Granular Resource Requirements for Proposed Mackenzie Valley Pipelines:

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SECTION 6.

TECHNICAL PANEL "D"

POTENTIAL INDUSTRIAL DEMANDS

GRANULAR RESOURCE REQUIREMENTS FOR POTENTIAL HYDROCARBON DEVELOPMENT IN THE WESTERN NWT

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ABSTRACT

Historically, granular material has been used in the construction of roadways, airfield runways, embankments to support buildings and other physical structures, and in the construction of drilling pads and temporary offshore exploration structures in the shallow waters of the Beaufort Sea. Granular resources in the Mackenzie Delta are limited in supply. One of the key variables in managing the resource is the identification of potential requirements. The land use studies in the region have identified local needs for the communities. Industry requirements have also been assessed. On the oil side, development scenarios have ranged from the optimistic production levels of 700,000 barrels per day in the early 1980s, to today's current thinking that additional onshore reserves need to be discovered before oil development occurs. Development of the large gas reserves in the region has been proposed, but again, under the existing price regime, onshore gas cannot compete with gas reserves in Alberta and the continental United States.

Despite the pessimistic outlook, future hydrocarbon development in the region will likely occur. This paper reviews historical exploration and development planning in the region and identifies potential development scenarios. Granular resource requirements for the potential development scenarios will also be identified.

Introduction

North of 60 Engineering Ltd. has identified, in collaboration with industry, granular resource requirements for a number of oil and gas development scenarios in the Beaufort/Mackenzie Delta region. These scenarios have the potential to be economic under current price outlooks, given plausible technological and fiscal uplift. This paper summarizes the potential development scenarios, their possible timing, and granular resource requirements.

The motivation for this work is driven by the ongoing need of the Department of Indian Affairs and Northern Development (DIAND) to assess granular resource requirements in the region. This work has been sponsored under the Northern Oil and Gas Action Program (NOGAP) Project A4: "Granular Resources Inventory and Management".

Hydrocarbon Exploration

The western region of the Northwest Territories (NWT) represents one of the major undeveloped petroleum frontiers of Northern Canada (GSC, 1983). Exploration in the NWT started in the early 1920s, when oil seeps into the Mackenzie River led to the discovery of the Norman Wells Oilfield in 1921. Over 1,000 wells have been drilled in the area since 1921 which has resulted in a number of discoveries in the mainland region of the NWT and in the Mackenzie Delta - Beaufort Sea area.

Exploration in the Mackenzie Delta - Beaufort Sea region began in the early 1960s. The first well was drilled at Winter Harbor on Melville Island in 1962 and this was followed by wells in the Mackenzie Delta and Tuk Peninsula region. Oil was first discovered at Atkinson Point on the Tuktoyaktuk Peninsula in 1969 by Imperial Oil Limited. In 1971, large gas deposits were discovered in the Taglu area of Richards Island by Imperial Oil and in 1972 in the Parsons Lake area by Gulf Canada. In 1973 Shell Canada made several oil and gas discoveries in the Niglingtak and Kugpik areas of the Mackenzie Delta.

The first offshore well in the Mackenzie Delta - Beaufort Sea was drilled from an artificial island in 1973. Drilling from near shore artificial islands, Esso discovered oil at Adgo in 1974, at Issungnak in 1980,

West Atkinson in 1982, Itiyok in 1983 and Nipterk in 1985. In the deeper waters, Dome Petroleum/Canmar Marine Drilling undertook an ambitious exploration program using drill ships. Between 1976 and 1980, Dome encountered oil at the Nektoralik, Koakoak, Kopanoar, Ukalerk and Tarsuit locations. In intermediate waters, Gulf found oil at Pitsiulak and Amauligak. These wells were drilled from a mobile arctic caisson which was placed on the sea floor, or a berm (depending on the water depth), and then filled with a sand core to provide sliding resistance against moving ice in the winter. Several gas discoveries were also made in the offshore regions. Dingwall (1990) provides an overview of Beaufort Sea/Mackenzie Delta hydrocarbon reserves.

