



**Identification of the Biophysical  
Information and Research Gaps  
Associated with Hydrocarbon  
Exploration, Development and  
Transmission in the Mackenzie Valley:**

**ACTION PLAN**

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# Executive Summary

This *Action Plan* is the compilation of the research and synthesis efforts that were completed as part of the third and final component of the project, *Identification of the Biophysical Information and Research Gaps Associated with Hydrocarbon Exploration, Development and Transmission in the Mackenzie Valley*. The project was undertaken to improve the level of preparedness of the federal and the territorial governments, industry, communities, and other decision-makers to be able to respond to the environmental assessment and regulatory processes associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley.

The *Action Plan* was prepared to guide the information gathering and research activities related to a potential Mackenzie Valley pipeline and hydrocarbon development in other parts of the Mackenzie Valley. It summarizes and prioritizes the gaps identified through the first two components of the project, which included preparation of a *Background Paper Report* and holding a community workshop in Norman Wells and a Scientists' Workshop in Yellowknife.

The identified information and research gaps are listed in this *Action Plan* by biophysical discipline topic (e.g., permafrost, surface water, vegetation). For each discipline topic, information gap statements are provided. For each gap statement, the following information is provided: background information for the gap, level of urgency (timeframe), identification of organizations best suited to address the gap, and the origin of the gap. A complete listing of the gaps is provided in Appendix A.

A total of 102 individual gaps are outlined in this Action Plan, of which 48 were categorized as having immediate priority in terms of urgency of action. These 48 gaps are listed below.

### Terrain and Surficial Geology

- Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology.
- Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south from Great Bear River.
- Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley.
- Update and verify granular resources information in terms of location, quantity and quality parameters.
- Need to assess forest fire as a landslide trigger along the potential pipeline route.
- Need to assess susceptibility of slope destabilization caused by right-of-way thawing.
- Need to assess creep of frozen ground as a cause of pipeline deformation.

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- Need to document the general locations of terrain and soils that are susceptible to instability due to thaw<sup>1</sup>.

### Permafrost

- Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.
- Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost.
- Need to establish the long-term viability and best practices of using permafrost-excavated pits (sumps) for containing drilling muds.
- Need to research alternatives to using sumps for projects in the Mackenzie Valley.
- Identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.

### Hydrogeology

- Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor<sup>2</sup>.
- Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings.

### Surface Water

- Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas.

### Fish and Fish Habitat

- Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap:

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<sup>1</sup> The level of urgency is immediate for potential pipeline, but moderate for oil and gas areas.

<sup>2</sup> Level of urgency is immediate for Travaillant Lake area, but is moderate to immediate for other areas, driven by project timing.

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### Lakes:

- ⇒ Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant.
- ⇒ Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio.
- ⇒ Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor.

### Rivers:

- ⇒ Gwich'in Settlement Area: Travaillant R. and Thunder R.
  - ⇒ Sahtu Settlement Area: Oscar Ck, Donnelly R., Hare Indian R., and Loon R.
  - ⇒ Deh Cho Region: Trail R. and Willow Lake R.
- Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above.
  - Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed above.
  - Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed above.
  - In existing oil and gas development areas and along existing pipeline corridors, need to identify and quantify impacts on fish and fish habitat as a result of development.
  - In existing oil and gas development areas and along existing pipeline corridors, need to determine what mitigation measures have been implemented and determine their effectiveness.
  - Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells.

### **Vegetation and Forests**

- Need landcover (vegetation) mapping including identification of terrestrial and wetland vegetation types.
- An ecological land classification (ELC) system needs to be developed.
- Need to identify and map locations of rare and medicinal plants.
- Need to document TK with respect to project effects on vegetation and forests.
- Need to determine long-term recovery rates of disturbed vegetation communities.
- Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley.
- Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank).

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### Mammals

- Need to study the potential effects of habitat fragmentation on different wildlife species.
- Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness for Boreal Woodland Caribou.
- Need information on factors affecting Boreal Woodland Caribou survival and responses to human activities.
- Bluenose West Caribou Herd - Information on movements and winter range use is needed.

### Migratory Birds/Raptors

- TK information on forest birds is required.

### Biodiversity

- Need TK that conveys information about biodiversity.
- Methodologies for assessing impacts to biodiversity need to be improved.

### Climate Change

- Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions<sup>3</sup>.
- Need to document spatial and temporal variability in permafrost response to climate change<sup>4</sup>.
- Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas<sup>5</sup>.
- Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change<sup>6</sup>.

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<sup>3</sup> Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

<sup>4</sup> Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

<sup>5</sup> Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

<sup>6</sup> Level of urgency is immediate to address engineering design needs and mitigation, but moderate to track climate change caused permafrost variability

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### Protected Areas

- A specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the ISR to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas which would contribute to ecoregion representation goals.
- Detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each site, will then be needed for each potential candidate protected area.

### Cumulative Effects

- Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline which can be used to determine significance and impact thresholds<sup>7</sup>.
- Need to gather regional baseline information for the purposes of cumulative effects assessment<sup>8</sup>.

### Community Identified Gaps

- Requirement for improved information base (mapping, data) of traditional land use areas and cultural sites before large-scale developments are allowed to proceed.
- Training, workshop or other information is required to improve understanding in communities about all phases of the oil and gas industry.
- Training, workshop or other information is required to facilitate a better understanding in communities of the EIA, regulatory and management processes as related to the oil and gas industry.

