SUSTAINABLE IRRIGATION IN MANITOBA
UNDER THE HILL FARMS - A CASE STUDY

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ABSTRACT

Under the Hill Farms Ltd., located in South Central Manitoba, diversified into irrigated crop production in 1997. The farm operation includes up to 900 acres (360 ha) of irrigated potatoes and specialty crops (e.g., grass, hybrid seed, garlic), in rotation with grains and oilseeds. The total farm base involves over 3100 acres (1250 ha). The entire project overlies the Assiniboine Delta Aquifer, an extensive unconfined aquifer which provides municipal, domestic and agricultural water supplies. The project withdraws up to 525 ac-ft (650 dam³) of water per year from the Assiniboine Delta Aquifer, the Assiniboine River and two wetlands. Potential exists to recharge the wetlands from the Assiniboine River.

The Under the Hill Farms irrigation project was the first irrigation project on the Assiniboine River or the Assiniboine Delta Aquifer to receive a Manitoba Environment Act Licence. The licencing process considered an array of environmental issues including habitat and fisheries protection, and soil and water quality maintenance. The licence conditions include monitoring of environmental impacts. Under the Hill Farms is required to monitor water consumption, wetland water levels, Assiniboine River levels, and soil and plant nitrate levels. Under the Hill Farms also cooperates with the Manitoba Crop Diversification Centre on a water quality monitoring project to aid in research into the movement of nitrates and pesticides to the groundwater.

The Environment Act Proposal and Licence documents and confirms the producer commitment to the environment through sustainable production. In addition, the licencing process has heightened the producer’s awareness of environmental issues and impacts. Ongoing monitoring will help Under the Hill Farms to refine their management practices to maintain a sustainable farm operation for generations to come and provide research information for future irrigation developments.

INTRODUCTION

Under the Hill Farms Ltd. is located in South Central Manitoba (Fig. 1). The farm converted to irrigated crop production in 1997, in order to diversify from dryland cereal and oilseed crops. By 1999, Under the Hill Farms Ltd. included up to 900 acres (360 ha) of irrigated potato and specialty crops (e.g., grass and hybrid seed, garlic). The total land base for the farm includes over 3100 acres (1250 ha), all of which has access to irrigation in rotation. Under the Hill Farms also brings in feeder cattle each fall, as a means of diversifying their operation.

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2 Senior Soil Specialist, Prairie Farm Rehabilitation Administration (PFRA), 200-101 Route 100, Morden, MB, Canada, R6M 1Y5.
In 1997, environmental sustainability of the proposed Under the Hill Farms irrigation project was an issue for the producer as well as the public. From a public perspective, the project had several implications:

- the project overlies the Assiniboine Delta Aquifer, an extensive unconfined aquifer which supplies municipal, domestic and agricultural water;
- the project draws from the Assiniboine River, a spawning ground for the Lake Winnipeg fishery, and source of municipal water supply, waste assimilation, and public recreation;
- two surface and ground water fed wetlands are impacted; including the option to enhance recharge to the wetlands using water from the Assiniboine River;
- the public desires sustainable land management to be practiced by producers.

Sustainability is also an issue for Under the Hill Farms. Generally speaking, they have a long term interest in soil and water quality maintenance, as this is the basis for production. Moreover, Under the Hill Farms has a moral commitment to making management decisions which protect their own and their neighbours' water supplies from contamination. Lastly, any pollution of ground or surface water could put their production contracts and investment at risk due to the possibility of legal action.

For the producer, irrigation allows for diversification by limiting the risk of drought related crop failure. This is critical on the Prairies relative to securing contracts for higher value crops, such as potatoes or hybrid seed production. For the project area the average water deficit for potatoes is 4.5 inches (115 mm) and the deficit at 10% risk\(^3\) is 7 inches.

\(^3\) 10% risk refers to the water deficit for potatoes equaled or exceeded 1 in 10 years.
Sustainable Irrigation in Manitoba (180 mm) (MB Ag, 1998). This water shortage generally occurs equally between July and August, well after major spring runoff from snow melt. For 900 acres this shortage translates to an average irrigation demand of 340 ac-ft (420 dam³), and a demand at a 10% risk³ of 525 ac-ft (650 dam³).