Over 200 wells have been drilled in the Mackenzie Delta - Beaufort Sea area including about 90 wells offshore. Estimated discovered reserves to date and potential for the region are given in Table 1. The significant oil and gas discoveries in the region to date are shown in Figure 1.

Current Outlook

It took sixty-five years after oil was discovered at Norman Wells, before oil production finally flowed to southern markets (although the oil field had been tapped to produce refined product for the region for several decades). At the commencement of production in 1985, the expanded Norman Wells reservoir was estimated to contain about 200 million barrels of oil. Norman Wells is Canada's most northerly oil field with sustained year round production. The Norman Wells field currently produces about 35,000 barrels of light crude per day.

Production from the Mackenzie Delta - Beaufort Sea region has yet to occur despite the considerable investment by industry into development planning, engineering studies, as well as regulatory and environmental reviews. In fact, exploration drilling in the area has dropped to a twenty-year low and there has been little interest shown in obtaining new frontier exploration leases.

A major factor in this low activity is the current price of oil which has fluctuated in recent years around $20 US per barrel. The prevailing industry view is that the existing oil reserve base in the Mackenzie Delta is not large enough to support a costly pipeline transportation system to southern markets. Industry's efforts are therefore focused on identifying and discovering onshore oil prospects.

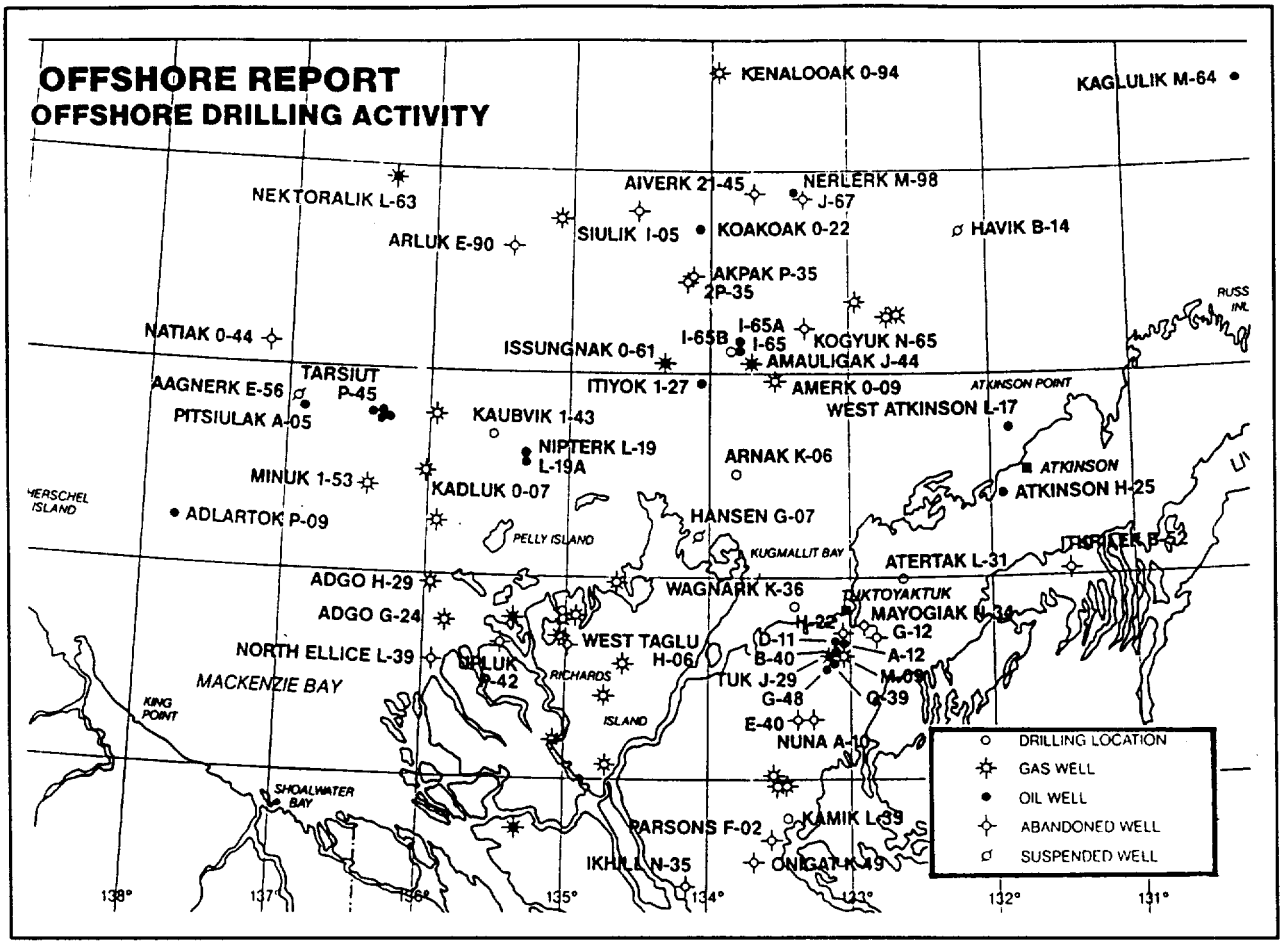
Frontier natural gas discoveries, while significant in size, are currently not competitive with the existing reserves in southern Canada due to the costly transportation system that would be required to move the gas to market. Given current low gas prices and the unexpected near term growth in those prices, it is unlikely that the discovered reserve base will be developed within the next decade although significant changes in fuel use (i.e. increased conversion from oil to natural gas by industry and consumers) could alter this outlook.

