Winter Roads in Manitoba

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Winter roads have connected isolated northern communities for over 50 years. Originally, winter roads were constructed by private contractors. Since 1979, the Department of Transportation has been overseeing the construction and maintenance of winter roads through contracts with Indian Bands and other local groups. The winter road network in Manitoba spans a length of 2178 km and services 30 communities (approximately 29000 people). It is extremely important for the shipment of goods, employment of locals and travel between communities. With the certainty of climate change and expected temperature increases of 4-6°C by the end of this century, there is a real threat to the seasonal operation of winter roads. The inevitable climate change from greenhouse gas emissions will result in later freeze-ups, earlier spring melts and more frost-free days. The implications of this climate change would be detrimental to the winter road network. An example of these implications was the airlifts required in 1998 to transport essential supplies to several communities as a result of drastic changes in the climate predominately due to El Nino. This shortened the winter road season and didn’t allow some of the routes to be constructed at all.
1. Introduction

Winter roads originated over 50 years ago as a private operation until the government took over the network in 1971. The fundamentals of winter road building are similar today as in the past, only the technology has changed. This paper will explore the history of winter roads, the various types of winter roads, route selection, the effects of climate change, bridges used and relocations currently in progress.

The winter road network in Manitoba spans a length of 2178 km and services 30 communities. It is extremely important for the shipment of goods, employment of locals and travel between communities. With the certainty of climate change and expected temperature increases of 4-6°C for December to February and increases of 2-4°C for June to August by 2050 in Manitoba; there is a real threat to the seasonal operation of winter roads. The inevitable climate change from greenhouse gas emissions will result in freezing later in the winter, melting earlier in the spring and more frost-free days.

The implications of this climate change would be detrimental to the winter road network. Several alternatives will be explored in this paper to ensure supplies get to the northern communities. The problems associated with the increased temperatures and climate change will get worse, therefore the issue must be addressed now to come up with alternatives.

2. History

Winter roads in Manitoba were originally constructed by private contractors. Goods were transported by “cat trains” pulled by truck dozers which was a very slow operation. The winter roads were in operation from December to March. Crown Land Use permits were distributed by the Crown Lands branch of the Department of Natural Resources for temporary use of the land. Toll fees were charged by the contractor to recoup the costs of construction. The construction and maintenance costs were covered by freight rates.

By 1971 the Department of Mines and Natural Resources assumed the role of the Winter Road System. In 1972, the Department of Mines introduced an Open Bid process. The construction and maintenance of the winter roads was cost-shared: 50% by Province and 50% by Indian and Northern Affairs. The Province funds 100% of the contract for winter roads on land within communities that are predominantly aboriginal but not First Nation.

Svein Sigfusson developed 3,560 km of winter roads over 33 years in Manitoba, Saskatchewan and Northern Ontario as shown in Figure 1.

The Sigfusson Company started the winter road network for fishing and freight initially. There was a railroad 650 miles north from Winnipeg to a mining town called Flin Flon which acted as the gateway to the north. They transported trains consisting of cats and sleighs over ice. The equipment included: 2 cats, various tractors and International TD6s weighing 4 tons each. The 2 cats had forged ice grousers to move more efficiently through the snow and ice. The lead tractor (plough cat) had a Lake Winnipeg plough. “Cat trains” consisted of tractors, cats and swings. Each cat pulled 2-3 cargo sleighs, which resembled farm wagons on runners.
When the road breaking crew encountered cracks in the ice, they would bridge the cracks in the ice with wooden wedges. Several machines and men sank; drowned through the ice. Sigfusson fished Reindeer Lake from Flin Flon north for trout and whitefish.

In 1972, the licenses were arbitrarily voided. In the 1972-73 winter road season, the Ministry of Mines and Natural Resources advertised for bids on all road break contracts. The socialists wanted to break the Sigfusson monopoly. Sigfusson was the lower bidder on 6 out of 7 road break contracts and the low bidder on 2 out of 3 gravel contracts. All of their bids were subsequently turned down which put them out of the roadbreaking and freighting business. Most of the contracts went to an Indian Company by the name of Me-Ke-Si (Lone Eagle); part of an Indian brotherhood.
Figure 1. Sigfusson’s Winter Road Network
3. Present and Proposed Winter Road System

The Province of Manitoba’s Department of Transportation has jurisdiction over the winter road system (Figure 2).

