GROUNDWATER RESOURCES
IN THE
COOKS CREEK CONSERVATION DISTRICT

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SUMMARY

1. The main aquifer in the District is formed by carbonate rock that underlies the whole District. Sand and gravel aquifers are common along the eastern boundary of the District.

2. Groundwater for rural non-farm residential and farm requirements is readily available throughout most of the District.

3. Groundwater is of acceptable quality for domestic water supply and is available in most of the District.

4. The groundwater resources in the District are adequate for existing and some new development.

5. In the central and southwestern part of the District salty water appears to be common in deep aquifers. Hence developing the deep aquifers should be avoided in this area.

6. Extensive flowing and high water level well areas exist in the central part of the District. Wells in these areas should be properly constructed to prevent uncontrolled groundwater discharge.

7. Groundwater pollution hazard areas exist at several locations in the District where sand and gravel deposits or the carbonate rock are at or near the ground surface. Most of the groundwater pollution hazard areas are located in the eastern part of the District.
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1 INTRODUCTION

The purpose of this report is to provide an appraisal of the groundwater resources in the Cooks Creek Conservation District for the Conservation District Board.

The report is based on available information comprising a groundwater availability study of the Winnipeg Area by the Water Resources Branch (J. Little, 1980), soils maps (Ehrlich et al, 1953) and groundwater data in the files of the Water Resources Branch of the Department of Natural Resources.

The International System of Units (SI), commonly referred to as the metric system, and the following symbols of the SI units are used in the report:

- metre: m
- square metre: m²
- cubic metre: m³
- kilometre: km
- square kilometre: km²
- litre: L
- second: s
- litres per second: L/s
- cubic metres per year: m³/a (annum)
- milligrams per litre: mg/L

All dimensions and quantities are also shown in commonly used Imperial units in parentheses.
PHYSIOGRAPHY

The western central part of the District as illustrated in Figure 1 is occupied by a very flat lake plain, which corresponds to the extensive area underlain by clay indicated in Figure 3. In the areas underlain by glacial till, sand and gravel, the topography is slightly undulating. A few low hills exist in the area adjacent to Birds Hill Provincial Park. The difference in elevation between the headwaters area and the mouth of Cooks Creek is about 80 m (260 ft.). Most of this change in elevation is in the upper reach of the Creek before it enters the extensive central plain area.

GEOL OGY

3.1. Geology and Groundwater

Rock formations and the unconsolidated deposits overlying the bedrock contain the openings through which groundwater flows and in which it is stored. Consequently the geology of an area has a significant effect on groundwater resources in it. Hence, the geological setting of the Cooks Creek Conservation District is described. The general geological setting of the District is schematically depicted in Figure 1.

3.2. Bedrock

The whole District is underlain by carbonate bedrock (limestone and dolostone). The thickness of the carbonate rock formation ranges from about 150 m (500 ft.) in the area along the Red River Floodway to a few metres in the extreme southeast corner of the District, (Figure 1). In the northern part of the District (north of TH No. 44) and along the western boundary the total thickness of the carbonate rock formation is around 70 m (230 ft.) and along the eastern boundary it is less than 60 m (200 ft.).

The depth to the bedrock as indicated in Figure 2 ranges from
a few metres (yards) to more than 30 m (100 ft). In the area north and northeast of the Birds Hill Provincial Park buried sinkholes penetrating the carbonate rock are common. The approximate locations of the sinkholes are indicated on the depth to bedrock map (Figure 2). The lower part of the sinkholes is usually filled with clayey shale, sandstone, boulders, sand and silt deposited before the Ice Age and the upper part is filled with deposits of glacial origin. The bottom of the sinkholes commonly is from 50 m (165 ft.) to 70 m (230 ft.) below ground level and, consequently, often more than 60 m (190 ft.) below the surface of the carbonate rock adjacent to the sinkholes.

The carbonate rocks are underlain by interbedded shale and sandstone. The thickness of the shale and sandstone formation is about 50 m (150 ft.). The shale and sandstone sedimentary rocks are underlain by granitic and other igneous and metamorphic rocks.

The carbonate rock usually contains highly permeable zones and, therefore, can transmit and store groundwater. The sandstone beds are also permeable and play a significant role in respect to groundwater movement in the area. The materials filling the sinkholes usually are of low permeability. The igneous and metamorphic rocks that underlie the sedimentary rocks generally are practically impermeable and, therefore, they are considered to form the base of the zone in which significant groundwater movement takes place.