Table 1. Mackenzie Delta/Beaufort Sea: Discovered and Potential Reserves

	Oil (billion bbls)		Gas (Tcf)	
Region	**Discovered**	**Potential**	**Discovered**	**Potential**
Onshore-Shallow Offshore	0.22 to 0.26	0.82 to 1.18	6.6 to 8.3	9.4 to 19.7
Offshore Delta	0.8 to 1.0	1.0 to 1.3	3.0 to 4.0	12.0 to 15.0
West Beaufort	0.05 to 0.35	1.35 to 2.15	0.0	12.0
Deep Offshore	0.2 to 0.4	0.9 to 1.3	0.4 to 0.8	13.0 to 19.0
Total	**1.27 to 2.01**	**4.07 to 5.93**	**10.0 to 13.1**	**46.4 to 65.7**

Source: GSC, 1988

Figure 1. Beaufort Sea/Mackenzie Delta: Significant Oil and Gas Discoveries



Source: Oilweek, 1986

Foreseeable Granular Requirements

Despite the pessimistic outlook, the oil and gas industry has identified a number of ongoing or potential projects that will require granular material in the near term. They include the following:

- Shell Canada will potentially require up to 15,225m³ to support their ongoing exploration activities in the Mackenzie Delta during the 1993-94 period, however they will attempt to utilize surplus material currently stockpiled in the area.
- An annual requirement of 500m³ rock, and 750m³ sand to support ongoing operations by Imperial Oil at Norman Wells.
- Imperial has planned a number of small projects for 1993 that will require 3,000m³ rock, 10,000m³ gravel and 1,300m³ sand.
- A new well pad at Norman Wells is planned for 1994 which would require 40,000m³ of rock and 53,000m³ of gravel.
- An estimated 500,000m³ of granular would be required for a 40 to 50 km access road into the Cameron Hills area to support potential resource development in the area.
- An estimated 90,000m³ of granular for a potential refinery and access road in the Jean Marie River area.

Future Development

The key to future development in the current economy is finding innovative ways of reducing the high costs associated with oil and gas development and transportation.

Towards that end, North of 60 Engineering Ltd. in association with K.R. Croasdale and Associates Ltd. recently completed a study to identify key research and development thrusts, which, if successful, would significantly improve the potential of oil and gas development in the region. A number of generic oil and gas development scenarios were considered:

- A 100 million barrel (recoverable reserves) onshore field utilizing the 12-inch extension of the Interprovincial Pipe Line system from northern Alberta to Norman Wells.
- A 350 million barrel offshore pool producing at a rate of 80,000 barrels per day into a 16-inch pipeline from the offshore location to northern Alberta.
- A 350 million barrel offshore pool producing at a rate of 80,000 barrels per day utilizing year-round ice-breaking tankers to transport the product to market.
- A 350 million barrel offshore pool producing at a rate of 35,000 barrels per day utilizing the 12-inch extension of the Interprovincial Pipe Line system from northern Alberta to Norman Wells.
- A 350 million barrel offshore pool producing seasonally into a tanker which would transport the product to market.
- A gas scenario to produce only the onshore reserves at a rate of 800 mcf/day through a 30-inch pipeline constructed from Taglu to northern Alberta.