Figure 2. Manitoba’s Winter Road Routes
The Department of Transportation is responsible for the specifications, standards and length of operation of winter roads. Table 1 illustrates the various winter roads in the province as well as their lengths and opening dates.

Table 1. Winter Roads in Manitoba

<table>
<thead>
<tr>
<th>#</th>
<th>Location</th>
<th>Length (km)</th>
<th>Normal Opening Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manigotagan to Bloodvein</td>
<td>88</td>
<td>January 16</td>
</tr>
<tr>
<td>2</td>
<td>Bloodvein to Berens River</td>
<td>80</td>
<td>January 16</td>
</tr>
<tr>
<td>3</td>
<td>Berens River to Poplar River</td>
<td>96</td>
<td>January 16</td>
</tr>
<tr>
<td>4</td>
<td>Bloodvein to Round Lake</td>
<td>61</td>
<td>January 16</td>
</tr>
<tr>
<td>5</td>
<td>Lake Winnineg Crossing at Pine Dock</td>
<td>16</td>
<td>January 16</td>
</tr>
<tr>
<td>6</td>
<td>Round Lake to Little Grand Rapids</td>
<td>79</td>
<td>January 16</td>
</tr>
<tr>
<td>7</td>
<td>Little Grand Rapids to Pauingassi</td>
<td>16</td>
<td>January 16</td>
</tr>
<tr>
<td>8</td>
<td>Round Lake to McPhail River</td>
<td>107</td>
<td>January 16</td>
</tr>
<tr>
<td>9</td>
<td>McPhail River to St. Theresa Point</td>
<td>183</td>
<td>January 16</td>
</tr>
<tr>
<td>10</td>
<td>St. Theresa Point to Wasagamack</td>
<td>13</td>
<td>January 23</td>
</tr>
<tr>
<td>11</td>
<td>St. Theresa Point to Garden Hill</td>
<td>16</td>
<td>January 23</td>
</tr>
<tr>
<td>12</td>
<td>Garden Hill to Red Sucker Lake</td>
<td>96</td>
<td>January 23</td>
</tr>
<tr>
<td>13</td>
<td>Cross Lake to Oxford House</td>
<td>220</td>
<td>January 24</td>
</tr>
<tr>
<td>14</td>
<td>Oxford House to God’s Lake Narrows</td>
<td>83</td>
<td>January 24</td>
</tr>
<tr>
<td>15</td>
<td>God’s Lake Narrows to God’s River</td>
<td>60</td>
<td>February 7</td>
</tr>
<tr>
<td>16</td>
<td>PTH #6 to Thicket Portage</td>
<td>64</td>
<td>January 24</td>
</tr>
<tr>
<td>17</td>
<td>PTH #6 to Pikwitonei</td>
<td>60</td>
<td>January 24</td>
</tr>
<tr>
<td>18</td>
<td>Pukatwayagan to Kisissing Lake</td>
<td>67</td>
<td>January 24</td>
</tr>
<tr>
<td>19</td>
<td>Split Lake to York Landing</td>
<td>32</td>
<td>January 24</td>
</tr>
<tr>
<td>20</td>
<td>York Landing to Ilford</td>
<td>32</td>
<td>January 24</td>
</tr>
<tr>
<td>21</td>
<td>Gillam Road to Shamattawa</td>
<td>196</td>
<td>February 1</td>
</tr>
<tr>
<td>22</td>
<td>South Indian Lake</td>
<td>10</td>
<td>January 23</td>
</tr>
<tr>
<td>23</td>
<td>PR 394 to Brochet</td>
<td>108</td>
<td>January 23</td>
</tr>
<tr>
<td>24</td>
<td>Brochet Junction to Lac Brochet</td>
<td>178</td>
<td>January 23</td>
</tr>
<tr>
<td>25</td>
<td>Lac Brochet Junction to Tadoule Lake</td>
<td>172</td>
<td>February 6</td>
</tr>
<tr>
<td>27</td>
<td>PR 391 to Granville Lake</td>
<td>45</td>
<td>February 4</td>
</tr>
<tr>
<td>28</td>
<td>Sealls Crossing at PR 373 Crossing</td>
<td>Crossing</td>
<td>Dec. 15</td>
</tr>
<tr>
<td>29</td>
<td>Pinestone Crossing</td>
<td>Crossing</td>
<td>Dec. 15</td>
</tr>
</tbody>
</table>