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<sup>7</sup> Level of urgency is immediate for potential pipeline, but moderate for other areas

<sup>8</sup> Level of urgency is immediate for potential pipeline, but moderate for other areas

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### List of Abbreviations

<b>CAPP</b>	Canadian Association of Petroleum Producers
<b>CEAM Strategy &amp; Framework</b>	Cumulative Effects Assessment and Management Strategy & Framework
<b>CIMP</b>	Cumulative Impact Monitoring Program
<b>DFO</b>	Department of Fisheries and Oceans
<b>DIAND</b>	Department of Indian Affairs and Northern Development
<b>EC</b>	Environment Canada
<b>EIA</b>	Environmental Impact Assessment
<b>ESRF</b>	Environmental Studies Research Funds
<b>GIS</b>	Geographic Information System
<b>GNWT</b>	Government of the Northwest Territories
<b>LIMS</b>	Land Information Management System
<b>NEB</b>	National Energy Board
<b>NRCan</b>	Natural Resources Canada
<b>NWT</b>	Northwest Territories
<b>RWED</b>	Resources, Wildlife and Economic Development
<b>TK</b>	Traditional Knowledge

# 1. Introduction

## 1.1 Project Overview

This *Action Plan* is the compilation of the research and synthesis efforts that were completed as part of the third and final component of the project, *Identification of the Biophysical Information and Research Gaps Associated with Hydrocarbon Exploration, Development and Transmission in the Mackenzie Valley*. The project was undertaken to improve the level of preparedness of the federal and the territorial governments, industry, communities, northern boards and other decision-makers to be able to respond to the environmental assessment and regulatory processes associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley. This project required an identification of the current gaps in biophysical information, confirmation of the gaps by communities and scientific experts and finally a plan of action to address those gaps. The project will also assist Aboriginal organizations, communities, and the non-government sector in evaluating future hydrocarbon exploration, development, and transmission projects in the Mackenzie Valley.

Information and research gaps were identified for the following topics:

- Terrain and surficial geology;
- Permafrost;
- Hydrogeology;
- Surface water;
- Fish and fish habitat;
- Vegetation and forests;
- Wildlife – mammals and forest birds;
- Wildlife – migratory birds / raptors;
- Biodiversity;
- Air;
- Climate change;
- Land and resource use/harvesting/protected areas; and
- Cumulative effects.

The project was consisted of four main components:

**Component 1, Background Paper Report:** The first component involved the identification of gaps for each of the biophysical components listed above. This was achieved through literature searches, personal communications with principal researchers and others expert in these areas of study, the professional and technical knowledge of the project team members, traditional knowledge, and input from communities in the Mackenzie Valley. The compilation of this gap identification process is contained in the *Background Paper Report*.

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**Component 2, Workshops and Consultation:** The second component involved presenting the identified gaps to communities, scientists, aboriginal groups and other stakeholders in the Mackenzie Valley for discussion and confirmation through a series of workshops and community visits. The gaps were confirmed, refined or dismissed by participants according to their validity. Additional gaps were also identified. The *Gwich'in and Sahtu (Norman Wells) Community Workshop Results, May 3-5, 2003* and *Scientists' Workshop Results, April 8-9, 2003* were prepared to summarize the results of this work.

**Component 3, Action Plan:** The *Action Plan* was prepared as the third component of this project. The *Action Plan* summarizes the gaps finalized through Component 2 and includes a listing of gaps requiring immediate action. The *Action Plan* was prepared to guide information gathering and research activities related to the Mackenzie Valley hydrocarbon developments to be used by government, industry and communities and others.

**Component 4, Final Report:** The *Final Report* provides an overview of the *Background Paper Report*, community and scientists' workshop reports, and the *Action Plan*.

This report forms the *Action Plan*. The gaps identified in the *Action Plan* are directly or indirectly related to the need to prepare for environmental assessment and regulatory processes associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley. In preparing the *Action Plan* (and throughout the biophysical gap analysis project), it was recognized that an understanding of the natural variability in the biological environment (e.g., population trends) is important for appropriate determination of potential impacts due to hydrocarbon related activities and development.

The structure of the *Action Plan* is outlined in the following subsection.

### 1.2 Action Plan Structure

Section 2 outlines the gap statements for each biophysical discipline topic, and for each gap statement a brief summary of the background, timing, responsibilities, and origin of the gaps is provided as follows:

#### **Gap Statement:**

Identifies a gap in a brief statement. The gaps are categorized using the following terms: baseline, impact, process, communications or capacity. Baseline gaps are noted where a lack of information exists with respect to baseline information for a particular topic. It is important to have adequate baseline information to support impact predictions, as well as to have a good understanding of the potential impacts on the environment as a result of oil and gas development and pipeline construction in the Mackenzie Valley. Impact gaps are identified where a lack of information exists with respect to our understanding of impacts from oil and gas development and/or the response to the impacts, i.e.,

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mitigation. Process, communications and capacity gaps were identified through community visits and workshops (and did not form part of the *Background Paper Report*)

### **Context:**

This part provides brief context for each gap statement, based on the information in the *Background Paper Report*, and covers:

- Supporting background and rationale for the identified gap;
- Links to appropriate development scenario, where applicable;
- Links to appropriate phase of development, where applicable; and
- Cross-references to other gaps in the report, where applicable.