The study identified the cost, economic viability, and economic sensitivities associated with each of the above scenarios. In addition, it outlined a number of potential research initiatives which could reduce costs and thus improve project economics.

One of the important conclusions from the study was that small scale oil development using either an extension of the Norman Wells pipeline or tanker transportation could be economically attractive without additional reserves if technology advancements could achieve lower costs. The study also recommended a framework to focus future research into areas that could potentially make development a reality.

Potential Development Scenarios

Based on the results of the previous work by the author, a number of potential development scenarios have been considered for this study. They include:

- The development of a small onshore oil or gas field to provide a fuel source to meet local energy demands.
- The potential for seasonal production from the Amauligak reservoir.
- A generic 200 million barrel onshore field.
- The processing of onshore gas for sale to southern markets.

The timing of these scenarios has been phased to reflect the ongoing level of exploration, the time required to develop a particular scenario and the current economic outlook.

The initial development scenario is shown in Figure 2. It assumes that development of local energy sources, or seasonal oil production from an offshore discovery could take place in the 1995-2000 time frame. It also assumes a discovery, and the development of an onshore 200 million barrel pool by the year 2000. As initial production started to decline additional onshore fields would be brought on stream. The timing of these additional developments would depend on available pipeline capacity and the actual timing of gas development.

The author has assumed that sufficient demand and growth in gas prices will occur by the year 2005 to justify development of the three major onshore fields. This would trigger the construction of a gas pipeline, development drilling and production facilities which would come on stream in the year 2010. A possible development scenario for the year 2010 is presented in Figure 3. And finally, as additional capacity in the transportation system is established additional onshore fields would be added.

