Economic Study of the Mackenzie Valley All-Weather Highway

Submitted to:

Department of Transportation
Government of the Northwest Territories

Submitted by:

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1. Introduction

1.1 Background to the Report

The Mackenzie Valley Highway (MVH) connecting Wrigley to Inuvik consists of both permanent and temporary winter road segments and bridges. The Department of Transportation (DOT) of the Government of the Northwest Territories (GNWT) wishes to upgrade the portion of the Mackenzie Valley Highway that connects Wrigley to Norman Wells from a temporary winter road to a permanent all-weather highway.

The GNWT DOT is seeking federal funding to support the highway upgrade project. Specifically, the DOT is preparing an application for funding under the National Infrastructure component of the *New Building Canada Fund (NBCF)*. Per the guidelines set forth in the NBCF, the GNWT submission must include an estimate of “the economic advantages and broader public benefits” of an all-weather road.

Nichols Applied Management Inc. has conducted two separate economic analyses – a cost-benefit analysis (section 3) and an economic impact analysis (section 4) – of the proposed highway upgrade to support the GNWT submission.

1.2 Regional Setting

The Mackenzie Valley Highway begins as a paved highway at the Alberta – NWT border, slightly south of the community of Grumbler, and extends north and west via the Hamlet of Enterprise to the community of Kakisa. At Kakisa the road surface turns to gravel and extends further north through the Village of Fort Simpson and on to the community of Wrigley, at which point the all-weather road surface comes to an end (Figure 1.1).

Approximately 2,341 people (5.6% of the NWT population)[1] live in the communities located beyond the end of the all-weather road, specifically: Tulita, Norman Wells, Deline, Fort Good Hope, and Colville Lake. Vehicle access to these communities is currently only available via a network of winter roads that consists of:

- a 333 km winter road between the community of Wrigley and the Town of Norman Wells;
- a 149 km winter road between the Town of Norman Wells and the community of Fort Good Hope;
- a 105 km access road to the community of Deline; and
- a 165 km winter road from the community of Fort Good Hope to Colville Lake.

The winter road network is operational for approximately 15 weeks per year, generally beginning in late December and closing in early to mid-April. Since 2005, the winter-road season has been lengthened considerably through targeted construction programs, primarily along the Wrigley to Norman Wells portion of the road. It is likely that the winter road season has now been maximized as a result of these projects which included:

- 10 permanent bridges over water courses;

1 2011 Statistics Canada Census Profile of NWT Census Division Region 2.

- adjustments to the winter road alignment and grade in selected places; and
- 13 permanent pipeline crossings and improved signage.

Outside of the winter road season, access to the communities north of Wrigley is limited to air or marine craft. Air service operates year-round to the regional airport in the Town of Norman Wells and to the smaller community airports in Tulita, Fort Good Hope, Deline and Colville Lake. Barge service is available for approximately 3 to 4 months a year once the Mackenzie River is clear of ice. Barge services are one part of the Mackenzie Valley intermodal transportation network that links the all-weather highway network to the Mackenzie River via loading docks at the Town of Hay River and the Village of Fort Simpson. The Hay River loading dock is also serviced by the CN Rail line, which is the only rail line in the NWT.

All components of the NWT transportation system are susceptible to environmental interruptions; low flows or river debris during high flows can limit barges[2], storms and wind can ground planes, and spring melt and winter storms can limit road transportation. An all-weather highway would contribute to a more reliable year-round transportation network in the region.

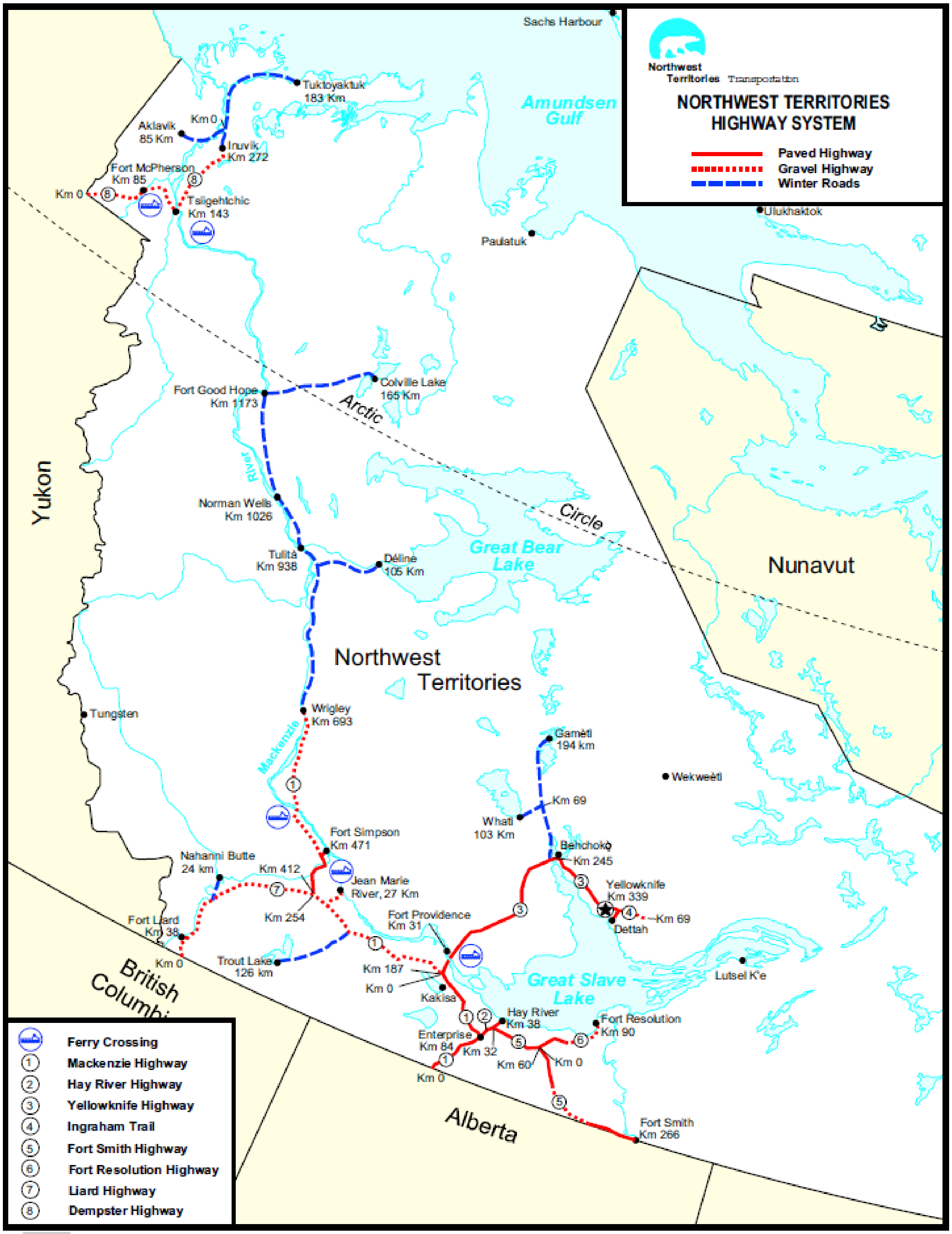
1.3 The Mackenzie Valley Highway Project

The proposed upgrade to the Mackenzie Valley Highway (the Project) being contemplated by the GNWT DOT consists of replacing the winter road between the community of Wrigley and the Town of Norman Wells with a gravel surface two lane highway, similar to the existing Fort Simpson to Wrigley segment.

The GNWT DOT estimates that the cost to upgrade the Wrigley to Norman Wells' segment will be approximately $700 million and cost, on average, $1.67 million per year to maintain. Design and construction of the all-weather road is expected to be carried out over a ten year period beginning in the 2014-2015 fiscal year provided the funding application is successful.

