Monitoring Water Quality Sand Point Wells

East End Development
Planning Area
County of Annapolis,
Nova Scotia

COUNTY OF ANNAPOLIS

By Brenda Seymour

nscc
Centre of Geographic Sciences

To Mike Donnelly, even though you were not directly involved this year with the research project, you were a definitely an important part of the first year at COGS and without that, I would not be here at this point, completing my second year of Planning and the Research project.

To my three children, Jason, Tracy, and Melanie, thank you for your patience and understanding. Yes the roles were certainly reversed at times. I know it was tough for me and for you, when my life was consumed with school and I had very little time for you. Thank you for the sacrifices that were made.

To a very important person in my life, Jack, you have given me great support and lots of patience with me through this last year at school. Thank you for your understanding. You listened to my frustrations, anxieties, my triumphs and my accomplishments, and you always had lots of encouragement for me. Thank you.

If there is anyone I have missed, I will take this time to thank you too.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank the many people that have been there for me these past two years at COGS and for those of you that have given me your knowledge and advice with this research project.

To Ed Symons, my faculty advisor for this research project and instructor over the past two years. Your guidance and extreme patience were an important factor in helping me complete this project. You were also a very important person in helping me get through these past two years at COGS. Your door was always open to listen to our complaints, questions and just offering a listening ear when it was needed. Again, thank you.

To my client, Laurie Emms, County of Annapolis Planning Department, thank you for your cooperation and knowledge in making this research project a success. It was a great pleasure to have had the opportunity to work in your office this past summer and to also have had the opportunity to work on this research project with you. I hope this pilot program will be of use to the county in the future.

To Andrew Cranton, Public Works employee, thank you for taking the time out of your work schedule to help me out with the water testing sampling. It was greatly appreciated.

TABLE OF CONTENTS

APPENDIX C

(The following three documents are available only to Laurie Emms, P.Eng, Annapolis County Planning Department, due to privacy laws)

1. Listing of Property Owners of Sandpoint Wells
2. Well Information
3. Well Testing Sampling Information

Certificates of Analysis – Maxam Analytics Inc, Chemical Results

Microbiology Water Testing Reports, Valley Regional Hospital

Probability Charts by Laurie Emms, P.Eng

Spreadsheet of Water Test Results

Sample of Capital District Health Authority Lab Reports, outlining descriptions of each chemical as used for reference.

Sample Forms used in collecting water sampling

Various maps of the study area.

LIST OF FIGURES

CHAPTER 1: OVERVIEW

Water is essential for all dimensions of life. Over the past few decades, use of water has increased, and in many places water availability is falling to crisis levels. More than eighty countries, with forty percent of the world's population, are already facing water shortages, while by year 2020 the world's population will double. The costs of water infrastructure have risen dramatically. The quality of water in rivers and underground has deteriorated, due to pollution by waste and contaminants from cities, industry and agriculture. Ecosystems are being destroyed, sometimes permanently. Over one billion people lack safe water, and three billion lack sanitation; eighty per cent of infectious diseases are waterborne, killing millions of children each year.

World Bank Institute, WATER POLICY REFORM PROGRAM - Nov. 1999

1.1 INTRODUCTION

The study area for this research project was in District I & II, East End Development Planning Area of the County of Annapolis, N.S. The focus was on three subdivisions in the

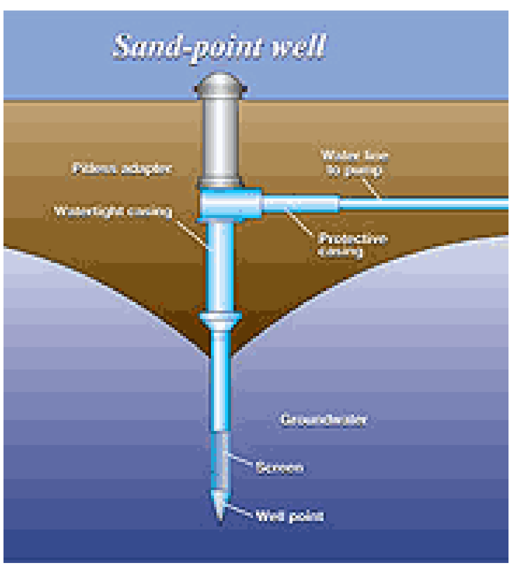
Figure 1.1 Research Study Area; Wilmot

Source: http://www.gov.ns.ca/snsmr/muns/info/mapping/ANNJ.asp

Wilmot area. (Figure 1.1) At time of report this was an unserviced area. Property owners are on private well systems, some of which are drilled and some are sand point wells. This area has been growing steadily and Laurie Emms, Director of Public Works, feels that there could possibly be a concern with the water quality in the lower aquifer. (Emms, L., personal communication)

An estimated 46% of Nova Scotian's that live in the rural areas, rely on dug or drilled wells for their drinking water. They are responsible for ensuring their wells are constructed to provincial standards. They are also responsible for ensuring their water is free of impurities. Contamination of a private well is not only the concern of the household using the well, but also the households using other nearby water supplies and the aquifer that the water is drawn from.

Types of Wells



Sand-point wells are probably the most vulnerable to contamination because they are shallow—typically less than 40 feet deep. In addition, they are used in areas that have highly permeable sand and gravel aquifers.

Figure 1.2 Sandpoint Well

Large-diameter dug or bored wells are also particularly vulnerable to contamination from sources near the well because of their design and generally shallow depth.

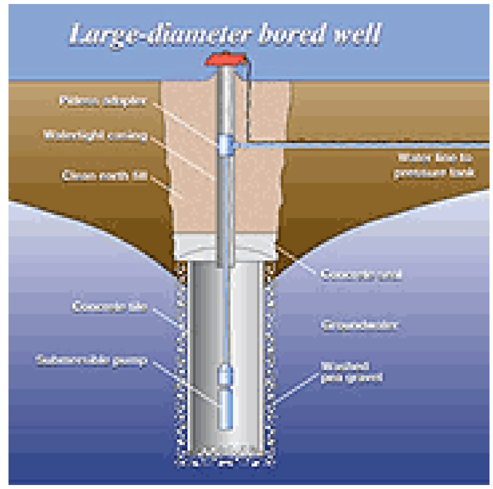


Figure 1.3 Bored (Dug) Well

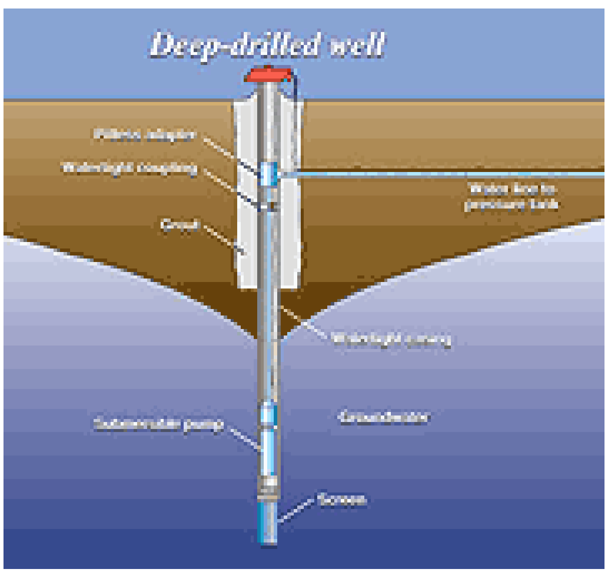


Figure 1.4 Drilled Well

Deep-drilled wells are often not considered vulnerable to contamination from non-point sources of pollution. Also, a lot depends on the well's solid-steel casing, which keeps out shallow groundwater. If only a few feet of a deep well is cased, shallow groundwater may seep in. Shallow groundwater can carry contaminants.

(50 Ways farmers can Protect their Groundwater, nd)

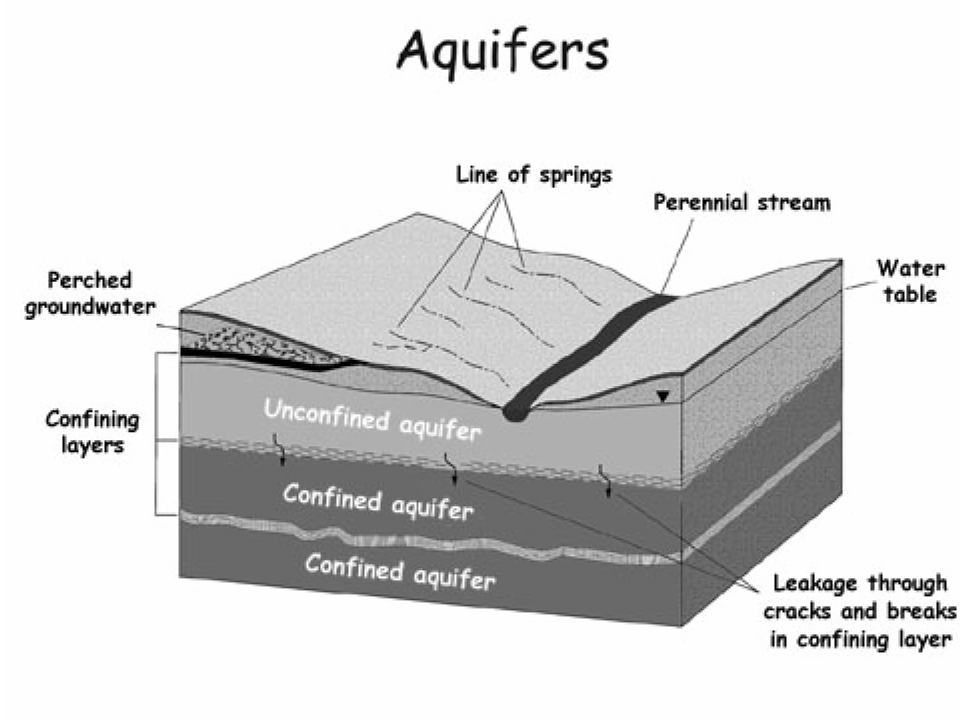
How do these wells become contaminated? Potential sources of ground water contamination which may be present include: septic tanks, animal waste, pesticides, fertilizers, fuel storage tanks, household chemicals, used motor oil and movement of groundwater between contaminated and clean aquifers, etc.

Water quality of the private wells can also be affected when an increase in development arises and the area begins to get quite congested. Smaller lots and more housing create an environment with higher risks of contamination.