Figure 2. **Beaufort-Mackenzie Oil Development Scenario: Year 2000**

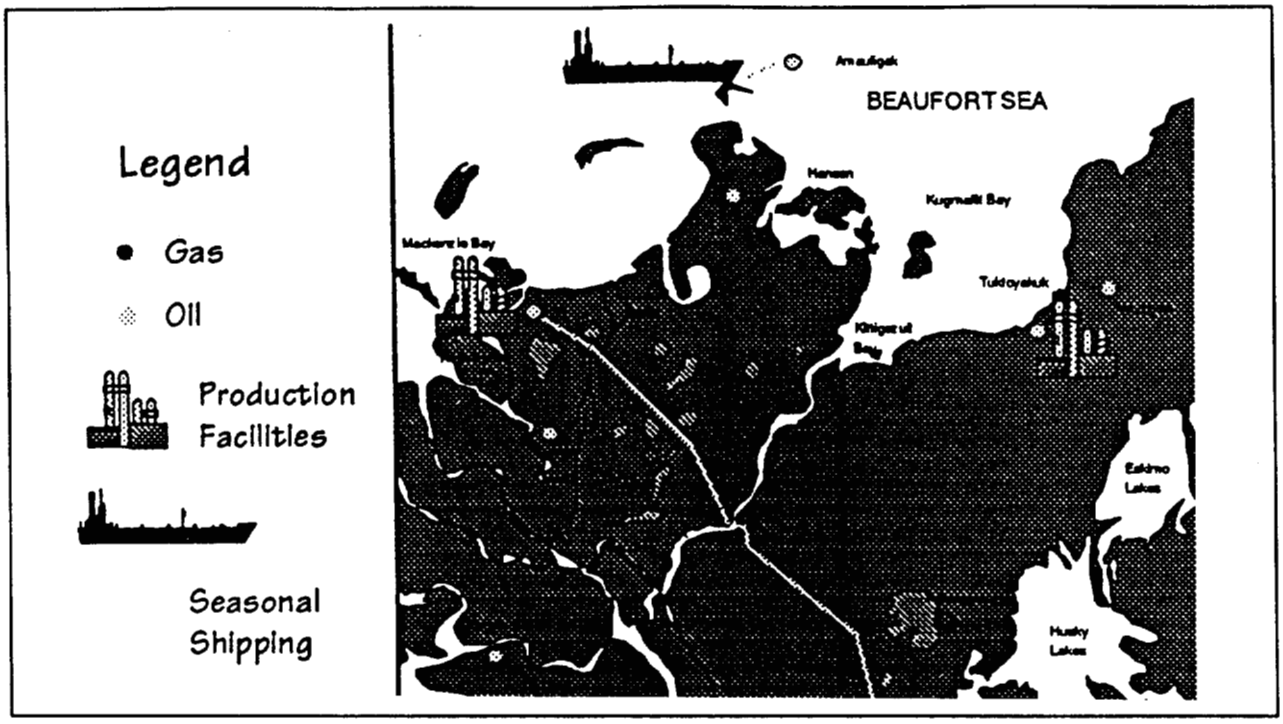
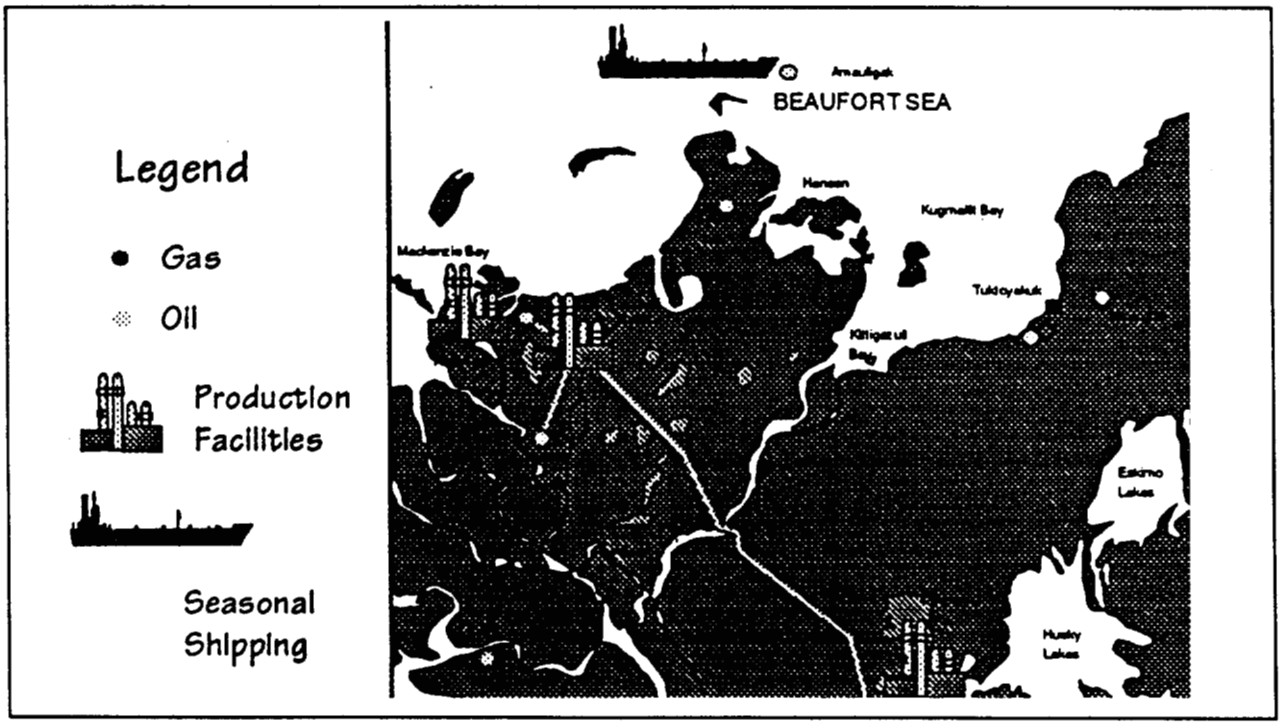


Figure 3. **Beaufort-Mackenzie Oil and Gas Development Scenario: Year 2010**



Granular Requirements

The general scope of each development scenario was established in order to identify the associated granular resource requirements. Generally, the scope was based on inputs from a variety of sources including industry, the experience of the author, and past studies available in the public domain. In some cases, where data was unavailable for a particular scenario, the scope was established using NORCOST, a Northern Regions Venture Cost Model developed by North of 60 Engineering. The NORCOST model establishes the scope and cost of facilities necessary to produce and transport oil and gas from frontier regions to southern markets. As a subset of the output it also quantifies the granular resources required for the development.