4. Manitoba and Climate Change

When considering climate change; it is the change in climate of the Earth as a whole. The “Greenhouse Effect” is a natural system, which regulates the temperature on the earth. The earth acts as a greenhouse through the atmosphere trapping the sun’s heat near the earth and keeping it warm. Greenhouse gases include water vapor, carbon dioxide, nitrous oxide and halocarbons as shown in Table 2. Heat-trapping gases have increased due to human activity. There is continual adding of greenhouse gases to the atmosphere by burning fossil fuels for manufacturing, heating homes and running cars. The planet is warming at a rate never seen before in history (Figure 3).
The results of global warming include: sea levels rising, glaciers retreating and climatic zones shifting. The warming will be felt greater in the interiors than coastal areas.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Concentration: fraction * or parts per million by volume (ppmv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N₂)</td>
<td>0.78*</td>
</tr>
<tr>
<td>Oxygen (O₂)</td>
<td>0.21*</td>
</tr>
<tr>
<td>Water Vapour (H₂O)</td>
<td>Variable (0-0.02*)</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>360</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>1.8</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
<td>0.3</td>
</tr>
<tr>
<td>CFCs</td>
<td>0.001</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>Variable (0-1000)</td>
</tr>
</tbody>
</table>

Carbon dioxide is the most significant greenhouse gas, which is produced as a result of burning fossil fuels. Every year there is an additional 7,000 million tonnes of carbon dioxide added to the already present carbon. Methane is produced by vegetation burning, rotting or digesting in the absence of oxygen. Methane comes from garbage dumps, grazing cows, rice paddies, etc. Nitrous oxide levels have increased as a result of agricultural activities when chemical fertilizers and manure are used. Halocarbons consist of: CFCs, chlorine and fluorine (man-made). Without these gases, the sun’s heat would be more easily released and the average temperature on the earth would be -18°C.

Figure 3. Average Global Temperature Trends
The consequences of warmer temperatures are: flooding, forest fires and more extreme weather events. Scientists are predicting doubled carbon dioxide projections with substantial warming over Canada in the winter.

Summer and winter temperatures in Manitoba will increase significantly by year 2080 (Table 3).

<table>
<thead>
<tr>
<th>Months Concerned</th>
<th>Year</th>
<th>Temperature Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>December – February</td>
<td>2020</td>
<td>2 – 4 °C</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>4 – 6 °C</td>
</tr>
<tr>
<td></td>
<td>2080</td>
<td>6 °C</td>
</tr>
<tr>
<td>June – August</td>
<td>2020</td>
<td>1 – 2 °C</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>2 – 4 °C</td>
</tr>
<tr>
<td></td>
<td>2080</td>
<td>4 – 5 °C</td>
</tr>
</tbody>
</table>

The projected temperature changes expected from doubled CO₂ concentrations are identified in Figure 4.

Since the Industrial Revolution, the greenhouse gases have increased by the following amounts: carbon dioxide by 30%, methane by 145% and nitrous oxide by 15%. Scientists predict human consumption rates will continue meaning that carbon dioxide concentrations could exceed 3 times that of pre-industrial times by 2100.

In Manitoba, specifically the east side of Lake Winnipeg, the winter roads have been open a shorter number of days on the average as a result of climate change evident in Figure 5.
4.1 Consequences of Climate Change - 1998 Airlift

Due to the mild weather experienced in the winter of 1997-98, some of the winter roads to the remote communities were inoperable. The Grand Chief of Manitoba, Rod Bushie, requested assistance from the Province. The Federal and Provincial government approached the Manitoba Emergency Measures Organization to handle it.

