

IV. Methodology

A. Data Collection and Synthesis

The AE 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) 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
- 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 to the database is the lack of adequate spatial information. The present database for the project area contains approximately 400 duplicate water well IDs.

The AE 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. This situation has been improved for Special Areas and the M.D. Prairie Farm Rehabilitation Administration (PFRA) and HCL have repositioned 3,208 water wells within Special Areas and the M.D. using a Global Positioning System (GPS) instrument. These coordinates are provided with the records on the CD-ROM.

The present project uses the 10TM coordinate system. This means that a record for the NW ¼ of section 23, township 024, range 09, W4M, would have a horizontal coordinate with an Easting of 268,860 metres and a Northing of 5,661,368 metres, the centre of the quarter section. If the water well has been positioned by PFRA as a result of field verification, the location will be more accurate, possibly within ten 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) from the Resource Data Division of AE.

At many locations within the project area, 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.

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.

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
- 5) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity⁸ and apparent yield⁹ 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 regional hydrogeology map was published in 1979 (Borneuf, 1979), 223 values for effective transmissivity have been added to the groundwater database.

The 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
- 4) drill stem test (DST) summaries.

Values for apparent transmissivity, apparent yield 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 (pages 42-44). 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.

B. 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
- 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.

The values for the elevation of the top and bottom of individual geological units at specific locations help to determine the spatial distribution of the individual surfaces. Establishment of a surface distribution digitally requires preparing a grid. The inconsistent quality of the data necessitates creating a representative sample set

⁸ For definitions of Transmissivity, see glossary

⁹ For definitions of Yield, see glossary

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.

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

C. 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 interval of a water well cannot be established unequivocally, the data from that water well are not used in establishing 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 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. Even when only limited data are available, grids are prepared. However, the data from these grids must be used with extreme caution because the gridding process can be unreliable.

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 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, based on 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 - 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

D. 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 established. This process provides both the outline and the thickness of the geological unit.

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 NPWL and the elevation of the top of the aquifer are combined to determine the available drawdown¹⁰. The available drawdown data and the transmissivity values are used to calculate values for projected long-term yields for individual water wells, which are completed in a specific aquifer.

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 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 NPWLs. Data from individual geological 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. This report includes these cross-sections and poster-size drawings. As well, both Appendix A and the CD-ROM contain the cross-sections; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

E. Software

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

- Acrobat 4.0
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Microsoft Office 2000
- Surfer 7.0

¹⁰ See glossary