3.3. Surficial Deposits

3.3.1. Classification

The surficial deposits in the District have been deposited mainly by glaciers and glacial lakes during the Ice Age. Based on mode of origin and grain size the surficial deposits in the District can be classified as follows:

- till,
- clay,
- silt,
- sand,
3.3.2. Till

Till, which is a mixture of clay, silt, sand, gravel and cinders deposited by glaciers during the Ice Age, overlies the bedrock throughout the District (Figure 1). The thickness of the till ranges from a few metres to more than 10 m (100 ft.) and varies considerably from place to place. Till is the dominant material of surficial deposits along the eastern boundary of the District and in the northern part of it. The areas where the till is exposed or is overlain by only a thin layer (less than one metre) of other surficial deposits are indicated in Figure 3. The permeability of till is low and, therefore, groundwater movement through it is very slow. The till, however, may contain lenses of sand and gravel that can be water bearing.

3.3.3. Clay

In extensive areas the till is overlain by clay. As indicated in Figure 3, clay covers most of the central part of the District. The clay thickness ranges from zero to 50 m (150 ft.) and varies considerably from place to place. Along the middle reach of Cooks Creek and west of it the clay thickness generally ranges from 5 m to 15 m (15 - 50 ft.). Because clay is practically impermeable it inhibits groundwater movement and, consequently, has a negative influence on the groundwater resources in the District.

The clay layer, however, has a beneficial effect in respect to aquifer pollution; the impermeable layer prevents surface pollutants from seeping into the aquifers that underlie the area.

3.3.4. Silt

In a few small areas (Figure 3) the surface deposits consist of
silt. The surface silt deposits generally are less than 10 m (30 ft.) thick. Indications are that at some locations, particularly in the area adjacent to the eastern boundary of Birds Hill Provincial Park, thick silt deposits underlie the surface sand. Silt is more permeable than clay but the movement of water in it is so slow that it cannot be withdrawn at an adequate rate for water supply.

3.3.5. Sand

Fairly extensive surface sand deposits are common in the area along the eastern boundary of the District (Figure 3) and in the area adjacent to Birds Hill Provincial Park. In the eastern part of the District the sand deposits generally are underlain by till and in the Birds Hill Provincial Park and adjacent area the sand often is underlain by silt and gravel. Sand deposits interbedded in the till or at the base of it also are common in the same general areas where sand is at surface. The thickness of the sand deposits ranges from zero to more that 20 m (65 ft.). Sand can readily transmit and store water. Consequently saturated sand may yield water in appreciable quantities.

3.3.6. Sand and Gravel

Sand and gravel deposits in the District form surface deposits in the same general areas as the sand deposits (Figure 3). A few small sand and gravel areas also exist in the vicinity of East Selkirk. As with the sand deposits, sand and gravel deposits are also interbedded in till and are found at the base of it. The thickness of the sand and gravel deposits ranges from a few metres to more than 50 m (10 to 150 ft.). In general, the narrow long deposits, which are ancient beach deposits, are thin but in the more extensive sand and gravel areas the thickness may be considerable. The sand and gravel deposits usually are highly permeable and, therefore, can form high yield water bearing formations.
3.3.7. **Swamp Deposits**

Swamp deposits overlie the till and other surficial deposits in the headwaters area (Figure 3). In respect to groundwater supply the swamp deposits are of no practical significance.
4. GROUNDWATER

4.1. Aquifers

4.1.1. Definition

In the discussion of the geology of the District it was indicated that some of the surficial deposits and some kinds of the bedrock readily transmit and store groundwater. The rock formations and surficial deposits that yield water to wells at a rate sufficient for a water supply are called aquifers.

4.1.2. Classification

Based on the materials forming them the following aquifers can be discerned in the District:
- carbonate rock,
- sandstone, and
- sand and gravel.

4.1.3. Carbonate Rock Aquifer

The carbonate rock that underlies the entire District and much of the surrounding area constitutes an extensive aquifer. Minor sand and gravel deposits laid down directly on the carbonate bedrock and hydraulically connected to it are considered as part of the carbonate aquifer. The carbonate aquifer is the main aquifer in the District and most wells draw water from it.