2 In 2014, low water levels at the Ramparts along the Mackenzie River resulted in barges being unable to deliver fuel to Tuktoyaktuk and community supplies to Fort Good Hope. In the case of Fort Good Hope, supplies were off-loaded at Norman Wells and flown to Fort Good Hope using Buffalo Air's Electra.

Figure 1.1: Northwest Territories Highway System



Source: www.dot.gov.nt.ca/_live/documents/content/highway_system_map.pdf

2. Study Approach

This study includes two separate economic analyses of the MVH. They are:

- a cost-benefit analysis (CBA) that weighs the social costs of development against the social benefits resulting from the Project; and
- an economic impact analysis which traces the economic ripple effects of project related expenditures through the economy.

A conceptual overview of the methodologies used for each approach is presented below.

2.1 Cost-Benefit Analysis

A cost benefit analysis is a generally accepted methodology for establishing the net social benefit of a particular investment or activity. Conceptually, a CBA of a highway project such as the MVH involves:

- Establishing whose costs and benefits are included in the analysis. Only the costs and benefits accruing to individuals and groups said to have standing in the analysis are considered. For example, standing for the MVH analysis could be extended to all residents and the government of the Northwest Territories but exclude individuals from outside the Territories.
- Identifying the social costs associated with the construction and maintenance of the highway. Social costs include the cost of project construction and regular maintenance.
- Identifying the social benefits of constructing and operating the highway. Social benefits could include items such as reduced travel time, improved safety, and the reduced cost to move freight into the region.
- Assigning a dollar value to each of the identified costs and benefits. Costs and benefits are not always goods or services traded in markets. For example, a highway project that reduces the number of fatalities on a highway requires that a dollar value be assigned to a human life. In cases where non-market values are needed, a variety of statistical techniques can be used to arrive at estimated values. In some cases, a qualitative discussion of selected costs and benefits may be appropriate.
- Adjusting the value of benefits and costs that occur over time. Costs and benefits that occur in the future are discounted back to a present value and expressed in equivalent 2014 dollars.
- Subtracting the total social costs of the project from the total social benefits. If the total social benefits outweigh the costs, the project is said to be of a net benefit to society and considered to be an economically efficient and socially desirable investment.

It is important to note that a cost-benefit analysis is concerned with economic efficiency (i.e. maximizing the net social benefit) as opposed to distributive equality. The criterion used for project evaluation in a CBA is simply: do total social benefits outweighing total social costs? Individuals may be made worse off by the proposed project but if their losses are overwhelmed by the benefits accruing to others, the project is considered to be an overall benefit to society.

Additionally, a CBA is limited to the direct costs and benefits resulting from a project. The indirect or induced effects that may occur as project-related impacts ripple through the economy and society are not included in the analysis.

2.2 Economic Impact Analysis

Conceptually, an economic impact assessment (EIA) aims to quantify the level of economic activity associated with a project as the spending associated with the project ripples through the economy due to the interconnected nature of various sectors and markets. Specifically, an EIA considers the:

- direct effects of project-related expenditures on goods and services;
- indirect effects of project expenditures as suppliers to the project and related industries expand their output to meet the needs of the project; and
- induced effect of the project as the additional income paid to employees of the direct and indirect sectors is circulated through the economy.

Together, the direct, indirect, and induced effects constitute the full economic impact of a project which can be characterized using a number of metrics that include:

- Employment creation (jobs);
- Gross Domestic Product (GDP);
- Employment income; and
- Government revenue.

The most sophisticated tool available, and the one used in this study, to estimate the ripple effects of a project or activity is the Statistics Canada Interprovincial Input-Output (IO) Model. This model allows an analyst to estimate the direct, indirect, and induced effects of a project or activity across 235 industries and 473 commodities in all Canadian territories and provinces. A technical discussion of the assumptions and related limitations of the Statistics Canada IO model is included in Appendix B. It is important to note that the level of economic activity estimated using an IO model is not equivalent to the net benefit estimated using a CBA methodology nor should the activity be construed strictly as a benefit to society.

3. Cost Benefit Analysis

This section of the report summarizes the anticipated costs and benefits associated with the proposed MVH upgrade.

3.1 Study Perspective

The perspective used when calculating costs and benefits is important, it determines who is given standing in the analysis and effectively delineates whose costs and benefits are considered. In this study, two perspectives are considered:

- a territorial perspective, which includes only the costs and benefits that accrue to the GNWT and its people; and
- a national perspective that considers the costs and benefits that accrue to all Canadians and the federal government.

There are two key differences between the two perspectives:

- The territorial perspective considers only the GNWT portion of capital costs and views toll revenue from those based outside of the territory as a benefit.
- The national perspective considers the full capital cost of the project and views toll revenue simply as a transfer from one party to another; no benefit is associated with the toll revenue.

3.2 Project Benefits

The project is expected to generate economic benefits primarily by reducing the cost of moving people and goods into and out of the region. These cost savings are expected to accrue to both:

- the existing freight and passenger shipment pathways; and
- new freight and passenger shipments resulting from the construction of the all-weather road.

The benefits of extending the all-weather highway between Wrigley and Norman Wells that are quantified and included in this study are:

- Reduced cost-of-living related to;
  - realized time-cost savings for existing truck transportation
  - savings related to a shift from high-cost year-round transportation methods (i.e., air) to a lower cost alternative (i.e., truck or personal vehicle)
  - savings related to a change in the scheduling of the transportation of key goods (i.e., reduced need to ‘bulk transport’ and stockpile inventory)
- Improved personal mobility;
  - facilitation of residents’ mobility during the spring and summer seasons (i.e., latent local resident traffic)
- Increased economic development;
  - facilitation of resource development (i.e., Canol and Indian Hare formation) via transportation cost reductions (i.e., latent resource development traffic)
- Increased tourism;

  - facilitation of summer vehicle access (i.e., induced tourism traffic)
- Improvements in safety;
  - reductions in collision rates on the all-weather versus the winter road
- Toll revenues;
  - collection of toll revenues from commercial and industrial trucks[3]
- Horizon value of the road asset;
  - value of the roadway as a physical asset to the GNWT at the end of the 30 year study period
- Avoided winter road construction costs.

These benefits are expected to accrue annually over the study period of 30 years. The detailed calculation of the benefits and underlying data sources and assumptions is included in Appendix A.

3.2.1 Intangible Benefits

In addition to the benefits outlined in the preceding section, there are a number of difficult to quantify or otherwise intangible benefits that should be considered when evaluating the project. These include, but likely are not limited to:

- improvements in travel comfort, or reliability, for those with year-round access to an all-weather road rather than a combination of winter road, summer barge and year-round air service;
- the potential changes in carbon emissions resulting from transportation mode shifts;
- the enhancement of Canada's northern sovereignty via the construction of this key component of the Mackenzie Valley All-weather Highway, ultimately capable of connecting southern NWT to the resource-rich Beaufort Delta and Arctic coast; and
- offsetting the possible negative effect of climate change on the length of the winter road season.

3.3 Project Costs

The cost of the project is estimated to be $700 million, including the $70 million cost of building the Great Bear River Bridge located near Tulita (km 941 of the MVH). Construction of the project is anticipated to take 10 years (2014-15 to 2023-24) with the first three years allocated to planning, design and assessments (2014-15 to 2017-18) and the final 7 years allocated to highway and bridge construction (2018-19 to 2023-24). The cost schedule for the project is outlined in Table 3.1.

3 Using a NWT perspective for the analysis implies that any tolls collected from a NWT operator is simply a transfer; however, tolls collected from non-NWT operators are a net benefit to the NWT.

Table 3.1: Road Construction Cost Schedule

Fiscal Year	Phase	NWT Cost Portion (25%)	Canada Cost Portion (75%)	Total Cost
		$ Million		
2014-15	Canada-NWT Funding Partnerships	$2.5	$7.5	$10
2015-16	Environmental Assessment and Design	$7.5	$22.5	$30
2016-17		$7.5	$22.5	$30
2017-18		$7.5	$22.5	$30
2018-19	Highway Construction	$30	$90	$120
2019-20		$25	$75	$100
2020-21		$25	$75	$100
2021-22		$25	$75	$100
2022-23		$22.5	$67.5	$90
2023-34		$22.5	$67.5	$90
Total		**$175**	**$525**	**$700**

Notes: Figures are in 2014 CAD.

