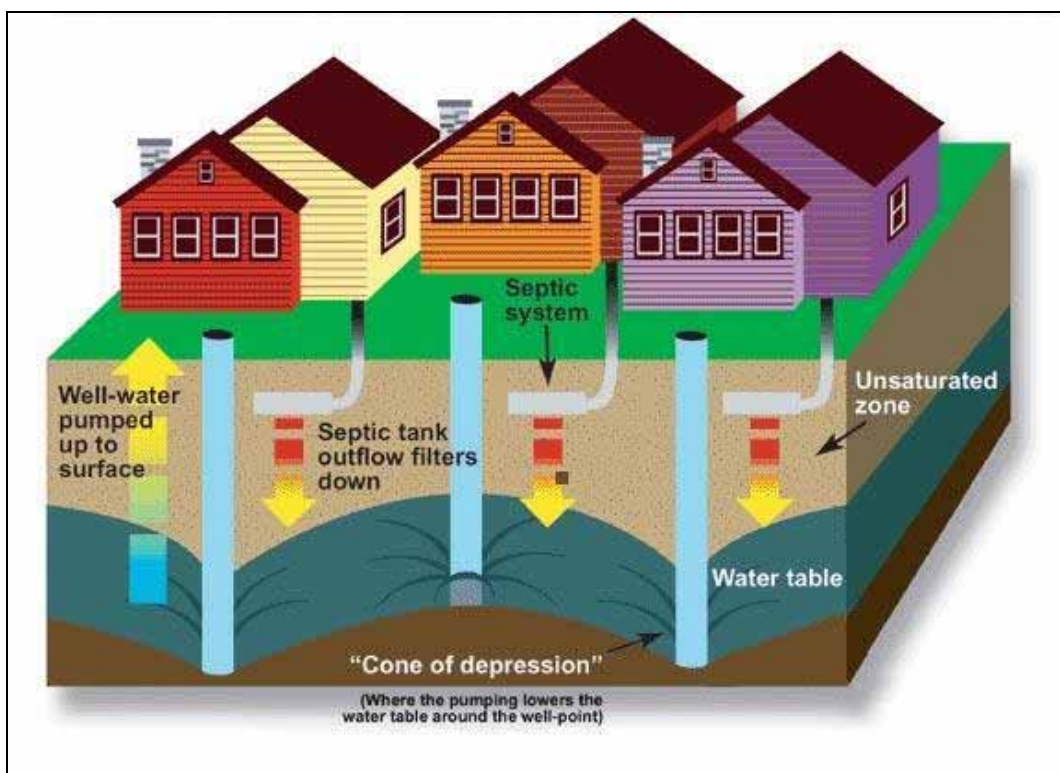


Figure 6. Concentrated housing increases the density of wells in an area. Superimposing cones of depression increases drawdown of the water table level.

Source: Effect of concentrated housing on groundwater, <http://www.ec.gc.ca/water/images/manage/effic/a6f5e.htm>, Environment Canada, 2004.

Sampling locations

When developing a Static Level Program, a broad sampling density in many different regions will characterize the aquifers throughout the community. Conversely, some communities can

¹⁰ In a linear system, each point (pumping well) acts individually; however, the total displacement is the sum of the displacement of the each individual point.

choose to focus their resources and efforts on specific areas that are more susceptible to water shortages. These areas can be identified by first conducting a Water Census¹¹ or Water Questionnaire¹². For example, the results of H₂O Chelsea's 2003 Water Questionnaire (illustrated in figure 7) helped us demarcate areas of the municipality that had reported a higher incidence of well water shortages, and therefore, we targeted these areas for our static level program.

