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 includes 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 expected yield of water wells completed in aquifer(s) within different geologic units, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.1.1 Surficial Aquifers

Surficial deposits in the County are mainly less than 30 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 40 metres. The Buried Beverly Valley is the main linear bedrock low in the County; this Valley has a southwest-northeast trend. The south-north cross-section A-A', shown below, passes across the Buried Beverly Valley and shows the surficial deposits being up to 50 metres thick within the Valley.

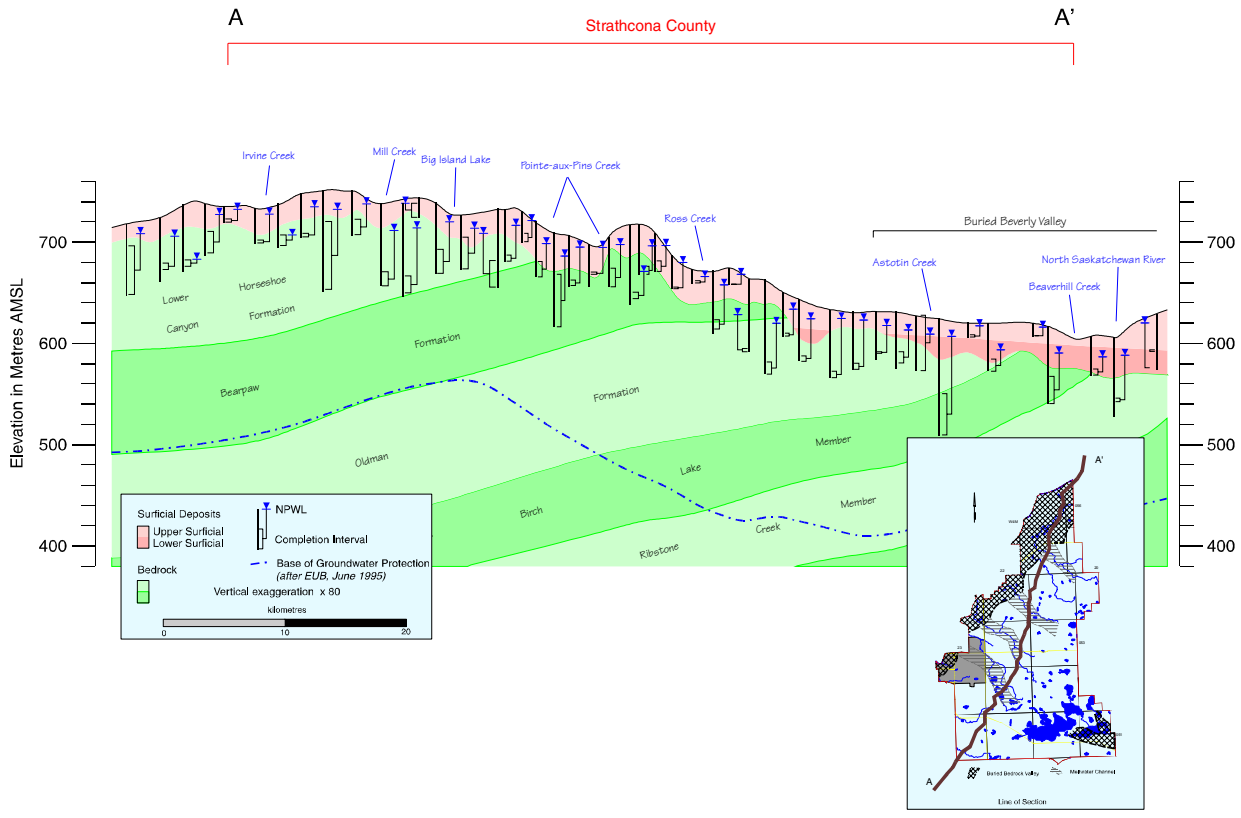

Figure 8. Cross-Section A - A'

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 not saturated, a sand and gravel deposit is not an aquifer. The top of the surficial aquifers has been determined from the NPWL in water wells that are less than 20 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. Some 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 hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the County, casing-diameter information is available for 436 of the 509 water wells completed in the surficial deposits; 20 percent of these have a casing diameter of more than 275 millimetres, and are assumed to be bored or dug water wells.