The depth to the aquifer in most of the District is equal to the depth to the bedrock as indicated on the depth to bedrock map (Figure 2). At some locations in the vicinity of Carson and East Selkirk the bedrock is at or near ground surface and the water table is below the rock surface. Consequently wells must be drilled through dry rock before reaching the water bearing zone. In the buried sinkholes the depth to the carbonate rock can be more than 40 m (130 ft.); deeper than the depth to bedrock. In other words, wells that happen to be located on a buried sinkhole have to be drilled deeper than wells in the adjacent area to reach the carbonate rock aquifer. As indicated in Figure 2,
sinkholes are common in the area north and northeast of Birds Hill Provincial Park.

The static or non-pumping level in wells in the carbonate aquifer in the District ranges from a few metres above ground level at some locations in the southeastern and central parts of the District to more than 10 m (33 ft.) below ground level in the higher areas adjacent to the Birds Hill Provincial Park. In general, the static level is less than 10 m below ground level.

The main water-bearing zone usually is in the upper part of the carbonate rock, if the rock is saturated to its surface. In addition to the upper water-bearing zone other water-bearing zones exist deeper in the rock.

The water-bearing properties of the carbonate rock can vary greatly within short distances. The yield of similar wells, i.e., wells of similar depth, dimensions of casing, and elevation, can range from 1 L/s to more than 10 L/s (13 to more than 130 G.P.M.) within a distance of a few hundred metres (yards). Consequently, despite the fact that some high-capacity wells have been constructed in the District, it cannot be assumed that high-pumping rates can be readily obtained at every location.

4.1.4. Sandstone Aquifers

The sandstone aquifers are formed by the sandstone beds in the shale and sandstone formation that underlies the carbonate rock throughout the District. The sandstone aquifers are used for water supply in areas where water in the carbonate rock aquifer has high sulphate concentration and is very hard and water in the sandstone aquifers is very soft. The total dissolved mineral concentration, however, is about the same in both aquifers but for many users the soft and usually slightly salty water is more acceptable than the hard water. These conditions are common in the vicinity of Dugald and at a few other locations south-west of there. In general, the sandstone aquifers are not developed because, in most of the District, they are at considerable depth or the water is too salty for most uses. The maximum
yield of wells in the sandstone aquifers usually is less than 20 L/s (260 G.P.M.).

4.1.5. Sand and Gravel Aquifers

Some of the surface sand and gravel deposits and most of sand and gravel deposits that are interbedded in or underlying the till or the clay are water bearing. As indicated on the surface deposits map (Figure 5) some of the sand and gravel deposits are fairly extensive and consequently may form extensive aquifers. The sand and gravel aquifers, however, generally are not used for water supply because it is technically simpler and, in most cases, less expensive to drill a well through the sand and gravel aquifers into the carbonate rock aquifer. In areas where the carbonate aquifer is at more than 30 m (100 ft.) below ground level, where the yield of the carbonate rock aquifer is not satisfactory and where higher yield and better quality sand and gravel aquifers are available; it may be economically advantageous to draw water from the sand and gravel aquifers. Indications are that some high yield sand and gravel aquifers exist in the area just south of Birds Hill Provincial Park. It is very likely that some high yield sand and gravel aquifers exist along the eastern boundary of the southern half of the District. The yield of wells completed in the sand and gravel aquifers usually is in the 0.5 L/s to 2 L/s range (5 to 25 G.P.M.) The intermittent yield of high capacity wells in the thicker and more permeable sand and gravel aquifers could be up to 100 L/s (1300 G.P.M.).

4.2. Groundwater Flow Systems

Groundwater constitutes the underground component of the water that flows through the District. Part of the groundwater that flows through the District originates from precipitation outside the District and enters it as subsurface inflow. This inflow may have originated
hundreds of kilometres (miles) west of the District and is called the regional flow system. The flow systems that originate from precipitation within the District and, in some places, just outside it are called local flow systems; in area extent they may cover a large part of the District or less than one square kilometre. The main trends of the groundwater flow systems are indicated in Figure 1.

Because water dissolves the minerals in the strata through which it moves, the water of the regional flow system that arrives in the District after travelling a long distance is considerably more mineralized than water in the local flow systems. Water in the regional flow system that enters the District from the south and southwest is very salty and is the source of the salty water in the District.

Groundwater that enters the District from the east and northeast originates only a short distance outside the District and, therefore, the flow systems that cross the eastern and northeastern boundaries are considered as local flow systems. Other local flow systems originate in elevated surface sand and gravel areas and other higher parts in the District and in the Birds Hill Provincial Park Area. Because water in most of the local groundwater flow systems has travelled only a short distance, it is fresh and its quality in most of the District ranges from fair to excellent.

