1 PROJECT OVERVIEW

“Water is the lifeblood of the earth.” - Anonymous

How a County takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but creates a solid base for increased economic activity. **This report, even though it is preliminary in nature, is the first step in fulfilling a commitment by the County toward the management of the groundwater resource, which is a key component of the well-being of the County, and is a guide for future groundwater-related projects**

1.1 About This Report

This report provides an overview of (a) the groundwater resources of the County of St. Paul No. 19, (b) the processes used for the present project and (c) the groundwater characteristics in the County.

Additional technical details are available from files on the CD-ROM provided with this report. The files include the geo-referenced electronic groundwater database, grid files used to prepare distribution of various hydrogeological parameters, the groundwater query, and ArcView files. Likewise, all of the illustrations and maps from the present report, plus additional maps, figures and cross-sections, are available on the CD-ROM. For convenience, poster-size maps and cross-sections have been prepared as a visual summary of the results presented in this report. Copies of these poster-size drawings have been forwarded with this report, and page-size copies are included in Appendix A.

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of the Appendix.

Appendix B provides a complete list of files included on the CD-ROM.

Appendix C includes the following water well information:

1) a procedure for conducting aquifer tests with water wells;
2) a table of contents for the Water Well Regulations under the Environmental Protection and Enhancement Act; and
3) additional information.

The Water Well Regulations deal with the wellhead completion requirement (no more water-well pits), the proper procedure for abandoning unused water wells and the correct procedure for installing a pump in a water well.

1.2 The Project

It must be noted that the present project is a regional study and as such the results are to be used only as a guide. Detailed local studies are required to verify hydrogeological conditions at given locations.

The present project is made up of five parts as follows:

Module 1 - Data Collection and Synthesis
Module 2 - Hydrogeological Maps
Module 3 - Covering Report
Module 4 - Groundwater Query
Module 5 - Training Session

This report represents Modules 2 and 3.

1.3 Purpose

This project is a regional groundwater assessment of the County of St. Paul No. 19. The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the County. Groundwater resource management involves determining the suitability of various areas in the County for particular activities. These activities can vary from the development of groundwater for agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the County.**

The regional groundwater assessment includes:

- Identification of aquifers[1] within the surficial deposits[2] and the upper bedrock;
- Spatial definition of the main aquifers;
- Quantity and quality of the groundwater associated with each aquifer;
- Hydraulic relationship between aquifers; and
- Identification of the first sand and gravel deposits below ground level.

Under the present program, the groundwater-related data for the County of St. Paul No. 19 have been assembled. Where practical, the data have been digitized. These data are then being used in the regional groundwater assessment for the County.

[1] See glossary
[2] See glossary

2 INTRODUCTION

2.1 Setting

The County of St. Paul No. 19 is situated in east-central Alberta. This area, part of the Alberta Plains region, exists within the drainage area of the North Saskatchewan River drainage basin. The area includes some or all of townships 055 to 062, ranges 03 to 13, west of the 4th Meridian.

Most of the County boundaries follow township or section lines. The exception is the western part of the southern boundary, which is the North Saskatchewan River. The ground elevation varies between 550 and 670 metres above mean sea level (AMSL). The topographic surface generally decreases from the west to the east.