In Manitoba, the development of this volume of water requires an environmental impact assessment and granting of an Environment Act Licence before the project can proceed. PFRA, a Branch of Agriculture and Agri-Food Canada, provided environmental impact analysis of the proposed farm practices, mitigation and monitoring measures (PFRA, 1998). Manitoba Environment Act Licence #2345 (July, 1998), was the first irrigation project licence issued on the Assiniboine River or the Assiniboine Delta Aquifer.

PROJECT DESCRIPTION

Irrigated Areas and Soil Suitability

Figure 2 shows the lands that can be irrigated in the project. The soils to be irrigated are clay loams to fine sands. Table 1 shows the percentage breakdown according to irrigation suitability⁴. Limitations to these soil types for agricultural production include moisture holding capacity (sands) to imperfect drainage (clay loams).

Table 1 - Under the Hill Farms Ltd. - Soil Suitability for Irrigation

<table>
<thead>
<tr>
<th>Irrigation Rating⁴</th>
<th>% Project</th>
<th>Acres</th>
<th>Surface Soil Textures</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>11</td>
<td>345</td>
<td>loams</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>52</td>
<td>1648</td>
<td>loamy sand to sand</td>
<td>moisture holding</td>
</tr>
<tr>
<td>Fair</td>
<td>22</td>
<td>700</td>
<td>sand or clay loam</td>
<td>moisture holding, topography, imperfect drainage</td>
</tr>
<tr>
<td>Poor</td>
<td>5</td>
<td>147</td>
<td>sand</td>
<td>not irrigated (bush)</td>
</tr>
<tr>
<td>No Soils Map⁵</td>
<td>10</td>
<td>324</td>
<td>unknown</td>
<td></td>
</tr>
</tbody>
</table>

Water Sources and Infrastructure

Infrastructure: Figure 2 shows the layout of the project infrastructure. Close to 17 miles (28km) of pipelines connect 4 water sources and 6 pumps. The system will support five quarter section pivots running at 650 USgpm (41 l/s) each. Two traveling guns using 450 USgpm (28 l/s) are used in rotation with the pivots. The water sources are provided in Table 2 and descriptions of each source follows with respect to water quantity and quality.

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⁴ Based on Agriculture Canada, 1987, Contribution 87-83; and unpublished data from Centre for Land and Biological Resources Research, Manitoba Land Resources Unit.

⁵ 1:20000 soils maps are incomplete but reconnaissance maps rate the area good.
Fig. 2 - Under the Hill Farms - Irrigated Lands and Water Infrastructure

Table 2 - Under the Hill Farms Ltd. - Water Sources and Pumping Rates

<table>
<thead>
<tr>
<th>Description</th>
<th>Volume</th>
<th>Water Sources</th>
<th>Pump Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herman’s Slough</td>
<td>200 +/- ac-ft</td>
<td>Runoff, Aquifer, pump from River</td>
<td>1300 USgpm</td>
</tr>
<tr>
<td>East Slough</td>
<td>35 ac-ft</td>
<td>Runoff, Aquifer, pump from River</td>
<td>650 USgpm</td>
</tr>
<tr>
<td>North Dugout</td>
<td>15 ac-ft</td>
<td>Assiniboine Delta Aquifer</td>
<td>100 USgpm</td>
</tr>
<tr>
<td>Assiniboine River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>200-250 ac-ft</td>
<td>Runoff, Shellmouth Dam</td>
<td>1300 USgpm</td>
</tr>
<tr>
<td>Summer</td>
<td>100-275 ac-ft</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6 Useable volume depends on the rate of recharge from the aquifer during July/August.
Assiniboine River: The Assiniboine River (Fig. 1) emanates in Saskatchewan to the west of the project area. Spring runoff on this River averages over 1,000,000 USgpm (63,000 l/s); while the average summer flow is in the order of 300,000 USgpm (19,000 l/s). During summer, fall and winter and droughts the River is supplemented by releases from the Shellmouth Dam (Fig. 1).

