When the hydraulic gradient is from the bedrock aquifers to the surficial deposits, the condition is a discharge area from the bedrock aquifers.

The hydraulic gradient between the surficial deposits and the bedrock aquifers has been determined by subtracting the non-pumping water levels in the surficial deposits from the non-pumping water levels in the bedrock. The bedrock recharge classification includes those areas where the water level in the surficial deposits is more than five metres above the water level in the upper bedrock aquifer. The area classified as a bedrock discharge area is one where the water level in the surficial deposits is more than five metres lower than the water level in the bedrock. When the water level in the surficial deposits is between five metres above and five metres below the water level in the bedrock, the area is classified as a transition area.

The adjacent map shows that over more than 80% of the County there is a downward hydraulic gradient between the surficial deposits and the bedrock aquifers. The main area where there is an upward hydraulic gradient is associated with buried valleys or meltwater channels that have been incised into the bedrock. The largest area of upward hydraulic gradient is in the Buried Beverly Valley north of the Town of St. Paul. This area is approximately the size of four townships and in this area, groundwater from the bedrock could recharge the sand and gravel aquifers in the surficial deposits.

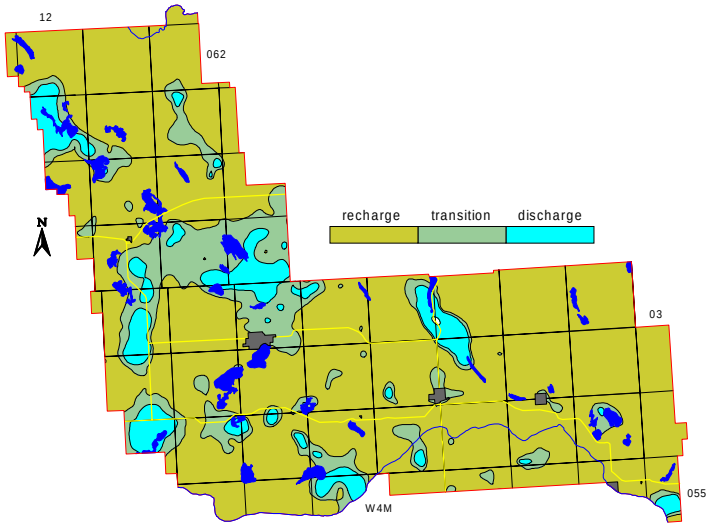

Figure 17. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

Because of the paucity of data, a meaningful calculation of the volumes of groundwater entering and leaving the surficial deposits is not possible.

6.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits. The recharge/discharge maps show that in most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock. On a regional basis, calculating the quantity of water involved is not possible because of the complexity of the geological setting and the limited amount of data. However, because of the generally low permeability of the upper bedrock materials, the volume of water is expected to be small.

One area where an estimate of groundwater recharge to the bedrock has been attempted is south of the Town of St. Paul. In this area the upper bedrock is the *continental* Foremost Formation. The non-pumping water level indicates that most of the groundwater flows to the north or south of an east-west divide. The water-level map for the *continental* Foremost Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre to the north of the divide and approximately the same to the south. With an average transmissivity for the Aquifer of 5 m^2/day and an Aquifer width of 60 kilometres, the flow through the Aquifer would be 600 m^3/day. Because there would be a similar set of conditions south of the divide, the total flow through the *continental* Foremost Formation near St. Paul would be 1,200 m^3/day. This means that half of the groundwater is flowing toward the North Saskatchewan River Valley, and the other half of the groundwater is flowing toward the Buried Beverly and Vegreville Valleys.

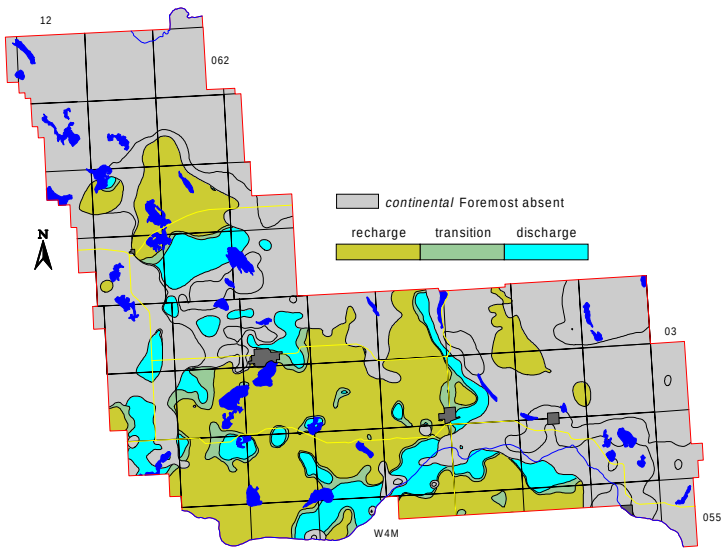

Figure 18. Recharge/Discharge Areas between Surficial Deposits and continental Foremost Aquifer