Source: Government of the Northwest Territories, Department of Transportation, 2014.

In addition to the one-time construction costs, there will be ongoing costs associated with the operation of the project. These costs include:

- Annual maintenance costs of the all-weather highway estimated to be $5,000/km or $1.67 million annually for the 333 km project (2014 CAD).
- Administrative costs related to the collection of tolls. These costs are estimated to be negligible and are therefore not included in the analysis.

3.4 Project Net Benefits

Historically, the Treasury Board of Canada has recommended that costs and benefits accruing over time be discounted using a real rate of 10%. However, the most recent Cost-Benefit Analysis Guide recommends the application of an 8% discount rate[4]. Project net benefits have been calculated using both the 10% and 8% discount rates.

3.4.1 Discount Rate of 8%

The net benefit of the project was estimated under two discount rate scenarios (8% and 10%), two operational scenarios (tolls and no tolls) and two societal perspectives (territorial and national). Benefits and costs were estimated over a 30 year time horizon (2014 to 2044) using real 2014 Canadian dollars. The results of the NWT perspective using a discount rate of 8% for both operational scenarios are summarized in Table 3.4.

4 Canadian Cost Benefit Analysis Guide Regulatory Proposals. Treasury Board of Canada. 2007

Table 3.2: Cost Benefit Summary, NWT Perspective (8% discount)

Project Impact	No Tolls	Tolls
	$ Million (NPV 2014)	
Benefits		
Cost-of-Living	$23.9	$23.9
Increased Mobility	$45.8	$45.8
Increase Economic Development	$13.3	$13.3
Increased Tourism	$0.8	$0.8
Improvements in Safety	$0.0	$0.0
Tolls Revenue	$0.0	$24.5
Horizon Value	$43.5	$43.5
Avoided Winter Road Construction	$11.6	$11.6
Avoided Winter Road Maintenance	$3.4	$3.4
Costs		
Construction	$114.6	$114.6
Maintenance	$8.3	$8.3
Net Benefits	**$19.3**	**$43.8**
Benefit/Cost Ratio	**1.16**	**1.36**

When considered from the NWT perspective, the project is expected to generate a net social benefit whether or not tolls are charged to commercial road users. When tolls are not collected, the project will generate an expected $19.3 million in net benefit (NPV 2014). When tolls are collected[5], the project generates a net social benefit of approximately $44 million (NPV 2014).

5 Using a NWT perspective for the analysis implies that any tolls collected from a NWT operator is simply a transfer; however, tolls collected from non-NWT operators are a net benefit to the NWT. The benefit associated with tolls and shown in Table 3.2 reflects tolls paid by non-NWT operators.

Table 3.3: Cost Benefit Summary, NWT vs Canadian Perspective, Tolls (8% discount)

Project Impact	NWT Perspective	Canadian Perspective
	$ Million (NPV 2014)	
Benefits		
Cost-of-Living	$23.9	$23.9
Increased Mobility	$45.8	$45.8
Increase Economic Development	$13.3	$33.3
Increased Tourism	$0.8	$3.1
Improvements in Safety	$0.0	$0.0
Tolls Revenue	$24.5	$0.0
Horizon Value	$43.5	$43.5
Avoided Winter Road Construction	$11.6	$11.6
Avoided Winter Road Maintenance	$3.4	$3.4
Costs		
Construction	$114.6	$458.6
Maintenance	$8.3	$8.3
Net Benefits	**$43.8**	**-$302.4**
Benefit/Cost Ratio	**1.36**	**0.35**

When the full capital cost of the project is included in the analysis (Canadian Perspective), the project is expected to result in negative net social benefits of -$302.4 million (NPV 2014; Table 3.3). This result is driven primarily by the inclusion of the full capital cost of the project, whereas the NWT perspective includes only the 25% paid for by the territorial government.

Should the federal government have a stated policy objective of supporting long term development prosperity in the NWT, it may be appropriate to consider the NWT perspective as the relevant analytical framework as the territory and its people will benefit as a result of the support offered by the federal government. The project may also be appealing to the federal government if the assertion of Canadian sovereignty in the north is considered to be of significant value to society.

3.4.2 Discount Rate of 10%

The results of the NWT perspective using a discount rate of 10% for both operational scenarios are summarized in Table 3.4.

Table 3.4: Cost Benefit Summary, NWT Perspective (10% discount)

Project Impact	No Tolls	Tolls
	$ Million (NPV 2014)	
Benefits		
Cost-of-Living	$17.7	$17.7
Increased Mobility	$34.5	$34.5
Increase Economic Development	$9.8	$9.8
Increased Tourism	$0.5	$0.5
Improvements in Safety	$0.0	$0.0
Tolls Revenue	$0.0	$17.9
Horizon Value	$25.1	$25.1
Avoided Winter Road Construction	$8.7	$8.7
Avoided Winter Road Maintenance	$2.5	$2.5
Costs		
Construction	$114.6	$114.6
Maintenance	$8.3	$8.3
Net Benefits	**-$24.2**	**-$6.3**
Benefit/Cost Ratio	**0.80**	**0.95**

When considered from the NWT perspective, the project is not expected to generate a net social benefit under either operational scenario. When tolls are not collected, the project will generate an expected net loss of $24.2 million (NPV 2014). When tolls are collected, the project generates a net social loss of approximately $6.3 million (NPV 2014).

Table 3.5: Cost Benefit Summary, NWT vs Canadian Perspective, Tolls (10% discount)

Project Impact	NWT Perspective	Canadian Perspective
	$ Million (NPV 2014)	
Benefits		
Cost-of-Living	$17.7	$17.7
Increased Mobility	$34.5	$34.5
Increase Economic Development	$9.8	$24.4
Increased Tourism	$0.5	$2.1
Improvements in Safety	$0.0	$0.0
Tolls Revenue	$17.9	$0.0
Horizon Value	$25.1	$25.1
Avoided Winter Road Construction	$8.7	$8.7
Avoided Winter Road Maintenance	$2.5	$2.5
Costs		
Construction	$114.6	$458.6
Maintenance	$8.3	$8.3
Net Benefits	**-$6.3**	**-$351.9**
Benefit/Cost Ratio	**0.95**	**0.25**

When the full capital cost of the project is included in the analysis (Canadian Perspective), the project is expected to result in negative net social benefits of -$351.9 million (NPV 2014; Table 3.5).

As referenced earlier, should the federal government have a stated policy objective of supporting long term development prosperity in the NWT, it may be appropriate to consider the NWT perspective as the relevant analytical framework as the territory and its people will benefit as a result of the support offered by the federal government. The project may also be appealing to the federal government if the assertion of Canadian sovereignty in the north is considered to be of significant value to society.

4. Economic Impact Assessment

The economic impact of the construction and operation of the MVH upgrade was estimated using expenditure data provided by the GNWT and the Statistics Canada Interprovincial Input-Output Model.

4.1 Project Expenditures

The construction and maintenance of the MVH upgrade will require the direct purchase of goods and services in the GNWT, across Canada, and internationally. These initial expenditures will in turn ripple through the economy as businesses expand and people spend their income.

4.1.1 Construction Expenditures by Region

Total capital expenditures associated with the MVH upgrade over the 2015 to 2024 period is estimated to be $700 million, with 25% ($175 million) contributed by the GNWT and 75% ($525 million) contributed by the federal government of Canada. Construction capital expenditures will include wages and salaries paid to construction workers, professional engineering and environmental services, and the direct purchase of goods and services, such as major equipment and gravel.