Detailed background information to support the gaps can be found in the *Background Paper Report*.

### **Timing and Timeframe:**

- Identifies the amount of time required to fill the gap: short-term (1 – 3 years), long-term (> 3 years).
- Identifies the relative length of time to collect the information: short lead-time (information can be obtained for the EA process) or long lead-time (research or information collecting needs to commence now in order to have it available at a later stage of a particular project - i.e., information needed to monitor a change in a biophysical parameter over time).
- Identifies the level of urgency or priority of filling the gap: immediate (1 – 2 years), moderate (2 – 5 years), low (> 5 years). The level of urgency is related to the EA and regulatory process in advance of pipeline construction, and hydrocarbon exploration and development.

### **Responsible and Contributing Organizations:**

- Identifies responsible organizations that could fill the gap.
- Identifies contributing organizations that could assist in filling the gap, where applicable.

### **Origin of Gap:**

- Identifies the origin of the gap, whether it be the Background Paper Report, the Scientists' Workshop Report, Norman Wells Workshop, and/or general community consultations and visits

Section 3 describes the management of the information that will be collected in an effort to address the gaps outlined in this report. A complete listing of the gaps and level of urgency to address the gaps is contained in Appendix A.

## 2. Biophysical Information and Research Gaps

### 2.1 Community Identified Gaps

Community input was one source of information considered in this project. Information was gathered through community visits, workshops and personal communication with traditional knowledge (TK) holders, researchers and residents. Many of the identified gaps were identical to those identified from other sources. This section features gaps unique to the community perspective<sup>9</sup>.

#### 2.1.1 Capacity and Process Gaps: Traditional Knowledge

1. **Capacity Gap: Increased human and financial resources, tools and training in communities and regions for collecting, recording, archiving and using TK from all regions in the Mackenzie Valley is required.**
2. **Process Gap: Need to advance work on how to link TK with scientific knowledge to better understand impacts to the biophysical environment and baseline environment characteristics.**
3. **Process Gap: Need to create a consistent process for accessing TK and governing the use of TK.**

Discipline specific gaps related to TK were also identified through this project (see Sections 2.2.1, 2.8.4, 2.10.1, 2.11.1).

#### **Context:**

1. TK is recognized as a valuable source of information applicable to all aspects and components of life. Initiatives to collect and record TK have been undertaken and continue in many areas of the Mackenzie Valley. Increased human and financial resources, tools and training are required to systematically accomplish this over the long term in all communities and regions of the Mackenzie Valley.
2. TK holders in many regions of the Mackenzie Valley are getting older and passing away. Without recording their TK, it will be lost to future generations. Collection, review and analysis of TK is required in order to use it for specific applications, such as many of the biophysical gaps identified in this Action Plan.
3. By including both traditional and scientific knowledge in all aspects of hydrocarbon activities in the Mackenzie Valley, i.e., environmental impact assessments (EIA), regulatory and management processes, many community and resident issues and concerns could be adequately addressed.
4. This information is required for EIA and regulatory processes.

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<sup>9</sup> Community Identified Gaps are not identified in the Background Paper Report

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### **Timing and Timeframe:**

- TK could be gathered over the short and long term depending on the development pressures in an area.
- This information has a long-lead time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

Regional and community based aboriginal organizations; including renewable resource boards (Gwich'in Renewable Resources Board, Sahtu Renewable Resources Board) and other land claim organizations could be responsible for gathering, recording and archiving TK. The federal government (Department of Indian Affairs and Northern Development – DIAND, Government of the Northwest Territories – GNWT, and other federal departments) could assist in the acquisition of the tools to collect, manage and retrieve this information.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

### **2.1.2 Baseline Gap: Requirement for improved information base (mapping, data) of traditional land use areas and cultural sites before large-scale developments are allowed to proceed**

#### **Context:**

1. Concerns have been raised that cultural sites and traditional use areas may be lost due to development if not properly documented. By filling this gap, the potential for loss of these sites would be reduced.
2. This information is required for all oil and gas development areas and for the potential pipeline route.
3. This information is required for development, field operations and pipeline construction phases.
4. This information is required for the EIA as well as regulatory and management processes.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long-lead time to gather.
- The urgency to fill this gap is immediate.



## Action Plan

### **Responsible and Contributing Organizations:**

Renewable resource boards, community organizations, and land use planning boards and committees of the Gwich'in and Sahtu could be responsible for gathering, recording and archiving this information. Project proponents have a responsibility to demonstrate that they have considered TK in any application made to any of land and water boards and the Mackenzie Valley Environmental Impact Review Board. Project proponents could gather project specific information and provide it to these boards.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

### **2.1.3 Baseline, Impact and Communications Gaps: Cumulative Impacts**

1. **Baseline Gap: Need to identify the induced (spin-off) impacts from development in undisturbed areas and the cumulative impacts from accessory developments.**
2. **Impact Gap: Need to identify the cumulative impacts from past and existing oil and gas exploration and development activities in the Mackenzie Valley.**
3. **Communications Gap: Need improved communications between communities and government regarding past and current information (e.g., mapping) that is available and accessible on seismic lines, seismic exploration activities and exploration drilling sites held by the federal government (National Energy Board – NEB and DIAND)**

### **Context:**

1. Few post-development studies have been completed documenting past or current impacts. There is an opportunity to learn from past experiences before more development takes place.
2. This information can be used to support projects in all of the oil and gas development areas and the potential pipeline corridor in the Mackenzie Valley.
3. Cumulative effects initiatives such as the Northwest Territories (NWT) Cumulative Environmental Affects Management Strategy and Framework (CEAM Strategy and Framework) could be used for assessment of these gaps.
4. Past and current information (e.g., mapping) on seismic lines, seismic exploration activities and exploration drilling sites is publicly available through the NEB (with limitations). Communities expressed interest as to where and if this information was available.

