There are other linear bedrock lows shown on the bedrock topography map. These lows trend northwest to southeast in the M.D. and are indicated as being of meltwater origin. However, 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 and Onoway valleys' drainage systems present in the M.D.

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur over less than 25% of the M.D., in association with linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than ten metres, but can be up to 25 metres in the areas of linear bedrock lows. 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 and Onoway valleys. The lowest sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

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. The greatest thickness of upper surficial deposits occurs mainly in association with the linear bedrock lows; there are several areas in the M.D. where these deposits are not present.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than 15 metres but can be more than 15 metres in the areas of the linear bedrock lows and meltwater channels.

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 15% of the M.D., the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. The areas where the sand and gravel percentages are more than 50% in the M.D. are mainly associated with the linear bedrock lows.

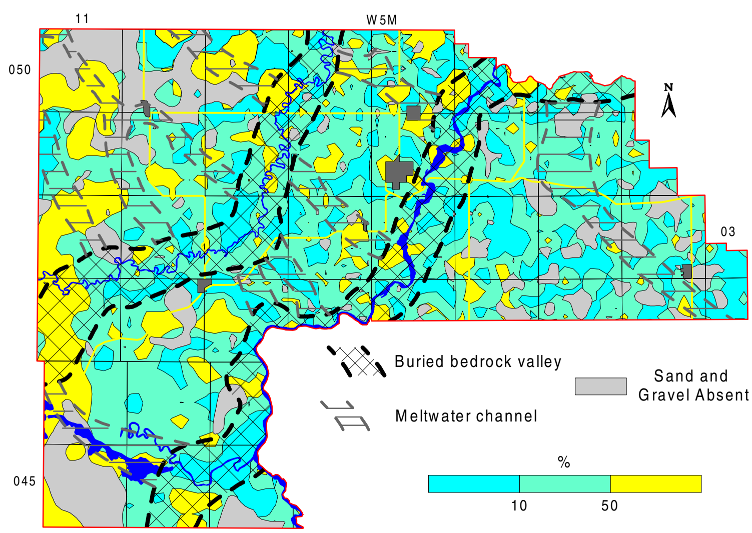

Figure 10. Amount of Sand and Gravel in Surficial Deposits

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the M.D. 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. From the present hydrogeological analysis, 68 water wells are completed in aquifers in the lower surficial deposits and 341 are completed in aquifers in the upper surficial deposits. This number of water wells is nearly four times the number 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 expected elevation of the bedrock surface at the same location, then the water well is determined to be completed in an aquifer in the surficial deposits.

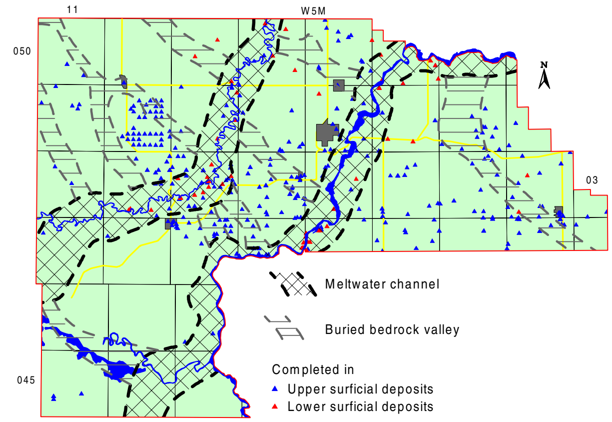

Figure 11. Water Wells Completed in Surficial Deposits

The majority of the water wells completed in the upper surficial deposits in the M.D. are north of the middle of township 047, as shown in Figure 11. The majority of the water wells completed in the lower surficial deposits are located along the Buried Beverly and Onoway valleys.

The adjacent map shows expected yields for water wells completed in aquifers in the sand and gravel aquifer(s), based on the aquifers that have been developed by existing water wells. These data show that water wells with yields of less than 100 m³/day from sand and gravel aquifer(s) can be expected in most areas of the M.D. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with linear bedrock lows. In 30% of the M.D., the sand and gravel deposits are not present or, if present, are not saturated.