It should be noted that, on average, the upgrade of the MVH will result in the displacement of $335,000 in annual spending related to the construction of the winter road between Wrigley and Norman Wells. The values shown in Table 4.1 are the present value of the upgrade expenditures net of the present value of the winter road construction expenditures for the next 10 years (2015 to 2024)[6].

Table 4.1: Construction Expenditure by Type

Expenditures	Total NPV ($ Millions)	Total (%)
Engineering and Design	46.50	7
Labour	181.00	28
Fuel and Parts	316.50	16
Materials and Equipment	103.50	49
Total	**647.50**	**100**

It is estimated that approximately $46.5 million (7%) will be spent on engineering and design during the 2015 to 2018 period followed by $181 million, $316 million, and $103.5 million on labour, fuel, and materials and equipment over the 2019 to 2024 period. The goods and services necessary to upgrade the MVH will be procured from the Northwest Territories (NWT), across Canada, and internationally.

4.1.2 Maintenance Expenditures by Region

Once fully constructed, the upgraded portion of the MVH will require regular maintenance in the form of regular grading, ploughing, dust suppression, pothole repair, and culvert maintenance. In a typical year, the expenditures associated with roadway maintenance on the upgraded portion of

6 Discount rate of 2.25% per 10 year Canadian benchmark bond yield.

the MVH will average approximately $1.7 million. It should be noted that the annual maintenance of the all-weather road will displace $0.6 million in annual expenditure related to the maintenance of the winter road between Wrigley and Norman Wells. The values shown in Table 4.2 are net of the displaced winter road maintenance expenditures.

Table 4.2: Average Annual Maintenance Expenditures by Region

Expenditures	Total Average Annual ($ thousands)	Total Average Annual (%)
Engineering	119	7
Labour	476	28
Fuel and Parts	272	16
Materials and Equipment	833	49
Total	**1,700**	**100**

Once the MVH upgrade is complete, it is estimated that in an average year of operations the GNWT will spend approximately $119,000 (7%) on engineering and related services, $476,000 on labour, $272,000 on fuel and parts, and $833,000 on materials and equipment. The goods and services necessary to maintain the newly upgraded portion of the MVH will be procured from the Northwest Territories (NWT), across Canada, and internationally.

4.2 Project Construction Effects

The expenditures associated with the MVH upgrade will constitute income for contractors, suppliers, and workers. These primary recipients will, in turn, spend a portion of this income on goods and services, thus circulating the expenditures throughout the economy, compounding the effect of the Project.

The direct, indirect, and induced effects of the MVH upgrade on GDP, employment, income, and government revenue was estimated using the Statistics Canada Inter-Provincial Input-Output model. The results are summarized in section 4.2.1 through 4.2.4.

4.2.1 Gross Domestic Product

As shown inTable 4.3, over the ten year design and construction period, the MVH upgrade will contribute $681 million to the GDP of the Northwest Territories. The average annual GDP effect represents approximately 1.5% of the NWT GDP in 2013. The project will also contribute an additional $533 million to the GDP in the rest of Canada. The average annual direct, indirect, and induced impact of project construction represents less than 0.01% of Canada's GDP in 2013.

Table 4.3: Total Construction Effect on GDP

Gross Domestic Product	Northwest Territories	Rest of Canada	Total
	[$ millions]		
Direct	181	-	181
Indirect	223	219	442
Induced	277	314	591
Total	**681**	**533**	**1,214**
Total [%]	**56**	**44**	**100**

4.2.2 Employment

As shown in Table 4.4, the total employment effect of the MVH upgrade over the ten year design and construction period will be approximately 6,635 person-years of employment in the Northwest Territories. On an average annual basis, this represents approximately 664 full-time equivalent positions or 0.3% of the territorial labour force. The project will also generate a total of additional 3,745 person-years of employment in the rest of Canada. On an average annual basis, the total employment impact of project construction represents less than 0.01% of Canada's total labour force.

Table 4.4: Total Construction Effect on Employment

Job Type	Northwest Territories	Other Canada	Total
	[Full-Time Equivalent Jobs]		
Direct	1,970	-	1,970
Indirect	2,195	1,425	3,620
Induced	2,470	2,320	4,790
Total	**6,635**	**3,745**	**10,380**
Total [%]	**64%**	**36**	**100**

4.2.3 Income

The economic activity associated with the MVH upgrade will result in wages and salaries being paid to workers throughout the economy. As shown in Table 4.5, the MVH upgrade will result in approximately $603 million of income being paid to workers in the Northwest Territories over the ten year design and construction period, or approximately $60.3 million annually. The project will also generate an additional $261 million of income for workers in the rest of Canada over the construction period, or approximately $26.1 million annually.

Table 4.5: Total Construction Effect on Income

Job Type	Northwest Territories	Other Canada	Total
	[$ millions]		
Direct	181	-	181
Indirect	201	106	307
Induced	221	155	376
Total	**603**	**261**	**864**
Total [%]	**70**	**30**	**100**

4.2.4 Government Revenue

The economic activity associated with the MVH upgrade will result in additional government revenue related to the purchase of goods and services and the employment of individuals (i.e. HST, GST, PST, import duties, personal income taxes). Government revenue expands the ability of different levels of government to fund programs and initiatives

As shown in Table 4.6, over the ten year period of design and construction, the MVH upgrade will result in approximately $43 million of revenue being collected by the GNWT (approximately $4.3 million per year), an amount that, on an average annual basis, represents 0.24% of total territorial government revenue in 2012[7]. An additional $21 million is expected to accrue to other provincial and territorial governments. The federal government of Canada is also expected to collect $107 million in revenue related to the MVH upgrade (approximately $10.7 million per year), an amount that, on an average annual basis, represents less than 0.1% of total federal government revenue in 2012[8].

Table 4.6: Total Construction Effect on Government Revenue

Government Revenue	Northwest Territories	Other Provinces & Territories	Federal Government
	[$ Millions]		
Total	43	21	107
Total [%]	25	12	63

4.3 Project Maintenance Effects

The expenditures associated with the maintenance of the upgraded portion of the MVH will constitute income for contractors, suppliers, and workers. These primary recipients will, in turn, spend a portion of this income on goods and services, thus circulation the expenditures throughout the economy, compounding the effect of the Project.

The direct, indirect, and induced effects of the average annual maintenance expenditures related to the upgraded portion of the MVH on GDP, employment, income, and government revenue was estimated using the Statistics Canada Inter-Provincial Input-Output model. The results are summarized in section 4.1.3.1 through 4.1.3.4.

7 Latest available data. Source CANSIM 385-0034.
8 2012 year used for consistency with Territorial data. Source: CANSIM 385-0032.

4.3.1 Gross Domestic Product

As shown in Table 4.7, the average annual maintenance of the MVH upgrade will contribute $1.77 million to the GDP of the Northwest Territories, which would represent 0.04% of 2013 levels. The project will also contribute an additional $1.55 million to the GDP in the rest of Canada. In total, the impact of maintaining the newly upgraded portion of the MVH represents less than 0.001% of Canada's GDP in 2013.

Table 4.7: Average Annual Maintenance Effects on GDP

Gross Domestic Product	Northwest Territories	Other Canada	Total
	[$ Thousands]		
Direct	465	-	465
Indirect	585	640	1,225
Induced	720	910	1,630
Total	**1,770**	**1,550**	**3,320**
Total [%]	**53**	**47**	**100**

4.3.2 Employment

As shown in Table 4.8, the average annual employment effect of maintaining the MVH upgrade will be approximately 15 jobs in the Northwest Territories, which represents approximately 0.01% of the territorial labour force. Maintaining the newly upgraded portion of the MVH will also generate an additional 10 jobs in the rest of Canada related to the supply of goods and services required by contractors or employees of the GNWT. In total, the employment impact of maintaining the highway represents less than 0.001% of Canada's total labour force.