The water quality in the Assiniboine River is considered excellent for the purposes of irrigation with EC of 550 to 1300 μS/cm and an SAR in the order of 1.0. Sodium (Na) ranges from 20 to 150 ppm, calcium (Ca) from 40 to 600 ppm, and magnesium (Mg) from 15 to 90 ppm; with pH ranging from 7.2 to 8+ (PFRA, 1997). At times, the following parameters slightly exceed the Manitoba guidelines for irrigation: sulphate, iron, aluminum, manganese, nickel and the herbicide MCPA. Fecal coliform counts within the Assiniboine River can range to 200 cfu/100 ml, which is below the field crop criteria. Several other pesticides have been detected at levels below concern for irrigation; namely Dicamba and 2,4-D (KGS Group, 1999).

Assiniboine Delta Aquifer: The geologic setting for the irrigable area is the Assiniboine Delta Aquifer. The Assiniboine Delta Aquifer resulted from the formation of a large delta at the mouth of the glacial age Assiniboine River where it flowed into glacial Lake Agassiz (Fig. 1). The aquifer is a deltaic sand and silt deposit which directly overlies the clay bed of former Lake Agassiz.

The recharge to the Assiniboine Delta Aquifer is about 1 to 1.5 inches per year, with only 50%, or about 40 ac-ft (50 dam³) per section of land, allocated for consumptive use (PFRA, 1998). Well yields in the vicinity of the project area were estimated by local well drillers to be only 100 USgpm (6 l/s) (personal comm. D. Berry), limiting the potential to provide for a larger project (e.g., 3000+ USgpm). The North Dugout was excavated into the Aquifer but the slow recharge rate limited pumping to 100 USgpm (6 l/s). For this reason the wetlands and the Assiniboine River were considered as water sources.

The water quality in the Assiniboine Delta Aquifer is generally considered excellent for the purposes of irrigation and domestic consumption. In the vicinity of the project area, water quality within the surficial sands (i.e., 20 to 70 feet) ranges from EC of 400 to 2400 μS/cm. Sodium (Na) ranges from 10 to 260 ppm, calcium (Ca) from 70 to 110 ppm, magnesium (Mg) from 20 to 55 ppm, and pH from 7.3 to 8.

Herman's and East Slough: The Herman's and the East sloughs have surface storage amounting to 250+/- ac-ft (310 dam³) and 35 ac-ft (43 dam³) respectively. Herman's slough is located in an area with potential for groundwater recharge. The East slough appears to be outside the area of coarse sand deposits, having little groundwater recharge potential. Mathematical modelling predicted little groundwater recharge during the two month irrigation season. Moreover, the Herman's slough was expected to recharge by only about 50 to 75% from groundwater one year after being drawn down (PFRA, 1998).

Water monitoring on the Herman's slough (Fig. 3) confirms limited groundwater recharge during the irrigation season. No recharge or drawdown monitoring has been implemented on the East slough at this time.

7 The lower end of this range is more typical, with pockets of poorer quality water showing up towards the upper end of the range reported.
Under the Hill Farms Ltd. - Herman's Slough Elevations

<table>
<thead>
<tr>
<th>Date</th>
<th>Water Elevation (m)</th>
<th>Measurements</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-Jul-99</td>
<td>373.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-Sep-99</td>
<td>373.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Nov-99</td>
<td>373.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Jan-00</td>
<td>373.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Mar-00</td>
<td>372.9</td>
<td>130 ac-ft @ 372.9 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.7</td>
<td>105 ac-ft @ 372.7 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>372.3</td>
<td>40 ac-ft @ Minimum Drawdown 372.3 m</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3 - Herman's Slough - Monitoring Data (1999/2000)

Hydrologic studies indicate that adequate surface runoff for full recharge of both sloughs occurs in more than 50% of the years. Historically, the Herman's slough was dry in the drought of the 1930's (pers comm. D. Berry); while more recent infrared photos show the East slough dry during the drought of the 1980's. On this basis and given the incremental demand of the irrigation projects, the sloughs cannot be counted on as firm water supply.