A) Reserve and Non-reserve Communities

Manitoba civilization dates back 12,000 years ago. People moved in small groups in the southwest of the province where big game was located. Alaskan people migrated to Northern Manitoba.

B) Island Lake Area First Nation

The Island Lake Area First Nation is also known as the Rork people. They migrated from St. Lawrence River 250-300 years ago. The hunters and gatherers moved with the seasons. They obtained food using trapping, fishing and hunting tools. All of the members of a family had an important role in the society.
C) Island Lake Area Non-reserve Community
This was a European settlement from the Hudson’s Bay Company in 1818 and continued as a post when it merged with the Northwest Company. The people shared the services such as: airport, stores and school. This area could be accessed by travelling over water and winter roads.

D) Little Grand Rapids Area First Nation
The Little Grand Rapids Area First Nation people are also known as Objiwas. They migrated from Sault Ste. Marie two centuries ago. They were exceptional hunters who traded furs, blankets, hatchets, etc.. The Pauingassi people came originally from Moose Factory.

Normal Winter Road Hauling Costs for Fuel
The hauling costs on winter roads for fuel was determined to aid in the calculations for subsidy rates.

<table>
<thead>
<tr>
<th>Island Lake Communities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden Hill</td>
<td>$0.08/litre</td>
</tr>
<tr>
<td>Red Sucker Lake</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keewatin Communities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brochet/Lac Brochet</td>
<td>$0.25-0.27</td>
</tr>
<tr>
<td>Tadoule Lake</td>
<td>$0.25-0.27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Southeast Communities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Grand Rapids</td>
<td>$0.05</td>
</tr>
<tr>
<td>Pauingassi</td>
<td>$0.06</td>
</tr>
</tbody>
</table>

This averages out to be about $0.11/litre. However, the year of the airlift 1997-98, due to load restrictions only half loads were allowed. Therefore the winter road haul cost was $0.20-0.24/litre.

Air Lift Subsidy for Fuel
The airlift subsidy for fuel averaged out to be approximately $1.15/litre. Due to the different types of aircraft and ground handling, it does not reflect the cost by the community.

Normal Winter Road Hauling Costs for Dry Goods

| Island Lake Communities | $0.08-0.10/lb. |
| Keewatin Communities    |                |
| Brochet/Lac Brochet     | $0.20 approximately |
| Tadoule Lake            | normally almost all of their goods are flown in. |

Southeast Communities

| Little Grand Rapids, Berens River, Bloodvein and Poplar River | $0.06/lb. |

Airlift Subsidy for Dry Goods

$0.40 = $0.50 (normal air cost) - $0.10 (average normal winter road cost)  
Handling Charges from Airport to Retailer or Store  
Approximately $0.06/lb., but this value varies.
Development of Subsidy Rates

A **Ground Haul Subsidy Rate** is based on the difference between the cost of hauling freight on winter roads and the cost of flying fuel into communities plus additional ground transport costs. The communities normally obtained fuel from Winnipeg where the fuel was hauled by truck to Thompson, Red Lake and Lac du Bonnet. The fuel is taken from the community airport and then trucked or transported by helicopter to its destination.

*Fuel Subsidy Calculations:*

Subsidy Rate = \( \text{Cost/litre of flight} + \text{Additional ground handling costs} - \text{normal winter road cost/litre} \)

<table>
<thead>
<tr>
<th>Fuel Additional Ground Handling/Transport $/litre</th>
<th>Food Air Freight $/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berens River  N/A</td>
<td>0.32</td>
</tr>
<tr>
<td>Bloodvein    N/A</td>
<td>0.26</td>
</tr>
<tr>
<td>Garden Hill  0.11</td>
<td>0.40</td>
</tr>
<tr>
<td>Little Grand Rapids  0.12</td>
<td>0.30</td>
</tr>
<tr>
<td>Pauingassi   To be announced</td>
<td>0.36</td>
</tr>
<tr>
<td>Poplar River N/A</td>
<td>0.35</td>
</tr>
<tr>
<td>Red Sucker Lake  0.12</td>
<td>0.40</td>
</tr>
<tr>
<td>St. Theresa Point  0.11</td>
<td>0.40</td>
</tr>
<tr>
<td>Wasagamack   0.11</td>
<td>0.40</td>
</tr>
</tbody>
</table>