"Chances of groundwater becoming contaminated depend on the size or strength of the contaminated source, how easily the source runs through the soil. Contaminates move most easily through coarse-textured soils (sand and gravel) and fractured bedrock. Once the contaminates reach the aquifer, they are difficult and expensive to remove. High levels of the contaminant in an aquifer can make the water unfit and unsafe to use". (Canadian Water and Wastewater Assoc.)

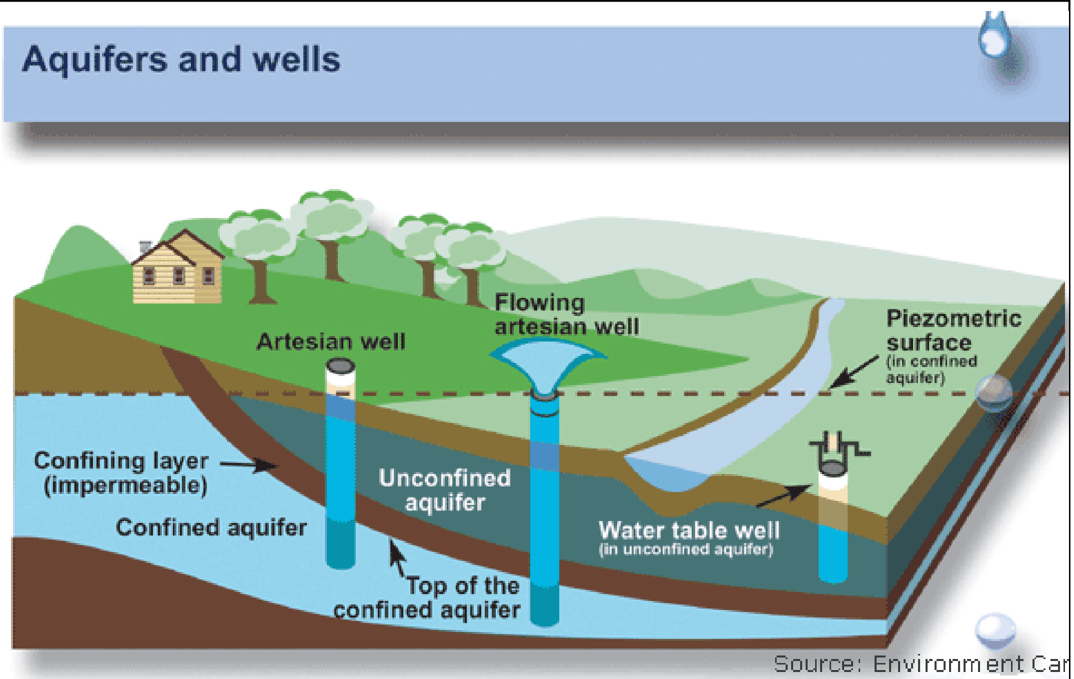
In the East End Development Planning area, there are two aquifers. One is a shallow resource consisting of sands and gravels which are vulnerable and not monitored. There is also a deeper resource confined and separated. It is a higher quality deeper resource which consists of a layer of clay on bedrock 1 – 2 metres thick which seals it. This aquifer is being monitored by the county on a daily basis. (Emms, L. October 3/05)

Figure 1.5Description of Aquifers



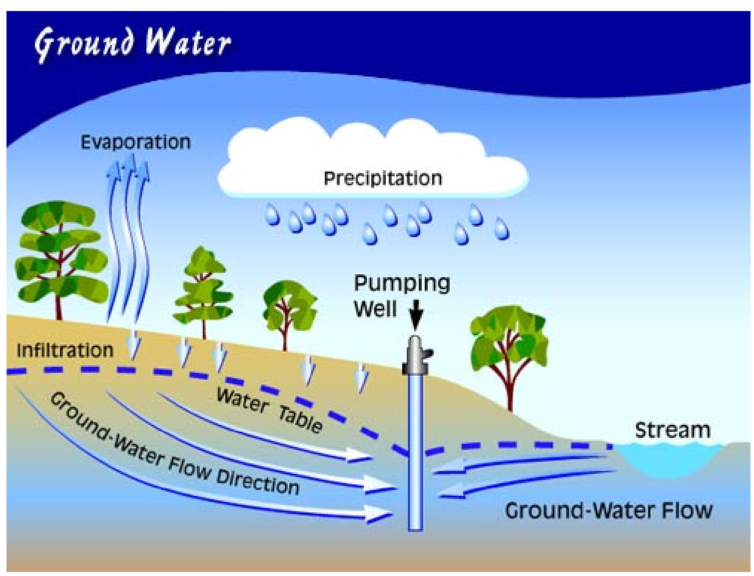
Defining an **aquifer**: In most areas the material underground are arranged in layers, formations, or zones with different porosities and groundwater capacities. Those materials with especially large concentrations of usable groundwater are widely known as **aquifers.** Many different types of materials may form aquifers, but porous material with good permeability, such as beds of sand and fractured rock formations, are usually the best. An aquifer is evaluated or ranked according to (1) how much water can be pumped from it without causing an unacceptable decline in its overall water level; and (2) the quality of its water. (Marsh, Third Edition, 1998)

Figure 1.6 Aquifers and Wells



An **aquifer** is a porous, water-saturated layer of sand, gravel, or bedrock through which groundwater flows.(Figure 1.6) It can be compared to a large, horizontal sponge that absorbs and transports water along its length. A **confined aquifer** is one that is bounded above and below by beds of rock, while an **unconfined aquifer** lies underneath a water table.

Figure 1.7 Groundwater



Aquifers continuously receive more water at **recharge areas**, areas of land through which groundwater passes downward into the aquifer. This groundwater moves from the recharge area through the aquifer and out into a **discharge area**. Examples of discharge areas include lakes, geysers, streams, and oceans. Groundwater usually moves from regions of high altitude and air pressure to regions of low altitude and air pressure. It travels at an extremely slow rate, averaging about only a meter per year. (Library, Think Quest, nd)

Without testing the water on a regular basis, water contamination can go undetected. If we are to prevent cases like the Walkerton water contamination issue in Ontario, we require a system to give us ample warning of potential problems that may be developing.

It is when these issues arise that the municipality approaches the idea of whether municipal servicing is an option that should be addressed.

1.1A THE CLIENT

This project was completed in conjunction with the County of Annapolis Planning Department. The contact person was Laurie Emms, P.Eng, and Director of Public Works. A second contact person was Cheryl MacKintosh, Planning Technician. They both can be contacted at 902-584-2255. Email address is ACPS@NS.SYMPATICO.CA The address is 396 Main Street, Lawrencetown, Nova Scotia, B0S 1M0.

1.2 RELATED PROJECTS

There are a few past research projects by planning students at Centre of Geographic Sciences (COGS) that references water quality in the Annapolis Valley. One of these projects, (Woodman, 1994) researched ground water and its relations to on-site disposal systems. ("Ground Water Study in District I, of the Annapolis County") The delineated area was north of the Annapolis River, west of the Annapolis/Kings County border and east of Ruggles Rd. This area does not cover the full study area of this project but does cover a substantial area. The study area was unserviced at that time, which is unchanged at this point in time.

In 1993, The Department of Health did a survey in District I and II. The survey was called the Sanitary Survey of 1993 and dealt with the quality of ground water. Well water was tested for coliform and it was determined that there was a relationship between geographic factors and areas with counts of coliform bacteria.

Woodman's research project conclusions show that there were concerns on water quality in the high density residential areas. Poor soil suitability for septic drainage was also a factor in some of the problem areas.

In 1998, Giselle Winchester, Planning student, researched groundwater ("Toward Clean Groundwater"). The aim of her project was to *"help maintain clean groundwater reserves through* *public awareness",* in collaboration with Clean Annapolis River Project (CARP). She looks at groundwater contamination from household wastewater. Her study area was from Kings county line west to Aylesford. Contamination of aquifers in the Annapolis Valley is another area that is briefly mentioned. This project concludes that there were water quality issues in the study area and recommends promoting public awareness and education on the importance of proper septic maintenance, water conservation and disposal of hazardous and toxic wastes.

In 2000, another research project by Inglis, ("Testing the Waters, 2000") was a study on ways to improve the water quality in the tributaries of the Annapolis River watershed. Problems had been identified in the area, by volunteers who had taken water samples for fecal coliform bacteria testing. This project concentrated on the fecal coliform pollution issue, at which time, test results showed some of the tributaries were badly polluted. Again, we see that water quality was an ongoing issue in this area.

The community of Pumphandle, B.C. developed a Well Protection Plan in response to rising nitrate levels in one of the area's three community wells and the desire to protect the groundwater supply from possible contamination from a variety of sources. (Well Protection Plan for Pumphandle, B .C. 1999) The objective of this well protection plan was to bring the community together to protect their drinking water supplies. Three community wells and 12 surrounding private wells were chosen to be monitored on a regular basis with the implementation of their protection plan. Sources of potential contaminates were identified and priorities for action were set up based on proximity to the wells. The results of the well protection plan were to be evaluated annually.

Iowa set up a monitoring network to monitor their groundwater and measure water quality changes and identify trends in the aquifer. (Iowa DNR/IGS, Watershed Monitoring and Assessment, nd) The system is called the Iowa Groundwater Level Network and has been in existence since 1982 and is conducted by the Iowa Department of Natural Resources and the U.S. Geological Survey. The groundwater was monitored on a quarterly to monthly basis and then entered into the USGS Groundwater Site Inventory database. Each year, a selected aquifer and its respective wells were reevaluated to determine which wells to continue monitoring and whether additional wells in that aquifer should be included in the groundwater level network.

The Iowa Groundwater Level Network originated from a system that began in 1950 by the State Health Department. (Iowa DNR/IGS, Watershed Monitoring and Assessment, nd) The program at that time, took periodic and non specific sampling of untreated water from municipal wells. In 1990, the program changed its focus and chose a fixed network of 50 wells that were to be sampled annually out of 250 wells that were selected on a rotational basis.

Although the Iowa monitoring program primarily sampled municipal wells, the primary goal was to develop a monitoring program to provide important information for the overall management of groundwater in Iowa.

In 1988 and 1989, Iowa also had a one time Rural Well Water Survey (SWRL) which was a statistically based sampling of 686 wells across the state. The object of the survey was to evaluate the water quality of private drinking water used by rural Iowans. The survey was conducted by the Iowa Department of Natural Resources and the University of Iowa Center for Health Effects of Environmental Contamination. An inventory questionnaire was completed for each household and a health assessment questionnaire was completed for each person in the household. The well water was tested for pesticides, bacteria, inorganic and chemicals.