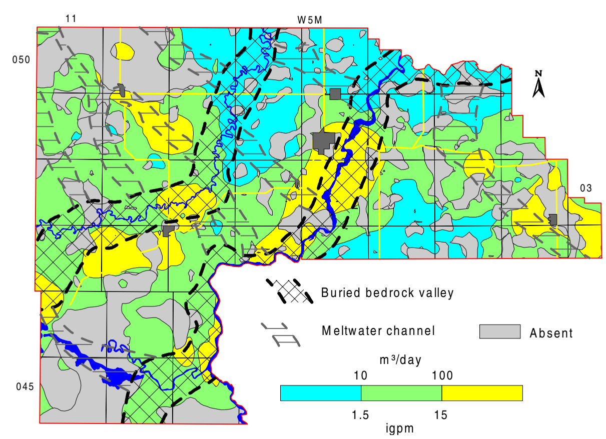

Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits have not been differentiated based on aquifers in the upper or lower surficial deposits. The main reason for not separating the chemical analysis results into the different aquifers is the lack of data that can be attributed to the Lower Sand and Gravel Aquifer. This is in part related to the number of control points from this Aquifer, which is in part related to the limited areal extent of the lower surficial deposits.

The other justification for not separating the analyses was that there appeared to be no major chemical difference between groundwaters from the upper and lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron.

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate, sodium-bicarbonate or sodium-sulfate-type waters, with 90% of the groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with TDS of less than 500 mg/L occur mainly in the western part of the M.D. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of greater than 1 mg/L.

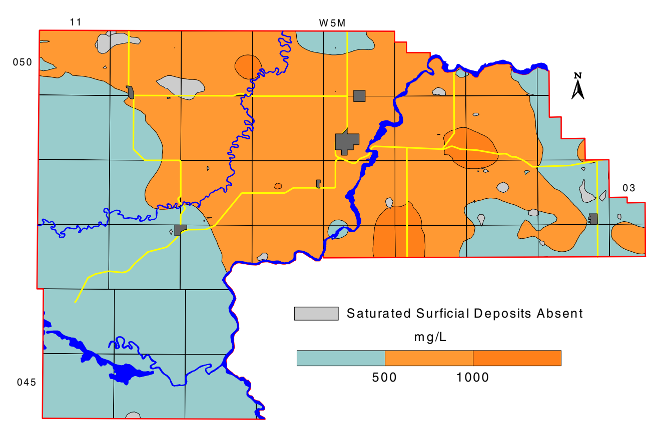

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

Although the majority of the groundwaters are calcium-magnesium-bicarbonate-type waters, there are groundwaters from the surficial deposits with sodium as the main cation; there are also groundwaters with significant concentrations of the sulfate ion. 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 most of the M.D., the chloride ion concentration is less than 30 mg/L.

Constituent	Groundwater Concentrations from Surficial Water Wells in the M.D. Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	258	1486	591	500
Sodium	6.2	346	133	200
Sulfate	8.2	469	81	500
Chloride	1.1	40	5.5	250
Fluoride	0.1	3.1	0.3	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives

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

Table 4. Groundwater Concentrations from Water Wells Completed in Surficial Deposits

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the surficial deposits in the M.D. have been compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) in the adjacent table. On the average, the groundwaters are below the GCDWQ; the exception is TDS, which exceeds the guidelines slightly.

5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. These aquifers can directly overlie or be close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 70% of the M.D.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the upper surficial deposits; and (2) the depth to the bedrock surface. Since the non-pumping water-level surface in the surficial deposits tends to be a subdued replica of the bedrock surface, the thickness of the Upper Sand and Gravel Aquifer tends to be directly proportional to the thickness of the surficial deposits.

While the sand and gravel deposits in the upper surficial deposits are not continuous, the Upper Sand and Gravel Aquifer includes all of the aquifers present in the upper surficial deposits. The Upper Sand and Gravel Aquifer is more than 20 metres thick in a few areas, but over the majority of the M.D., is less than ten metres thick; over 20% of the M.D., the Aquifer is absent. Most of the greater thickness in the Upper Sand and Gravel Aquifer occurs in the areas of linear bedrock lows.