*Food/Dry Goods Subsidy Calculations:*

Subsidy Rate = \( \text{Airlift of dry goods Cost/lb.} - \text{normal winter road Cost/lb.} \)

**Sample Calculation:**
Ex. Little Grand Rapids

Normal Winter Road Rate: $0.10/lb.
Air Freight Cost: $0.40/lb.

\[
\text{Subsidy Rate} = 0.40 - 0.10 = \$0.30/lb.
\]

For winter roads, the payload of a semi-trailer is 82,500 lb.
The following planes were used for the airlift with varying payloads:

- Bristol Freighter 12,000 lbs
- C-46 12,500 lbs
- DC-3 28,000 lbs
- DC-6 50,000 lbs
- Summit Skyvan 4,500 lbs

**Determining Eligibility**

The eligibility is determined by an A and B group where A is the priority.

“A” Group: necessities of life – dry goods, fuel and medical supplies

“B” Group: other goods

**Development of Funding**

The cost is shared between reserve and non-reserve populations. Reserve and non-reserve populations are averaged over all communities. The % of non-reserve population is paid by the Provincial government. The Federal government covered 98.4% of the costs while the Provincial government covered 1.6% of the costs. The % of non-reserve population averaged out to 1.6%. The retailer provided a copy of the supplier’s invoice to get the payment for the subsidy. The freight carrier was required to provide proof of destination, route flown and weight to receive the subsidy. The subsidy claimed was for half loads via the winter roads.

**5. Types of Winter Roads**

There are two types of winter roads: snow and ice.

**5.1 Snow Roads**

1. Compacted Snow Road – has snow as cut and fill for grade using graders and dozers.
2. Ice Capped Snow Road – water is used to produce a bond between snow particles adding stability to the road.

**5.1.1 Compacted Snow Road**

The compacted snow road having a width between 9 and 12 m is the most simple snow road (Figure 6). It comprises 80% of the winter roads in the province. It uses snow for cuts and fills to obtain grade.
Once the surface has been shaped, it is dragged. The snow is compacted to 20 cm thick and snow is imported if it’s not there. The transformation to ice starts with compacted snow roads and upgrading them to ice-capped or processed snow roads.

5.1.1.1 Construction

Construction begins with lightweight machines such as snowmobiles, followed by bombardiers as shown in Figure 7.
The road is then cleared with some of the following equipment: flex track (Figure 8) with V-plow, loader with bucket, skidder with blade and ¾ ton truck with blade. A grader can then be used to further shape the road and a loader pulling a drag to level it. Use wood rather than steel for the drag so it is less harmful to the surface. Induce frost into muskeg, wait a week to peel off snow leaving a couple inch layer.

5.1.1.2 Preventative Maintenance
A grader is used to remove bumps. The hardness depends on ambient temperatures. The winter road must be shut down if softening occurs during the day and resumed at night or during colder temperatures.

5.1.1.3 Selection of Route
Site selection is the same for compacted, artificial, ice-capped and processed snow roads. In general, the route should follow the lee side of hills where there is low snowfall and close proximity to lakes for short hauls. It is important to avoid drift areas with high snowfall. In valleys, choose north-facing slopes where snow stays longer. A 10% or greater slope should be avoided.

5.1.1.4 Equipment
Prior to the award of the Contract, upon request of the Department, equipment must be made available for inspection. The equipment must be in satisfactory working condition and approved by the Department. It must also be maintained for the duration of the contract. If the equipment
proves to be inadequate then it must be replaced by the Contractor. If adequate equipment is not brought in, the Engineer will provide the necessary equipment at the Contractor’s expense.

