

3 TERMS

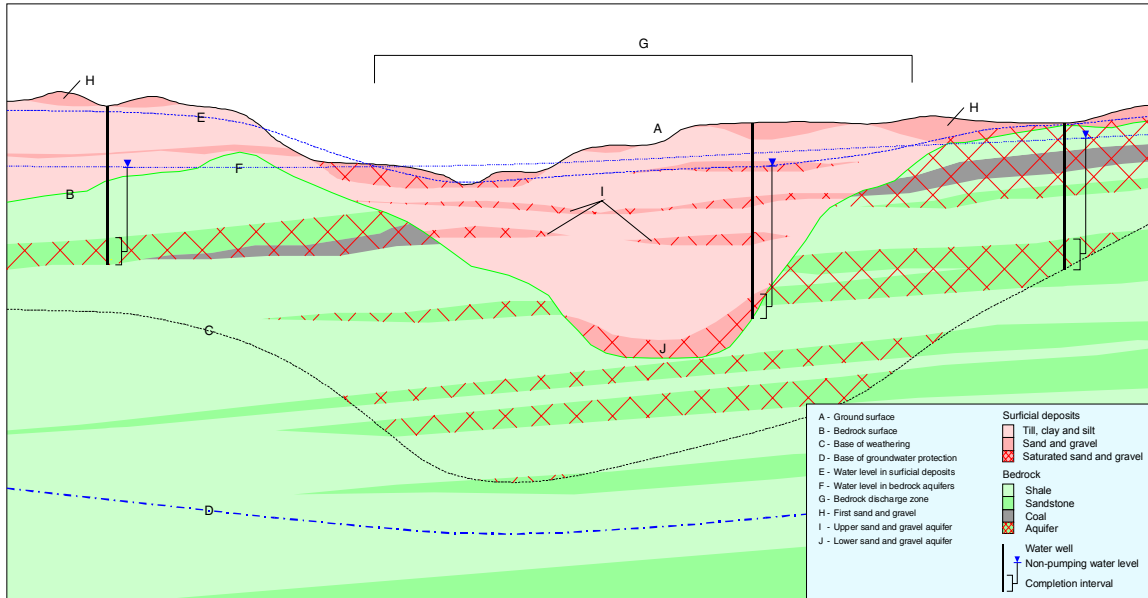


Figure 5. Generalized Cross-Section (for terminology only)

(for larger version, see page A-8)