5.1.2 Bedrock Aquifers

In the County, the upper bedrock includes the Lower Horseshoe Canyon, Bearpaw and Oldman formations, and the Birch Lake Member equivalent of the Foremost Formation. Cross-section B-B' (Figure 9) shows that the upper bedrock includes rocks that are mainly less than 200 metres below the bedrock surface. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, although some of the sandstones may be friable[9] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

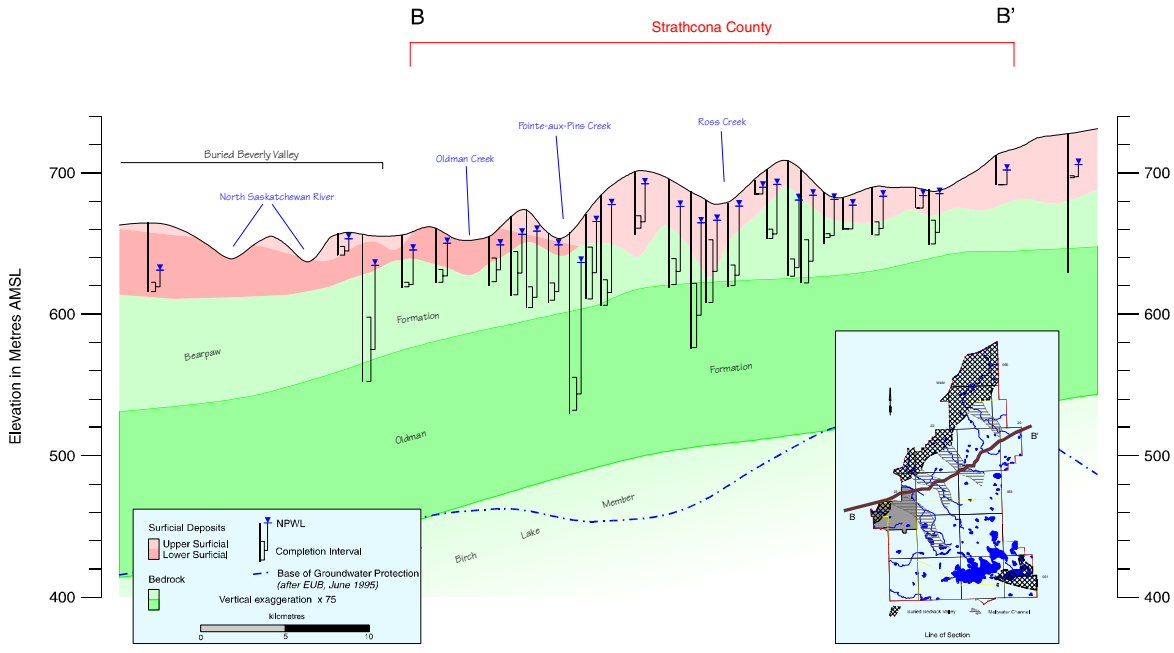

Figure 9. Cross-Section B - B'

The data for 2,234 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. Within the County, casing-diameter information is available for 1,938 of the 2,234 water wells completed below the top of bedrock. Of these 1,938 water wells, 98% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a perforated liner or as open hole; there are 67 bedrock water wells completed with a water well screen.

[9] See glossary

5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. These include pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly as a result of glaciation. The *lower surficial deposits* include pre-glacial fluvial[10] and lacustrine[11] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[12] and meltwater deposits. In the County, pre-glacial materials are expected to be mainly present in association with the Buried Beverly Valley.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic parts. The first unit is the sand and gravel deposits of the lower surficial deposits, when present. These deposits are mainly saturated, where present. The second and third hydraulic units are associated with the sand and gravel deposits in the upper surficial deposits. The sand and gravel deposits in the upper surficial deposits occur mainly as pockets. The second hydraulic unit is the saturated part of these sand and gravel deposits; the third hydraulic unit is the unsaturated part of these deposits. For a graphical depiction of the above description, please refer to Figure 5, Page 8. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for liquid contaminants to move downward into the groundwater.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map.

Over the majority of the County, the surficial deposits are less than 30 metres thick (page A-15). The exceptions are mainly in association with areas where buried bedrock valleys are present, where the deposits can have a maximum thickness of close to 50 metres. The main linear bedrock low in the County is a southwest-northeast-trending bedrock low that has been designated as the Buried Beverly Valley, as shown on Figure 10.

The Buried Beverly Valley is present in the northern part of the County, and mainly parallels the present-day North Saskatchewan River. The Valley is four to ten kilometres wide within the County, with local bedrock relief being up to 60 metres. Sand and gravel deposits can be expected in association with this bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than 15 metres.