In 1994, there was a Survey of the Quality of Water Drawn from Domestic Wells in Nine Midwest States. (CDC, National Center for Environmental Health, nd). Coliform, E-Coli, Nitrates and Atrazine were present in many of the wells tested. Most of the samples with these pollutants were from old and shallow-dug or bored wells with a large-diameter brick or concrete tile casing. An opening in the well; a septic tank within 100 feet; a well down gradient from a pollutant source; and recent use of fertilizers, pesticides, or manure near the well each had a modest detrimental effect on water quality. (CDC, National Center for Environmental Health, nd).

Under Nova Scotia's Drinking Water Strategy Program, a guide has been set up for Municipalities for "Developing a Municipal Source Water Protection Plan". This concentrates on municipal water supplies only. There is no monitoring system for private well water.

1.3 PROJECT PURPOSE

Concern of water quality deteriorating in the sands and gravel aquifer due to ground water issues in the underlying area is what initiated this research project. With increased development, areas become congested, which in turn creates environments for well water contamination. With smaller lot sizes there is more risk of septic systems becoming too close to neighbouring wells and possibly contaminating the water supplies. This can happen as a result of improper care of the septic systems.

Source: **www.nelabservices.com**

Measuring the groundwater quality and changes in the project study area is a present concern of the County as there is no system in force at present. Decision making for installing municipal servicing is based on public complaints. There are no support systems in place to aid the County in identifying problems before it become public issues.

The goal is that the information gathered through this project, can be used to assess the resource, project future conditions of supply, and provide the information necessary to effectively manage the resource.

This purpose of this pilot program is to assist in providing the municipality with data for analysis and aid in helping with the decision making of installing municipal servicing in a developing area. It will also aid in monitoring the water quality of the aquifer. This system could invariably be used for other areas of development that are not presently serviced by the municipality. At present, there are no such monitoring systems in Nova Scotia. Development of monitoring private well water will provide important information for the overall management of developing areas.

Source www.exitrealestate.com

CHAPTER 2:

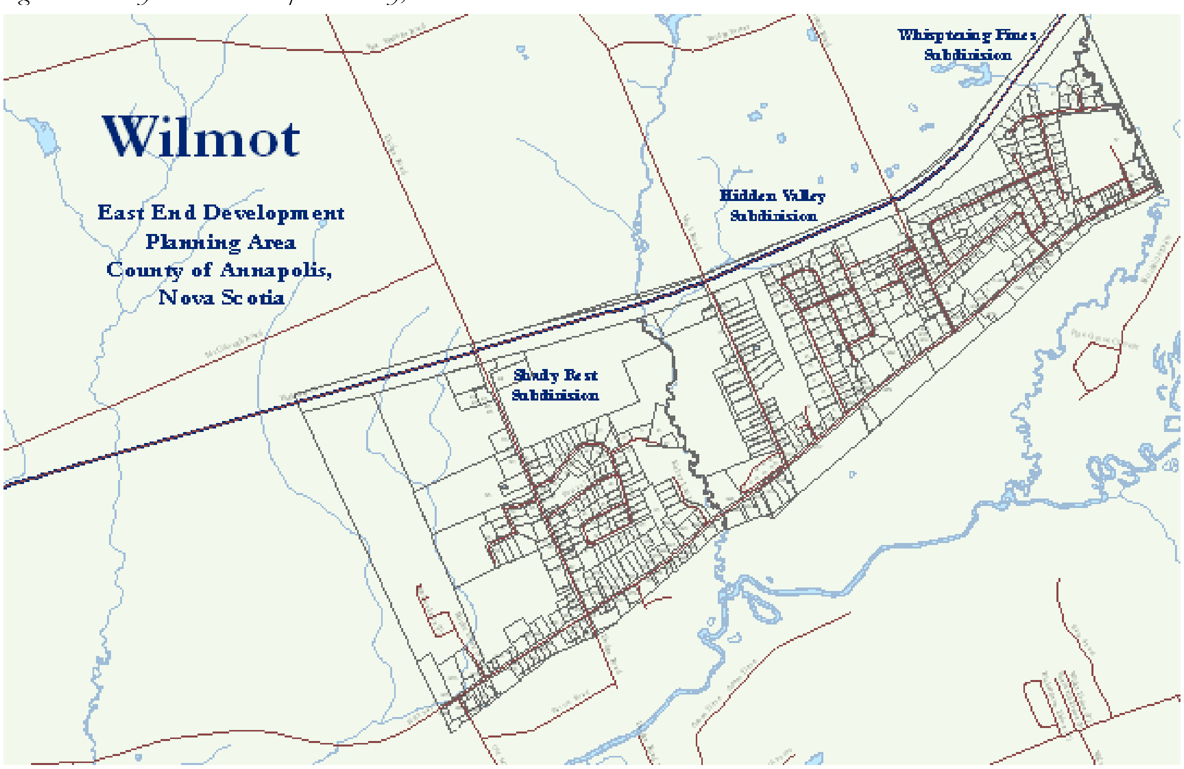
THE PROJECT STUDY AREA

"A good supply of fresh water is essential to human existence. We use fresh water not only for drinking, but for bathing, growing food, cleaning, watering animals and watering lawns." (Tyson, n.d)

2.1 DELINEATING THE STUDY AREA

The project study area consists of three subdivisions within District I & II, of the East End Development Planning Area; Shady Rest, Hidden Valley and Whispering Pines. These three subdivisions are located in the community of Wilmot, (Figure 2.1) which are adjacent

Figure 2.1 Study Area in Annapolis County, N.S



Source: ArcMap 9.1

to the communities of Kingston and Greenwood. District I & II is one of the few planned areas in the county. These subdivisions are close in proximity to Kingston and Greenwood which are large growth centers in the County of Kings.

2.2 THE TRESCOTT REPORT

In 1968 the Province of Nova Scotia, Department of Mines, initiated a program to evaluate the groundwater resources in Nova Scotia. (Trescott, 1968) The Annapolis-Cornwallis Valley was the first area studied. This study was done jointly with Canada Department of Forestry and Rural Development.

This report provides information on the aquifers in the area and is the only data available on the aquifers. There are no digital maps of these aquifers.

As stated in this report, groundwater is the largest resource of freshwater in the Annapolis Valley. Underlying the entire Valley is an extensive aquifer: the Triassic Wolfville sandstones and conglomerates. The most important aquifers are the glacial sand and gravel deposits. These are found in the eastern and central parts of the valley.

Water testing was done for groundwater quality. Most of this testing was done using dug wells, irrigation pits and test holes and testing was done in the summer.

Potential sources of groundwater pollutants were cited in the report. Some of these sources included, poorly located and/or maintained individual septic tanks, abandoned dug wells, poorly located garbage dumps. In testing for pesticides, none were found in three samples taken from areas that were sprayed periodically.

This study was initiated to investigate the availability and quality of the groundwater. Most of the mountain lakes had already been developed and with the expanding development and population, it was time to look at other means of water supply. The groundwater had only been utilized to a minor extent up to that point and more investigation was needed in order to find out the potential that was available. With this investigation, surficial deposits and bedrock boundaries were mapped, along with investigating potential pollution problems.

2.3 VALLEY AQUIFER STUDY

A regional hydrogeological study in the Annapolis Valley, Nova Scotia, was being undertaken through the Geological Survey of Canada Groundwater Program. (Natural Resources Canada, 2006), which began in 2003 and is set to complete in 2006. This study looked at existing data, such as the Trescott Report, which was the last study of this kind up until this present study, and entered and analyzed the new data. This project looked at surface water/groundwater interactions and groundwater nitrate migration modeling. It also elaborated on the aquifers in the Valley. Nitrate concentrations were of concern in different areas of the Valley. (DNR, Valley Aquifer Study, 2003) The concluding information will be available to all residents of the Valley with hopes in aiding in decision making for managing and protecting water supplies.

2.4 DELINEATING THE AQUIFERS

The main regional bedrock aquifer within the Valley is the Wolfville Formation, which belongs to the Fundy Group (Late Triassic age). This formation comprises mainly reddish thickly bedded medium to coarse grained sandstone, with subordinate conglomerate. Its thickness gradually increases towards the northwest, from 0 to approximately 1150 m. (Trescott, 1968)

The study area is located in what is referred to in the Trescott report as the Annapolis – Cornwallis Valley, which is situated between the North and South Mountains. It varies in width from 3 miles near the Annapolis Royal to 8 miles near Wolfville. Using the National Topographic Series Maps (1:50,000) you will find this location at 21 A 14, 21 A 15.

This area is divided into three physiographic units of which this study area is located in the Triassic Lowlands which is formed on sandstone and shale beds of Triassic age. (Trescott, 1968)

Within the Triassic Lowlands there are three bedrock geology areas.

1. North Mountain Basalt
2. Blomidon Formation
3. Wolfville Formation

The study area is located in the Wolfville Formation area.