Provision has been made to pump from the Assiniboine River during the spring freshet to recharge the sloughs at a rate of about 1300 USgpm (82 l/s). The Manitoba Government has not approved the recharge pumping at this point in time. Clause 14 of the Environment Act Licence indicates that:

... storage of water from the Assiniboine River in water storage areas over the Assiniboine Delta Aquifer (e.g., Herman's wetland) shall be considered for approval by the Director only if engineering studies show that the seepage velocity of the water from the water storage areas to the aquifer will be less than 1 x 10^-7 cm/sec.

Further studies, including water level monitoring, are required to prove this is possible.

The water quality of Herman's slough (Table 3) reflects the evaporative history, the surface runoff water quality and the water quality in the upper zone of the Assiniboine Delta Aquifer. No water samples have been taken on the East slough.
Table 3 - Water Quality in the Herman's Slough

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Na (mg/L)</th>
<th>Ca (mg/L)</th>
<th>Mg (mg/L)</th>
<th>EC (μS/cm)</th>
<th>pH</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-02-98</td>
<td>128</td>
<td>53</td>
<td>216</td>
<td>2080</td>
<td>8</td>
<td>1.7</td>
</tr>
</tbody>
</table>

The water quality in Herman's slough is of poorer quality than the Assiniboine River and the Assiniboine Delta Aquifer with respect to soil and water compatibility, having an EC of 2000 μS/cm and an SAR of 1.7. Maximum recommended salt concentrations on the Canadian Prairies for well drained loams to sands is 2500 to 4000 μS/cm and for well drained clay loams is 2000 μS/cm (Sask Water, 1987). For this reason the slough water supply is better suited to the coarser and better drained soils in the project area (approximately 80% of the area is coarse to medium textured). Furthermore, potato yield reductions could be as high as 12% (Sask Water, 1987) for an irrigation water EC of 2000 μS/cm and a leaching fraction of only 10%. Thus the importance of using this water on well drained soils, with a good leaching fraction.

The future recharge with water from the Assiniboine River will have small impact on the Herman's and East slough quality due to the infrequent nature of the pumping, but if anything should improve the water quality in the sloughs. Additional water quality testing on Herman's and East slough is warranted (PFRA, 1998). Additional work is warranted with respect to soil and water compatibility on individual quarters where drainage is a limitation.

BEST MANAGEMENT PRACTICES

Soil Erosion Control

Approximately 80% of the land to be irrigated is coarse to medium textured soils (sands grading to loams). Under the Hill Farms employs many Best Management Practices for soil conservation and is committed to continuing them to maintain long term soil quality and productivity.

When growing cereals and oilseeds (including annual ryegrass) the following management techniques will be employed. Many of these practices are undertaken already (*):

- leave standing stubble until spring seeding (*);
- spread manure on erodible areas (e.g., knolls) up to 300 acres/year (*);
- use air seeder to handle extra residue at seeding (*);
- use direct seeding (both into stubble and potato hills) (*);
- use noble blade for fall weed control (where necessary) (*);
- avoid soil incorporated herbicides where possible (*);
- plant and maintain shelterbelts (*);
- plant annual barriers for snow catch and erosion control;
- plant low height shelterbelts on irrigated quarters.

The water quality is likely significantly poorer (e.g., 50%) due to the ice formation on the slough at the time of the sampling.
When growing potatoes the following management techniques will be employed. Many of these practices are undertaken already (*):

- implement zero till production depending on management considerations such as affordability of chemical (e.g., Prism currently at $40/ac) and equipment (e.g., power hiller) (*);
- use non soil incorporated herbicides (*);
- use vine chopper and disc to anchor vines (*);
- perform no fall tillage on potato land (*);
- plant and maintain shelterbelts (*);
- plant fall cover crops (rye, barley) to protect soil over winter and spring (*);
- plant annual barriers for snow catch and erosion control;
- plant low height shelterbelts on irrigated quarters;
- seed corners on lighter land to cereals/forages (i.e. outside pivot circle).

Water Quality Protection

Groundwater Quality: Groundwater protection involves the controlled management of inputs: water, fertilizer and biocides. Under the Hill Farms is committed to judicious use of nutrients and pesticides in order to minimize the impact on the groundwater.