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5. This information would be useful for planning and designing infrastructure development, field operations and pipeline construction.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long-lead time to gather.
- The urgency to fill these gaps is low.

### **Responsible and Contributing Organizations:**

Regional and community based aboriginal organizations, renewable resource boards, other land claim organizations, and the federal government (DIAND, NEB) and the GNWT could be responsible for gathering this information. A combined effort between all of these organizations could be undertaken to complete this work.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

### **2.1.4 Process and Communications Gaps: Research and Monitoring Programs in Communities**

1. **Process Gap: Need improved community involvement in monitoring programs and post-development studies.**
2. **Communications Gap: Need better co-ordination, organization and communication about research and other initiatives including taking results back to the community.**

### **Context:**

1. Encouraging community participation would develop awareness of the oil and gas industry and research underway to address issues.
2. Community participation in research programs would expand their knowledge of these programs and would bring knowledge back to communities to assist in alleviating concerns and perceptions.

## Action Plan

### **Timing and Timeframe:**

- Improved community involvement and communications should occur in the short term.
- This will take a long-lead time.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

Communities, regional organizations, the federal government (DIAND, Environmental Canada, and Department of Fisheries and Oceans - DFO) and GNWT (Resources, Wildlife and Economic Development - RWED) and project proponents all need to work together on accomplishing these goals.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

### **2.1.5 Communications Gaps: Communications and Community Awareness**

1. **Communication Gap: Training, workshop or other information is required to improve understanding in communities about all phases of the oil and gas industry.**
2. **Communication Gap: Training, workshop or other information is required to facilitate a better understanding in communities of the EIA, regulatory and management processes as related to the oil and gas industry.**

### **Context:**

1. Filling these gaps over the long term in communities will help to improve overall community understanding and enable more efficient consultation to occur for future EIA, regulatory and management processes.
2. These gaps are linked to the previous gap listed in this section dealing with capacity building (see Section 2.1.1).

### **Timing and Timeframe:**

- Community training programs should occur in the short and long term.
- These training programs will take a long lead-time to implement.
- The urgency to fill these gaps is immediate.

## Action Plan

### **Responsible and Contributing Organizations:**

The federal government and GNWT and project proponents could take the lead on designing and implementing community based training programs.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

## **2.2 Terrain and Surficial Geology – Database and Mapping**

### **2.2.1 Baseline Gap: Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology**

#### **Context:**

1. TK that relates to terrain and surficial geology has not been regularly gathered or interpreted.
2. This gap is linked to the need to map traditional land use and cultural sites, in particular place names that say something about the terrain.
3. The Elders are the holders of TK and there is a need to gather this information from them prior to their passing on.
4. Proponents are required to demonstrate that they have considered TK in any project application in the Mackenzie Valley.
5. This type of TK can be used to assist in planning and designing a proposed project.
6. This information may be particularly useful for seismic exploration, exploration drilling, infrastructure development, field operations, and pipeline construction phases.
7. This gap is linked to TK gathering initiatives being undertaken in the Sahtu and Gwich'in Settlement Areas.

#### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate as elders are ageing.

## Action Plan

### **Responsible and Contributing Organizations:**

Renewable resource boards and other community organizations, land use planning boards and committees of the Gwich'in and Sahtu could be responsible for gathering, recording and archiving TK, including TK related to terrain and surficial geology. These types of organizations could undertake the long-term gathering of this information. The gathering of TK could be supported by government (DIAND, Museum of Civilization), and project proponents could explicitly seek terrain and surficial geology TK information.

This type of TK may be acquired through place names, mapping of traditional trails, historic and culturally significant areas.

### **Origin of Gap:**

- Background Paper Report
- Scientist workshop.

### **2.2.2 Baseline Gaps: Surficial Geology Mapping**

1. **Baseline Gap: Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south from Great Bear River**
2. **Baseline Gap: Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley.**

### **Context:**

1. Currently, there is limited surficial geology mapping for the Colville Hills, Liard Plateau, Cameron Hills and Peel Plateau oil and gas development areas. The existing mapping along the potential pipeline route south of Great Bear River is of low quality and requires re-interpretation.
2. This baseline information is required for exploration and production drilling, infrastructure development, field operations, and pipeline construction phases.
3. The mapping provides a basis for understanding surficial geology and related geological / terrain hazards used for project design and location planning, and avoiding potential environmental impacts caused by the project, or caused by the environment on the project.
4. These gaps are linked to baseline information about slope stability conditions and earthquake potentials in the oil and gas development areas

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is immediate.