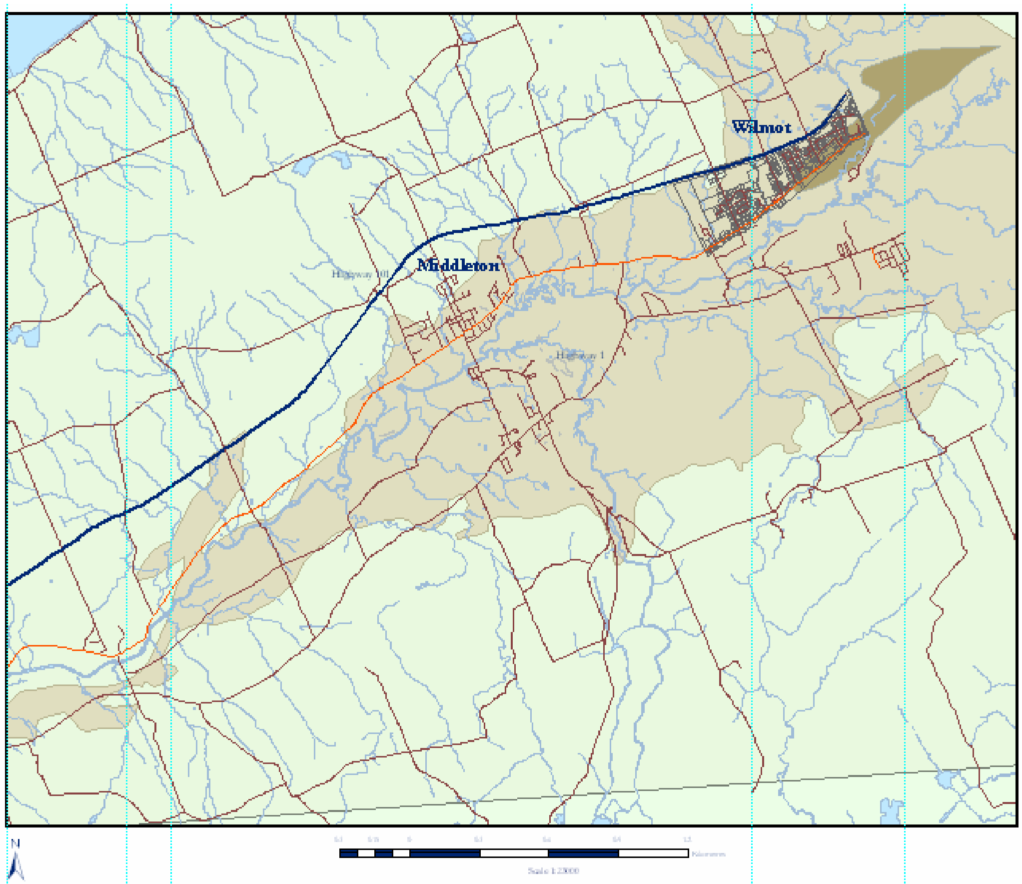
Wilmot is also located within the Upper Annapolis River Basin watershed. The parent material in most of the area is glacial till or glacial fluvial sand and gravel deposits.

Throughout the Valley, testing was done to measure the depth to the water table. The depth to the water table in the Wilmot area is between 4 feet – 12 feet. Figure 2.2 illustrates the location of the shallow aquifer. This was digitized from hard copy. (Trescott, 1968)

Figure 2.2 Map of Aquifer

The aquifer was digitized from hard copy. (Trescott, 1968) The light brown area outlines the shallow aquifer.

Source: Digitized using ArcMap 9.1)



CHAPTER 3:

ISSUES INVOLVED IN IMPLEMENTING A MONITORING SYSTEM

High quality water is more than the dream of the conservationists, more than a political slogan; high quality water, in the right quantity at the right place at the right time, is essential to health, recreation, and economic growth.

EDMUND S. MUSKIE, U.S. Senator, speech, 1 March 1966

3.1 RESPONSIBILITIES OF THE PROPERTY OWNER OF PRIVATE WELLS

Property owners are responsible for ensuring their wells are constructed to Provincial Standards and for testing their water regularly to ensure it is free of impurities. (*Nova Scotia Drinking Water Strategy*). All newly installed wells are required to be tested, but after that, it is left up to the owner to ensure it is tested. New home buyers are also required to have the well tested when purchasing the home. The government does not regulate private wells, nor do they monitor private well water supply, as resources are not available for the number of wells in Nova Scotia. They do provide resources for property owners to inform them on how to manage their wells in order that they are protecting their wells from contaminates. They also provide information on when and how to take water quality samples and what they should be testing for. Even though this information is available to homeowners, very few follow through with further testing. Most seem to feel comfortable with the fact that the initial water testing that was done when the well was installed was sufficient. Testing well water quality every six months for bacterial contamination is recommended. (*A Drinking Water Strategy for Nova Scotia)* The laboratories measure both coliform levels and E. coli. It is also advisable to have the water tested every one to two years for chemicals (Standing Committee on Resources, 2001)

3.2 HOW DO MUNICIPALITIES BASE THEIR DECISIONS ON SEWER SERVICING?

As mentioned in Chapter 1, Section 1.1, municipalities investigate public complaints and if the complaints are valid, servicing is then considered. The municipalities can be more readily aware of issues before it becomes a public concern if they have better resources to guide them in effective decision making. Costs can also be a deterrent when Municipal Governments are considering implementation of sewer and water servicing in an area. The less densely populated an area, the higher the costs are for servicing.

Property owners would have to pay an initial cost for this servicing and then a yearly charge would be billed to them. This is a disincentive that can create concerns for property owners. For many property owner's, finances are an issue. Because of this, they fail to look at the real issue; possible contamination of their drinking water which in turn is a huge health issue.

3.3 Anticipated Costs/Time requirments

Anticipated costs and time requirements for the monitoring program:

1. Bacterial Water Testing at an average of 1 X per year.
2. Chemical Water Testing at an average of 1 X per 2 years.
3. Survey of research area to locate the wells that need to be tested.
4. Time required collecting the water samples.
5. Hourly wages
6. Follow up phones calls.
7. Entering results in a database and GIS program to create reports and maps for analysis.

If the general public were submitting these water tests themselves they would pay $20.00 per water sample for the bacterial testing and $250.00 for the Chemical testing.

The approximate time for the initial survey was 14 hours over a four day span. The approximate time to collect the water samples was 15 – 20 minutes per household when taking into consideration the paperwork and actual sample taking. This does not account for traveling time to the locations and then transporting the water samples to the labatory (bacterial water samples must be taken the same day to the labatory). Note: Approximate charges could be up to $3,500 for the bacterial and chemical water testing.

CHAPTER 4:

ESTABLISHING PRIVATE WELL MONITORING SITES

When the well is dry, we know the worth of water.

BENJAMIN FRANKLIN, (1706-1790), Poor Richard's Almanac, 1746

4.1 DRAFTING THE SURVEY

In drafting the survey, the questions that needed to be answered were;

- Was the property owner willing to participate in the program?
- What is the type of well? Only sand point and dug wells are eligible for this project.
- Name and civic address of the property owner.

This was the only initial information that was required from the property owner at this time as the purpose of the initial survey was to find out if we had enough participants and if there were enough qualifying wells in these subdivisions.

4.2 COLLECTING STATISTICALLY SOUND DATA

Various considerations are involved in conducting a statistical test. If we are going to take random sampling of sand point wells, we need to ensure that our results are statistically sound. The importance of a sampling distribution and the problems in selecting a sample need to considered. For this survey, we are going to examine Probability Samples. Probability samples are random samples in such a way that beyond picking the sampling design, the preferences of the researcher do not influence the choice of individuals for inclusion in the sample. Two simple methods of sampling might be used. The first involves a random table which consists of block numbers that meet certain properties of randomness. The numbers are not serially ordered in any way, and ignoring numbers that occur more than once, one continues to select from the random number table until one has a *random sample* of the required size. The second method produces a *systematic sample*: one begins from a random starting point, and selects individuals from there on using a convenient fixed lag. The data cannot be ordered in any way that will influence the characteristics of the resulting sample. (Norcliffe, 1977, 1982)

The collection of a sample involves inputs of time, manpower and money; hence if two sampling designs provide equally unbiased and precise estimates, then the design which makes the sample easier to collect is the better.

In principle, it is important that the statistical criteria should override the convenience criterion.

In reviewing this survey, we have three subdivisions on private well systems, but we have no idea, whether they are on drilled or sand point wells. Properties with drilled wells will not be included in this study, as their water supply will be drawing from the bedrock aquifer. As there are no logs of well types in this area, it will be difficult to proceed with random sampling testing as described.

The first step is to proceed with this survey to acquire the data on number of sand point and drilled wells in each subdivision. With this information, it can be decided if we need to take random sampling on the results and proceed from there.

Options in conducting the survey:

Option 1: Door to door survey. As there are approximately 150 to 250 properties within each subdivision, it would be impossible to complete this survey in a reasonable time if everyone was to be surveyed.

Figure 4.1 Door to door survey

Source: Jack Long

Option 2: Survey by phone.

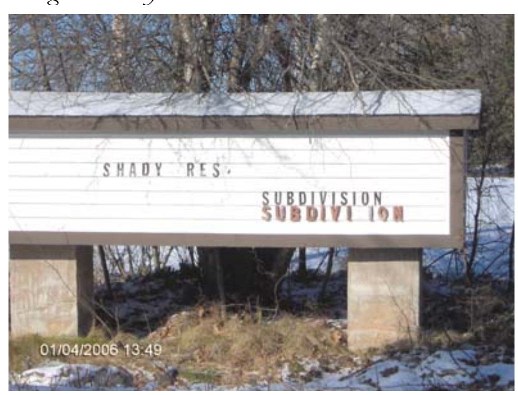
Again, the question is, do we phone everyone? Do we randomly select households to call? Is there a listing of phone numbers for the area?

Door to door survey was the option that was decided on. Option two was decided against as phone listings were unavailable, and secondly, the general census is that cooperation with telephone surveys are low as people are bombarded with telephone surveys and do not like to be bothered. There is a higher rate of response with door to door surveys.

I had decided to do a random selection on the first day and see what kind of results I got and proceed from there.

My first day out in the field, I soon discovered that the subdivision that was the most concern (Shady Rest Subdivision), had a majority of drilled wells in that area. Out of 29 surveyed that day; which were scattered throughout the subdivision; only one was sand point well. The property owner was hesitant in participating and would get back to me.

Fig 4.2 Shady Rest



Source: Brenda Seymour

As Whispering Pines was on the opposite end, I decided to check that area to get an idea on what types of wells were in that area. I randomly chose 19 properties in one area of the subdivision which resulted in 14 drilled wells and 5 sand point wells.

Figure 4.3 Whispering Pines

Source: Brenda Seymour

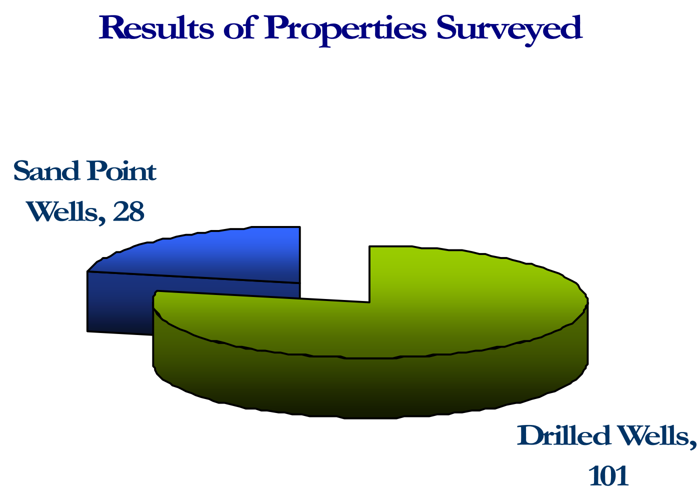
Figure 4.4 Geiger Drive, Whispering Pines

Source: Jack Long

4.3 EVALUATING THE RESULTS

It took a total of 14 hours over a 4 day period to survey 129 households. Out of the 129 households, there were 28 sand point wells and 101 drilled wells. (*Figure 4.5*) As a result of the minimal sand point wells available for the study, it was decided we would have to include all willing participants. Random sampling was not an option as the result of the survey gave us a representation of close to a full population

Figure 4.5 Pie Graph for Results of Properties Surveyed



Source: Excel

Originally, 22 of the 28 sand point property owners were willing to participate in the pilot program. (Figure 4.5) A few of the property owners not willing to participate were concerned with consequences of the results. They had concerns that they would be informed by the county that they would have to convert to a drilled well if the results showed there was contamination. Others gave no reason. The owners were reassured that this was only a pilot program to set up a monitoring system, that was part of a research project, and the test results were available to them at no charge and no consequence.