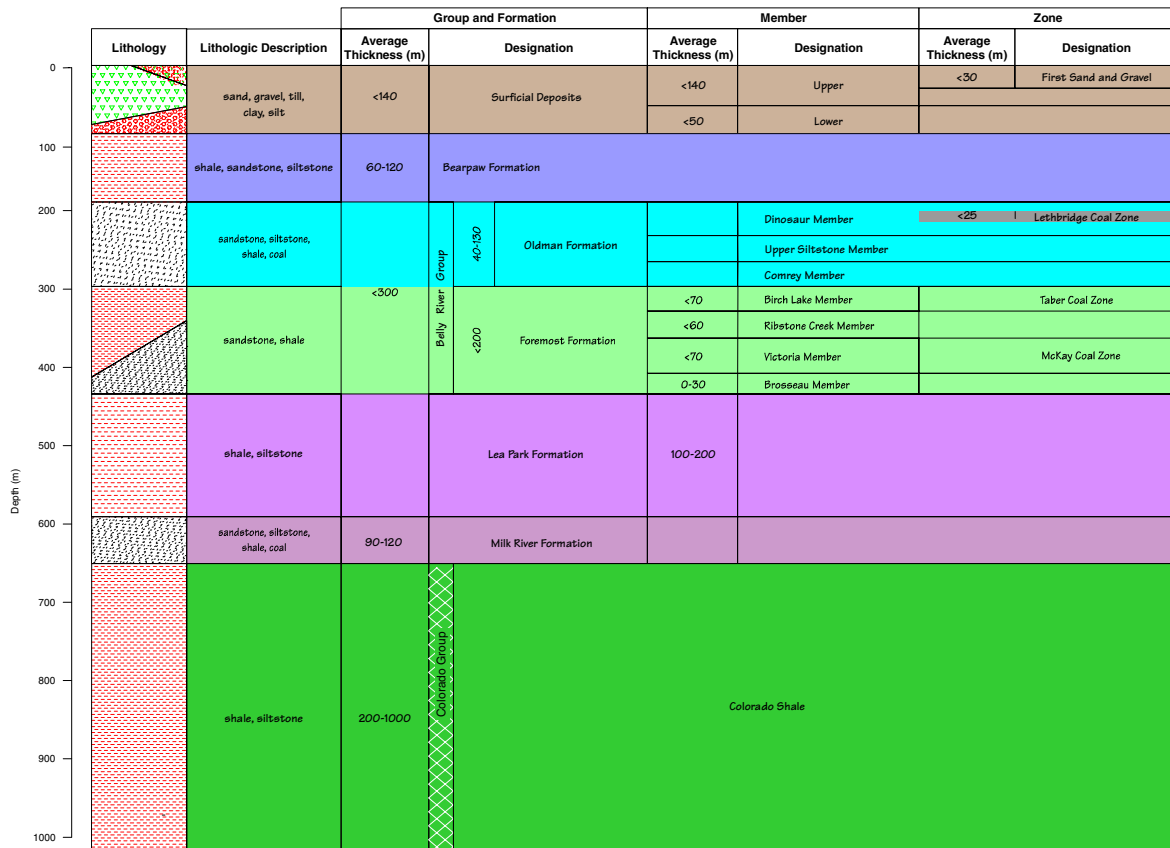


Figure 6. Geologic Column

(for larger version, see page A-9)

4 METHODOLOGY

4.1 Data Collection and Synthesis

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

- 1) water well drilling reports
- 2) aquifer test results from some water wells
- 3) locations of some springs
- 4) locations for some water wells determined during water well surveys
- 5) chemical analyses for some groundwaters¹⁰
- 6) locations of some flowing shot holes
- 7) locations of some structure test holes
- 8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the reliability of the information entered into the database. 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 to the database is the lack of adequate spatial information. Any duplicate water wells that have been identified within the M.D. have been removed from the database used in this regional groundwater assessment.

The AENV groundwater database uses an area-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 10TM coordinate system based on the NAD27 datum. This means that a record for the NW ¼ of section 21, township 066, range 01, W5M would have a horizontal coordinate with an Easting of 58,217 metres and a Northing of 6,062,520 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photographs, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLIS Ltd. provides the DEM.

At many locations within the M.D., more than one water well is completed at one legal location. Digitally processing this information is difficult. To obtain a better understanding of the completed depths of water wells, a digital surface was prepared representing the minimum depth for water wells and a second digital surface was prepared for the maximum depth. Both of these surfaces are used in the groundwater query on the CD-ROM. When the maximum and minimum water well depths are similar, there is only one aquifer that is being used at a given location.

After assigning spatial control for the ground location for 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.

¹⁰ Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data after 1986.

Where possible, determinations are made from individual records in order to assign water wells to aquifers and to obtain values for the following:

- 1) depth to bedrock
- 2) total thickness of sand and gravel below 15 metres
- 3) total thickness of saturated sand and gravel
- 4) depth to the top and bottom of completion intervals¹¹.

Also, where sufficient information is available, values for apparent transmissivity¹² and apparent yield¹³ are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological maps covering the M.D. were published in 1973 (Borneuf), in 1977 (Tokarsky), in 1978 (Vogwill), and in 1980 (Ozoray and Lytviak), more than 230 values for apparent transmissivity and apparent yield have been added to the groundwater database. The median apparent yield of the water wells with apparent yield values in the M.D. is 30 m³/day. Approximately 20 percent of the apparent yield values for these water wells are less than ten m³/day. With the addition of the apparent yield values, including a 0.1-m³/day value assigned to “dry” water wells and water test holes, a hydrogeological map has been prepared to help