The Under the Hill Farms Best Management Plan for nutrients does or may include the following techniques. Many of these practices are already undertaken (*):

- avoid fall N application (*);
- use small starter N (e.g., 50 lbs/acre in 1998) (*);
- perform soil testing (to 3' spring/fall; for fields in potatoes the following year) (*);
- perform periodic deep nitrate testing to 8 to 12 feet (every 5 to 10 years) (*);
- split N applications for potatoes (spring, at hilling and subsequent to hilling) (*);
- foliar N applications (3-4 lbs/acre/pass applied with fungicide) (*);
- perform petiole testing on potato plants (used for N scheduling) (*);
- lower the yield goal (200 cwt/acre) on lighter soils and use less N (*);
- use manure credits where applicable;
- use fertigation (in the future);
- use irrigation scheduling methods that closely match crop water requirements.

A lower yield goal is reflected in lower total N applications for the crop relative to other areas in the Province. Nitrogen applications will be split. Soil and petiole testing is used to control the amount and timing of fertilizer to minimize the potential for leaching of nutrients into the groundwater. The current plan is to use foliar application to achieve a close match to fertilizer requirements. Local researchers indicate this may not be the best method to ensure the plant receives adequate nitrogen (pers. comm. Blair Geisel). Accordingly, the Under the Hills may consider fertigation (i.e., application of fertilizer through an irrigation system).
Under the Hill Farms Ltd. does or will employ the following Best Management Practices with respect to pesticides. Some of these practices are undertaken already (*):

- use mechanical weed control (e.g. during hilling) when appropriate (*);
- implement integrated pest management techniques, including blight forecasting;
- use pesticides with Immobile or Nearly Immobile ratings, and Moderate to Non Persistent properties (NDSU, 1988).

**Surface Water Quality:** Water quality on the Assiniboine River and the sloughs will be protected using:

- appropriate backflow prevention devices on the pipeline;
- double wall, non-syphoning fuel storage for diesel motors;
- soil erosion conservation measures (see above).

**Habitat Protection - Fisheries**

At the Assiniboine River pumpsite, fish successfully reproduce and survive in most years, migrating along the length of the river. For this project, impact analysis considered entrainment and impingement of migrating fish, reduced stream flows, the contribution of sediment to the stream during construction, and fuel spills.

**Fish Screen:** The intake to the diesel pumps on the Assiniboine River will be screened to protect fish against entrainment and impingement. Currently, a floating intake will be sized to limit the intake velocity to 0.2 ft/sec (0.06 m/s) which is adequate for walleye with a 25 mm (1 inch) length or greater and northern pike of 45 mm (1.75 inch) length or greater. The intake will have a spray bar rotating at 10 rpm to continuously clean the screen and protect fish from impingement of longer than 6 seconds. The Federal Department of Fisheries and Oceans has tentatively approved this screen.

**Minimum Instream Flow:** Under the Hill Farms is required by Clause 15 of their Environment Act Licence as follows:

TheLicencesehall ensure that a minimum instream flow is maintained below the diversion point at all times while water is being pumped into the Development.

This minimum flow rate, when Under the Hills will “shut-down”, will be set by the Manitoba Government to protect downstream senior licences, instream biota, and recreation needs.

**Pumpworks Design:** The location of the intake is on a benched river flat adjacent to an outside bend of the Assiniboine River lending itself to the deep water preferred for the intake. This site requires minimal improvements resulting in little disturbance on the flood plain and within the river, with the following provisions for protection of habitat:

- stabilization of the pump pad with geo-fabrics (e.g., geo-web or geomembrane) and gravel to prevent erosion;
- provision of a double wall, non-syphoning, fuel tank (KGS Group et al., 1999) to prevent fuel contamination of the flood plain and the river;
- mobility of the pumpworks for removal during periods of high water levels.
Habitat Protection - Wetlands

A combination of surface and ground water and, potentially Assiniboine River water, will be used to maintain water levels in the sloughs. The goal is to fill the sloughs in spring and then pump from them starting in July, in order to maintain higher spring and early summer levels for the benefit of wetland birds. Late June irrigation demands could be met directly from the Assiniboine River, depending on impacts on fisheries (i.e., adequacy of the screen\(^9\)). Adequate capacity exists to top up the sloughs from the Assiniboine River during the summer; thereby enhancing the habitat.