4.6 "Participation Response" in the survey

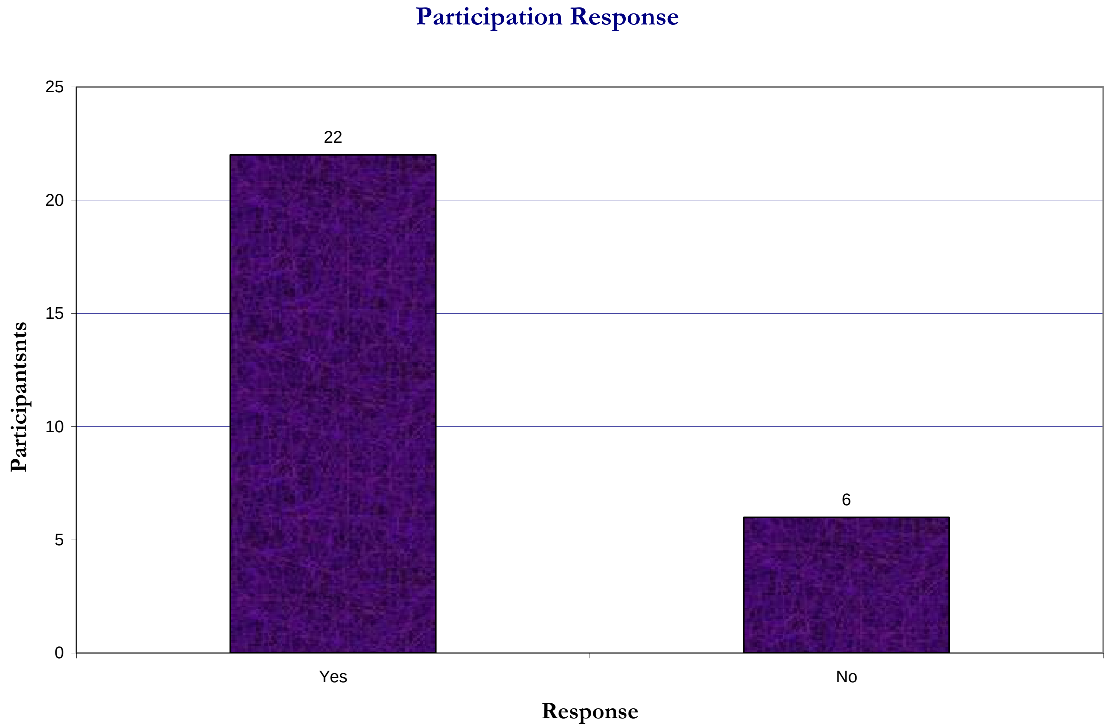
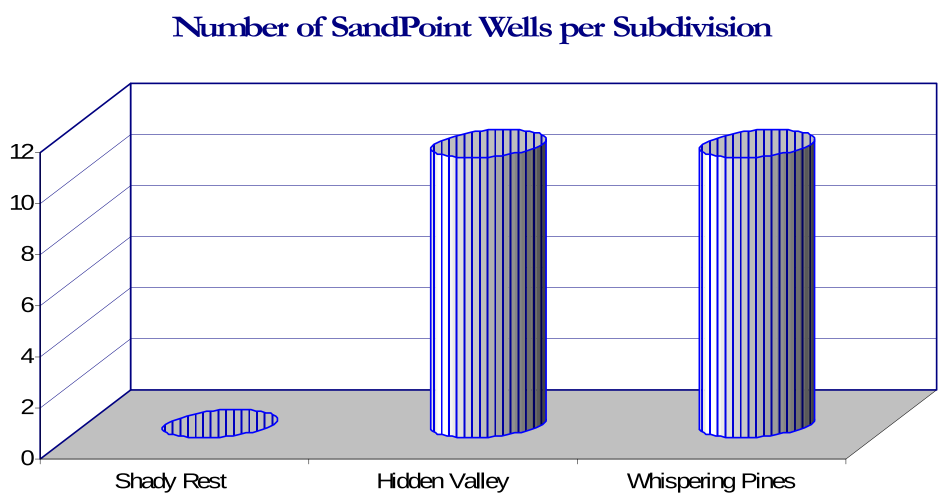


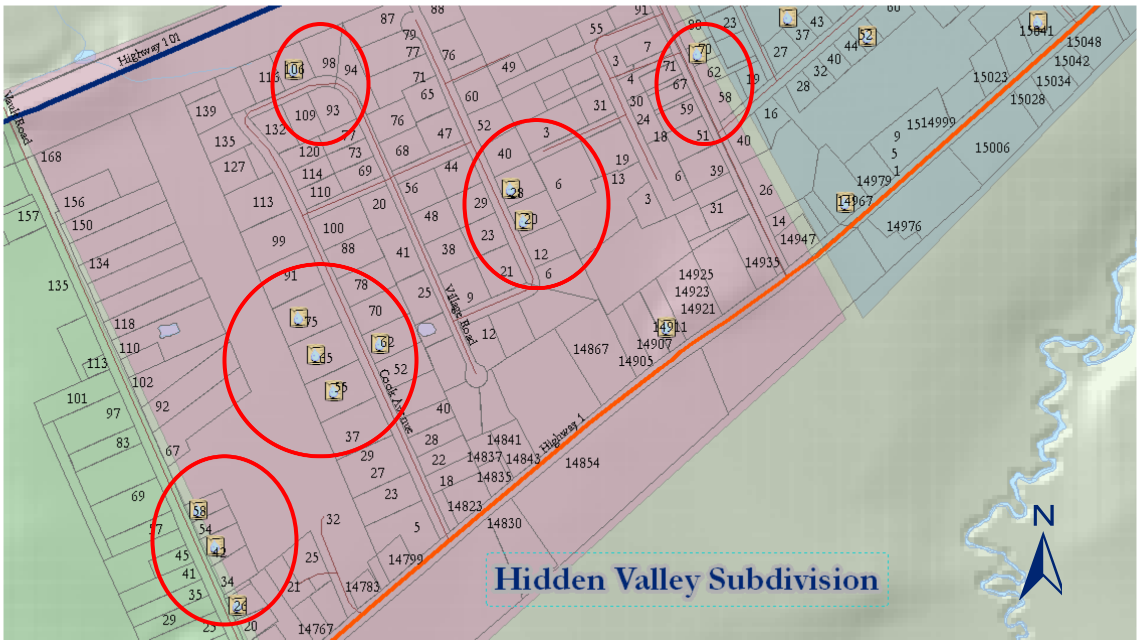
Figure 4.7 Number of Sandpoint per Subdivision



Source: Excel

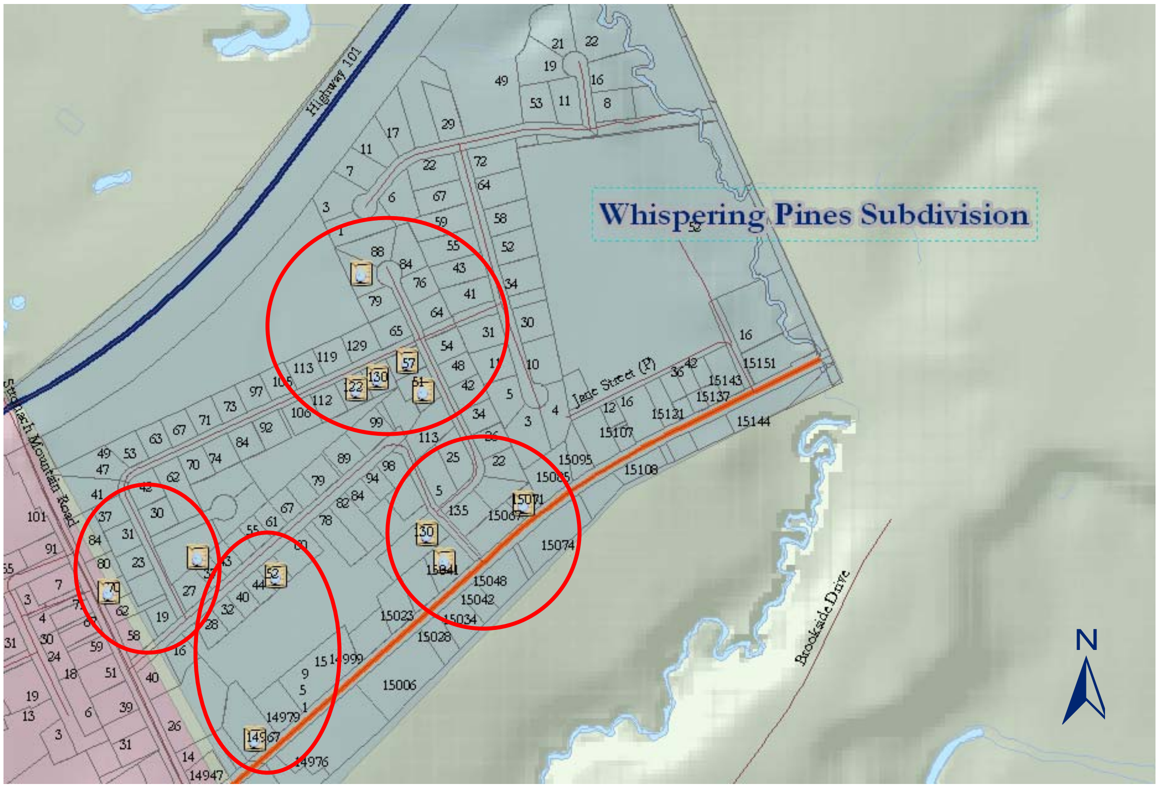
As shown in *Fig 4.7, 4.8* and Fig *4.9*, there is even distribution of sand point wells in two of the subdivisions, but we have no participation in the Shady Rest Subdivision. As a result, our research project will proceed with only two subdivisions for testing.