5.1.1.5 Building and Operating Winter Roads
It is difficult to increase the density of the snow road. Snow crystals are similar to tiny ice cubes of varying shapes. It is impossible to get enough pressure to squeeze out the air to form a solid. It is possible to partially achieve this by:
1. Processing – break up crystals and re-fit them.
2. Flooding or Melting Snow – enough water so the density of the snow can support traffic.

5.1.2 Ice-Capped Snow Road
There needs to be a source of water close by. Water is applied to the surface of the snow road to make it stronger. This type of road has an additional step of adding water to a snow road. Ice-capping can be achieved with 2.5 cm of water.

The thickness of the ice is checked with snowmobiles or bombardiers. Snow is cleared for faster thickening. Windrow of snow may cause ice to crack along windrow. Travel is not advised close to the windrow.

The bearing capacity of ice is determined using Gold’s formula in metric units:
\[ P = Ah^2 \]
- \( P = \) load in kg
- \( h = \) ice thickness in cm

Speed limits are required on ice due to the damage resulting from the water wave. A water wave forms beneath the ice from vehicles moving at high speeds. When approaching shore, it is necessary to slow down so that the water wave coming off the shore won’t damage the ice as the vehicle passes.

Vehicles generate waves in ice at critical velocity. The wave with the highest amplitude is formed which causes the most damage to the ice sheet. According to Gold, critical velocity occurs between 32-48 km/hr. Large loads should be distributed over large areas.

Variations in ambient temperatures cause ice to expand or contract. Thermal stresses build up; lighter vehicles would cause minor cracking to relieve stresses. Cracks form because of variations in temperatures, heavy loads and variations in water levels. Surface cracks aren’t serious, but cracks all the way through the ice mean that loads should be reduced.

5.2 Ice Roads
1. Winter Road on Ice – on lakes and rivers.
2. Ice Bridges – timber across frozen lakes and rivers.
Winter Roads on Ice – roads on lakes and rivers are cleared off as seen in Figure 9.

![Figure 9. Winter Road Over Ice](image)

### 5.2.1 Construction Standards of Winter Roads Over Lakes, Rivers and Streams

Freezing is induced on lake crossings by lightweight low ground pressure equipment such as snowmobiles. The work should commence when the ice is at least 300 mm thick. The first pass should be approximately 15 m wide down the centre for frost penetration.

When the contractor determines that the bearing capacity of the ice can sustain the loads of the snow clearing equipment the snow can be cleared to the required width. Extra clearing outside the required widths is used to store the windrows beyond the 60 m required width (Figure 10). Markers of evergreen trees are placed on the inside windrows at 60 m intervals.

Winter roads over lakes must be cleared of snow to the specified width. In the event that the Contractor has failed to construct the winter road 60 metres wide and the Department has to open the road to traffic, the Department will deduct an amount equivalent to the following formula:

\[
\text{No. of km} \times \frac{(60 - \text{average width cleared}) \times \text{Unit Price}}{60}
\]

The minimum acceptable width shall be 30 m. Once a portion of the road has been officially opened, no additional clearing of an ice road will be permitted. The bearing capacity of blue ice for ½ loads is 24 inches and full loads is 29 inches.
Rivers and streams need to be flooded as early as possible. Prior to flooding, the snow should be windrowed to a specified width from the Engineer. Weather permitting, there may be a requirement for more than one flood per day. The first flood should not exceed a depth of 25 mm and any subsequent floods not more than 50 mm in depth. Before the next flood is applied, the previous flood should be frozen solid first. The layers of ice should be built up to support a 36,500 kg load.

Once the road is built to the required standard, the Contractor will advise the Engineer so that they can examine the road together. The Engineer will inform the Contractor, in writing, if any further work is required and when the road is acceptable.

5.2.2 Construction

Fill any holes with snow and then allow it to age-harden 4-5 hours. Water by drilling a hole with an auger into the ice, allowing some of the area to flood.