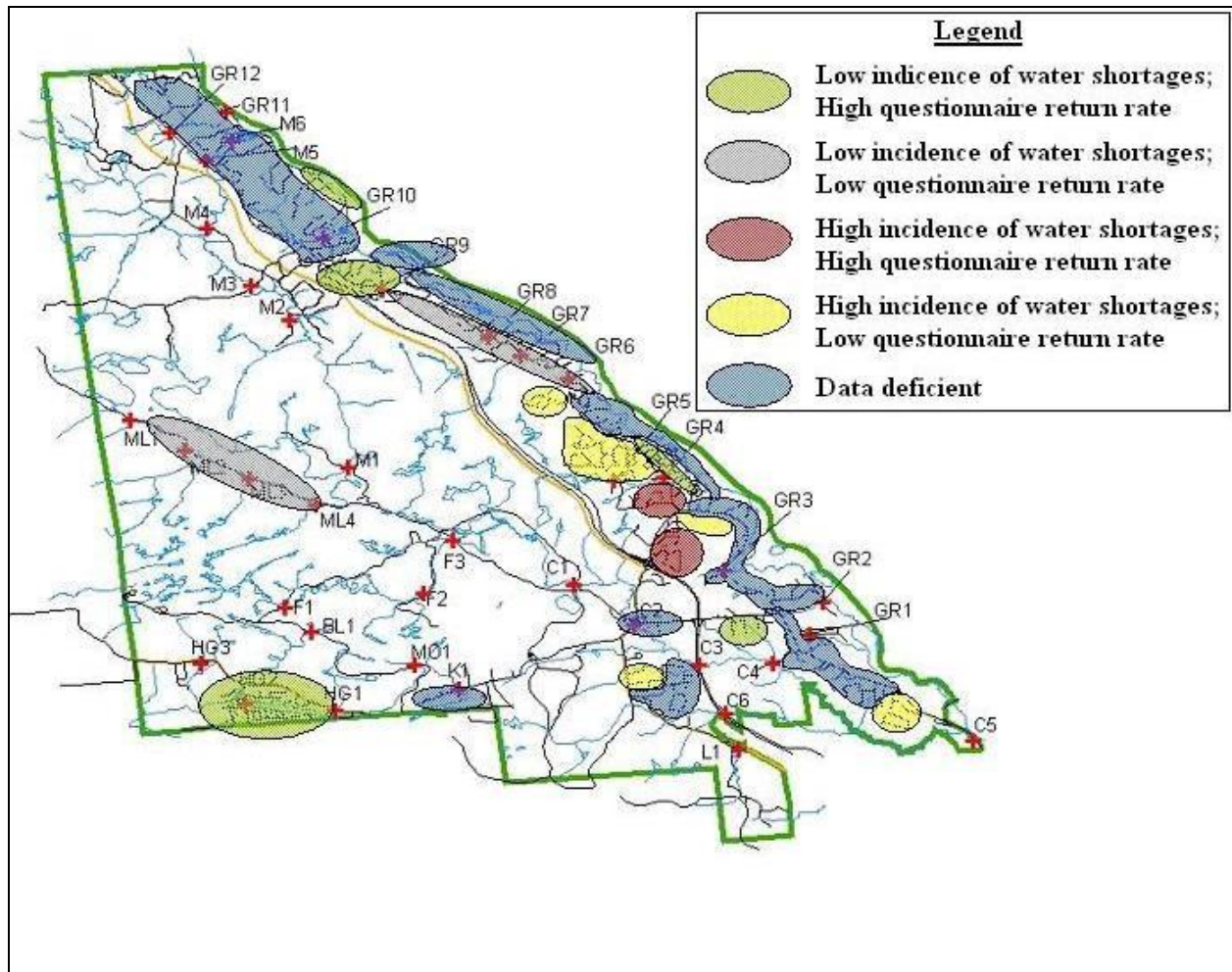


Figure 7. Results of the 2003 H₂O Chelsea water questionnaire on groundwater quantity

Sampling periodicity

For the H₂O Chelsea Static Level Program, static level measurements are taken once per month, from May to October. Winter measurements would add valuable information to the project (winter is another dry season; the water level usually decreases throughout the season). However, volunteers are less likely to want to sample in cold weather.