### **Responsible and Contributing Organizations:**

This baseline information could be gathered by the federal government (Natural Resources Canada - NRCan), the GNWT (C.S. Lord Geoscience Centre), university research institutions, and augmented by project specific information gathered by project proponents.

Existing information should be synthesized, evaluated and mapped, in addition to the collection, analysis and mapping of new information. TK should be collected to help identify terrain hazards and slope stability problem areas in the Mackenzie Valley.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

### **2.2.3 Baseline Gap: Update and verify granular resources information in terms of location, quantity and quality parameters**

#### **Context:**

1. This information would be particularly useful for Cameron Hills, Liard Plateau and a possible Mackenzie Valley pipeline.
2. Granular resources have been mapped throughout the NWT, but the information requires verification and updating in terms of location, quantity and quality parameters. Current knowledge of granular resources is needed to effectively manage the resource to ensure that it meets the needs of interested parties.
3. As part of any EIA, detailed information on granular requirements must be provided and the source of those resources. For example, granular resources are used during production drilling, infrastructure development, field operations/ongoing project maintenance, and pipeline construction.
4. The extraction of granular resources has been associated with environmental impacts (e.g., to fish and wildlife), depending on the location, quantity and quality of the material. Granular resource inventory information will assist in the assessment of impacts to fish and wildlife.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to acquire.
- The urgency to fill this gap is immediate particularly for a potential pipeline corridor.

### **Responsible and Contributing Organizations:**

Federal (DIAND, NRCAN) and territorial (Commissioner's land) governments and private landowners in the Gwich'in and Sahtu Settlement Areas could collect this information. Project proponents, too, have a responsibility to determine project related granular resource needs, and to quantify granular resource reserves at potential extraction locations.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop

## **2.3 Terrain and Surficial Geology – Geotechnical Considerations**

### **2.3.1 Baseline Gap: Need to assess the earthquake potential in the oil and gas development areas in the Mackenzie Valley, particularly in the Liard Plateau area**

#### **Context:**

1. Engineering guidelines are used to influence the design and construction of project related infrastructure to ensure a minimum level of built-in resilience to/protection from earthquakes. In order for these guidelines to be effective, an accurate indication of the true earthquake potential in the oil and gas development areas in the Mackenzie Valley, or for the potential pipeline route.
2. This information can be used to support projects in all of the oil and gas development areas and for the potential pipeline.
3. This information is necessary for project planning related to exploration and production drilling, infrastructure development, field operations, and pipeline design, engineering and construction phases.

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### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate for the Liard Plateau area, and low for other oil and gas development areas.

### **Responsible and Contributing Organizations:**

This baseline information could be gathered by the federal government (NRCan), and augmented with any related project specific information gathered by project proponents.

Existing information should be synthesized and evaluated to improve understanding of earthquake potential in the oil and gas development areas.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

### **2.3.2 Impact Gaps: Slope Movement Mechanics**

1. **Impact Gap: Need to assess forest fire as a landslide trigger along the potential pipeline route**
2. **Impact Gap: Need to assess susceptibility of slope destabilization caused by right-of-way thawing**
3. **Impact Gap: Need to assess creep of frozen ground as a cause of pipeline deformation**
4. **Impact Gap: Need to assess slope failures in the Liard Plateau and Peel Plateau**

### **Context:**

1. There is limited understanding of the possible interaction between right-of-way thawing and excessive thawing adjacent to a right-of-way caused by a forest fire. It has been predicted that climate change may cause an increase in forest fire frequency.
2. Although slope destabilization caused by right-of-way thawing was only a minor occurrence for the Norman Wells pipeline, wider right-of-ways are more susceptible to slope failures.



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3. Permafrost temperatures very close to 0°C throughout much of the Mackenzie Valley may promote gradual but ongoing movements (creep) at depths well below the active layer on slopes. It is also possible that creep within an excessively deep thawed zone may contribute to pipeline deformations.
4. Landslide distribution is documented in the Liard and Peel Plateau areas and mechanisms for failure have been proposed. However, the understanding of the factors controlling the ongoing movement that seems characteristic of many of the landslides in these areas is limited.
5. This information on slope movement mechanics would assist in the locating, design, construction and maintenance of new and existing pipelines in an economic and environmentally acceptable manner.
6. This information is required for all phases (except seismic exploration) of oil and gas exploration, development and transmission activities.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill these gap is immediate for Gaps 1 to 3, and moderate for Gap 4 (above).

### **Responsible and Contributing Organizations:**

The federal government (NRCan) could take the lead on acquiring this information by setting the research context. Project proponents could then gather detailed information on a project specific basis; universities and research institutions could contribute expertise in gathering this type of information.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

### **2.3.3 Baseline Gap: Need to document the general locations of terrain and soils that are susceptible to instability due to thaw (also see Section 2.2.2, Gap 2)**

#### **Context:**

1. This information will provide a general determination<sup>10</sup> of areas of terrain instability due to thaw. Some information is available for the existing Enbridge pipeline (Norman Wells to Zama), but is required for a potential pipeline corridor between Norman Wells and Inuvik and the development areas.