6. Stream Crossings

6.1 Ice bridges

For ice bridges, it is necessary to have gentle entrance and exit grades. The grades can be achieved with fills of snow. When constructing ice bridges, avoid fast-flowing sections.
6.1.1 Construction of Ice Bridges
The first step in constructing an ice bridge is to build up the banks where the bridge is going to go. This will hold the water used to increase the thickness of the ice. Flooding is accomplished by small pumps or by drilling a hole in the ice with an auger. The ice is then cleared of snow. The bridge will continue to freeze at the bottom of the ice surface. The thicker the ice, the heavier the loads allowed. Timber is sometimes used as reinforcement, however for environmental reasons this approach is usually avoided. The ice bridge can support moving loads rather than static loads so stopping on bridges is not permitted.

6.2 Acrow Panel Bridge
The Acrow Panel Bridge (Figure 11) was developed from the Bailey Bridge invented in World War II. The bridge was capable of carrying heavy military roads. It is constructed by hand with only a few tools. There have been improvements from the original design.

The 700XS Acrow Panel Bridge is stronger in shear and bending. It requires less labor than the previous design and it can be erected faster. The Acrow Panel Bridge is available in single lane, double lane and triple lane widths with single or multi-spans.

The method of construction includes a cantilever launch and a modified crane assisted launch. If cranes are available, the bridges are lifted with bracing, transoms and trusses. The decking is put in at a later time.

Figure 11. Construction of an Acrow Bridge
6.3 Meccano Bridge

Meccano Bridges (Figures 12-14) consist of welded steel frames manufactured by the Department or contracted to outside sources. Once the frame has been built, the decking is made out of timber. They are easily constructed, safe and very affordable which make them a popular alternative to ice bridges.

Figure 12. Location for Meccano Bridge
Figure 13. Meccano Bridge Construction
Figure 14. Completed Meccano Bridge
7. Planning a Winter Road

Planning a winter road involves reviewing: topographic maps, aerial photos, past climate history and what the road is used for. The following steps are taken in route selection:

1. Preliminary Route Selection
2. Review and Select Preliminary Route
3. GPS Preliminary Route
4. Take and Analyze Air Photos
5. Digitize Air Photos
6. Write Report on Selected Route

The route is affected by field reconnaissance and economics. Contingency plans for alternate routes should also be included.

Selecting the route initially is done by locating where the road will go on aerial maps with contours at a scale of 1:250,000 or more. The best corridor will be on a flat course with the least amount of clearing required and where water crossings are at a minimum. There is a new approach to planning winter roads, that is using a helicopter to do an aerial survey.

The following meteorological records are useful in route selection:

- Date of first snowfall
- Date of first freeze-up
- Date of accumulated snow depth of 10cm
- Monthly snowfall
- Total snowfall
- Date of lake freeze-up
- Date of beginning of thaw
- Date of mean accumulation of $306 \, ^\circ C$ freezing degree-days (this gives an approximation of the starting date for construction)

Thaw dates give an idea as to when winter roads need to be closed. Snow can limit frost penetration by insulating the ground from freezing temperatures.

7.1 Acquisition of Land for Winter Roads

For winter roads, the acquisition of land is done by easement agreements because of the temporary nature of them. The actual easement agreements between Canada and the reserve can take several months to obtain.

7.2 New Technology Used to Plan a Winter Road

Helicopters can now be used to do aerial surveys of the proposed route by filming the proposed road, post-processing the data and creating an HTML file for the Department to use. The system involves linking multimedia with GIS maps, more specifically it links computer file, images and video to mapped locations. It also uses a GPS receiver to collect mapping information. This approach would speed up the planning process along with the environmental review requirements.
8. Current Winter Road Relocations in Progress

8.1 Cochrane River Bridge
An Acrow bridge is currently being assembled to be launched over the Cochrane River. It will be used instead of the lake at Brochet. This river is open all year round (Figure 15).