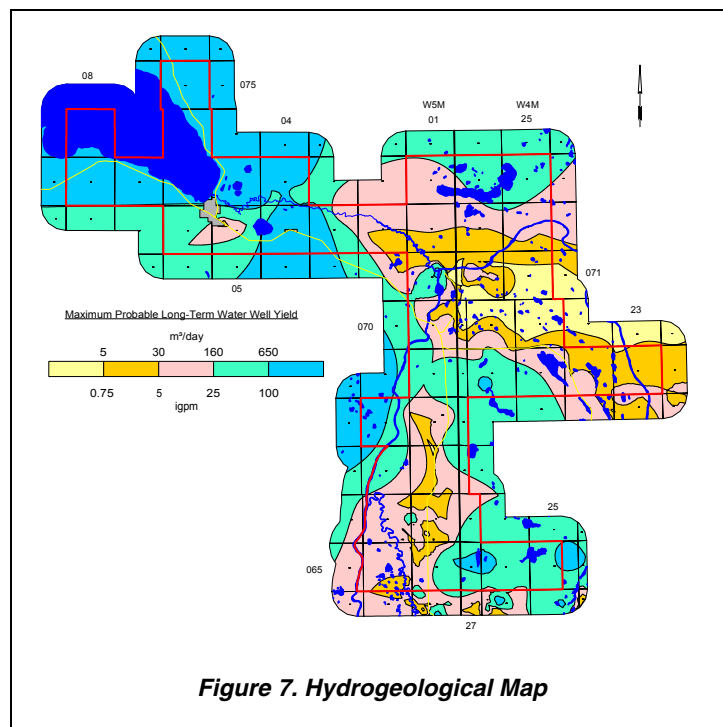


Figure 7. Hydrogeological Map

illustrate the general groundwater availability across the M.D. (Figure 7 and page A-10). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Research Council (ARC) hydrogeological maps. In general, the ARC maps show lower estimated long-term yields. The differences between the two map renderings may be a result of fewer apparent yield values and the gridding method employed by the ARC.

The EUB well database includes records for wells drilled for 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 geologic units
- 3) type and intervals for various down-hole geophysical logs
- 4) drill stem test (DST) summaries.

Values for apparent transmissivity and apparent yield 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 support the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

¹¹ See glossary

¹² For definitions of Transmissivity, see glossary

¹³ For definitions of Yield, see glossary

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) geophysical logs for wells drilled by the oil and gas industry
- 4) data from existing cross-sections.

The aquifers are defined by mapping the tops and bottoms of individual geologic units. The values for the elevation of the top and bottom of individual geologic units at specific locations help to determine the spatial distribution of the individual surfaces. Establishment of a surface distribution digitally requires preparation of a grid. The inconsistent quality of the data 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 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.

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 individual water wells are completed. When the completion depth of a water well cannot be established, 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), apparent transmissivity, and apparent water well yield. The NPWL given on the water well record is usually the water level recorded when the water well was drilled, measured prior to the initial aquifer test. In areas where groundwater levels have since fallen, the NPWL may now be lower and accordingly, the potential apparent yield would be reduced. The total dissolved solids, sulfate and chloride concentrations from the chemical analyses of the groundwaters are also assigned to applicable aquifers. In addition, chemical parameters of Nitrate + Nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s). Nitrate + Nitrite (as N) concentrations are often related to water-well-specific data and may not indicate general aquifer conditions.

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these 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. The representative data set included using the available data from townships 065 to 073, ranges 23 to 27, W4M and townships 065 to 075, ranges 01 to 08, W5M, plus a buffer area of at least 5,000 metres. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable; for the maps, the areas with little or no data are identified.

On some maps, values are posted as a way of showing anomalies to the underlying grid or as a means of emphasizing either the lack of sufficient data or areas where there is concentrated hydrogeological data control.