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<sup>10</sup> A general determination can be obtained through interpretation of surficial geology mapping and aerial photographs. Detailed information on terrain instability can only be obtained through specific sampling (boreholes) of soil and ground ice conditions

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2. This information is required for production drilling, field operations, and pipeline construction and maintenance phases.
3. This gap is related to the baseline gap requiring surficial geology mapping.
4. There are related fish and wildlife habitat issues and maintenance issues (more maintenance required and different engineering techniques if these areas cannot be avoided or mitigated by above ground construction or the use of granular resources).

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information requires a short lead-time to gather in areas where oil and gas activities are ongoing, and a long-lead time in other oil and gas development areas in the Mackenzie Valley where there are fewer activities.
- The urgency to fill this gap is moderate for the oil and gas areas; and immediate for the potential pipeline.

### **Responsible and Contributing Organizations:**

This information could be gathered by the federal government (NRCan), and augmented with any related project specific information (e.g., soil and ground ice conditions at specific locations) gathered by project proponents. Information should be synthesized, analyzed and mapped. Existing Quaternary geology mapping (some areas currently being upgraded) can be used for general determination of terrain instability due to thaw, supplemented with extensive borehole data that exists from earlier route assessments.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## **2.3.4 Impact Gap: Identify environmental impacts and appropriate mitigation measures related to soil compaction and rutting**

### **Context:**

1. The operation of vehicles over land can cause soil compaction and rutting, which in turn can cause adverse environmental effects. These impacts have been well studied in more southern areas such as Alberta, but are not well understood in northern regions. A better understanding of the short and long-term effects is required for the Mackenzie Valley, especially in permafrost regions. Specific

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operating criteria and regulatory terms and conditions to reduce or avoid these effects could then be developed.

2. There is a need to understand whether the impacts vary particularly on soils that are sensitive/susceptible to disturbance such as liquefaction and ice lensing.
3. There is a need to evaluate suitability of existing mitigation measures on these soils.
4. This information is required for the environmental assessment and regulation of projects in the oil and gas development areas and along the potential pipeline corridor.
5. This information is required for all phases of hydrocarbon development and facilities operation.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The federal departments (such as DIAND, NRCan and others) and GNWT could be responsible for gathering this information, with assistance from project proponents, universities and research institutions. Organizations such as Canadian Association of Petroleum Producers (CAPP) and Environmental Studies Research Funds (ESRF) can also contribute.

Specific research programs should be undertaken to identify the short and long-term environmental effects of soil compaction and rutting in various environmental settings and soil types in the Mackenzie Valley. This should include synthesizing and analyzing existing information and gathering new information to better understand these effects especially in sensitive soils. Consideration should be given to developing appropriate operating criteria or guidelines to reduce and avoid these types of effects.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## 2.4 Permafrost

### 2.4.1 **Baseline Gap: Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.**

#### **Context:**

1. Much of the information compiled in existing ground temperature and geotechnical (providing information on ice content and soil water contents) databases was collected 25-30 years ago and the quality and quantity of ground ice data is limited. The majority of the ground temperature sites are inactive, and any changes in near surface ground temperature conditions that may have occurred in the last few decades are not known. Active shallow permafrost ground temperature monitoring in response to anthropogenic and climate changes is more limited - and focussed on the Norman Wells pipeline corridor and the Mackenzie Delta. Both ground temperature and geotechnical databases are being updated with Norman Wells pipeline corridor data. There is little ground temperature data between Norman Wells and Inuvik, as well as in the proposed development areas.
2. Gathering this information where there are spatial (laterally and with depth) as well as large temporal gaps would provide needed data for oil and gas project planning and design, and environmental assessment.
3. This baseline information would be useful for exploration and production drilling, infrastructure development, field operations, pipeline planning, construction and operation phases.
4. Knowledge of ground temperatures and ground ice conditions is relevant to sump integrity and climate change.
5. Communities have raised concerns over the lack of knowledge about permafrost conditions.

#### **Timing and Timeframe:**

- Compilation and/or updating of databases should be gathered in the short term; and new field investigation/data collection should be gathered in the long term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate.

#### **Responsible and Contributing Organizations:**

This baseline information could be gathered by the federal government (NRCan), and augmented by project specific information gathered by project proponents where such information is not proprietary and is accessible. Collaborative activities (government-industry) could be explored as industry field programs are planned and executed to compile information in data sparse areas. Universities and research institutions could also participate in gathering this information. Efforts at compiling new and updating

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existing databases, which have been supported by PERD and NRCan, need to continue. Existing information throughout the region whose synthesis is not complete (e.g., numerous reports have been released on the Enbridge pipeline and a final synthesis of government research results is underway) should be analyzed and reported along with results of new investigations-

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop
- Community visits
- Norman Wells Workshop

### **2.4.2 Impact Gap: Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost**

#### **Context:**

1. A critical component of the engineering design of northern gas pipelines will be designing for frost heave to ensure the chilled pipe can withstand differential movements in either previously frozen or newly frozen ground.
2. Knowledge of the physical environment, soil conditions (thermal, frost susceptibility), transitions from frozen to unfrozen ground, drainage and moisture availability, and information on thermal mode of pipeline operation, depth of burial, will all be important parameters for assessing /determining frost heave design. Such data are not in the public domain. It will be important to undertake a thorough and up-to-date review, synthesis of data and knowledge on frost heave, to improve assessment of frost heave impacts on pipeline integrity and terrain.
3. This information is required for pipeline planning, design, environmental assessment, construction and operation.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate.