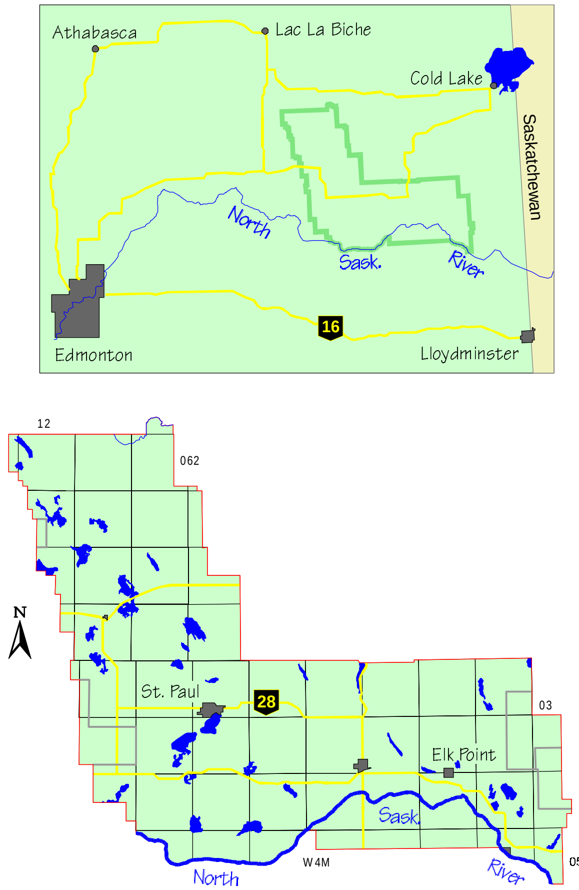

Figure 1. Index Map

2.2 Climate

The climate of the County is a Dfb based on the Köppen classification. This means a climate of a cold-snowy forest with no distinct dry season and cool summers. The mean annual precipitation at the Elk Point Climatological Station measures 435.9 millimetres (mm), based on data from 1961 to 1990. For the same time interval, the maximum annual precipitation reached 563 mm, and the minimum was 292 mm. Between 1961 and 1990, the annual temperature averaged 1.1 degrees C. The potential evapotranspiration for the area is more than 50 centimetres per year (Hackbarth, 1975).

2.3 Background Information

Currently in the County of St. Paul, there are 5,116 water wells in the groundwater database. Based on a rural population of 6,300, there are three water wells per family of four. The domestic or stock water wells vary in depth from less than 1 metre to 152.4 metres below ground level. Lithologic details are available for 3,164 water wells.

Data for casing diameter are available for 1,865 water wells, with 427 indicated as having a diameter of more than 300 mm and 1,438 having a diameter of less than 300 mm. The casing diameters of less than 300 mm are for drilled water wells, of which 65% were drilled before 1980. The water wells with a diameter of greater than 300 mm are mainly bored water wells.

Before 1980, plastic casing was used in 0.4% of the water wells. From the beginning of 1980 to the end of 1989, 35% of the water wells were completed with plastic casing. This figure has risen to 96% since the beginning of 1990.

Water wells not used for domestic needs must be licensed. At the end of 1996, 82 groundwater diversions were licensed. The total maximum authorized diversion from these 82 water wells is 1,494 cubic metres per year; 81 percent of the authorized groundwater diversion is allotted for agricultural use. The Town of St. Paul obtains its water from the North Saskatchewan River and is the only community in the County that is not using groundwater.

Little or no groundwater is available in the northern and eastern parts of the County. In these areas the upper bedrock, the Lea Park Formation, is primarily shale with no significant amount of fracturing. The surficial[3] deposits may contain sand and gravel layers. However, the sand and gravel deposits occur as pockets and are therefore not identifiable on a regional scale.

The total dissolved solids in the groundwater are generally less than 2,000 milligrams per litre (mg/L). Groundwaters from the surficial deposits are chemically hard with a high dissolved iron content. Groundwaters from the bedrock aquifers are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Very few chemical analyses indicate a fluoride concentration above 1.0 mg/L.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, these data are available from two observation water wells operated by **Alberta Environmental Protection** (AEP). Additional data can be obtained from some of the licensed groundwater diversions. In the past, these data have been difficult to obtain from AEP, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget. The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.