4.3.1 Risk Criteria

The main source of groundwater contamination involves activities on or near the land surface. The risk of groundwater contamination is high when the near-surface materials are porous and permeable and low when the materials are less porous and less permeable. The 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) surficial geology and/or the soil maps. 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 and/or the soil map is categorized based on relative permeability. The information from these sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the above table.

Surface Permeability	Sand or Gravel Present - Top 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 3. Risk of Groundwater Contamination Criteria

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 geologic units. For example, the relationship between an upper bedrock unit and the bedrock surface must be determined. This process provides both the outline and the thickness of the geologic unit.

Once the appropriate grids are available, the maps are prepared by contouring the grids. 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 figures 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 geologic units are then transferred to the cross-section from the digitally prepared surfaces.

Once the technical details of a cross-section are correct, the drawing file is moved to the software package CorelDraw! for simplification and presentation in a hard-copy form. Five cross-sections are presented in Appendix A of this report and as poster-size drawings forwarded with this report; only one (E-E') is included in the text of this report. The cross-sections are also included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

4.5 Software

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

- Acrobat 5.0
- ArcView 3.2
- AutoCAD 2002
- CorelDraw! 11.0
- Microsoft Office XP
- Surfer 8

5 AQUIFERS

5.1 Background

An aquifer is a permeable rock unit that is saturated. In this context, rock refers to subsurface materials, such as sand, gravel, sandstone and coal. If the NPWL is above the top of the rock unit, this type of aquifer is a confined or artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the rock unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the M.D. The first geological setting includes the sediments that overlie the bedrock surface. In this report, these sediments 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.

5.2 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 fluvial¹⁴ deposits. The *upper surficial deposits* include the traditional glacial sediments of till¹⁵ and ice-contact deposits. Pre-glacial materials are expected to be present in association with linear bedrock lows. Meltwater channels are associated with glaciation.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic units. The first unit is the preglacial sand and gravel deposits of the lower surficial deposits. These deposits are mainly saturated. 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 that occur close to ground surface. For a graphical depiction of the above description, please refer to Figure 5, page 9 and to page A-8. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for soluble contaminants to move downward into the groundwater. Because of the significance of the shallow sand and gravel deposits, they have been mapped where they are present within one metre of the ground surface and are referred to as the “first sand and gravel”.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown in Figure 8 on the following page. Regionally, the bedrock surface varies between 460 and 820 metres AMSL. The lowest elevations occur along the present-day Lesser Slave River Valley, as shown on Figure 8 and page A-16. Over the majority of the M.D., the surficial deposits are less than 30 metres thick (see CD-ROM).

The main linear bedrock low in the M.D. is designated as the Buried High Prairie Valley. This Valley trends north-northeast, occupied by the present-day Athabasca River Valley, then turns northwest and is occupied by the present-day Lesser Slave River Valley. The Buried High Prairie Valley is approximately six to ten kilometres wide, with local relief being up to 80 metres. Sand and gravel deposits can be expected in association with the Buried High Prairie Valley, where the thickness of the sand and gravel deposits can be more than 30 metres.

¹⁴ See glossary

¹⁵ See glossary

The lower sand and gravel deposits are composed of fluvial deposits. Lower sand and gravel deposits are identified mainly in association with linear bedrock lows. The total thickness of the lower sand and gravel deposits is mainly greater than ten metres (see CD-ROM).

In the M.D., there is a linear bedrock low that trends west to east and is indicated as being of meltwater origin. Because sediments associated with the lower sand and gravel deposits are indicated as being present in parts of the meltwater channel, it is possible that the meltwater channel was originally a tributary to the Buried High Prairie Valley (see CD-ROM). Because meltwater channels are mainly an erosional feature, the sand and gravel deposits associated with these features are considered not to be significant aquifers.

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 greater than 25 metres. Upper surficial deposits are present throughout the M.D. (see CD-ROM). The upper sand and gravel deposits are mainly greater than ten metres thick (see CD-ROM).