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of water wells with high yields; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the apparent yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly less than 100 m³/day. Where the Upper Sand and Gravel Aquifer is absent and where the yields are low, the development of water wells for the domestic needs of single families may not be possible.

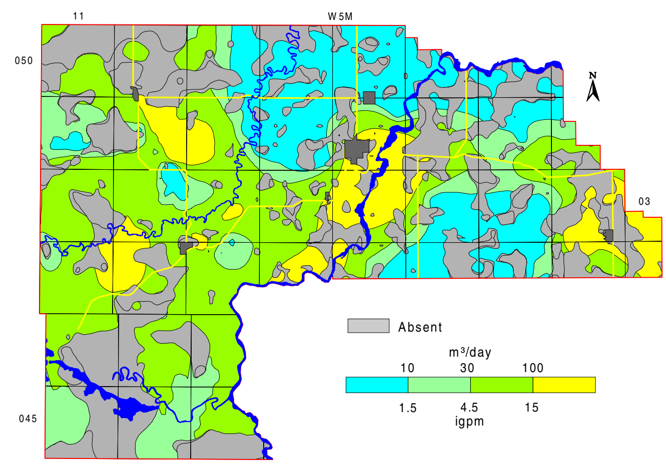

Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deepest part of the pre-glacial linear bedrock lows. The thickness of the sand and gravel deposits is mainly less than five metres. The Lower Sand and Gravel Aquifer is mostly restricted to the Buried Beverly and Onoway valleys and meltwater channels in the M.D.

5.2.4.1 Apparent Yield

Apparent yields for water wells completed in the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 30 m³/day. The highest yields are expected in the Buried Onoway Valley, in townships 048 and 049, range 09, W5M.

The Town of Drayton Valley has completed at least some of its water test holes in the Lower Sand and Gravel Aquifer associated with the Buried Beverly Valley. However, the projected long-term yields from these water test holes were not suitable for the Town's needs and water is now obtained from the North Saskatchewan River (UMA, 1971).

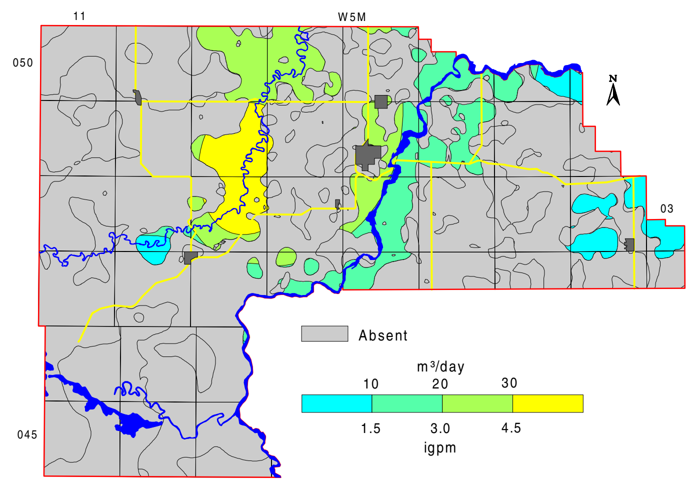

Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

Yearly groundwater production records from the EUB database for two water source wells completed in the Lower Sand and Gravel Aquifer associated with the Buried Onoway Valley have average daily yields of up to 180 m³/day. The higher yields are associated with a water source well in 16-22-048-09 W5 and the lower yields are from a water source well in 14-04-048-10 W5M.

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the M.D. is the Paskapoo Formation and the Edmonton Group. The Paskapoo Formation consists of cycles of thick, tabular sandstones, siltstone and mudstone layers (Glass, 1990). The Edmonton Group consists of fresh and brackish-water deposits of fine-grained sandstone and silty shale, thick coal seams, and numerous bentonite beds (Carrigy, 1971). The maximum thickness of the Paskapoo Formation can be 800 metres, but in the M.D., the thickness is from 0 to 500 metres. The thickness of the Edmonton Group varies from 300 to 500 metres. The Edmonton Group in the M.D. includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations.