#### **Responsible and Contributing Organizations:**

The synthesis information could be gathered by the federal government (NRCan, DIAND) and other organizations such as ESRF and could include documenting knowledge/theories of frost heave, summary

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of large-scale observations (field experiments, controlled environment tests, operational pipelines), laboratory tests, and predictive models. Project-specific information could be collected by the proponent.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop

### **2.4.3 Impact Gaps: Drilling Waste Fluid (Mud) Containment Sumps**

1. **Impact Gap: Need to establish the long-term viability and best practices of using permafrost excavated pits (sumps) for containing drilling muds.**
2. **Impact Gap: Need to research alternatives to using sumps for projects in the Mackenzie Valley.**
3. **Impact Gap: Identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.**

### **Context:**

1. Sumps have been used in the Mackenzie Valley for many decades as the preferred method for disposal of wastes from drilling operations. Drilling mud is placed in pits (sumps) excavated in permafrost and covered once the contents are partially or completely frozen. It has been observed that there has been failure in permafrost performance. Leaking sumps have the potential to cause environmental impacts.
2. Drilling waste disposal and management associated with oil and gas exploration and development drilling is an ongoing issue in the Mackenzie Valley, particularly as there is an increasing incidence of failure of abandoned sumps. New drilling techniques and technology has improved over the years, resulting in a reduction of total drilling waste volumes. There is an ongoing need to develop better sump construction techniques, or to develop alternatives to using sumps for drilling waste disposal outside of the Mackenzie Delta.
3. The construction of drilling fluid containment sumps may contribute to terrain disturbances related to sumps excavation (blasting).
4. Documenting the location and state of sumps will enable traditional land users and project planners to avoid those areas. Documenting these sites will also enable a program to be set-up to monitor the integrity of existing sumps and deal with any that have lost integrity; and monitor the effects of climate change on their integrity.
5. Community concerns over the stability of existing sumps and the effects of sumps with lost integrity were raised at the Norman Wells Workshop. Clean-up of leaking sumps is also a major concern with

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communities. With increased oil and gas activity in the Mackenzie Valley, there is a need to develop alternatives and use best practice measures.

6. These gaps are linked to research work currently being undertaken on sumps by CAPP and by an Environmental Studies Research Funds (ESRF) project for the Mackenzie Delta.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short and long lead time to gather.
- The urgency to fill these gaps is immediate. The need for funding this research is low due to the ongoing study of sumps for the Mackenzie Delta - this study is not considering the question of alternatives to using sumps. Research into alternatives to using sumps is immediate and required.

### **Responsible and Contributing Organizations:**

The documentation of long-term stability of sumps especially in permafrost conditions could be undertaken jointly by the federal government (DIAND, NEB, Environment Canada – EC and others), GNWT and project proponents through the development of guidelines and best practices for sump construction. ESRF, universities and other research institutions could also assist in addressing these gaps.

These information gaps are linked to other permafrost baseline gaps such as locating ground temperature and ground ice conditions and the effects of climate change on permafrost conditions in the Mackenzie Valley.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop
- Community visits
- Norman Wells Workshop

## 2.5 Hydrogeology

### 2.5.1 **Baseline Gap: Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor**

#### **Context:**

1. The information available is site specific and limited to some work done in the Nahanni area (e.g., not associated with an oil and gas development area or the pipeline), and some general baseline work

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completed for the 1970s Canadian Arctic Gas Pipeline Limited pipeline proposal. Information related to specific projects would likely only become available during construction.

2. This information is critical for the area between Great Bear Lake to Fort Simpson coming out of the Franklin Mountains, as well as the Travaillant Lake area.
3. This gap relates to near surface groundwater flow and interference with this flow as a result of building a pipeline, and resulting pipeline integrity.
4. Communities have raised concerns over the quality of groundwater in development areas, and potential impacts to fish and wildlife.
5. This information is required for the potential pipeline, and for buried pipelines associated with the Cameron Hills, Liard Plateau and Norman Wells oil and gas development areas.
6. This information is needed prior to pipeline construction and during operation phases.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate to immediate, driven by project timing. It is immediate for the Travaillant Lake area.

### **Responsible and Contributing Organizations:**

The federal government (EC, NRCan, and DIAND) could contribute to the collection of data and could prepare guidance material on collection of data. Project proponents could gather this information on a project-specific basis.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Norman Wells Workshop
- Community visits

## **2.5.2 Impact Gap: Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings**

### **Context:**

1. Operating a chilled pipeline in unfrozen ground could potentially cause frost bulb development around the pipeline and subsequently interfere with groundwater flow. Frost bulbs can also create



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problems at stream crossings and interfere with water flows, fish movement, erosion and pipeline integrity.