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[3] See glossary

3 TERMS

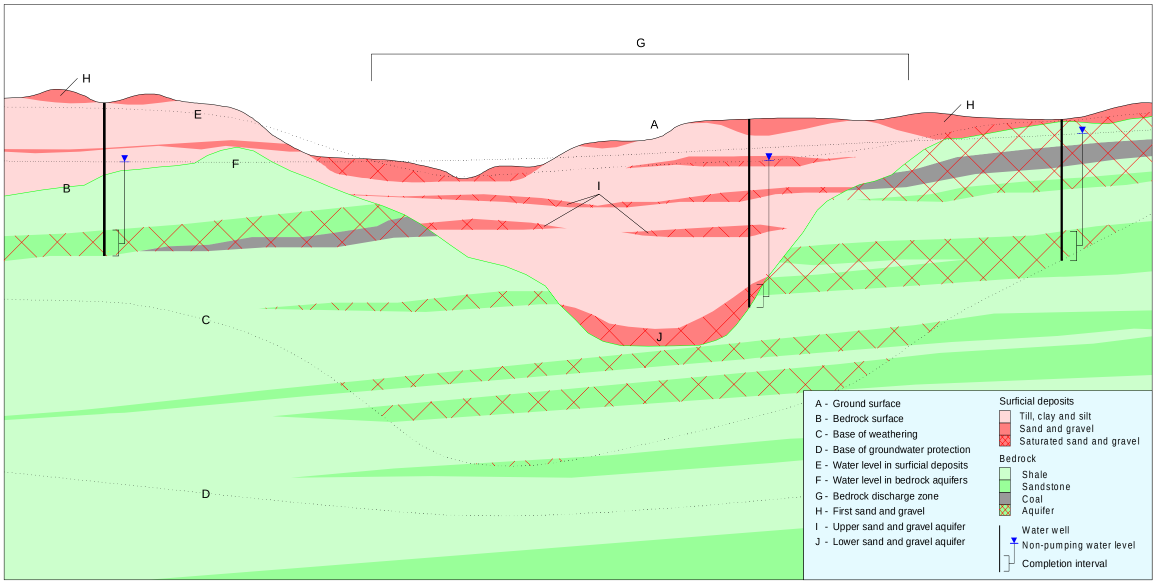

Figure 2. Generalized Cross-Section (for terminology only)

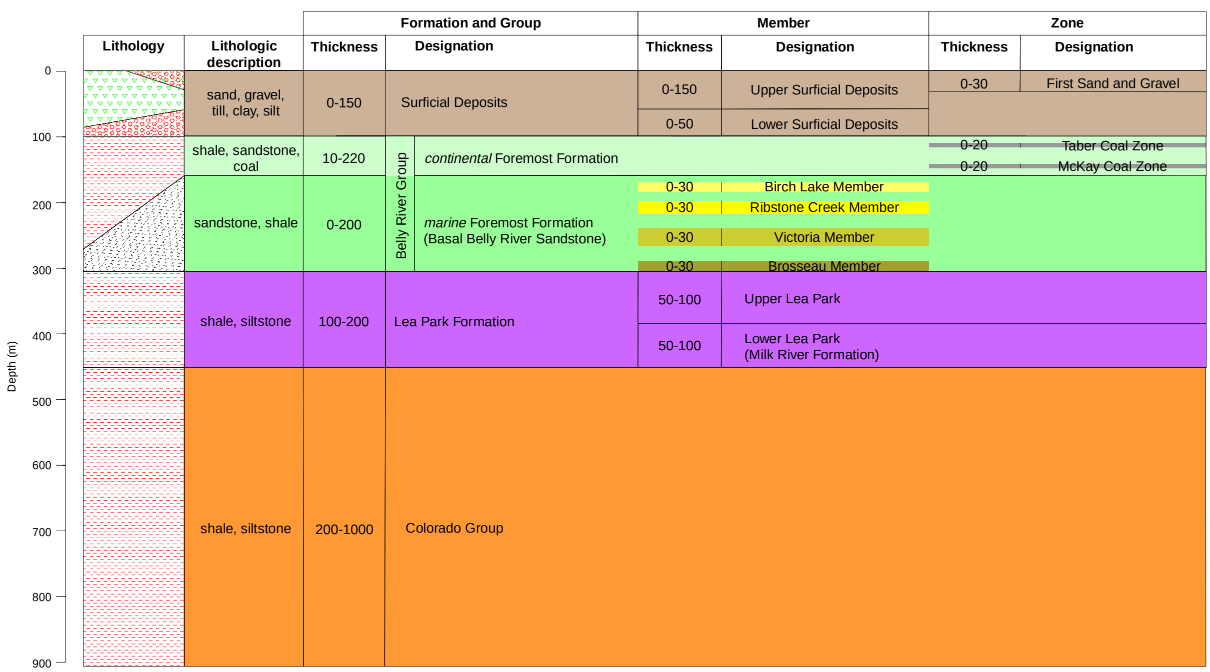

Figure 3. Geologic Column

4 METHODOLOGY

4.1 Data Collection and Synthesis

The AEP groundwater database is the main source of groundwater data available. The database includes the following:

1) water well drilling reports;
2) aquifer test results from some water wells;
3) location of some springs;
4) water well locations determined during water well surveys;
5) chemical analyses for some groundwaters;
6) location of flowing shot holes;
7) location of structure test holes; and
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage is the lack of adequate spatial information.

The AEP groundwater database uses a land-based system with only a limited number of records having a value for ground elevation. The locations for records usually include a quarter section description; a few records also have a land description that includes a Legal Subdivision (Lsd). For digital processing, a record location requires a horizontal coordinate system. In the absence of an actual location for a record, the record is given the coordinates for the centre of the land description.

The present project uses the 10 TM coordinate system. This means that a record for the SW ¼ of section 05, township 058, range 09, W4M, would have a horizontal coordinate with an Easting 232886 and a Northing 5984513, the centre of the quarter section. Once the horizontal coordinates are determined, a ground elevation is obtained from the 1:20,000 Digital Elevation Model (DEM) from the Resource Data Division of AEP.

After assigning spatial control to the records in the groundwater database, the data are processed to determine values for hydrogeological parameters. As part of the processing, obvious keying errors in the database are corrected.

Where possible, determinations are made from individual records for the following:

1) depth to bedrock;
2) total thickness of sand and gravel;
3) thickness of first sand and gravel when present within one metre of ground surface;
4) total thickness of saturated sand and gravel; and
5) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity[4] and apparent yield[5] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. The apparent transmissivity results are then used to estimate a value for hydraulic conductivity[6]. The conductivity values are obtained by dividing the apparent transmissivity by the completion interval. To obtain a value for regional transmissivity of the aquifer, the hydraulic conductivity is multiplied by the effective thickness of the aquifer based on nearby e-log information. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity.

The Alberta Energy and Utilities Board (EUB) well database includes records for all of the wells drilled by the oil and gas industry. The information from this source includes:

1) spatial control for each well site;
2) depth to the top of various geological units;
3) type and intervals for various down-hole geophysical logs; and
4) drill stem test (DST) summaries.

Unfortunately, the EUB database contains very little information from above the base of groundwater protection. Because the main interest for a groundwater study comes from data above the base of groundwater protection, the data from the EUB database have limited use.

Values for apparent transmissivity and hydraulic conductivity are calculated from the DST summaries.

Published and unpublished reports and maps provide the final source of information to be included in the new groundwater database. The reference section of this report lists the available reports. The only digital data from publications are from the Geological Atlas of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994). These data are used to verify the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

4.2 Spatial Distribution of Aquifers

Determination of the spatial distribution of the aquifers is based on:

1) lithologs provided by the water well drillers;
2) geophysical logs from structure test holes;
3) wells drilled by the oil and gas industry; and
4) data from existing cross-sections.

The identification of aquifers becomes a two-step process: first, mapping the tops and bottoms of individual geological units; and second, identifying the porous and permeable parts of each geological unit in which the aquifer is present.

After obtaining values for the elevation of the top and bottom of individual geological units at specific locations, the spatial distribution of the individual surfaces can be determined. Digitally, establishment of the distribution of a surface requires the preparation of a grid. The inconsistent quality of the data

[4] For definitions of Transmissivity, see glossary
[5] See glossary
[6] See glossary

necessitates creating a representative sample set obtained from the entire data set. If the data set is large enough, it can be treated as a normal population and the removal of extreme values can be done statistically. When data sets are small, the process of data reduction involves a more direct assessment of the quality of individual points. Because of the uneven distribution of the data, all data sets are gridded using the Kriging[7] method.

The final definition of the individual surfaces becomes an iterative process involving the plotting of the surfaces on cross-sections and the adjusting of control points to fit with the surrounding data.