¹¹ H₂O Chelsea, Water Census
<http://www.h2ochelsea.ca/PDFs/Water%20survey%202005.pdf>

¹² H₂O Chelsea, Water Questionnaire
http://www.chelsea.ca/english/environment/h2o_chelsea.asp

Sampling precautions

Consult well drillers and pump repair specialists before training your volunteers on how to remove a well cap. For example, it is imperative that the electricity to the well's pump be turned off to eliminate chances of electrocution. Sampling should never be done alone. Participants must be careful to avoid personal injury as well as damaging the well's cap and electrical wiring. Equipment contamination is also an important concern. All monitoring equipment that comes in contact with the well should always be decontaminated (see Static Level sampling protocol) before and after each use.

We encourage you to seek legal advice in order to protect both the participants and the municipality. Please view our *Disclaimer and Privacy Statement Form*¹³ that must be signed by all program volunteers and participants. Communities should develop a document that is tailored to their community's monitoring program and legal environment.

Educational Value

The Static Level Program is not only a scientific monitoring tool but an awareness and educational tool as well. Participants learn that the overdraw of groundwater could one day lead to the lowering of the water level in their well and the local aquifer. Over time, other neighbours will learn about the monitoring program and the reasons for its existence. This chain of communication spreads the message that the water consumption behaviour of individual residences could impact on the sustainability of the groundwater supply of the neighbourhood.

To complement this learning process, H₂O Chelsea sends out education resources that detail ways that residents can reduce their domestic water use¹⁴.

Adopt our Program and Resources

In 2007, H₂O Chelsea will be working to publicize and transfer our research, monitoring and education resources (including the Static Level Program) as part of our *Water Monitoring Kits Initiative*¹⁵. All resources will be made available for adoption by interested communities, free-of-charge. Please consult our website to learn more about how you can develop a successful volunteer-based monitoring and education program in your community. We look forward to working with you!

Contact us:
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J9B 1C1
(819) 827-1124 X227
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¹³ Legal disclaimer

http://www.h2ochelsea.ca/PDFs/Privacy_Disclaimer.pdf

¹⁴ H₂O Chelsea Education Resources

www.h2ochelsea.ca/adopt_programs.htm

¹⁵ H₂O Chelsea Water Monitoring Kits Initiative

www.h2ochelsea.ca/adopt_programs.htm

Appendix 1: List of Static Level Program Resources

The following resources are also available on the H₂O Chelsea website:

Sampling Protocols –

http://www.h2ochelsea.ca/PDFs/StaticLevel_2006_Protocol_en.pdf

Data Sheets

http://www.h2ochelsea.ca/PDFs/StaticLevel_2006_startupDataSheet_bi.pdf

http://www.h2ochelsea.ca/PDFs/StaticLevel_2006_monthlyDataSheet_bi.pdf

Database

Please contact us if you are interested in receiving a copy of the database.

Legal Disclaimer and Privacy Statement Form

http://www.h2ochelsea.ca/PDFs/Static_Privacy_Disclaimer.pdf

Appendix 2: Making Manual Water Level Meters

Manual water level meters are easy to make and inexpensive.

What you need:

Long tape measurer (100 or more feet – depending on depth of wells and depth to water table)
Steel or copper 2cm diameter pipe
Steel or copper round sheet
Steel or copper small hook
Welding equipment

Steps:

Cut pipe to approximately 5 – 7 cm length
Puncture steel or copper sheet to make 2cm diameter disk
Weld pipe to disc forming a cylinder with one (1) end open
Weld hook to disc
Attach hook to end of measuring tape

How it works:

The metal cylinder is lowered down the well in brief jerks. When the open section of the cylinder comes into contact with water, it will make a distinct “plunk” sound. The quiet sound is amplified by the enclosed area (well). The measurement is taken on the tape at the depth where the sound is heard. Remember to correct reading for the length of the sounding apparatus (hook and cylinder).