Drawdown levels for each slough were examined relative to the operational requirements of the irrigation project, maintenance and/or enhancement of the existing habitat and recharge characteristics (both ground and surface water). The current drawdown limits are:

<table>
<thead>
<tr>
<th>Slough</th>
<th>Volume</th>
<th>Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>2 ac-ft (3.5 dam(^3))</td>
<td>7.5 acres (3 ha)</td>
</tr>
<tr>
<td>Herman's</td>
<td>38 ac-ft (47 dam(^3))</td>
<td>42 acres (17 ha)</td>
</tr>
</tbody>
</table>

These limits will be modified as the operational and environmental requirements become apparent.

MONITORING AND MITIGATION

Soil and Water Quality

Several monitoring programs are in place to assess the performance of Under the Hill Farms relative to soil and water quality maintenance. Soil testing within the root zone and petiole testing determine the fertilizer requirements, while periodic deep nitrate surveys and groundwater quality monitoring provide feedback to the producer and the licensing and research agencies.

Annual Soil Sampling: Under the Hill Farms carry out soil testing 0 to 6" (15 cm) and 6 to 24" (15 to 60 cm) for chosen fields, post harvest. The soil tests can be compared to the guidelines set out by the Manitoba Government for annual crop production. The guidelines stipulate maximum nitrate-nitrogen in the top 2 feet (60 cm) of soil as:

- 140 lb/ac for medium to heavy soils.
- 90 lb/ac for light soils.

Deep Nitrate Soil Sampling: Under the Hill Farms has used deep nitrate soil sampling to an 8 foot (240 cm) depth to provide an indication of the efficiency of their nitrogen management program. Maintaining fall soil nitrate levels at low values will minimize the risk of nitrates leaching into groundwater. Current guidelines from the Manitoba Government set maximum fall levels of nitrate-nitrogen in the soil as:

- nitrates accumulated between 0 and 4 feet (120 cm) not to exceed 150 lb/ac.
- nitrates accumulated between 4 (120 cm) and 12 feet (360 cm) not to exceed 20 lb/ac in each 1 foot (30 cm) increment.

\(^9\) The adequacy of the screen for pumping in June has yet to be determined.
Deep nitrate soil sampling was undertaken on two potato fields and one cereal field in January 1998 as shown in Table 4.

Table 4 - Deep Nitrate Sampling (NO$_3$-N; lbs/ac) Results and Government Guidelines

<table>
<thead>
<tr>
<th>Location</th>
<th>NE 20-7-13 W1 Potatoes, 1997</th>
<th>SW 26-7-13 W1 Potatoes, Manured, 1997</th>
<th>NE 19-7-13 W1 Cereal, 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Sample Depth (feet)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Depth | GB guideline (MB Ag, 1998) | BH1 | BH2 | BH3 | BH7 | BH8 | BH9 | BH4 | BH5 | BH6 |
|-------|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 to 4 | 150                       | 69  | 37  | 100 | 16  | 53  | 55  | 85  | 38  | 32  |
| 4 to 5 | 20                        | 11  | 4   | 23  | 8   | 9   | 14  | 21  | 4   | 4   |
| 5 to 6 | 20                        | 13  | 4   | 34  | 4   | 9   | 33  | 7   | 4   | 6   |
| 6 to 7 | 20                        | 12  | 4   | 21  | 4   | 9   | 20  | 6   | 4   | 4   |
| 7 to 8 | 20                        | 9   | 4   | 10  | 5   | 11  | 30  | 5   | 4   | 4   |

The results (Table 4) illustrate the following:

- Results for the two potato fields are consistent with a minor number of the 4 to 8 foot (120-240 cm) samples slightly exceeding the Manitoba Government guidelines$^{10}$. There is no apparent difference resulting from manure application$^{11}$ (BH 7, 8, 9);
- The cereal field shows lower average NO$_3$-N values than potatoes for the 4 to 8 foot (120 to 240 cm) samples, suggesting some downward movement of nitrates in land under potato production;
- All fields are below the guidelines for the top 4 feet and are of consistent magnitude;
- As is commonly observed, there is substantial NO$_3$-N level variability for the three holes in a single field leading to unanswered questions of extent and severity of soil nitrate accumulation at the field scale;
- BH3$^{12}$ in the NE 20 shows the highest total (approximately 190 lb/ac in the top 8 feet (240 cm)) of all the sample locations but is still lower than the Government guidelines (230 lb/ac in the top 8 feet (240 cm));

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$^{10}$ Both potato fields suffered serious hail damage in August 1997 or the soil nitrate values shown would likely be lower.