Total granular resource requirements for the various development scenarios discussed in the previous section are summarized in Tables 2 and 3. Table 2 represents a breakdown of the granular requirements for oil development while Table 3 summarizes the requirements for gas development. A more detailed breakdown of these granular requirements is contained in the final report of this study to the Department of Indian and Northern Affairs.

Granular resource requirements for a 12-inch extension of the Interprovincial Pipe Line (IPL) crude oil system from Norman Wells to the Mackenzie Delta are relatively small. According to IPL, approximately 50,000 m^3 of granular resource material would be required for construction of the line north from Norman Wells. This small volume (when compared to the gas pipeline requirements discussed below) is likely attributable to the small diameter of the line.

Granular resource requirements for the gas pipeline development are significantly larger. The gas scenario considered in this study consists of a 914 mm diameter, 2,330 km long, pipeline stretching from the Mackenzie Delta to Edson, Alberta where it would connect into existing distribution systems.

General fill would be required for work pads, access roads, airstrips and other associated pipeline facilities. Select fill would be required to improve the durability of subgrade surfaces and for trench bedding and packing around the pipe. Finally, a limited quantity of aggregates would be required for manufacture of concrete pipe weights and structural foundations. Granular resource requirements for the pipeline, by type, and construction spread, are summarized in Table 4. Operating and maintenance facilities to support the pipeline would require an additional 244,073 m^3 of general and select material.

Total granular resources requirements are therefore estimated to be 2 million m^3 for Mackenzie-Beaufort oil development and 8 million m^3 for gas development.

Conclusions

A number of conclusions can be made from the study:

- The static hydrocarbon reserves that have been discovered in the region are significant.
- Future oil development in the region will likely require additional reserves. Gas development will depend on the economic outlook and future demand.
- Technology and fiscal uplift will enhance the likelihood of development.
- Granular resources required to support ongoing operations at Norman Wells, the southern region of the NWT and ongoing exploration in the Mackenzie Delta-Beaufort Sea are relatively small.
- A number of development scenarios have been identified that are potentially viable given technology and fiscal uplift. Granular resources requirements for these scenarios are significant, but considerably lower than historical estimates for larger developments.

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Table 2. Granular Material Required for Mackenzie-Beaufort Oil Development (m^3)

Period/Years	Onshore Facilities	Offshore Facilities
1993-1995	716,275	0
1996-2000	575,447	650,000
2001-2005	6,250	0
2006-2010	6,250	0
2011-2015	388,525	2,700,000
2016-2020	235,615	0
Total	**1,928,362**	**3,350,000**

Table 3. Granular Material Required for Mackenzie-Beaufort Gas Development (m^3)

Period/Years	Onshore Facilities	Offshore Facilities
1993-1995	0	0
1996-2000	40,000	0
2001-2005	0	0
2006-2010	2,048,986	0
2011-2015	573,413	0
2016-2020	0	0
Total	**2,662,399**	**0**

Table 4. Granular Material Required for Mackenzie-Beaufort Pipeline Development (m^3)

Pipeline Spread	Spread Length (km)	General Fill (m^3)	Pipe Protection (m^3)	Aggregate (m^3)	Total (m^3)
1	210	432,840	345,585	948	794,845
2	245	674,806	331,207	1,228	1,054,443
3	250	539,338	321,863	32,780	931,002
4	260	571,607	342,556	62,025	1,020,739
5	275	278,318	318,104	47,956	662,904
6	395	262,217	216,467	44,740	566,105
7	485	237,263	184,610	35,464	495,957
Total	**2,120**	**2,996,389**	**2,060,392**	**225,141**	**5,525,995**

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