Figure 4.8 Number of Sandpoint Wells in Hidden Valley Subdivision



Source: ArcMap

Figure 4.9 Number of Sandpoint Wells in Whispering Pines Subdivision



Source: ArcMap

4.4 THE FOLLOW-UP QUESTIONNAIRE

The follow up questionnaire is to obtain background history on the wells. The well history could be beneficial in the event of circumstances where it is required.

- Do you test your water on a regular basis?
- How often do you test?
- When was the last testing?

- What were the results?
- Have you deepened, cleaned or made any alterations to your well?

4.5 QUESTIONNAIRE RESULTS

- Do you test your water on a regular basis? Response: 21 No; 1 Yes
- How often do you test? Response: 1 year to 10 years
- When was the last testing? The only owners that remembered when their water was tested were the new home owners, as this is a prerequisite for purchasing a new home. The majority were very vague on dates.
- What were the results? Everyone was satisfied with their water quality, and yet few tested their water.
- Have you deepened, cleaned or made any alterations to your well? One person had replaced a point in their well. No other alterations had been done.

All property owners were comfortable that they had good quality water, with their only concern that their water was high in iron. Considering water testing was rarely done, high iron levels would show without a water test as per the following description of iron in the water.

Iron: The guideline of 300 ug/L has been established on the basis of aesthetic considerations. At concentrations above 300 ug/L iron can stain laundry and plumbing fixtures, and causes undesirable tastes in beverages. When exposed to the air, iron precipitates and imparts reddish-brown colour to the water. Iron may promote the growth of certain micro-organisms, leading to the deposition of a slimy coat in pipes. Iron is a major problem to many consumers in Nova Scotia. (*Lab report, Capital District Health Authority Dec. 2005)*

CHAPTER 5: WATER QUALITY TESTING

Water has become a highly precious resource. There are some places where a barrel of water costs more than a barrel of oil.

Lloyd Axworthy, Foreign Minister of Canada (1999 - News Conference)

5.1 WATER TESTING PROCEDURES

Nova Scotia Department of Environment and Labour’s website has a section on “Tips for Testing your Well”. Procedures and recommendations for testing your well water are available here for the public’s information.(Nova Scotia Department of Environment and Labour, nd)

Figure 5.1 Water testing

Source: Brenda Seymour

Certain procedures must be followed when collecting water samples for accurate results. (Figure 5.1) The strainer must be removed from the tap prior to sampling. The water must be run for 5-10 minutes before sampling. (Figure 5.1)

Figure 5.2 Water testing containers and proper storage for transportation to the lab.

Souce: Brenda Seymour and Andrew Cranton

Containers are provided for testing (Figure 5.2) and must be handled properly. Labeling of containers is also important. Water samples must be stored in a cooler and taken to lab within predetermined time limit. The bacterial water testing sample must be received the same day prior to the lab closing. These samples were taken to the Lab at the hospital in Kentville. The water samples for the chemical testing were sent by Purolator to Maxxam Analytical Inc. which is a lab on Bluewater Road in Bedford.

5.2 WHO WILL DO THE WATER TESTING

An operations employee, Andrew Cranton, (Figure 5.3) from Annapolis County Municipal Works will do the water sampling testing. The Municipal Works employees are trained in water testing procedures and it is imperative that the correct procedures are followed for accurate results.

Figure 5.3 Andrew Cranton, Public Works Employee taking water samples

Source: Brenda Seymour

5.3 HOW OFTEN DO WE TEST?

For this research project, there is the possibility that there will only be one testing which will take place late March.

All of the wells will have bacterial testing and will be tested as either "present" or "absent". If a high number of wells come back as "present", then further testing will be done. They then will be tested for count. All wells were tested for chemicals. Included in this testing is nitrate and conductivity.

After the initial testing, the county will then proceed with bacterial testing twice a year and chemical testing once a year on randomly selected wells.

5.4 WHO COVERS THE COSTS?

For this research project, the water testing costs will be covered by the Municipality. Water testing costs can curb the property owner's willingness to participate. The approximate cost of the testing is $20. per well for bacterial, and $250 per well for chemical.

5.5 NITRATES IN DRINKING WATER

Nitrates are a nitrogen/oxygen compound that naturally occurs in low concentrations in ground water. Under normal circumstances, only a very small percentage of the total nitrates consumed by adults come from drinking water. The vast majority of nitrates in the diet normally come from cured meats and vegetables such as spinach, lettuce, beets, and carrots. The recommended limit for nitrates-nitrogen (the amount of nitrogen in nitrates form) in drinking water is 10 milligrams per liter. (Nitrates and Coliforn Bacteria in Water Supplies.htm, nd)

Health risks from high levels of nitrates can be a very serious concern. "Blue baby syndrome" is associated with high levels of nitrates. Although babies under six months of age can become toxic, it is not normally fatal although immediate medical attention should be sought, as the baby will start turning blue due to lack of oxygen to the tissues. Pregnant women should also refrain from drinking water with high levels of nitrates, as it can cause birth defects.

Although older children and adults can handle higher levels of nitrates in the drinking water, there have been connections made with gastric cancer and higher then 10ml/litre of nitrate in the drinking water. For these reasons, drinking water should be tested yearly for level of nitrates. Boiling water does not reduce or eliminate the nitrates in the water. It actually increases the nitrate concentrations.

Previously mentioned in Chapter 2, 2.3, Nitrate concentrations were of concern in different areas of the Valley. (DNR, Valley Aquifer Study, 2003) Laurie Emms had also requested that water testing should include Nitrates.

5.6 COLIFORM IN DRINKING WATER

Coliform bacteria are microscopic, generally harmless organisms that live in the intestinal tract of many warm-blooded animals. They are excreted along with feces and may eventually make their way into ground water. The presence of bacteria such as coliform bacteria in drinking water would indicate the water is not safe for drinking and cooking. If you drink water which has coliform bacteria present, you could become ill. Pathogenic (disease causing) organisms present in water are capable of causing gastrointestinal disease.

It is recommended that you have your water tested for bacterial quality every six months. To check the bacterial quality of your water, it undergoes a present/absent test for total coliform and fecal coliform. The ABSENCE of either coliform or fecal coliform bacteria means that the water is suitable for drinking {PASSES}. The PRESENCE of either indicates that it is unsuitable {FAILS}. (Nova Scotia Agriculture and Fisheries, nd)

5.7 ESCHERICHIA COLI

The maximum acceptable concentration (MAC) of *Escherichia coli* in public, semi-public, and private drinking water systems is none detectable per 100 mL.

Testing for *E. coli* should be carried out in all drinking water systems. The number, frequency, and location of samples for *E. coli* testing will vary according to the type and size of the system and jurisdictional requirements. (Health Canada, Guidelines for Canadian Drinking Water Quality)

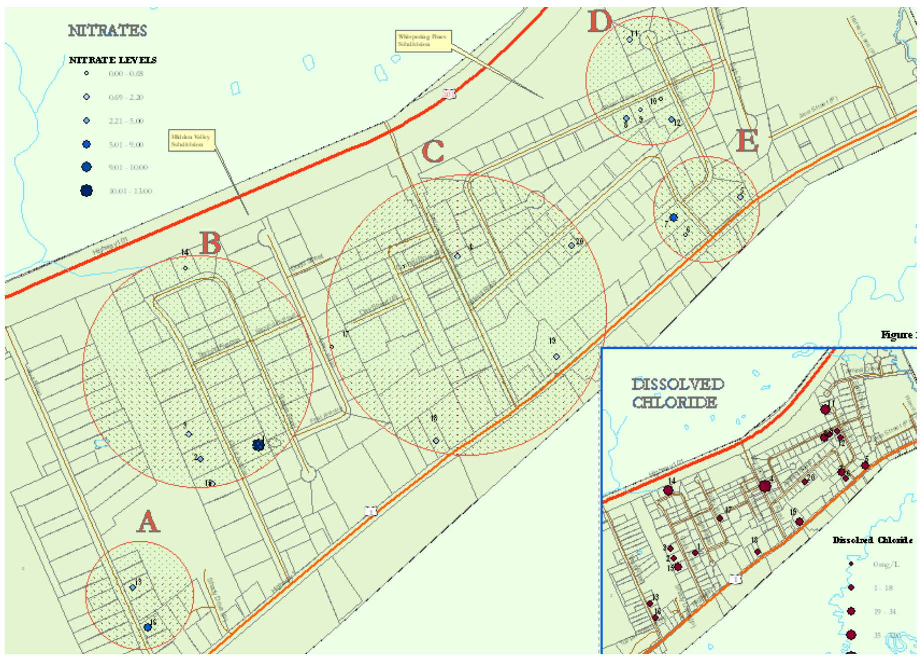
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/micro_e.html

5.8 CONDUCTIVITY IN WATER

Conductivity is a measure of a waters ability to conduct an electrical current; it increases as the amount of dissolved minerals (ions) increases. Conductivity is used as a check on the accuracy of other chemistry analyses.

5.9 OUTCOME OF THE WATER TESTING AND WHERE DOES IT GO?

Figure 5.4 Nitrates and Dissolved Chloride



Source: Created in ArcMap 9.1

Test results were entered into the database for generating reports as required. They were also entered into the GIS program to create thematic maps (Figure5.4) to provide an overview of the chemicals that could be a concern. Laurie divided the project area into groups (Emms L. April 10/06) and looked for similarities within these groups. (See Section 7.1 for further detail on the water test results) (See also Appendices for Test Results)

CHAPTER 6: PROCESS AND APPLICATIONS

Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it.

WILLIAM ASHWORTH, Nor Any Drop to Drink, 1982

6.1 IMPLEMENTATION

The first step is to find out what data might be available on the wells. If no data is available, then a survey to acquire this information will need to be completed. If property owners are agreeable in participating then water testing should follow. Water testing of bacterial analysis on all wells, should be completed as soon after the survey as possible. Chemical analysis should also be done. As chemical analysis is costly, testing ALL wells may not be mandatory for the initial testing. Unacceptable results might require the rest of the wells to be tested.

If the initial bacterial testing returns with a positive response, then further detailed testing should commence.