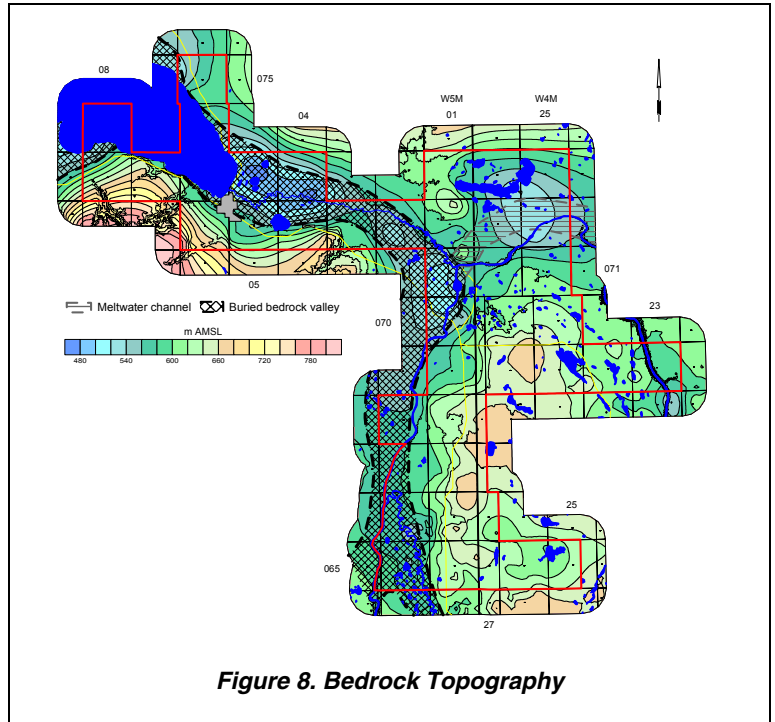


Figure 8. Bedrock Topography

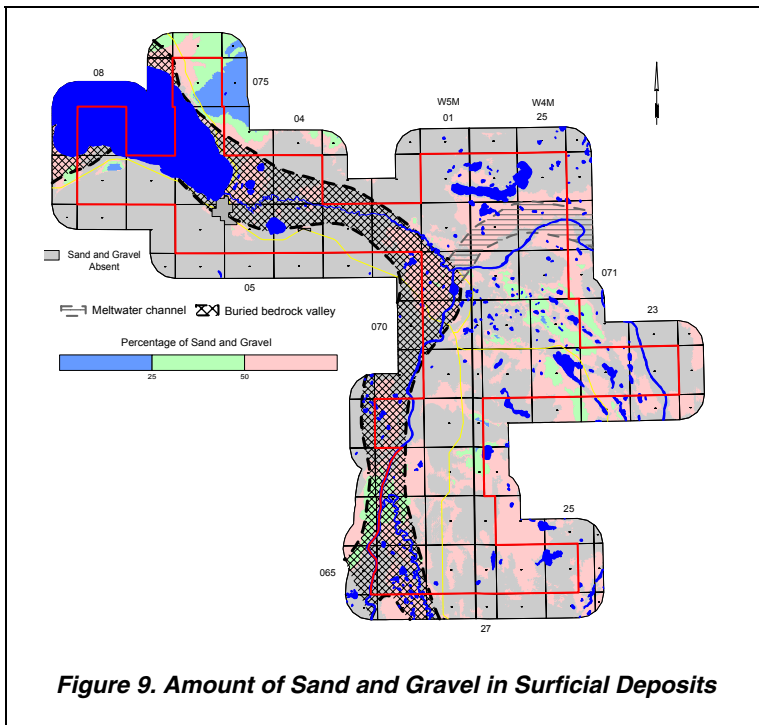


Figure 9. Amount of Sand and Gravel in Surficial Deposits

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than two metres but can be more than five metres in association with linear bedrock lows and river valleys.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 80% of the M.D. where sand and gravel deposits are present, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits, as shown on the adjacent figure. The areas where sand and gravel deposits constitute more than 50% of the total thickness of the surficial deposits may be in areas of buried bedrock valleys or meltwater channels or areas where linear bedrock lows exist but have not been identified due to a shortage of accurate bedrock control points.