$^{11}$ Manure applied non-uniformly on this quarter section.

$^{12}$ BH3 located along a fence line and not considered to be located “in field”.
Deep nitrate soil sampling is often a useful snapshot of a producer's nitrogen management program, indicating if nitrogen is being applied in excess of crop requirements. Based on the testing conducted to date in comparison to the Manitoba Government guidelines, Under the Hill Farms is doing a reasonable job of nitrogen management. Additional groundwater sampling is still warranted since the ability of deep nitrate soil sampling to pick up nitrate leaching in coarser textured soils is limited by the rapid downward movement of water and nitrites.

**Water Quality Monitoring Program:** The Manitoba Crop Diversification Centre (MCDC) is an industry led Centre for applied research located in Carberry (Fig. 1). MCDC has been monitoring groundwater quality since 1994 using a network of fourteen wells on the Assiniboine Delta Aquifer. To date, detection of pesticide residues were all below the Maximum Allowable Concentration (MAC) established in the Canadian Drinking Water Quality Guidelines (PFRA, 1998). Most of the monitoring wells show stable levels of NO$_3$-N with only three wells having levels slightly above the Canadian Drinking Water Quality Guidelines (ie. 10 ppm). For all three wells the baseline NO$_3$-N levels were high prior to irrigation (e.g., 11 to 12 ppm). Of particular interest here, MCDC installed a monitoring well (MW-F*) in May of 1996 in Section 20-7-13 W1.

Results of the monitoring (Fig. 4) show background (1996) levels of about 12 ppm NO$_3$-N, prior to irrigated potato production, and stable levels to the spring of 1997. During the summer of 1997, NO$_3$-N levels rose to a peak of 38 ppm (MW-F) prior to dropping back to 14 ppm in March, 1998; thereafter rising to about 20 ppm. The samples are generally from the surface (i.e. top 5 feet) of the aquifer. MW-F was sampled for a wide range of pesticide residues in the fall of 1996 and none were detected.

![Fig. 4 - MCDC Water Quality Monitoring](image-url)
Data from Oakes Test Area in North Dakota suggests that NO$_3$-N is typically stratified with highest readings on the surface of the aquifer and lower with depth (Knighton, 1997). Accordingly, the 1998 MCDC program included the installation of two more monitoring wells at increasing depths in order to track vertical distribution of nitrates at that site. The results from these wells show that nitrates decrease with depth to close to 0 ppm at about 12 feet (3.5 m) below the water table; consistent with the North Dakota data. A second well MW-H was installed in Section 19-7-13 W; results from this well show even higher nitrate levels in the top 5 feet (1.5 m) of the aquifer than in MW-F*.

MCDC also monitored several domestic wells in the Under the Hills Project area. One well has a recorded maximum level of 17 ppm NO$_3$-N (PFRA, 1998). It is difficult to tell the source and significance of the NO$_3$-N levels observed in this well due to the lack of historic data. The other wells in the vicinity of MW-F and MW-H that were monitored were well below the 10 ppm Canadian Drinking Water Quality Guideline (<1 ppm).

The results of the water quality program to date suggest relationships to land management practices should be investigated further. MCDC is also examining the fate of nitrate in unconfined near surface aquifers. On the Under the Hill Farms, one possibility could be that there was an initial flush of nitrate associated with change in crop rotation to potatoes and the associated increase in tillage and microbial activity. Subject to further monitoring and investigations, Under the Hill Farms may consider additional BMPs such as fertigation, planting of deep rooted perennial crops in rotation (e.g., alfalfa), and more intensive irrigation scheduling methods; if required and if economically viable.