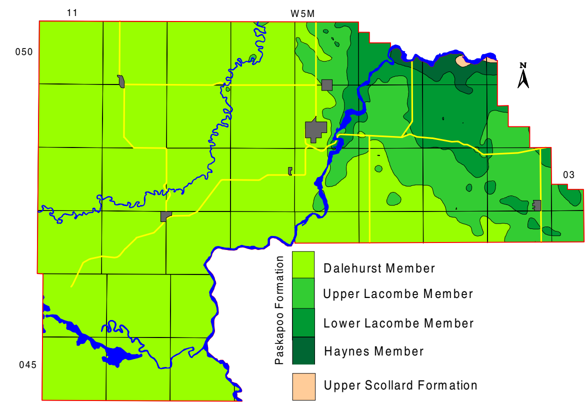

Figure 16. Bedrock Geology

The Paskapoo Formation is the upper bedrock and subcrops in all of the M.D., with the exception of a small area adjacent to the North Saskatchewan River in township 50, ranges 04 and 05, W5M. The Paskapoo Formation in central Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991).

The Dalehurst Member is the upper bedrock and subcrops in the southwestern two-thirds of the M.D. This Member has a maximum thickness of 300 metres within the M.D. and is mostly composed of shale and siltstone with sandstone, bentonite and coal seams or zones. Two prominent coal zones within the Dalehurst are the Obed-Marsh Coal (up to 30 metres thick) and the Lower Dalehurst Coal (up to 50 metres thick). The bottom of the Lower Dalehurst Coal is the border between the Dalehurst and Upper Lacombe members.

The Lacombe Member underlies the Dalehurst Member and subcrops in most of the northeastern one-third of the M.D. The Lacombe Member has a maximum thickness of 350 metres and has two separate designations: Upper and Lower. The Upper Lacombe Member is mostly composed of shale interbedded with sandstone and has a maximum thickness of 250 metres. The Lower Lacombe Member is composed of sandstone and coal layers. In the middle of the Lower Lacombe Member there is a coal zone, which can be up to five metres thick. The Lower Lacombe Member has a maximum thickness of 100 metres.

The Haynes Member underlies the Lower Lacombe Member and subcrops in the northeastern part of the M.D, in parts of township 50, ranges 04 to 06, W5M. The Haynes Member has a maximum thickness of 100 metres and is composed mainly of sandstone with some siltstone, shale and coal.

The Scollard Formation underlies the Haynes Member and subcrops in the northeastern part of the M.D., in a small area of township 50, ranges 04 and 05, W5M. The Scollard Formation has a maximum thickness of 220 metres within the M.D. and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard formations. The Lower Scollard Formation has a maximum thickness of 40 metres and is composed mainly of shale and sandstone. Due to the limited number of control points for the Lower Scollard Formation, there will be no direct review of the Lower Scollard Formation in the text of this report, nor will maps associated with the Formation be included on the CD-ROM.

Beneath the Scollard Formation are two formations having a maximum thickness of 30 metres; the two are the Battle and Whitemud formations. The Battle Formation is composed mainly of claystone, tuff, shale and bentonite, and includes the Kneehills Member, a 2.5- to 30-cm thick tuff bed. The Whitemud Formation is composed mainly of shale, siltstone, sandstone and bentonite. The Battle and Whitemud formations are significant geologic markers, and were used in the preparation of various geological surfaces within the bedrock. Because of the ubiquitous nature of the bentonite in the Battle and Whitemud formations, there is very little significant permeability within these two formations. There will be no direct review of these formations in the test of this report.

The Horseshoe Canyon Formation underlies the Lower Scollard Formation and consists of deltaic[12] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits. Because the Horseshoe Canyon Formation is mainly below a depth of 200 metres below the bedrock surface in the M.D., there will be no direct review of the Horseshoe Canyon Formation in the text of this report, nor will maps associated with the Formation be included on the CD-ROM.