The Buried Vegreville Valley is present in the southeastern part of the County but is not well defined based on the bedrock topography contours. The Buried Vegreville Valley, a southwest-northeast-trending linear bedrock low in Beaver County, joins the Buried Beverly Valley in the County of St. Paul. Within Strathcona County, the Buried Vegreville Valley is three to four kilometres wide, with local bedrock relief being less than 40 metres. Sand and gravel deposits can be

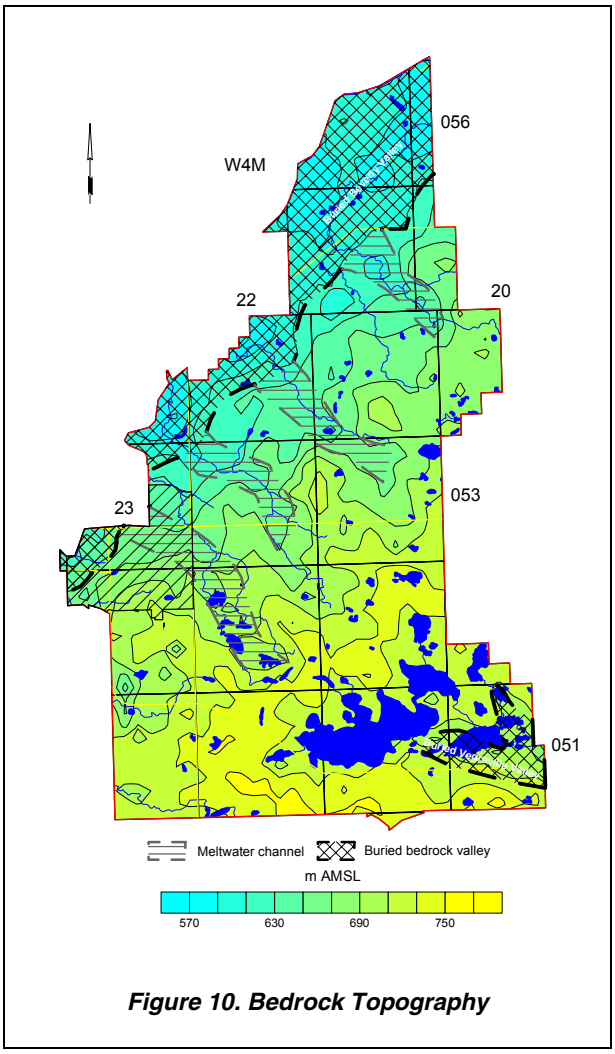

Figure 10. Bedrock Topography

[10] See glossary
[11] See glossary
[12] See glossary

expected in association with this bedrock low, but the thickness of sand and gravel deposits is expected to be mainly less than ten metres. Hastings Lake in township 51, range 20, W4M is present in the area where the Buried Vegreville Valley appears to be present.

Another prominent bedrock feature in the County is the Cooking Lake Divide, which is a regional preglacial feature (Carlson, 1967). This Divide is a general northeast-southwest-trending feature which, according to Carlson (1967), "enters the Edmonton district in Tp 049, R 22, W4M, skirts around the western shore of Cooking Lake, and leaves the study area in Tp 052, R 21, W4M". In Carlson's report, it is suggested that the Divide is so prominent that the "Ministik, Joseph, Cooking and Oliver lakes are all located in the drowned headwaters of preglacial valleys that extended down the eastern flank of the Cooking Lake Divide".

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur mainly in the Buried Beverly Valley. The total thickness of the lower surficial deposits is mainly less than 30 metres, but can be more than 30 metres in the buried bedrock valleys. The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally be expected to directly overlie the bedrock surface in the Buried Beverly Valley. The lowest sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

In the County, there are four linear bedrock lows that trend mainly northwest to southeast and are indicated as being of meltwater origin. Because sediments associated with the lower surficial deposits are indicated as being present in these linear bedrock lows, it is possible that the bedrock lows were originally tributaries to the Buried Beverly Valley as shown in the bedrock topography map on Figure 10.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which are expected to occur mainly as isolated pockets. The thickness of the upper surficial deposits is mainly less than 30 metres, but can be more than 30 metres in the meltwater channels and in the Buried Vegreville Valley.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than ten metres but can be more than 15 metres in the Buried Beverly Valley.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits (Figure 11). Over approximately 20% of the County, the sand and gravel deposits are more than 30% of the total thickness of the surficial deposits (page A-17). The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits are mainly in the areas of the buried bedrock valleys and meltwater channels.