No attempt has been made to estimate the flow through any other part of the *continental* Foremost Formation or any of the other bedrock aquifers.

7 POTENTIAL FOR GROUNDWATER CONTAMINATION

The most common sources of contaminants that can impact groundwater originate on or near the ground surface. The contaminant sources can include leachate from landfills, effluent from leaking lagoons or from septic fields, and petroleum products from storage tanks or pipeline breaks. The agricultural activities that generate contaminants include spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that do or can produce a liquid which could contaminate groundwater, it is prudent (from a hydrogeological point of view) to locate the activities where the risk of groundwater contamination is minimal. Alternatively, if the activities must be located in an area where groundwater can be more easily contaminated, the necessary action must be taken to minimize the risk of groundwater contamination.

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. When there are groundwater recharge areas, low-permeability materials impede the movement of liquid contaminants downward. Therefore, if the soils develop on a low-permeability parent material of till or clay, the downward migration of a contaminant is slower relative to a high-permeability parent material such as sand and gravel of fluvial origin. Once a liquid contaminant enters the subsurface, the possibility for groundwater contamination increases if it coincides with a higher permeability material within one metre of the land surface.

To determine the nature of the materials on the land surface, the surficial geology map prepared by the Alberta Research Council (Shetsen, 1990) has been reclassified based on the relative permeability. The classification of materials is as follows:

1. high permeability - sand and gravel;
2. moderate permeability - silt, sand with clay, gravel with clay, and bedrock; and
3. low permeability - clay and till.

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 3,164 records in the area of the County with lithology descriptions, 443 have sand and gravel within one metre of ground level. In the remaining 2,721 records, the first sand and gravel is deeper or not present. This information was then gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

7.1.1 Risk of Contamination Map

The information from the reclassification of the surficial geology map is the basis for preparing the initial risk map. The depth to the first sand and gravel is then used to modify the initial map and to prepare the final map. The criteria used for preparing the final Risk of Groundwater Contamination map are outlined 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 2. Risk of Groundwater Contamination Criteria

The Risk of Groundwater Contamination map shows that, over 35% of the County, there is a high or very high risk of the groundwater being contaminated. These areas would be considered the least desirable ones for groundwater development that has a product or by-product that could cause groundwater contamination. However, because the map has been prepared as part of a regional study, the designations are a guide only; detailed hydrogeological studies must be completed at any proposed development site to ensure the groundwater is protected from possible contamination. At all locations, good environmental practices should be exercised in order to ensure that groundwater contamination does not affect groundwater quality.

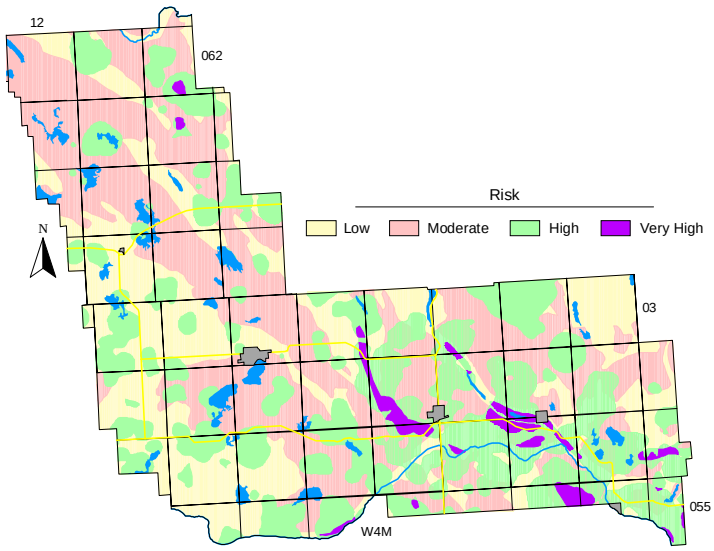

Figure 19. Risk of Groundwater Contamination