5.3.2 Aquifers

Of the 3,571 water wells in the database, 2,231 were defined as being completed in bedrock aquifers. This designation is based on the top of the completion interval being below the bedrock surface. For the remaining 1,340 water wells, a completion depth is available for the majority. In order to make use of the additional information within the groundwater database, it was statistically determined that water wells typically have completion intervals equivalent to one quarter of their completed depth. This relationship was used to increase the number of water wells identified as completed in bedrock aquifers to 2,983 from 2,231. With the use of the geological surfaces that were determined from the interpretation of geophysical logs, it has been possible to assign the water wells completed in bedrock aquifers to specific geological units based on their completion intervals. Of the 2,983 bedrock water wells, 2,714 have been assigned a specific geologic unit. The bedrock water wells are mainly completed in the Dalehurst Member, as shown in the adjacent table. Ten percent of the bedrock water wells are likely to have multiple completions, of which 90% have the top of the first completion interval less than 60 metres below ground level.

Geological Unit	No. of Water Wells
Dalehurst	1,755
Upper Lacombe	558
Lower Lacombe	316
Haynes	73
Upper Scollad	10
Lower Scollard	2
Other	269
Total	2,983

Table 5. Completion Aquifer

[12] See glossary

There are 1,347 records for bedrock water wells that have apparent yield values, which is 45% of all bedrock water wells. In the M.D., water well yields in the upper bedrock aquifer(s) are mainly less than 150 m³/day. The areas of higher yields that are indicated on the adjacent figure are mainly in the western part of the M.D.

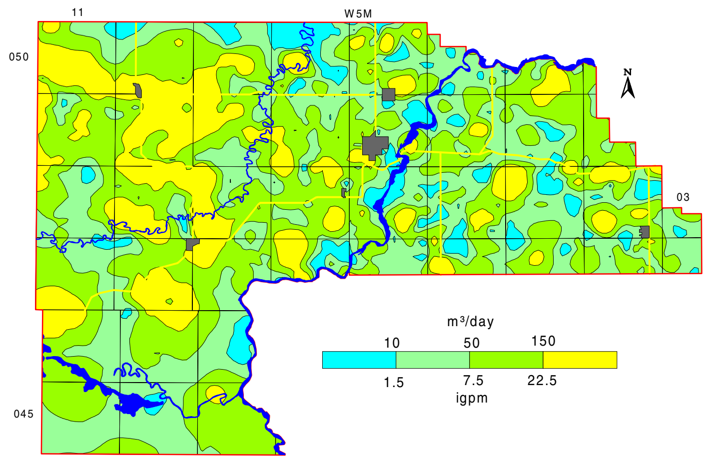

Figure 17. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

There are 1,283 apparent yield values that can be assigned to aquifers associated with specific geologic units. The majority of the water wells completed in the bedrock aquifers have apparent yields that range from 10 to 150 m³/day, as shown in the adjacent table.

Aquifer	No. of Water Wells with Values for Apparent Yields	Number of Water Wells with Apparent Yields <10 m³/day	10 to 150 m³/day	>150 m³/day
Dalehurst	830	128	529	173
Upper Lacombe	241	53	168	20
Lower Lacombe	166	47	94	25
Haynes	39	8	26	5
Upper Scollad	5	1	1	3
Lower Scollard	2	0	2	0
Totals	1,283	237	820	226

Table 6. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 1,000 mg/L. In more than 90% of the area, TDS values are less than 1,000 mg/L.

The relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 600 mg/L, the sulfate concentrations exceed 100 mg/L. The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 10 mg/L in more than 70% of the M.D.

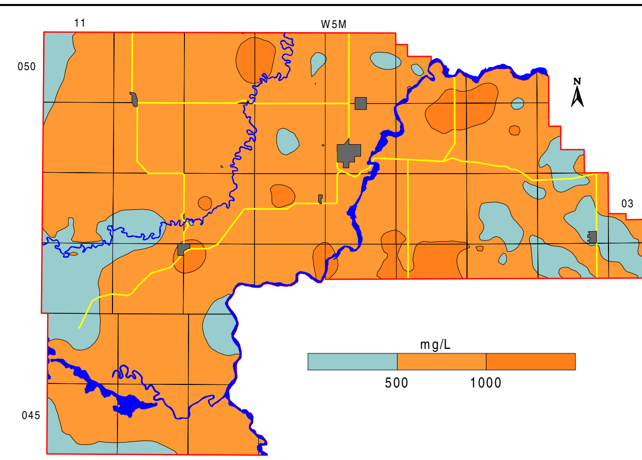

Figure 18. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

In 90% of the M.D., the fluoride ion concentration in the groundwater from the upper bedrock aquifer(s) is less than 1.0 mg/L.