Table 4.8: Average Annual Maintenance Effect on Employment

Job Type	Northwest Territories	Other Canada	Total
	[Full-Time Equivalent Jobs]		
Direct	5	-	5
Indirect	5	5	10
Induced	5	5	10
Total	**15**	**10**	**25**
Total [%]	**60**	**40**	**100**

4.3.3 Income

The economic activity associated with maintaining the MVH upgrade in an average year will result in wages and salaries being paid to workers throughout the economy. As shown in Table 4.9, maintenance of the MVH upgrade will result in approximately $1.6 million of income being paid to workers in the Northwest Territories. The project will also generate an additional $665,000 of income for workers in the rest of Canada.

Table 4.9: Average Annual Maintenance Effect on Income

Job Type	Northwest Territories	Other Canada	Total
	[$ Thousands]		
Direct	465	-	465
Indirect	520	270	790
Induced	570	395	965
Total	**1,555**	**665**	**2,220**
Total [%]	**70**	**30**	**100**

4.3.4 Government Revenue

The economic activity associated with maintaining the MVH upgrade will result in additional government revenue related to the purchase of goods and services and the employment of individuals (i.e HST, GST, PST, import duties, personal income taxes). Government revenue expands the ability of different levels of government to fund programs and initiatives

As shown in Table 4.10, maintaining the MVH upgrade in an average year will result in approximately $110,000 of revenue being collected by the GNWT, an amount that represents 0.6% of total territorial government revenue in 2013. An additional $60,000 expected to accrue to other provincial and territorial governments. The federal government of Canada is also expected to collect $274,000 in revenue related to maintaining the MVH upgrade in an average year, an amount that represents less than 0.01% of total federal government revenue in 2012.

Table 4.10: Average Annual Maintenance Effect on Government Revenue

Government Revenue	Northwest Territories	Other Provinces & Territories	Federal Government
	[$ Thousands]		
Total	110	60	274
Total [%]	25	13	62

5. Additional Economic Activity

There are several ancillary economic impacts that may result from improved year-round access to the Central Mackenzie Valley that are not reflected in the Cost-Benefit Analysis (Section 3) or in the Input-Output Analysis (Section 4). These include the activities that may be induced as a result of the all-weather road; namely job creation and GDP growth driven by increased tourism and resource development.

To the extent that the MVH upgrade improves the feasibility of mineral and oil and gas development (i.e. by lowering transportation costs, increasing all-season access etc.), the Project may indirectly result in substantial economic growth in the NWT. For example, an economic analysis of an all-weather road stretching from Wrigley to Tuktoyaktuk on the financial viability of the Mackenzie Valley Pipeline suggests that[9]:

- the proposed road will contribute to a reduction in the logistic, exploration, and well-development costs by approximately 15% which, depending on the capacity of the line, translates to increased after-tax cash flow of between $1.08 and $1.765 billion (IRR, $2009) over the life of the project; and
- year-round access will allow drilling rigs normally idle in the NWT to be moved and used in other locations, such as Alberta, outside of the winter drilling season. This will improve after-tax cash flow of the industry by an estimated $204 million (IRR, $2009) over the life of the project.

The MVH upgrade would constitute a portion of the all-weather road contemplated in the 2009 study and could potentially contribute to the above described benefits if the road were to be extended to reach Tuktoyaktuk.

9 Mackenzie Valley All-Weather Road Economic Analysis. Terra-Firma Consultants and Pacific Analytics In. 2009.

Appendix A - Calculating Benefits Technical Appendix

A. Calculating Benefits

The methods used to quantify the benefits of the highway upgrade project are outlined in this appendix.

A.1. Reduced Cost of Living

The project is expected to reduce the freight and passenger transportation costs in to, out of, and within the region. Due to the competitive freight-transport industry in the NWT, it is assumed that a sizable portion of the transportation cost-savings will be passed on to residents of the Sahtu region and subsequently reduce their cost of living.

The transportation cost-savings calculated here encompass both the benefits that will be retained by transport operators as well as the benefits to residents of the region to whom a proportion of the cost-savings will be passed.

A.1.1 Reduced Freight Travel Time

A recent study conducted by PROLOG Canada[10] indicates:

- a realized travel speed of 40 km/hr on the Mackenzie Valley Winter Road between Wrigley and Norman Wells;
- a speed of 75 km/hr on the proposed All-weather Highway; and
- an average 23.5 tonne payload per truck; and
- an hourly operating cost, per truck, of $165 per hour. [11]

Benefits related to existing freight traffic will result from the increased average speed on the all-weather road. Using the assumption listed above, these benefits are estimated to be a $1,363 (2014 CAD)[12] decrease in cost for each round trip between Wrigley and Norman Wells. Using an average payload of 23.5 tonnes, this equates to a $58 (2014 CAD) decrease in cost for each tonne of freight.[13]

A.1.2 Shift in Preferred Freight Transportation Modes

The increased cost-effectiveness of spring and summer ground transport, relative to air and barge transportation, as a result of the project are expected to be as follows:

- a savings of $4,240/tonne for freight moved via truck as compared to air

10 PROLOG Canada. 2010. The Northern Transportation Systems Assessment. Phase 2 Report: Infrastructure Needs Assessment. Prepared for Transport Canada.
11 Operating costs are assumed to account for the full opportunity cost of the truck and operator.
12 Adjusted using the Consumer Price Index (CPI) for Yellowknife (October 2010 = 118.4; October 2014 = 125.9)
13 Approximately 15% of avoided costs are driver's fees. Assume a $26.00/hour (2014 CAD) driver wage rate in the NWT. See: www.labour.gc.ca/eng/standards_equity/contracts/schedules/northwest_territories/schedule.shtml

- assuming a $4,408/tonne for air cargo movement between Yellowknife and Norman Wells[14] less $167/tonne for freight moved on a return trip originating at Hwy 1/3 Junction to Norman Wells at 75 km an hour[15]

- negligible cost-savings associated with the shift from barge deck cargo to truck transport
  - barge shipping is highly price competitive with truck transport; however, the decreased need to warehouse goods with a highly reliable, responsive and on-demand truck transport system is predicted to result in a shift to truck transport.[16]

Currently, freight moves into the central Mackenzie Valley using the combination of truck, barge, and air presented in Table A.1.

Table A.1 Freight Transportation to Mackenzie Valley (2014)

Cargo Type	Winter Road	Barge	Plane
Bulk Fuel (tonnes)	5,500	22,500	-
Resource Development (tonnes)	900	8,260	-
Community Re-supply (tonnes)	1,800	3,540	-
Total (tonnes)	**8,200**	**34,300**	**782**

Source: Adapted from PROLOG (2010) Phase 1 and Statistics Canada (2013) Cansim Table 401-0045
Note: Winter road freight uses the 2007 data (highest year reported by PROLOG) to approximate 2014 since traffic volumes suggest a higher freight load in more recent years.
Barge data are PROLOG estimates for 2010 with an adjustment to match truck freight categories.
Plane freight data uses cargo tonnes off-loaded in Yellowknife in 2013 scaled to the Sahtu regional population (5.6% of NWT). This is likely an underestimate of plane cargo shipments.

Following completion of the project and the possibility of the savings described above, it is expected that:

- All bulk fuel carried by barge will continue to be shipped by barge;[17]
- 95% of barge deck cargo will shift to truck transport;
- 95% of air cargo is shifted to truck transport;[18,19] and
- truck freight will continue to be transported by truck, but will now be delivered year-round.

In addition to the shifts described above, it is assumed that the future demand for freight will grow as follows:

- bulk fuel is expected to increases at 2% annually and receive a one-time 15% increase shock in 2022 as year-round local vehicle usage begins;
- resource development is expected to increases at 2% annually; and

14 Communication with Buffalo Air suggesting $2/lb is an average price for cargo shipments. First Air shipment rates between Yellowknife and Norman Wells are also approximately $2/lb (See: https://firstair.ca/wp/wp-content/uploads/tariffs/FirstAir_DomesticCargoRatesFrom_Norman_Wells.pdf)
15 Taken from Page 67 of PROLOG. 2010.Northern Transportation Systems Assessment. Phase 2 Report: Infrastructure Needs and Assessment. Adjusted into 2014 CAD using the Consumer Price Index (CPI) for Yellowknife (October 2010 = 118.4; October 2014 = 125.9)
16 Ibid.
17 Ibid.
18 Ibid.
19 Some cargo – especially cargo that is labelled as “do not freeze” in the winter will likely continue to be shipped via air.