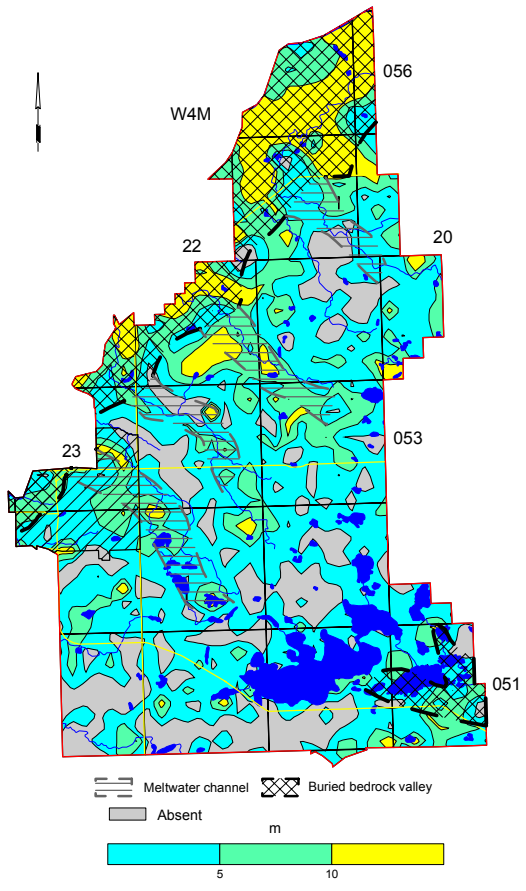

Figure 11. Thickness of Sand and Gravel Deposits

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the County includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. In the County, the thickness of the sand and gravel aquifer(s) is generally less than five metres, but can be more than ten metres in the vicinity of the Buried Beverly Valley (page A-19).

From the present hydrogeological analysis, 2,016 water wells are completed in aquifers in the surficial deposits. Of the 2,016 water wells, 1,885 are completed in aquifers in the upper surficial deposits and 131 are completed in aquifers in the lower surficial deposits. This number of water wells is nearly four times the number (509) determined to be completed in aquifers in the surficial deposits, based on lithologies given on the water well drilling reports. The larger number is obtained by comparing the elevation of the reported depth of a water well to the elevation of the bedrock surface at the same location. For example, if only the depth of a water well is known, the elevation of the completed depth can be calculated. If the elevation of the completed depth is above the elevation of the bedrock surface determined from the gridded bedrock topographic surface at the same location, then the water well is considered to be completed in an aquifer in the surficial deposits.

Water wells completed in the upper surficial deposits occur throughout the County. In the area underlain by the Buried Beverly Valley, there are a large number of water wells completed in the lower surficial deposits (Figure 12).

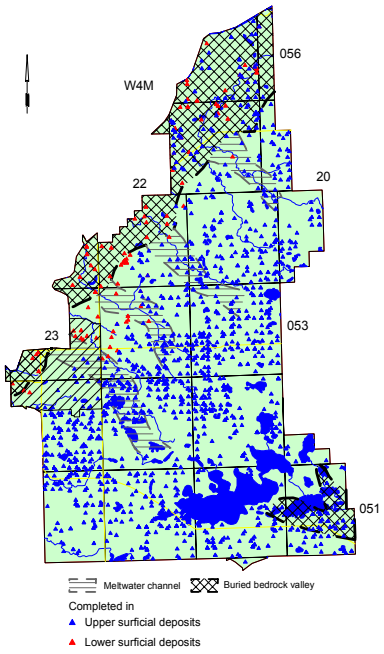

Figure 12. Water Wells Completed in Surficial Deposits

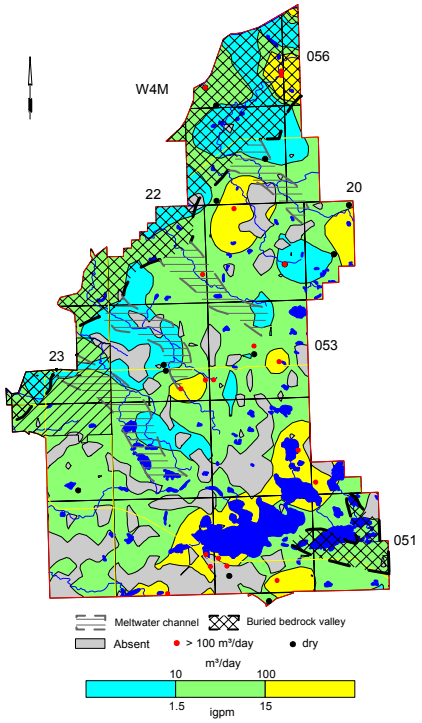

Figure 13. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The map to the left shows expected yields for water wells completed in sand and gravel aquifers(s). Over approximately 25% of the County, the sand and gravel deposits are not present, or if present, are not saturated.