Figure 15. Cochrane River

8.2 Hayes River Winter Road
The Hayes River winter road includes Hollow Water to St. Theresa Point and Garden Hill. It has existed since 1967. Before 1967, freight was hauled to these areas by Sigfusson’s cat trains. As the population increased so did the demand for more freight. Data was used for the freight hauled to St. Theresa Point/Garden Hill from 1987 to present, with a best fit regression analysis (Adam, 1998). The annual freight increase was determined to be 7.5% per year. The heavy use of winter roads expected for 2010-2020 would not be able to sustain the repeated loadings which would make an all-weather road a possibility.

If the density of the snow on the winter road was compacted to 0.60 gms/cc, this would improve with more use.

8.2.1 Partnering Agreement – Hayes River Winter Road
The Partnering Agreement exists to minimize stream crossings and reduce the cost of constructing and maintaining a winter road. There is potential for an all-weather road in the future.
8.2.2 Implementation

The communities will select the route. The Department will explore the route, estimate the cost to build it and determine the feasibility. Adjustments to the route will be made by the communities and the Department to develop the best route in terms of economics and practicality. The Department will do geotechnical exploration, surveying and mapping of the route. Communities have the opportunity to review the report before it is submitted to senior management.

8.3 Proposed Relocation of a Winter Road

This report will look at the Garden Hill to Red Sucker Lake Relocation to exemplify the Department’s commitment to improve the winter road system.

The original winter road from Garden Hill to Red Sucker Lake goes over the following frozen lakes: Island Lake, Angling Lake, Mistuhe Lake and Red Sucker Lake. The winter road is 96 km long with 80 km of that being ice. There is a concern about the shortening winter season. The communities currently have licensed airstrips for transporting goods and people. The winter roads are a cost-effective way of transporting goods to remote northern communities. There is a desire for a safe and straight alignment to avoid muskeg and rock outcroppings.

The proposed relocated winter road is 125 km long with only 8 km on ice and rivers, the rest is through brush and muskeg. Approximately 80% of the land-based road follows tractor trails and existing transmission lines. The right-of-way is cleared of trees and vegetation.

Winter Road Clearing Widths

<table>
<thead>
<tr>
<th>Description</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight Roadway</td>
<td>9 m</td>
</tr>
<tr>
<td>Corners and Curves</td>
<td>12 m</td>
</tr>
<tr>
<td>Over rivers and streams</td>
<td>30 – 60 m</td>
</tr>
</tbody>
</table>

8.4 Protocol Agreement – Relocation of Garden Hill to Red Sucker Lake Winter Road

The Protocol Agreement has been developed as a result of the warming trends affecting the length of operation of the winter road from Garden Hill to Red Sucker Lake. The existing winter road runs 80 km on ice and 16 km on land. The ice roads are unsafe with the warming trends and therefore must relocate the ice road to land. It is imperative to relocate ice roads, reduce water crossings and maximize safety. The communities, DIAND and Manitoba work together to find the best route which is most economical and practical. A Band Council Resolution is required before the Protocol Agreement can proceed.

9. Conclusion

The winter roads are extremely important for remote communities in Manitoba for the shipment of goods, employment of locals and travel between communities. Climate change will inevitably reduce the winter road season and therefore alternatives must be explored to ensure goods reach these communities. The relocation of winter roads from ice to land increases the safety to the driving public. It also provides a foundation for the remote community to fight for an all-
weather road. The Department is improving stream and river crossings by installing as many Meccano and Acrow bridges as feasible.

The Department must work together with the remote communities to come up with a solution for the winter roads. It is imperative for the remote communities’ survival.

10. References


Department of Transportation, 2001. Winter Road Inspector’s Guidelines. Winnipeg, Mb


Internet Sites for Winter Road Paper:

Permafrost and climate change
http://sts.gsc.nrcan.gc.ca/permafrost/climate.htm
http://www.crysyst.uwaterloo.ca/education/permafrost/permafrost_edu.cfm

Global Warming and Climate Change
http://www.msc-smc.ec.gc.ca/ccrm/bulletin/national_e.cfm
http://sts.gsc.nrcan.gc.ca/adaptation/sensitivities/graph/map2.gif
http://climatechange.gc.ca/english/issues/how_will/fed_science.shtml
http://www.ec.gc.ca/climate/overview_science-e.html