- community re-supply is expected increases at 2% annually.

The above-described increases in freight volumes are assumed to represent a "business as usual" case. Shocks to the demand for freight as a result of increased resource development are considered latent traffic demands and are considered separately in the following resource development section (A.3).

A.2 Improved Personal Mobility

The cost of personal travel to, from and within the region is expected to decrease due to:

- a reduction in the amount of time required to travel; and
- the differential in the cash cost of ground travel as compared to air transport.

A.2.1 Reduced Passenger Travel Time

The project is expected to generate benefits related to the time saved by individuals who are currently using the winter road and will, in the future, be able to travel at a higher speed in the winter season on the all-weather road. During the 15 weeks that a winter road would otherwise be available, the presence of the all-weather road is expected to generate benefits equal to approximately $300,130 per year.

This estimate was arrived at by assuming:

- a person's time is valued at $14.55/hour (2014 CAD), or one half the NWT average wage rate across all industries;[20]
- an average increase in speed of 35 km/hour on the all-weather road (40 km/hr versus 75 km/hr);
  - a time-cost savings of $0.17/km per person
- 1.62 passengers per light vehicle;[21]
  - a time-cost savings of $0.27/km per vehicle
- 90% of ADT is comprised of light vehicle traffic;[22]
- an average trip length of 207[23] km per personal vehicle trip;
- an average of 92 personal vehicle trips per day (149 passenger movements per day);[24,25]
- a 15 week winter road season; and

20 Source: Statistics Canada CANSIM Table 281-0030.
21 NRCAN (Natural Resources Canada). 2010. The 2008 Canadian Vehicle Survey Update Report. ISBN 978-1-100-16618-6
22 Ibid.
23 Note this is a conservative estimate. The assumed trip length of 207 km is half of the average light vehicle trip length calculated for the winter road using GNWT DOT ADT and VKM data.
24 Approximately 90% of the vehicle kilometers in Canada are from light vehicles (see: NRCAN (Natural Resources Canada). 2010. The 2008 Canadian Vehicle Survey Update Report. ISBN 978-1-100-16618-6). This analysis uses the proportion of vehicle kilometers per vehicle type as a proxy for percentage of trip per vehicle type. Thus, with an average of 102 trips per day at the two winter road traffic counters, an approximate number of light vehicle trips is 102*0.9 = 92 trips.
25 This is conservative and assumes that one personal vehicle trip is counted at both traffic counters. This ensures no double counting of trips, but also results in a likely underestimation of total trips.

- no annual growth in daily personal vehicle travel during the winter season regardless of the presence of the all-weather road.

A.2.2 Shift in Passenger Travel Mode

Ground transportation to, from, and within the central valley is currently limited to the winter road season. All other times of the year travel is by river access (3 – 4 months in the summer) or air transport (year-round).

It is estimated that a total of 49,194 passengers boarded and disembarked from aircraft at the Norman Wells airport in 2013 (Table A.2).[26] It is believed that, in the north, as many as 2/3 of the air passengers are government officials. [27] It is unlikely that these individuals will shift to ground transportation despite the all-weather road.[28]

Table A.2 Estimated Passenger Travel by Mode

Volume Metric	Winter Road		All-Weather Road	
	Vehicle	Air	Vehicle	Air
Passenger Trips per day	149	-	149	-
Passenger Trips per year	15,913	49,194	54,281	44,275

Source: Adapted from GNWT DOT Highway Statistics, 2014; GNWT DOT Airport Statistics Report, 2004; and Statistics Canada CANSIM Table 401-0044.

Notes: Ground daily passenger trips are calculated at 90% of 2013's winter road ADT (an average between the two counters) and adjusted using a 1.62 passenger/vehicle adjustment (NRCAN, 2010).
The winter road assumes scenario 107 days of vehicle travel. The all-weather road scenario assumes 365 days.
Air passengers were estimated using 2004 Norman Wells numbers scaled using the growth in passengers at Yellowknife airport between 2004 and 2013.
With the all-weather road, there is an assumed 10% decline in passenger volume.

However, it is expected that a proportion of the remaining personal travel will make use of the all-weather road and the access it provides to both Yellowknife and Edmonton – especially for families or groups travelling together. Using the PROLOG (2010) assumption that one tenth of the current passengers would instead make the trip by vehicle – with 4 passengers per vehicle – the following cost savings can be calculated:

- Per passenger return trip costs to Edmonton with the airline Canadian North are $1,266.30 and would take 11 hours return (8 hours flying and 3 hours for airport time) for a time cost of $160.05[29] (2014 CAD) and a total return cost of $1,426.35 per person.
  - Driving a 4,000 km round trip to Edmonton is estimated to cost $580.00 in vehicle and fuel operating costs and would take 50 hours return (driving an average 75 km/hour on

26 In 2004, 48,048 passengers boarded and disembarked at the Normal Wells regional airport. Adjusting this figure by a factor of 1.02 (the ratio of passengers enplaned/deplaned in 2004 versus 2013 at the Yellowknife airport) gives an estimated passenger volume of 49,194 in 2013.

27 Brownie, Don. 2013. A Northern Transportation Strategy for Canada: Discussion Paper. PROLOG Canada and The Van Horne Institute

28 Using a road allowance rate of $0.58/km, an hourly wage rate of $30/hour and a traveling speed of 75 km/hour, an individual can drive a return trip between Norman Wells and Yellowknife for approximately $2,311.48 (2014 CAD) or fly using Canadian North for approximately $1,029.60 per return trip ($894.60 for a round trip ticket plus $135 for 2.5 hours of flying and 2 hours of airport time; 2014 CAD).

29 This assumes time travel costs for an individual of $14.55/hour which is equal to ½ the NWT's industry aggregate wage value (Source: Statistics Canada CANSIM Table 281-0030).

NWT Highways and 85 km/hour on AB highways) for a time cost of $727.50 and a total return cost of $1,307.5 per person.

- The cost-savings per adult are $118.85 per trip, and the cost-savings per child are $686.30[30] per trip. A family of four would save $1,610.30 per vehicle trip.

- Per passenger return trip costs to Yellowknife with Canadian North are $894.60 and approximately 4.5 hours of travel (2.5 flying and 2 hours for airport time) for a time cost of $65.48 and a total return cost of $960.08 per person.
  - Driving a 2,356 km round trip to Yellowknife costs $341.62 in vehicle and fuel operating costs and would take 31.5 hours (75 km/hr average speed) for a time cost of $458.33 and a total return cost of $799.95 per person.
  - The cost-savings per adult are $160.13 per trip, and the cost savings per child are $552.98 per trip. A family of four would save $1,426.22 per trip.

With an estimated savings of approximately $1,500 for a return trip for a family of four between either Norman Wells and Edmonton or Norman Wells and Yellowknife, and approximately 2,460 fewer annual return air trips out of Norman Wells, annual flight cost-savings are estimated at $922,387 per year.

A.2.3 Increased Personal Travel of Residents

Increased road access (from 3-months to year-round) will result in increased travel opportunities for individuals. Personal and business travel will becomes less dependent on the schedule of air service, less subject to air travel delays and cancellations due to weather, and cheaper as road travel displaces air transportation. The analysis assumes:

- Air travel between Norman Wells and Tulita (distance of 88 km) costs $212.32 one way, or $2.41 per km;
- Air travel takes approximately one hour total, of which 20 minutes is spent flying. This suggests a $0.16/km time cost per person;
- Total air travel costs are, therefore, approximated at $2.57/km per passenger; and
- The cost difference between flying and driving for these passenger trips is estimated at $2.02/km.