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more than 100 m³/day from sand and gravel aquifer(s) can be expected in several areas of the County. The most notable areas where yields of more than 100 m³/day are expected are near Cooking Lake and in association with the main linear bedrock lows. Higher yields could be a result of the gridding procedure used to process a limited number of data points. In addition to the 103 records for surficial water wells with apparent yield data, there are 14 records that indicate dry or abandoned with “insufficient water”. In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the 14 dry holes prior to gridding. Also included in these postings is any record that includes comments that state the water well goes dry in dry years.

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the sand and gravel aquifers in the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In Strathcona County, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 200 mg/L (see CD-ROM).

The Piper tri-linear diagrams[13] (page A-26) show the groundwaters from the surficial deposits have no dominant cation or anion ranging from calcium-magnesium-bicarbonate or calcium-magnesium-sulfate to sodium-bicarbonate or sodium-sulfate-type waters. The records with the sodium-bicarbonate waters were individually checked in the database to confirm the completion aquifer. Ninety percent of the groundwaters have a TDS concentration of more than 500 mg/L. The groundwaters with a TDS concentration of less than 500 mg/L occur mainly in association with the Buried Beverly Valley, as shown on Figure 14. Sixty percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of less than one mg/L. However, many iron analysis results are questionable due to varying sampling methodologies.

There are groundwaters with sulfate as the main anion. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in 95% of the samples analyzed in the County, the chloride ion concentration is less than 100 mg/L. Groundwaters with a chloride concentration of more than the GCDWQ (250 mg/L) have been posted on the chloride map (see CD-ROM).

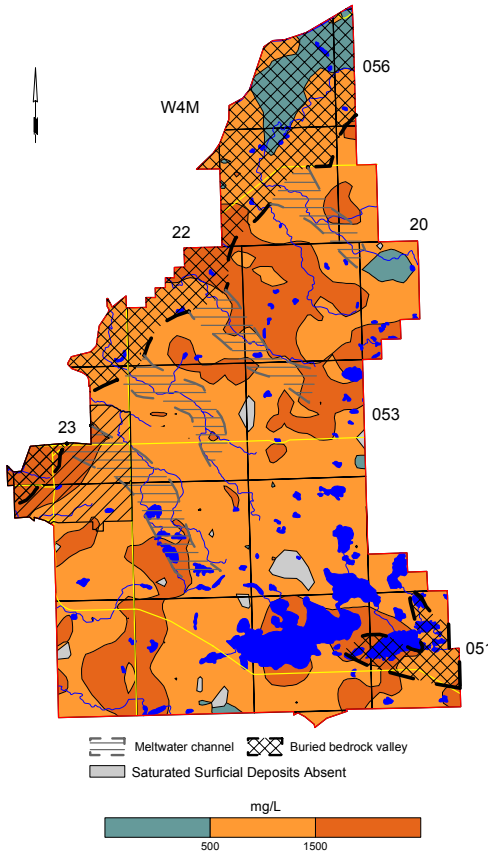

Figure 14. Total Dissolved Solids in Groundwater from Surficial Deposits

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	203	5250	1164	500
Sodium	<9	1348	219	200
Sulfate	0	1680	324	500
Chloride	0	1014	24	250
Nitrate + Nitrite (as N)	<0.01	610	2.9	10

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Nitrate + Nitrite (as N), which is for Maximum Acceptable Concentration (MAC)

GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition
Minister of Supply and Services Canada, 1996

Table 3. Concentrations of Constituents in Groundwaters from Surficial Aquifers

In the County, the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of 10 mg/L in six percent of the samples. Groundwaters with a nitrate + nitrite (as N) concentration exceeding the GCDWQ (10 mg/L) have been posted on the nitrate + nitrite (as N) map (see CD-ROM).

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and nitrate + nitrite (as N) in the groundwaters from water wells completed in the surficial deposits in the County have been compared to the GCDWQ in the adjacent table. Of the five constituents that have been compared to the GCDWQ, the average values of TDS and sodium concentrations exceed the guidelines.

[13] See glossary