Irrigation Water Quality: PFRA (1998) recommended the producer sample the sloughs’ water quality yearly. This has not occurred. Irrigation water quality monitoring on the Assiniboine River is covered by a Government monitoring program that is in place upstream of the project. However, PFRA (1998) recommended that the producer should inform himself as to the Government mechanisms for responding to a major spill on the Assiniboine River, in order to avoid pumping any polluted water. Pumping from the Assiniboine River to the wetlands might require additional water quality monitoring at the River.

Wildlife Habitat

Monitoring of the Wildlife Habitat included a baseline survey of the vegetation type at Herman’s and East sloughs, undertaken in the late fall, 1997. The survey only identified the common and indicator species. Endangered and other notable vegetation were not noted as being present or absent due to the time of year. Follow-up surveys are required to judge impact of the irrigation project and recommend further changes to management (e.g., modified drawdown and fill levels).

Herman’s Slough: The vegetation surrounding the Herman’s slough is host to numerous wildlife species including mammals, birds and waterfowl; most notably a bald eagle was spotted. Vegetation zones include grassland, both grazed and non-grazed, mature forest, and riparian, both shrubs and perennial (Fig. 5). Over 30 species were identified, including aspen and maple forest, dogwood and willow and cattail riparian, alkali cord grass and brome grass non-grazed grassland. Observations included the significant impact of cattle pasturing on the vegetation surrounding the west half of the slough, as indicated by the presence of snowberry (PFRA, 1998).
The vegetation along the riparian zone is already accustomed to seasonal water fluctuations as shown by the distinct zones of vegetation. The major recommendation is to establish a practical water level drawdown which will preserve the habitat associated with the wetland and provide adequate water for wetland birds during the hatching through adult molt stage (PFRA, 1998). Secondly, limiting the access of cattle to the riparian zone will enhance the value for wildlife habitat from the current state. Additional measures could include planting of trees and shrubs on the north and side of the slough, which could help with snow trapping and recharge as well.

![Fig. 5 - Photograph of Herman's Slough](image)

**East Slough**: Vegetation is adjusted to the fact that the East slough is often dry. The site reconnaissance shows indication of a dynamic habitat (i.e., non-permanent wetland). In addition, past management practices have disturbed the habitat, including trenching, burning, mowing as evident in the greater number and diversity of perennial species.

The management of the East slough for irrigation requirements will dictate it being fully drawn down each fall. By mid-summer the reduction will be to about less than one-half of the slough area. Refilling from the Assiniboine River could be used to further limit the drawdown impacts and create a more permanent wetland similar to the Herman’s Slough (albeit smaller).

**Fisheries Habitat**

**Minimum Instream Flow Needs**: Daily records of the pumping will be maintained by Under the Hill Farms and will be compared to established minimum water levels and provincial gauging stations by the Manitoba Government.

**Fish Screening**: The intake will be monitored in-season to ensure the screen remains unplugged, the rotating bar is operational, and screen corrosion is minimal.
CONCLUSIONS

The Environment Act Proposal and Licence documents and confirms Under the Hill Farms commitment to the environment through sustainable production practices. The licence requires Under the Hill Farms to monitor water consumption, wetland water levels, Assiniboine River levels, and soil and plant nitrate levels. In addition, they may periodically monitor deep nitrate profiles on selected fields, and are participating with MCDC on a water quality monitoring program. Ongoing monitoring in the areas of habitat protection will include periodic vegetation surveys, checking of intake screens, monitoring of Assiniboine River water levels, and observing slough drawdown limits.

Under the Hill Farms employs nutrient management techniques designated as Best Management Practices including: soil testing; lower target yields (on sandier soils); low spring starter nitrogen and split applications; foliar applications of nitrogen; and petiole testing. Fertigation, intensive irrigation scheduling, and modification of their crop rotation are the only BMPs left for them to implement. Monitoring to date indicates that pesticide movement is not an issue for this project. Deep nitrate and domestic well monitoring to date suggests nutrient management practices are generally working, but elevated NO₃-N results in the water quality monitoring warrant further investigation.

The licencing and monitoring process has heightened the producer’s awareness of environmental issues and will help them refine their management practices to maintain a sustainable farm operation for future generations.

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