At a travelling speed of 75 km/hr, an operating cost of $0.58/km,[31] an average of 1.62 passengers per vehicle, and a travel time cost of $14.55/hr, the cost of travel by vehicle is $0.67/km per passenger (see section A.2.1).

Assuming individuals continue to use the all-weather highway outside of the winter season at the same level that they use the winter road during the winter season, it is estimated that a total of 54,281 passengers (for a total of 38,369 newly induced passenger trips) will use the highway with

30 Assumes a time travel cost of zero for children.
31 Canada Revenue Agency 2014 Automobile Allowance Rate for the NWT. See: http://www.cra-arc.gc.ca/tx/bsnss/tpcs/pyrll/bnfts/tmbl/llwnc/rts-eng.html

an average trip distance of 207 km.[32] There is no assumed growth through time in the number of passengers traveling by vehicle.

A.3 Increased Resource Development Truck Traffic

A.3.1 Conventional Oil and Gas

Traffic movements related to existing oil and gas are included in the baseline freight movements for the central valley. As a result, all cost-savings to current oil and gas extraction activities as result of the all-weather road are included within the cost-of-living calculations (see above).

A.3.2 Future Unconventional Oil and Gas

The Canol and Hare Indian Formations in the Sahtu Region of the Mackenzie Valley promise to provide significant oil and gas opportunities. It is estimated that these shale deposits hold significant oil and natural gas liquids – with estimates that over the next 15 – 30 years cumulative production could equal more than one billion barrels of crude oil.[33] As with all tight oil formations, recent advances (in the last 10 – 15 years) in horizontal drilling and multi-stage hydraulic fracturing have offered the promise of profitable development of these resources.

The three companies with ongoing active exploration in the region are MGM, Husky and ConocoPhilips. Shell and Imperial have yet to propose activities within their exploratory licenses.[34] Currently, there are approximately 5 exploratory wells expected each year between 2014-15 and 2016-17.[35]

While development forecasts/schedules for the Sahtu region formations are unknown, generally the development of an unconventional oil play requires resource evaluation and appraisal (years 1 – 10), pilot production (years 4 – 15), and, finally, commercial development (years 6 – 25+).[36] ConocoPhillips[37] has created four possible production path scenarios – a combination of resource quality and economic conditions. They assume a 55% probability of finding good reservoir results. This then leads to two different scenarios based upon economic conditions:

- A 73% probability (40% overall probability) that economic conditions (including operating costs, mobilization and equipment costs among others) are prohibitive and no further exploration will occur but a significant discovery license might be sought.

32 Using the GNWT DOT vehicle kilometer statistics for the Mackenzie Valley Winter Rood in 2013, if 90% of the vehicle kilometers are due to 92 personal vehicle trips per day over the 107 day winter road season, then 4.5 Million vehicle kilometers are the result of 92*107 = 9,844 trips and the average distance per trip is 415 km. An average trip distance of 207 km is, therefore, intended to be a conservative estimate.

33 DPRA Canada Inc. 2013. Resource Exploration in the Sahtu Settlement Area: Opportunities and Challenges. Available at: http://www.iti.gov.nt.ca/sites/default/files/resource_exploration_sahtu.pdf

34 K'aalo-Stantec Ltd. 2013. The Canol Shale Play: Possible Outcomes of Early Stage Unconventional Resource Exploration. Available at: http://www.mvlwb.ca/Boards/slwb/Registry/2013/S13A-001%20-%20Conoco%20Phillips%20Canada/S13A-001%20-%20Canol%20Shale%20Potential%20Future%20Development%20and%20Effects%20Considerations%20-%20Discussion%20Paper%20-%20May%2031_13.pdf

35 DPRA Canada Inc. 2013. Resource Exploration in the Sahtu Settlement Area: Opportunities and Challenges. Available at: http://www.iti.gov.nt.ca/sites/default/files/resource_exploration_sahtu.pdf

36 Ibid.

37 Ibid.

- We extrapolate this scenario to all oil and gas companies in the region and use this as our resource development trajectory in the absence of an all-weather road
- No oil and gas activity will continue past the 2016-17 exploration

- A 27% probability (15% overall probability) that economic conditions are favourable and further exploration will occur (3 – 5 vertical wells and 2 – 4 horizontal wells between 2017-18 and 2018-19) and a significant discovery license would be sought with pilots and production tests potentially ensuing.
    - We extrapolate this scenario to all oil and gas companies in the region and use this as our resource development trajectory in the presence of an all-weather road
    - After 2018-19, production is expected to occur at the same rate as the 2017-18 to 2018-19 exploration for all 5 companies

The two horizontal exploratory wells drilled in 2013 resulted in an increased ADT on the Mackenzie Valley Winter Road of approximately 45 trips per day, or 4,680 trips over the winter road season.[38] This suggests that a horizontal well requires approximately 2,340 vehicle trips.[39,40]

The cost-savings associated with these trips occurring on an all-weather road rather than a winter road can be calculated using the following assumptions:[41]

- 58%, or 1,357 trips/well are heavy trucks and that 42%, or 982 trips/well are light vehicles;[42]
- half of the truck trips are return trips between Wrigley and Norman Wells and the other half are trips between Norman Wells and the site location (estimate of 50 km per trip); and
- the all-weather road will offer a 35 km/hour increase in travel speeds resulting in a reduction in time and operating costs of $2.05/km (2014 CAD) for heavy trucks[43] and $0.70/km for light vehicles.[44]

A.4 Increased Tourism-Related Travel

The NWT, and its Sahtu Region, sees few tourists in the months during which the winter road operates (January – April). Therefore, summer season tourism in the region requires passengers fly in and out of community airports or travel the Mackenzie River. While no estimates of the number of tourists that may make use of the all-weather road are available we make the following assumptions for this analysis:

38 Department of Transportation ADT Statistics were observed for the Mackenzie Valley Road between 1993 – 2014. Road traffic volumes in 2013 were the highest ever observed on the road by over 45 trips per day. We make the assumption that this volume increase is attributable to the oil and gas exploration activity in 2013.
39 This is potentially conservative since it assumes that one vehicle was counted on both highway counters and does not account for the fact that two different vehicles may have driven past them.
40 All Consulting. 2010. Suggests that a horizontal well requires approximately 1,979 one way truck movements (a total of 3,958 movements). Available at: http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisch6b0911.pdf
41 Drilling is assumed to continue to occur during the winter months when environmental disturbances caused by drilling are minimized. This also results in no shifts in transportation mode utilized and simplifies calculations.
42 All Consulting. 2010. Available at: http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisch6b0911.pdf
43 Using the $165/hour (2010 CAD) operating cost figure from PROLOG Canada's 2010 report on Northern Transportation Systems.
44 Light vehicle costs include the time costs of 2 employees per vehicle at a wage rate of $30/hour. No additional costs related to the vehicle operation are included.

- current tourism numbers to the Sahtu Region are proportional to the population of the region – i.e., 5,400 visitors (6% of the 90,000 visitors to the NWT[45]) would travel to the Sahtu Region;
- visitor numbers in the absence of the all-weather road are assumed to increase annually at an average of 2% per year; and
- visitor numbers in the presence of the all-weather road are assumed to increase annually at an average of 3% per year.
    - This additional growth is attributable to reduced travel costs (i.e., the ability to drive rather than fly) and represents the latent tourism traffic demand.

The cost-savings associated with the all-weather road include:

- A $1,500 cost-savings for each family (see A.2.2) of four that drives the all-weather road rather than flying from Edmonton or Yellowknife
    - this saving is applied to all of the latent travel (i.e., the additional 2% annual growth); and
    - to 10% of the existing tourism travel.

A.5 Safety

The safety differential between driving an all-weather road and a winter road can be extrapolated by comparing collision rate differences between the two road types. Using the Dempster Highway (Hwy 8) as a proxy for the travel conditions of the proposed all-weather road, the collision rates on the Dempster Highway and the Mackenzie Valley Winter Road can be compared to indicate the safety improvements that may result from the construction of the all-weather road.