The groundwater flow systems have a strong influence on the groundwater quality in the District; in places or depth zones where the local systems are dominant it is fresh and where the regional system is dominant it is salty.

The regional flow system is dominant in the sandstone aquifers in the western part of the District. In some places it has intruded deep water-bearing zones at the base of the carbonate rock.

The local flow systems dominate to the base of the sedimentary rocks in the area east of Cooks Creek, but only in the upper part of the carbonate rock and in the sand and gravel aquifers above it in the rest of the District.

4.1. Recharge

In the discussion of the groundwater flow systems in the District
it was indicated that the fresh or potable groundwater originates from precipitation that infiltrates the substrata within the District and in the vicinity of it. Hence, the fresh groundwater supply in the District to a large extent depends on the infiltration of precipitation or aquifer recharge in the District and immediate vicinity.

Groundwater recharge in Manitoba is mostly from snowmelt and early spring rains. Summer precipitation usually is returned to the atmosphere by evapotranspiration before it can contribute to the recharge of aquifers. Groundwater level monitoring, however, indicates that exceptionally heavy rainfall in the summer and particularly in the fall can be a significant factor in groundwater recharge.

Observations of groundwater level fluctuations in shallow sand and gravel aquifers in Manitoba indicate that on the average the yearly recharge in readily recharged aquifers is equal to about 0.1 m (0.3 ft.) of water over the recharge area. Because in some of the recharge areas in the District conditions are not favorable for high infiltration rates, it is assumed that the recharge is 0.05 (0.15 ft.) over the main recharge area.

Assuming that the main recharge area is equal to the surface sand and gravel areas and bedrock areas overlain by less than 5 m of till and clay with static level below the bedrock surface the total recharge area of the District is about 100 km² or 100 x 10⁶ m² (40 square miles). The total recharge over these areas is 5 x 10⁶ m³ (4050 acre-feet) of water. Minimal recharge likely takes place in areas underlain by till in the upper reach of the Cooks Creek watershed and along the eastern boundary of it. The area of this recharge area is about 200 km² or 200 x 10⁶ m² (80 square miles) and the recharge is assumed to be about one percent of the annual precipitation or 0.005 m (0.08 feet). The recharge over the till areas then is about 1.0 x 10⁶ m³ (810 acre-feet). Thus the total estimated recharge is about 6 x 10⁶ m³ (4900 acre-feet).

4.4. Total Supply

In the Cooks Creek Conservation District the total supply of potable groundwater depends mainly on local recharge. Water in the deep regional flow system that enters the District along the
west and south is salty and, therefore, deep water bearing zones in
most of the District are of no consequence in respect to fresh water
supply. Some inflow of fresh groundwater from adjacent areas may occur
in the upper reach of the District and adjacent to Birds Hill Provincial
Park.

Although the estimated total yearly recharge is about 6 x 10^6 m^3
(14900 acre-feet) not all of it is available for use because of losses by
evapotranspiration, groundwater discharge into streams and subsurface
outflow. Consequently, for a conservative estimate it can be assumed
that the total supply available for development is one half of the total
recharge or 3 x 10^6 m^3 (2450 acre-feet) a year. This is equivalent to a
sustained pumping rate of 95 L/s (270 GPM). This indicates that a few
high capacity wells in or near the district could have a serious effect
on groundwater resources in the area.

It should be noted that, on the one hand, the total supply of
groundwater available for development in the District depends on develop-
ment in adjacent areas and, on the other hand, groundwater development
in the District could cause considerable inflow of groundwater from
adjacent areas which would increase the total supply.

4.5. Well Yield

The yield of most wells installed in the carbonate rock aquifer
generally is more than 1 L/s (15 GPM) and the intermittent yield of high
capacity wells could be up to 100 L/s (1300 GPM). At a few locations,
however, the yield can be barely enough for a domestic supply. The yield
of wells installed in the sand and gravel aquifers has a similar range as
for wells installed in the carbonate rock aquifer. The pumping rates of
the wells drawing water from the sandstone aquifers are adequate for
domestic and farm requirements; the pumping rates of high capacity wells
are not likely to exceed 20 L/s (260 GPM).

4.6. Quality

Groundwater quality in the District ranges from excellent to
very salty. The terms used for quality description are described in
Appendix "A".
Excellent quality water is common in sand and gravel aquifers at surface and in the carbonate rock aquifer underlying or adjacent to the sand and gravel aquifers.