Bacterial testing will continue on a yearly basis and chemical testing will be done every two years. (Emms, April 10, 2006)

6.2 SOFTWARE

Software used for this research project

- ArcMap 9.1
- CorelDRAW and Corel Paint
- Excel
- Microsoft Access
- Microsoft Word
- Adobe Acrobat
- Power Point

6.3 ROLE OF THE DATABASE

A database is a collection of information that's related to a particular subject. Microsoft Access is the database used for this project. When using Microsoft Access, you can manage all your information from a single database file. Within the file, you can use tables to store your data; queries to find and retrieve the data you want; forms to enter data; and reports to view and analyze data.

For this research project, tables were created to include property owners' information, well history, and water test results. (See Appendix for copies of the reports)

6.3 Role of Geographic Information Systems

Geographic Information System is an essential tool for resource and management planning. Geographic information systems are used for land use planning, utilities management and infrastructure planning, just to name a few of the areas it can be used for.

With this project, it allows us to create thematic maps illustrating the distribution of selected wells and analyze any additional important details. Creating features on a map to illustrate distribution of the selected wells that are part of our quality water testing, again helps in decision making. Visualization on a map is easier to envision then numbers on paper.

Once the survey was complete, points were created in a shapefile, and then identified in the corresponding attribute table for future use. On completion of the water testing, the results were then mapped and various thematic maps created to symbolize the results of the primary chemicals that had a potential of being a concern if results were higher then acceptable standards.

CHAPTER 7: WAS THE PROJECT SUCCESSFUL?

All the water that will ever be is, right now.

National Geographic, October 1993

7.1 OVERVIEW OF THE WATER TESTING RESULTS

The results of the bacterial testing for Coliform and E-Coli were returned with an "All Negative" which means there are no concerns at this time.

Items that were of importance on the chemical testing:

Source: www.wsus.com

1. Dissolved Chloride > if elevated – could be from road salt.
2. Colour > discolouration could mean issues.
3. Nitrite+Nitrate (Nitrite is stabilized form of Nitrate) > health concern
4. Turbidity > quality of well construction
5. Conductivity > if high could suggest contaminates in the water
6. TDS > used to characterize water

Laurie created a Statistical Plot to be used for comparison with the next water testing.

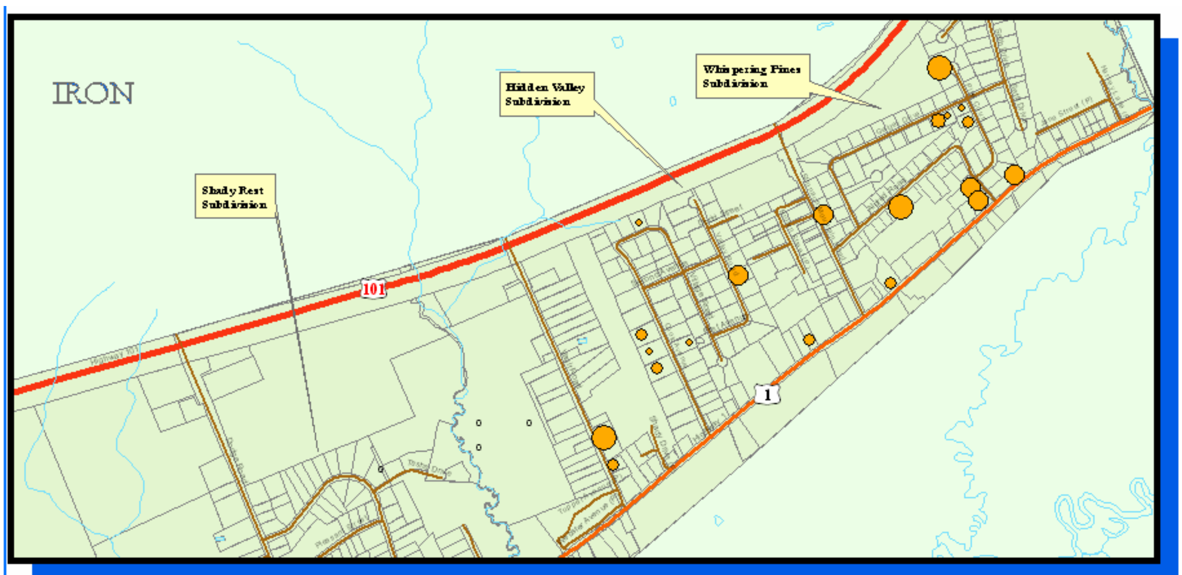
This plot describes the water condition of the groundwater. He will be looking to compare the "allowed limits" and if the numbers are outside those figures, it could mean there are issues that need to be addressed.

Laurie is referencing the **Guidelines for Canadian Drinking Water** which is a guide that is used by municipalities for monitoring public water supplies

There were some issues that showed up from the chemical water testing, that are not health issues. They are more of an aesthetic issue.

1. Iron > showed up in 4 wells with amounts higher then the guidelines (Figure 7.1)

Figure 7.1 Iron Results

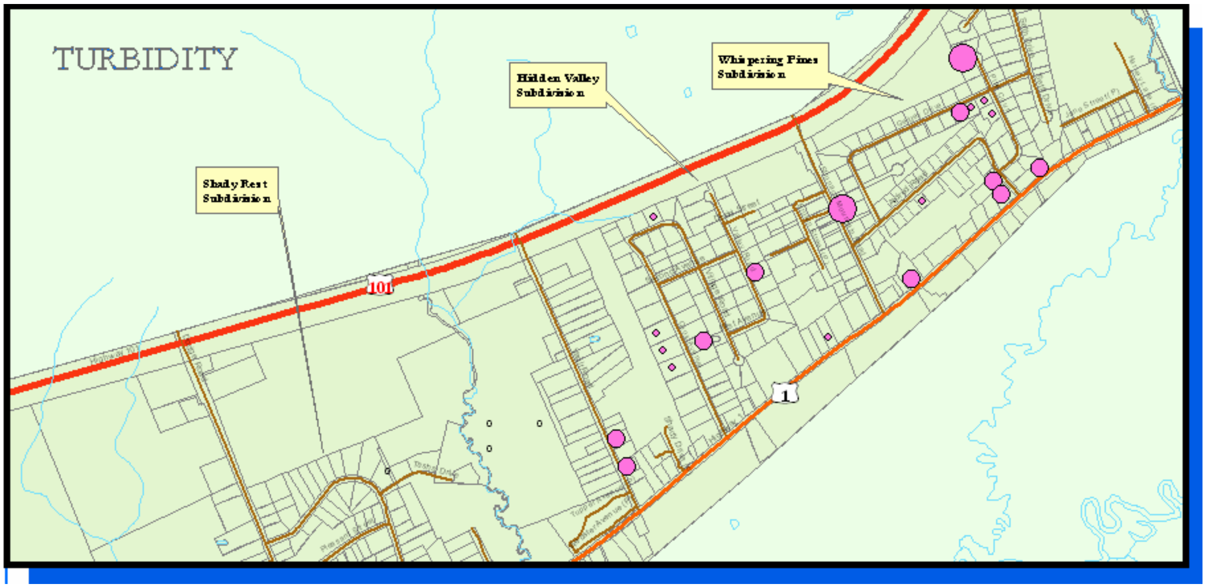


IRON LEVELS

Source: Created in ArcMap 9.1

2. Turbidity > if turbidity is high, but there are no other results over the guidelines, then there is no cause for concern > No bacterial contamination (Figure 7.2)

Figure 7.2 Turbidity in the Water



Source: Created in ArcMap 9.1

Health Concerns

Three wells showed up with high levels of Nitrate. As they were randomly situated over the study area, there is a suspicion that fertilizer was used either on their lawns or in neighbouring areas. Laurie had requested that I call the home owners and find out. The rest of the chemical results all comply.

I was able to contact two of the well owners with the high nitrate levels. For one property owner, I was informed that a neighbour across the road used lawn fertilizer, but the home owner also confided that they had had issues with their septic which had since been corrected subsequent to the water sampling. The second home owner admitted to using lawn fertilizer for the past couple years.

High Alkalinity and Hardness could be characteristics of the water supply coming from the bedrock aquifer. Test results from water sample #14 indicates that there is a possibility that the water supply is coming from the bedrock aquifer as the numbers are higher then the average of the rest of the sampling.

Samples #14, #4, and #11 are all close to Highway 101. These wells have high chloride results. High chloride can be the result of road salt. The PH level of Samples #62 and #14 are high which are consistent of bedrock water. (Emms, April 10, 2006)

Sample #4 has a high Sulphate result which can be caused from sewage. This would be an issue if there were high results from the other chemicals tested, such as Turbidity which would indicate lots of sediment.

7.2 WERE CLIENTS NEEDS MET?

Was this project a success? Laurie plans on continuing with the monitoring. From a Capital Planning Perspective, the county will not need to consider servicing for a number of years. (Emms L., April 10, 2006)

Initially:

1. No well data on private wells was available, besides the Nova Scotia Well Log which has accuracy issues. This log is for drilled wells only.
2. There was no data on water quality of this particular aquifer.
3. Was municipal servicing required in this area? The county had no factual information to base their decision.

As a result of the project:

1. There was now information and numbers on drilled, dug and sand point wells in the project area. As most drilled wells access the lower bedrock aquifer, the water quality would not be a concern as this aquifer is monitored on a regular basis.

2. Water quality data is now available as a result of the water testing from the sand point wells.
3. Once the survey was completed, the municipality was able to surmise that servicing is not an issue at this time as was originally thought. (Emms, April 10, 2006)

Laurie also advised me that they were looking at using this monitoring system in another area of the County.

The intent of this pilot program was to create a fact based decision process for their decision making, instead of as in the past, going on speculation or perceptions. (Emms, April 10, 2006)

7.3 RECOMMENDATIONS

Public awareness of the responsibilities of private well owners needs to be pursued. The Nova Scotia Drinking Water Strategy does identify the importance of private well owners testing their water and it also specifies that they have made available, publications on the importance of water testing, but public awareness is still lacking. The advertising needs to be improved upon. How many of the average household owners read the Nova Scotia Drinking Water Strategy or make a point of looking online for information on private well testing? If the information is not easily accessible for the average person, it is less likely they will find it. Personally, I have never seen any advertising or brochures or posters that the general public would view without actually looking for it. It is hard to keep drinking water testing in the publics mind. With this in mind, sending a brochure along with the tax bills on a yearly basis could be an idea. Random television commercials, maybe twice a year just as a reminder is another idea.