When using fatalities per million vehicle kilometres as a proxy for safety, there are no observed quantifiable differences in safety rates between the two road types. Over the last 5 years, both roads – the Dempster and the Mackenzie Valley Winter Road – have had no fatal collisions. While these statistics cannot account for the comfort or driving experience difference between the two road types, there are no quantifiable differences in safety between the two roads. Therefore, there are no substantive benefits or cost related to travel safety as a result of this project.

It should be noted that this analysis does not attempt to calculate the safety costs and benefits associated with shifts between transportation modes.

A.6 Toll Revenues

Toll revenues were estimated using information collected for the Deh Cho bridge and provided to the consultants by the GNWT DOT. Using a NWT perspective, any tolls collected from NWT operators are simply a transfer, and using a Canada-wide perspective, any tolls collected from Canadian operators are considered a transfer. It is assumed that 100% of operators are Canadian, and that 40% of operators are based out of the NWT.

45 Data collected from an address to the speaker available at: http://news.exec.gov.nt.ca/david-ramsay-tourism-numbers-rise-20-percent-across-the-territory/

Table A.3: Toll Rates

Commercial Vehicle Type	Proportion of Vehicles	Average Toll (per trip)
Tractor and One trailer (% of trucks)	43%	$158.13
Straight trucks (% of trucks)	3%	$83.13
Trains (% of trucks)	54%	$283.13
Representative Toll	**100%**	**$223.38**

Source: PROLOG (2002) Commercial Vehicle Traffic Forecast for the Mackenzie River Crossing at Fort Providence; Government of the Northwest Territories, Department of Transportation (2014) toll rates for the Deh Cho Bridge
Notes: Average tolls were calculated using single toll and monthly toll rates.
The representative toll is a weighted average. Tolls rates are weights using the proportion of vehicles that pay each rate.

The number of commercial vehicles anticipated on the all-weather road was estimated using:

- freight volumes transported by truck and an assumed average load weight of 23.5 tonnes; and
- latent heavy truck movement resulting from oil and gas development in the region
  - 1,357 heavy truck trips per horizontal, multi-fractured oil well

Each commercial vehicle trip was assigned a toll value of $223.38 allowing a total toll revenue calculation. This was then weighted by 60% for the NWT perspective (net, non-transfer, toll revenues), and by 0% for the Canadian perspective.

A.7 Horizon Value of the Highway

The horizon value of the highway is representative of the asset value of the highway at the end of the 30 year time frame used for this analysis. The value of the highway in 2044 (in 2014 CAD) is estimated to equal $437.5 Million, which is equal to a present value of $25.1 Million at a discount rate of 10%.[46]

A.8 Avoided Winter Road Construction and Maintenance Costs

The construction of the all-weather road relieves the need for the annual construction and maintenance of the Mackenzie Valley Winter Road. These annual costs (2014 CAD) are estimated at:[47]

- $6,046/km for construction; and
- $1,750/km for maintenance.

The winter road construction and maintenance costs will be phased out as the construction of the all-weather road takes place. The analysis assumes that:

- upon completion of the first 4 years of the construction program, the winter road costs associated with the segment between Wrigley and Tulita will be avoided; and

46 Utilizing an annual 1.25 percentage point depreciation of the asset value of the highway, the horizon value of the highway is assumed to equal 62.5% of the original construction costs of the highway (1.25% x 30 = 37.5% depreciation). See: Boardman, A, A. Vining, and W.G. Water II. 1993. Costs and benefits through bureaucratic lenses: Examples of a highway project. *Journal of Policy Analysis and Management.* **12(3)**: 532 – 555.
47 Government of the Northwest Territories, Department of Transportation, 2014.

- upon completion of the final 3 years of the construction program, all winter road costs between Wrigley and Norman Wells will be avoided.

A.9 Territorial vs. National Perspective

In order to define the national and territorial perspectives used in the analysis, it was necessary to assume a proportion of road users who are and are not based in the NWT. It was assumed that:

- tourists who benefit from cost-savings are all assumed to be Canadian, but only 25% are assumed to be NWT residents;
- truck operators are all assumed to be Canadian, but only 40% are assumed to be NWT owned; and
- oil and gas truck operators and workers are assumed to all be Canadian, but only 40% are from the NWT.

As a result, any cost-savings that accrued to tourists, truck operators or oil and gas workers were weighted by 25%, 40% and 40%, respectively, when using an NWT perspective for the CBA. All cost-savings were assumed to be realized at the Canada-wide level.

A.10 Cost-savings for Current versus Induced Traffic

A.10.1 Current Traffic Volumes – Freight and Passengers

Cost-savings calculations for current traffic (freight and passengers) volumes can be calculated as:[48]

$$Cost - Savings = V_t^{WR} * (C_t^{WR} - C_t^{AWR})$$

Where:

V_t^{WR} = the volume of traffic (freight or passenger) at time t with the winter road;

C_t^{WR} = the cost of transporting volume (freight or passenger) at time t with the winter road; and

C_t^{AWR} = the cost of transporting volume (freight or passenger) at time t with the all-weather road.

A.10.2 Induced Traffic Volumes – Freight and Passengers

Cost-savings calculations can conservatively be measured for induced traffic (freight and passengers) using:[49]

x$Cost - Savings = 0.5 * (V_t^{AWR} - V_t^{WR}) * (C_t^{WR} - C_t^{AWR})$

Where:

48 Harberger, A. 2009. Introduction of Cost-benefit Anlaysis. Part IV: Applications to Highways Projects. University of California, Los Angeles. Available at: http://www.econ.ucla.edu/harberger/introCBpart4.pdf
49 Ibid.

V_t^{WR} = the volume of traffic (freight or passenger) at time t with the all-weather road;

V_t^{WR} = the volume of traffic (freight or passenger) at time t with the winter road;

C_t^{WR} = the cost of transporting volume (freight or passenger) at time t with the winter road; and

C_t^{AWR} = the cost of transporting volume (freight or passenger) at time t with the all-weather road.

Note that the cost-savings for newly induced (latent) traffic is assumed to be ½ the difference between the current costs of travel and the future cost of travel with the all-weather road. The logic is as follows:

- since the trips are not currently made, the value of the trip to the individual is less than the cost of the trip in the absence of the all-weather road;
- however, since they do now make the trip on the all-weather road, the value of the trip is greater than the cost of the trip in the presence of the all-weather road;
- therefore, it is assumed that the value of the trip is the midpoint between the cost of the trip in the absence of the all-weather road and the cost of the trip in the presence of the all-weather road.

Appendix B - Input-Output Model Assumptions and Limitations

The economy is a highly complicated and dynamic system that is constantly changing as economic actors respond to a litany of signals across a number of markets over a series of time periods. Developing a model of such a complex system requires that several simplifying assumptions be made. These assumptions, in turn, affect how the analytical results can be interpreted.

- the infinite availability of resources. The IO model does not consider the availability or current use of resources necessary to build a given project. In reality, investment in a particular project may divert resources away from other uses and therefore result in the displacement of other economic activity. The estimates derived from the IO model should therefore not be interpreted as entirely net to the economy.
- scale invariant production relationships. The production relationships in the IO model are static and therefore do not reflect possible economies of scale as producers increase output to meet the additional demand resulting from the activity being analyzed. This may result in the overestimation of impacts.
- homogeneity in outputs. The output of a given industry is assumed to be constant across all producers. For example, the pulp and paper industry is assumed to produce a single product using a single representative production function. Differences across specific products and producers within a broader industry are not reflected in the model.
- expenditures and associated ripple effect occurs instantaneously. The IO model provides a snapshot of the economy and the aforementioned relationships at a single point in time. The dynamic and responsive nature of producers and consumers is not reflected in the model.

Although the Statistics Canada IO model has limitations, it is the most detailed representation of the Canadian economy available and its use is encouraged by a number of government and regulatory agencies across the country.

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