In the vicinity of Dugald and in a small area in the eastern part of Oakbank water in the upper part of the carbonate aquifer is of poor quality because of very high hardness and sulphate ion concentrations. In the vicinity of Dugald softer and low sulphate water can be obtained from the sandstone aquifers that exist below the carbonate rock. The deep water, however, has about the same dissolved minerals concentration as the shallower water and is slightly salty. In extensive areas of the District, as discussed in the following section, drilling to the deep sandstone aquifers is not recommended and, in fact, should be prohibited.

4.7. Salty Groundwater Area

As indicated in Figure 1 water is salty in the sandstone along the western and southwestern boundaries of the District and indications are it has intruded the central part of the District.

Water in the sandstone is very salty in the Winnipeg area. In the District salty water has been reported in deep wells in the area between Dugald and Oakbank, northeast of Oakbank and south of Garson. East of the District salty water has been found in wells drilled into the sandstone in Townships 12 and 13. Based on this information it seems that the salty water zone crosses the District from the Red River Floodway northeasterly towards Haseiridge and Garson. The salt water zone may extend towards East Selkirk west of Cooks Creek. Although the main salt water bearing formation is the sandstone that underlies the carbonate rocks, in some places the salty water has intruded the lower part of the carbonate aquifer. Consequently, in the salty water area drilling to the base of the carbonate rock is not advisable and drilling into the sandstone should be prohibited unless the well driller has made all preparations to seal off the potential salt water zone before drilling into the sandstone. Leaving wells or test holes that are drilled into the salt water zone unsealed or improperly constructed
is likely to cause saltwater intrusion into the potable water zones; i.e.,
potable water aquifer pollution by salty water intrusion. The recommended
basic well design for sealing off salty water is depicted in Figure 7.
The approximate boundaries of the deep salty water area are indicated in
Figure 4. As the boundaries are based on very limited information,
the exact boundaries of the salty water area could be considerably different.
However, there is no doubt that the central part of the District is underlain
by an extensive deep salty water zone and that a danger of fresh water pollu-
tion by improperly designed deep wells and unsealed test holes exists.

4.8. Availability

Fair to excellent quality groundwater for domestic and farm
requirements is readily available throughout most of the District. In
a few small areas groundwater quality is a problem or the yield is very
low.

Poor quality water is common in the vicinity of Dugald where
water in the carbonate aquifer is very hard and has high sulphate con-
centration and water in the deep sandstone aquifer is slightly salty.
The permeability of the carbonate aquifer is low at some locations
east and northeast of Birds Hill Provincial Park. In the same area
buried sinkholes filled with low permeability materials are also common
and may necessitate drilling deep wells or relocating wells.

On the other hand at many locations in the District the car-
bonate rock aquifer and sand and gravel aquifers may be suitable for
high capacity wells yielding more than 30 l/s (400 I.G.P.M.)

Since a single residence on the average requires about 1000
litres (220 gallons) of water per day or 365 m³ (10,000 gallons) per
year and the total recharge is several million cubic metres per year,
the supply, no doubt, is adequate for thousands of residences, and some
other development.

Furthermore, considerable inflow of groundwater into the
District from adjacent watersheds might occur along the eastern boundary
of the District, if groundwater use causes significant decline of ground-
water levels in the District.

Because the intensively developed part of the District is in the Municipality of Springfield and in respect to area and development, the Municipality can be considered as representative of the District, an estimate of current water consumption can be made based on statistics for the Municipality. According to 1976 statistics the population of Springfield was 6944. Assuming a water consumption of 250 L/d (65 gallons/day) per person the yearly consumption then is $0.63 \times 10^6$ m$^3$ (310 acre-feet). The total number of cattle in 1976 was 13,000. Assuming a consumption of 50 L/d (11 gallons/day) per head the total yearly consumption by cattle is $6.5 \times 10^5$ m$^3$ (195 acre-feet). Because some water is used by other livestock and there are other minor users, the total groundwater consumption for the District is about one million cubic metres (810 acre-feet) per year. Since the total groundwater supply of the District is around three million m$^3$ (4500 acre-feet), the supply is abundant for existing requirements and some new development.

4.9. Flowing and High Water Level Well Areas

In several areas in the District the water level in many wells rises above ground level. The flowing and high water level well areas are indicated on the map in Figure 5. Because uncontrolled flowing wells may cause a number of problems, wells in these areas should be constructed so that discharge can be controlled. The problems caused by flowing wells are discussed and a suggested basic design for flowing wells is shown in Appendix B.