Source: www.caw.com

Results of the questionnaires taken early on in the project indicates that the public are not conscious of the importance of regularly testing their drinking water and the consequences that could result by neglecting this important issue. Many home owners felt that their drinking water was safe even though it had been rarely tested, if tested at all.

An example of this would be Nitrate. Nitrate is a common concern in many areas of the country. Nitrate can be a health concern and yet it is not detectable by taste or colour. Unless the water is actually tested for it, you would not know there is an issue. Boiling water for any amount of time does not reduce or eliminate it from the water; in fact it increases the nitrate concentrations. This is one example of an issue that can be overlooked and where monitoring the well water could be beneficial. Should the municipality incorporate a by-law for private water quality testing to ensure all private drinking water is safe? Has any other municipality considered this as a possibility? In searching the web to see if this is or was a consideration in other areas, the following report was found.

In a follow-up report of the Walkerton case in Ontario, (Final Submissions Relating to the Provision of Safe Drinking Water in Ontario, 2001) which was submitted by Ontario Water Works Association and the Ontario Municipal Water Association, they also questioned "Should testing of private well water quality be mandatory? If so, what parameters, with what frequency and who should pay?" They feel that all water should be tested whether it is private or municipal. With the argument that private water should not be the responsibility of the province, they counter this with the comment "there are seatbelt laws for private vehicles for reasons of personal safety. Likewise there should be a requirement to test private well water in the interest of public safety." (Final Submission Relating to the Provision of Safe Drinking Water in Ontario, 2001)

They also suggest that the frequency of the testing should be risk-based and private well owners should be responsible for payment, the same as persons on public water who pay with their water taxes. As mentioned in a previous paragraph, I agree with the comments written in this report and feel it could certainly be a consideration that the government could look at. If the private well owner is responsible for payment of the well testing and the costs are as high as $250, this could be a deterrent unless there is a health concern. *The average person/family must be sufficiently "scared" of contamination to spend $200-$300 dollars for water quality testing. Women are more concerned then men.* (New Hampshire Dept of Environmental Services, 2005)

Further to this report, I also located a media release from December 2005 from the Canadian Environmental Law Association.(Long-awaited Source Protection Legislation Introduced, 2005) If passed, the Clean Water Act, 2005 will introduce a process by which threats to drinking water sources are identified and risk management strategies are put into action. It provides municipalities with more power to protect their waters. ***The legislation supports the implementation of at least 22 of Justice O'Connor's recommendations following the Walkerton Inquiry. (***Long-awaited Source Protection Legislation Introduced, 2005).But what is even more interesting here is the following:

Another positive aspect of the legislation is the inclusion of provisions respecting private water sources, in addition to municipal systems. The option exists for municipalities to extend the planning process to include "clusters" of private systems, such as small rural communities on well water. Other protections to private wells may be implemented in the source protection plans.

This research project only touched on a small area of the county, but it has potential to be used in other areas where servicing or water quality is questionable. The information gathered from this program will create a library of factual data to be used as an aid in effective decision making when the Municipality is determining at what point they should develop sewage collection and treatment facilities.

REFERENCES

50 Ways Farmers can Protect their Groundwater, retrieved October 20, 2005 http://www.thisland.uiuc.edu/50ways/50ways_38.html

A Drinking Water Strategy for Nova Scotia, retrieved Feb 20, 2006 http://www.gov.ns.ca/enla/water/docs/NSWaterStrategy.pdf

CDC, National Center for Environmental Health, nd, A Survey of the Quality of Water Drawn from Domestic Wells in Nine Midwest States, retrieved April 19, 2006, http://www.cdc.gov/nceh/emergency/wellwater/default.htm

Canadian Water and Wastewater Association, Private Water Supplies, "General Information, Frequently Asked Questions" Retrieved Oct. 20, 2005 http://www.cwwa.ca/faqprivate_e.asp

Final Submissions Relating to the Provision of Safe Drinking Water in Ontario, 2001, http://www.owwa.com/download/index.php?id=209.

Health Canada, Guidelines for Drinking Water Quality – Retrieved April 22/06 http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/micro_e.html

Inglis, S., (2000) College of Geographic Sciences, May 2000 p87 "Testing the Waters", A Study of Ways to Improve the Water Quality in the Annapolis River Tributaries

Iowa Statewide Rural Well Water Survey, retrieved Aug 19, 2005, http://www.igsb.uiowa.edu/Pubs/abstract/tis19.htm

Iowa DNR/IGS, Watershed Monitoring and Assessment, nd Retrieved 19/08/05 http://wqm.igsb.uiowa.edu/activities/groundwater/AboutGWmonitoring.htm

L.M. (Laurie) EMMS, P.Eng. Municipal Services Director
Municipality of the County of Annapolis, Lawrencetown, N.S.
Personal Communication

Library Think Quest, retrieved March 25, 2006 http://library.thinkquest.org/04oct/01590/humans/sources.html

Long-awaited Source Protection Legislation Introduced, Canadian Environmental Law Association, December 7, 2005
http://www.cela.ca/newsevents/detail.shtml?x=2441

Marsh, W.M. Third Edition, Landscape Planning, Environmental Applications 1998 p416

Natural Resources Canada, "Groundwater Program, Valley Aquifer Study, Annapolis – Cornwallis" retrieved March 2, 2006
http://gwp.nrcan.gc.ca/p3/a9/acvas2004_e.php

Nebraska Health and Human Services System, Nitrates and Coliform Bacteria in Water Supplies.htm Retrieved February 5, 2006

New Hampshire Department of Environmental Services, 2005
http://www.des.state.nh.us/factsheets/ws/ws-2-1.htm

Norcliffe, G.B., 1982 2nd edition, Inferential Statistics for Geographers, An Introduction, p258

Nova Scotia Department of Environment and Labour, Tips for Testing your Well Water Retrieved Oct. 10, 2005
http://www.gov.ns.ca/enla/water/welltips.asp

Nova Scotia Department of Agriculture, Fisheries and Aquaculture, Bacterial Analysis for Homeowners Retrieved March 3, 2006
http://www.gov.ns.ca/nsaf/qe/labserv/waterbac.shtml

Nova Scotia Water Strategy, retrieved November 10, 2005,
http://www.gov.ns.ca/enla/water/docs/NSWaterStrategy.pdf

Standing Committee on Resources, Halifax, Nova Scotia, May 8, 2001
http://www.gov.ns.ca/legislature/hansard/comm/r/re010508.htm

Tips for Testing your Well, Nova Scotia Environment and Labour, retrieved Feb 11, 2006
http://www.gov.ns.ca/enla/water/welltips.asp

The New England Private Drinking Well Symposium, November 2005,
http://www.usawaterquality.org/newengland/Focus_Areas/well/events/Wellsymposium05/FINAL_symposium_report.pdf

The New England Private Drinking Well Symposium, November 2005, New Hampshire Dept of Environmental Services, http://www.usawaterquality.org/newengland/Focus_Areas/well/events/Wellsymposium05/FINAL_symposium_report.pdf

Trescott, P.C., Province of Nova Scotia, Department of Mines, Memoir 6, Groundwater Resources and Hydrogeology of the Annapolis-Cornwallis Valley, Nova Scotia, 1968

Tyson, A.W. n.d., Wellhead Protection for Private Domestic Wells, Retrieved Oct. 10, 2005 http://www.engr.uga.edu/service/extension/publications/c819-12c.html

Water Quotes and Facts, World Bank Institute, WATER POLICY REFORM PROGRAM - Nov. 1999, Retrieved March 4, 2006, http://jperret.tripod.com/water.html

Water Quotes and Facts, Lloyd Axworthy, Foreign Minister of Canada (1999 - News Conference) Retrieved March 4, 2006, http://jperret.tripod.com/water.html

Water Quotes and Facts, *BENJAMIN FRANKLIN, (1706-1790), Poor Richard's Almanac, 1746,* Retrieved March 4, 2006, http://jperret.tripod.com/water.html

Water Quotes and Facts National Geographic, October 1993 Retrieved March 21, 2006, http://jperret.tripod.com/water.html

Water Quotes and Facts *WILLIAM ASHWORTH, Nor Any Drop to Drink, 1982*Retrieved March 21, 2006, http://jperret.tripod.com/water.html

Well Protection Plan for Pumphandle, B.C. May 1999, Ministry of Environment Retrieved August 12, 2005 http://wlapwww.gov.bc.ca/wat/gws/well_protection/acrobat.html

Winchester G., (1998) College of Geographic Sciences, May 1998 p34 "Toward Clean Groundwater"

Woodman P., (1994) College of Geographic Sciences, May 1994 p77 "Ground Water Study, District 1, Annapolis County"

APPENDIX A SURVEY QUESTIONNAIRE

Monitoring Water Quality of Private Wells in the East End Development Planning Area of the County of Annapolis, Nova Scotia

The purpose of this survey is to gather private well data that will be used in a pilot program that will aid the county in creating a monitoring system that will be used for observing water quality in areas that have grown in development. This will help in aiding the county with better decision making when planning infrastructure needs in these developed areas.

Please note:

1. *A follow up questionnaire will be done for those that have agreed to participate in this program.*
2. *This questionnaire is to acquire more well data information for our database.*
3. *There will also be water testing done at various intervals (to be established at a later date). Costs will covered by the municipality.*

Would you be willing to participate in this program? Yes / No (circle one)

If yes, please answer the following questions:

1. What type of well do you have?

   Dug?_____Drilled?____Sand Point?________Don't know._____

2. How deep is it? ______________________ft/meters Don't know.______

3. Do you know where it is located on your property? Yes/No (circle one)

Last Name:	*First Name:*
Civic #	*Street:*
Community:	*Home Phone:* *Day Contact #:*

Centre of Geographic Sciences, Planning Student in collaboration with the Municipality of the County of Annapolis

nscc Centre of Geographic Sciences

APPENDIX B *FOLLOW-UP QUESTIONNAIRE*

Part 1: Well System Information

Well Owner:	Well Owners Civic Address:
Phone Number : Day: Evening:	P.I.D. #

Part II Well Construction Information

	How long have you lived in this residence?	
Type of Well ☐Dug ☐Sand Point	Depth of Well (Approximation) ____________m or _________________ft	

Part III: Assessment of Water Quality

	Has your well ever been deepened, cleaned, new well constructed?
In this time has there ever been any water quality problems?	**How often have you tested your water?**

Sketch of location of well on property

nscc
Centre of Geographic Sciences

COUNTY OF ANNAPOLIS