The Piper tri-linear diagrams[13] (see Appendix A) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

[13] See glossary

5.3.4 Dalehurst Aquifer

The Dalehurst Aquifer comprises the porous and permeable parts of the Dalehurst Member. The Dalehurst Member subcrops under the surficial deposits in the southwestern two-thirds of the M.D. The thickness of the Dalehurst Member varies from less than 20 metres at the eastern edge of the subcrop to more than 300 metres in the western part of the M.D.; in the remaining one-third of the M.D., the Dalehurst Member has been eroded. The thickness of the Dalehurst Member decreases in the vicinity of the North Saskatchewan River Valley as a result of erosional processes.

5.3.4.1 Depth to Top

The depth to the top of the Dalehurst Member is a function of the thickness of the surficial deposits, which ranges from less than 20 metres to more than 80 metres.

5.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Dalehurst Aquifer are mainly between 50 and 150 m³/day. The adjacent map indicates that apparent yields of more than 150 m³/day are expected mainly west of range 08, W5M.

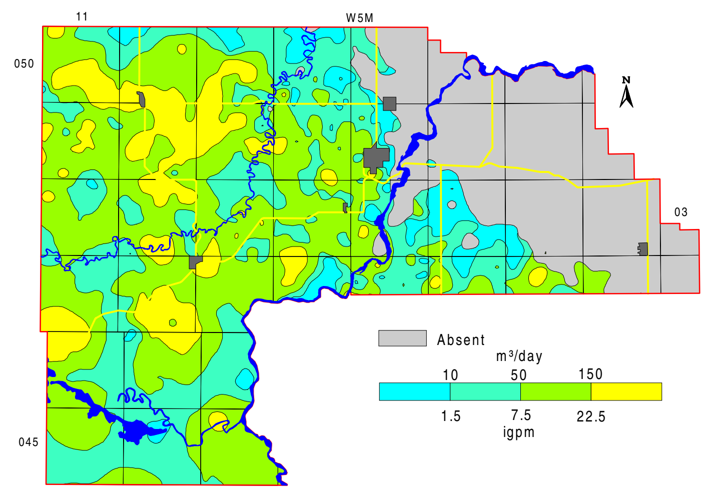

Figure 19. Apparent Yield for Water Wells Completed through Dalehurst Aquifer

Two-hundred and forty-nine water source wells (WSWs) from the EUB database have been designated as being completed in the Dalehurst Aquifer. From 1962 to 1998, a total of 68 million cubic metres of groundwater was pumped from these water source wells. The total number of WSWs varied between 35 and 249. The average daily production per WSW, assuming that each was producing the same amount, varied between 20 and 55 cubic metres per day. An Amoco Canada Petroleum Company Ltd. (Amoco) water source well in 16-05-047-09 W5M is authorized to divert 275 m³/day (Hydrogeological Consultants Ltd. (HCL), 1997b). The water source well is completed in the Dalehurst Aquifer.

5.3.4.3 Quality

The groundwaters from the Dalehurst Aquifer are mainly sodium-bicarbonate or sodium-sulfate types (see CD-ROM). The TDS concentrations are mainly between 500 and 750 mg/L. The higher values are mostly east of range 09, W5M. The sulfate concentrations are usually less than 250 mg/L. Chloride concentrations in the groundwaters from the Dalehurst Aquifer are mainly less than 10 mg/L.

Groundwater from the Amoco water source well (HCL, 1990), that is completed in the Dalehurst Aquifer, has a TDS concentration of 571 mg/L, a sulfate concentration of 30 mg/L and a chloride concentration of 2 mg/L.