In high water level wells the water level is below ground level but above or near the basement floor level. These conditions are common in areas adjacent to flowing wells. High water level wells may cause some of the same problems (See Appendix C) as those caused by flowing wells. Hence, their construction should make provision for control of discharge in a similar manner to that of flowing wells (Figure 8).
Groundwater pollution hazard in the District exists in areas where sand and gravel deposits or carbonate rock are at or near the ground surface. The groundwater pollution hazard areas are outlined in Figure 6.

The sand and gravel deposits are considered as groundwater pollution hazard areas because they may be water bearing and septic tanks installed in the deposits or other sources of pollutants could cause aquifer pollution.

The areas where the carbonate rock is at or near the ground surface are at and west of Carson. In some places within these pollution hazard areas the rock is only a metre (a few feet) below ground surface and groundwater pollution from septic fields and other sources is likely to take place.

Outside the groundwater pollution hazard areas indicated in Figure 6, the aquifers are covered by thick clay and/or till deposits and groundwater pollution is not likely.

Because in some parts of the municipality saline groundwater is found below the fresh water zones, pollution of the fresh water aquifers by saline water flowing upward through test holes and abandoned wells is possible. Hence, the abandoned wells and test holes should be backfilled with clay, clayey sand or other materials that would prevent groundwater flow as illustrated in Figure 7.
REFERENCES


Numerous flowing well areas exist in Manitoba. Extensive flowing well areas are common in the Interlake region and in the south-eastern part of the Province. In the flowing well areas the water level in most wells rises above ground level and in others it is near ground level. Some of the wells may flow when groundwater levels are high and stop flowing during periods of low levels.

Uncontrolled discharge from flowing wells may cause some of the following problems:

1. Icing up of drains that, in turn, results in ice covered roads and flooding during spring runoff;
2. Damage to roads, bridges and drains;
3. Damp basements;
4. Damage to buildings due to excessive soil moisture or ice;
5. Wet and swampy yards and fields;
6. Flooding of septic tank drain fields.

Since the aforementioned problems caused by uncontrolled flowing wells are likely to affect the well owner, his neighbours and public property in the vicinity, wells in flowing well areas should be constructed so that discharge can be controlled.

The discharge from flowing wells can be brought under control by proper well construction. A basic design for controlled flowing wells is shown in Figure 8.
APPENDIX C

High Water Level Wells

High water level wells are defined as wells where the water level is below ground level but above or near the basement floor level. If high water level wells are not properly designed they may cause problems similar to some of those caused by flowing wells, such as:

1. Damp basements,
2. Flooding of septic tank drain fields,
3. Unnecessary pumping from sumps,
4. Damage to foundations and basement floors.

The problems are caused by water seeping or flowing up outside the well casing and then flowing through the backfill of water pipe excavations towards the building. If well pits are used to make connections between the well and the water pipe these problems may be caused by water flowing from the well into the pit and thence to the basement.

To prevent the aforementioned problems, wells in high ground-water level areas should be constructed in the same manner as controlled flowing wells. The basic design for high water level wells is shown in Figure 8.
**Figure 7**

Provincial of Manitoba

Department of Natural Resources

Water Resources Branch

Basic Well Design for Sealing Off Highly Mineralized (Salty) Water

- **GEOLOGICAL AND GROUNDWATER CONDITIONS**
  - **WELL DESIGN AND SEAL**
  - **GROUND LEVEL**
  - **WELL CASING**
  - **STATIC LEVEL**

- **SURFICIAL DEPOSITS AND ROCK FORMATIONS**

- **WATER BORING ZONE**
  - **FRESH WATER**

- **IMPERMEABLE LAYER**
  - **CLAY, TILL, SHALE SOLID LIMESTONE**

- **HIGHLY MINERALIZED (SALTY) WATER**

- **BACKFILL (SAND)**

  - **CEMENT SEAL, NEAT CEMENT OR SAND AND CEMENT, MINIMUM 10 FEET (3m) OR THE THICKNESS OF THE IMPERMEABLE LAYER IF IT IS LESS THAN 10 FEET (3m). IMPERMEABLE FILL (CLAY, CLAYEY SAND) OR CEMENT GROUT.**
NOTE: This design is also advisable in places where the water level is below ground level but above or near basement floor level.

FIGURE 8

BASIC WELL DESIGN FOR
CONTROLLED FLOWING WELLS