Long tape manufacturers:

- **Stanley Hand Tools**
Open Reel Fiberglass Long Tape Rule (100’, 200’)
<http://www.stanleytools.com/default.asp?TYPE=CATEGORY&CATEGORY=HT%5FLONG%5FTAPES&PAGENUMBER=2>
- **CST/Berger**
Pro-Series Zip-Line PVC Coated Fiberglass Tape (100’, 200’, 300’)
<http://www.cstsurvey.com/Products/Measuring/MPVCFiberTapes.htm>
- **Empire**
Open Reel Fiberglass (50’, 100’, 165’, 300’)
http://www.empirelevel.com/tape_measures/open_reel_tapes/
- **Komelon**
Open Reel Fiberglass Measuring Tapes (100’, 200’, 330’)

**This list of manufacturers is offered as an aid to interested communities, it is not exclusive, and H₂O Chelsea does not endorse these companies. Note that various makes, models and lengths are available at local hardware stores. Prices vary.*

Appendix 3: Groundwater Monitoring Equipment Manufacturers and Providers

This list may not be complete. Prices and product availability are subject to change.

Manufacturers

- **Heron Instruments Inc.**
Water level meters are available in a variety of sizes and lengths, from 15m to 600m; prices range from 413.00\$ to 2766.00\$. For more information about the products offered by this company, please visit the company website.
https://heroninstruments.com/water_level_meters/
- **Global Water Instrumentation Inc.**
Along with the traditions Water level Meters, available with cable lengths of 15m to 150m priced from 4.00(US)\$ to 850.00(US)\$, Global Water Instrumentation Inc. produces the WL600 Sonic Water Level Meter. This instrument measures the water level without needing to insert a probe inside the well; the instrument measures water levels up to 365m depth. This water level meter is priced at 995.00(US)\$ For more information about the products offered by this company, please visit the company website.
<http://www.globalw.com/products/wl600.html>
- **RST Instruments Ltd.**
Water level meters are available in a variety of sizes and lengths, from 15m to 400m. For prices, and more information please visit the RST Instruments Ltd.
http://www.rstinstruments.com/product_water_level.html
- **Schlumberger – Waterloo Hydrogeologic**
The WLM Water Level Meter is available in a variety of sizes, cable length available in 15 to 600m. For prices, and more information please visit the Schlumberger – Water hydrogeologic website.
http://www.waterloohydrogeologic.com/equipment/water_level_meter/water_level_meter_ov.htm
- **Solinst Canada**
Water level meters are available in a variety of sizes and lengths, from the mini reel (10m) to the XL Reel (1500m); prices range from approximately 340.00\$ to 3400.00\$ for pre-made reels (process vary for custom water level meters). For more information about prices and products offered by this company visit the Solinst Canada website.
<http://www.solinst.com/Prod/101/101WaterLevelMeters.html>
- **Waterra**
Waterra Water Level Sensors are available with tape length of 100 to 500m. For more information and prices visit the Waterra website.
<http://www.waterra.com/pages/productpages/ws.html>

Providers

- **GENEQ Inc.**
GENEQ Inc. is a scientific instrument distributor; this company provides a variety of Water Level Meters from different makers. Please see their website for details.
<http://www.geneq.com/frames.html>
- **Hoskin Scientific Limited**
Hoskin Scientific Limited is a supplier of testing and monitoring instruments. This company offers a variety of Water Level Meters from different makers. Please see their website for details.
<http://ehoskin.xplorex.com/?p2=/modules/hoskin/categoryproducts.jsp&parentId=6734>
- **Rice Engineering and Operating Ltd.**
Rice Engineering and Operating Ltd. is a supplier of testing and monitoring instruments. This company offers a variety of Water Level Meters from different makers. Please see their website for details.
http://www.riceeng.com/flash/wlevel_temp.html