The porous and permeable parts of the individual geological units have been mainly determined from geophysical logs.

4.3 Hydrogeological Parameters

Water well records that indicate the depths to the top and bottom of their completion interval are compared digitally to the spatial distribution of the various geological surfaces. This procedure allows for the determination of the aquifer in which an individual water well is completed. When the completion interval of a water well cannot be established unequivocally, the data from that water well are not used in determining the distribution of hydraulic parameters.

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), transmissivity and projected water well yield. The total dissolved solids, chloride and sulfate concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers.

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of the various parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid.

4.3.1 Risk Criteria

The main source of groundwater contamination involves activities on or near the land surface. The risk is high when the near-surface materials are porous and permeable and low when the materials are less porous and less permeable, The two sources of data for the risk analysis include (a) a determination of when sand and gravel is or is not present within one metre of the ground surface, and (b) the surficial geology map. The presence or absence of sand and gravel within one metre of the land surface is based on a geological surface prepared from the data supplied on the water well drilling reports. The information available on the surficial geology map is categorized on the basis of relative permeability. The information from these two sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the adjacent table.

Surface Permeability	Sand or Gravel Present To Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 1. Risk of Groundwater Contamination Criteria

[7] See glossary

4.4 Maps and Cross-Sections

Once grids for geological surfaces have been prepared, various grids need to be combined to establish the extent and thickness of individual geological units. For example, the relationship between an upper bedrock unit and the bedrock surface must be determined. This process provides both the aquifer outline and the aquifer thickness. The aquifer thickness is used to determine the aquifer transmissivity by multiplying the hydraulic conductivity by the thickness.

Grids must also be combined to allow the calculation of projected long-term yields for individual water wells. The grids related to the elevation of the non-pumping water level and the elevation of the top of the aquifer are combined to determine the available drawdown[8]. The available drawdown data and the transmissivity values are used to calculate values for projected long-term yields for individual water wells, completed in a specific aquifer, wherever the aquifer is present.

Once the appropriate grids are available, the maps are prepared by contouring the grids. The areal extent of individual parameters is outlined by masks to delineate individual aquifers. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figurers that are included on the CD-ROM is given in Appendix B.

Cross-sections are prepared by first choosing control points from the database along preferred lines of section. Data from these control points are then obtained from the database and placed in an AutoCAD drawing with an appropriate vertical exaggeration. The data placed in the AutoCAD drawing include the geo-referenced lithology, completion intervals and non-pumping water levels. Data from individual geological units are then transferred from the digitally prepared surfaces to the cross-section.

Once the technical details of the cross-section are correct, the drawing file is moved to the software package CorelDRAW! for simplification and presentation in a hard copy form. These cross-sections are presented in Appendix A, are included on the CD-ROM, and are in Appendix D in a page-size format.

4.5 Software

The files on the CD-ROM have been generated from the following software:

- Microsoft Professional Office 97
- Surfer 6.04
- ArcView 3.0a
- AutoCAD 14.01
- CorelDRAW! 8.0
- Acrobat 3.0

Where possible, files are available in more than one format.

[8] See glossary

5 AQUIFERS

5.1 Background

An aquifer is a porous and permeable rock that is saturated. If the NPWL is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting is the sediments that overlie the bedrock surface. In this report, these are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. The geological settings, the nature of the deposits making up the aquifers within each setting, the nature of the water wells, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.1.1 Surficial Aquifers

The thickness of the surficial deposits varies from less than 20 to more than 140 metres. The main aquifers in the surficial materials are sand and gravel deposits. In order for a sand and gravel deposit to be an aquifer, it must be saturated; if it is not saturated, it is not an aquifer. The top of the surficial aquifers has been determined from the non-pumping water level in water wells less than 15 metres deep. The base of the surficial deposits is the bedrock surface. For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Many of the water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few 100 mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the County, 67% of the water wells completed in the surficial deposits have a casing diameter of greater than 350 millimetres or no reported diameter for the surface casing, and are assumed to be dug or bored water wells.