2. Addressing this gap will provide specific information needed at the design stage for the pipeline, and will also identify potential problem areas along the pipeline corridor.
3. Community concerns have been raised in relation to aquatic, permafrost and groundwater impacts.
4. This gap is linked to the hydrogeology baseline gaps

### **Timing and Timeframe:**

- This information should be gathered in the short term for identifying potential problem areas, and in the long term for monitoring the pipeline during operation.
- This information will take a short and long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

This information could be gathered by the federal government (NRCan) and other departments and agencies, with assistance by the universities and research institutions and by project specific information collected by project proponents. Initial identification of potential problem areas should be done to feed into pipeline engineering design. Long term monitoring should be undertaken during pipeline operation.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Norman Wells Workshop
- Community visits

## 2.6 Surface Water

### 2.6.1 **Baseline and Impact Gaps:** Background Hydrocarbon Levels

1. **Baseline Gap:** Need to determine natural background hydrocarbon levels (e.g., polyaromatic hydrocarbons – PAHs) in streams and lakes in oil development areas and along potential oil pipeline corridors.
2. **Impact Gap:** Need to research how stream and lake water quality is affected by natural hydrocarbon seeps.

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3. **Impact Gap: Need to determine how background hydrocarbon levels in streams and lakes can be distinguished from those resulting from exploration and development activities.**

### **Context:**

1. This information is needed to be able to distinguish background levels from those resulting from exploration and development activities. It would assist in identifying natural trends and determining source areas.
2. Information is available for the Mackenzie River, but not for its tributaries and lakes in the development areas.
3. This information would be useful for all phases of oil exploration (except seismic exploration), development and transmission.
4. These gaps are related to other surface water quality monitoring programs.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The federal government (e.g., DIAND, DFO) and research institutions could take the lead in acquiring this information. Where available, information from project proponents could be obtained. These gaps can be filled through long-term monitoring programs that are designed to identify temporal trends and sources.

### **Origin of gaps:**

- Background Paper Report
- Scientists' Workshop

## **2.6.2 Baseline Gap: Existing hydrologic models need to be adapted to Mackenzie Valley conditions.**

### **Context:**

1. Hydrologic models have been developed for southern Canada, and need to be adapted to include permafrost regions. It is noted that some work is underway under the Mackenzie Global Energy and Water Cycle Experiment study.

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2. Hydrologic models have been developed for Alaska and other circumpolar countries and should be examined.
3. Hydrologic modelling is an important aspect of project planning and design.
4. This information is required for the potential pipeline development and for projects located in the oil and gas development areas.
5. This information is applicable for all phases of oil and gas development activities.
6. This gap is linked to the need for baseline hydrometric data from tributary streams of the Mackenzie River (Section 2.6.3).

### **Timing and Timeframe:**

- This information will be needed in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

This information could be gathered by the federal government (EC), and augmented by project specific information gathered by project proponents. Universities and research institutions could contribute to the development of hydrologic models suitable to northern regimes. Models can be adapted and run, and then results can be field verified where appropriate.

### **Origin of Gap:**

- Background Paper Report
- Scientists Workshop

### **2.6.3 Baseline Gap: Additional hydrometric<sup>11</sup> data for tributaries of the Mackenzie River is required**

#### **Context:**

1. Hydrometric data are sparse for tributaries of the Mackenzie River (especially the east bank tributaries) along the potential pipeline route particularly for areas north of Norman Wells and for winter low flow regimes for all areas.
2. This information is particularly useful for seismic exploration, production drilling, infrastructure development, field operations, and pipeline construction and operations phases.
3. This gap is related to the need for adaptation of existing hydrologic models to Mackenzie Valley conditions (see Section 2.6.2).

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is moderate, project driven

### **Responsible and Contributing Organizations:**

The federal government (DIAND and EC) could be responsible for gathering this baseline information, and establishing additional hydrometric stations to collect the data where needed.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## **2.6.4 Baseline Gap: Expansion of the snow survey data collection program is required**

### **Context:**

1. The snow pack contributes to overall surface and ground water quantities each year. By monitoring snow pack, more accurate hydrological modelling can be completed, predictive models/assessments of the affects of climate change can be determined (as climate change affects snow pack and overall precipitation), and ground thermal regime changes as a result of changes in snow pack can be understood.
2. The snow survey network is sparse and is focused on basins with hydroelectric developments and major communities. Data, where available, are for end-of-season snowpack only. No snow data has been collected in the Mackenzie Mountains and very little in the oil and gas development areas.
3. This information is required for infrastructure development, field operations, and pipeline construction and operation phases.
4. This gap is linked to hydrological modelling initiatives, permafrost monitoring, climate change monitoring, and ground thermal regime monitoring.

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<sup>11</sup> Measurement of water, usually water quantity measurements such as flow and water levels.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered over the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

### **Responsible and Contributing Organizations:**

The federal government (EC and NRCan) could be responsible for collecting this baseline information.

### **Origin of Gap:**

- Scientists' Workshop.

## **2.6.5 Baseline Gap: Requirement to understand the natural processes that lead to rapid lake drainage<sup>12</sup> and identify areas where there is potential for this phenomenon to occur in relation to oil and gas activities**

### **Context:**

1. Rapid lake drainage has been documented in the Mackenzie Delta area where lakes are surrounded by ice-rich permafrost. There is potential for such drainage events to occur south of the delta, where appropriate conditions exist. The frequency and effects of rapid lake drainage may be influenced by climate change.
2. Research has shown that a naturally drained lake has sufficient energy in the lake water to melt ice-rich permafrost. This could in turn create issues (e.g., ground subsidence) to pipeline integrity and other oil and gas infrastructure.
3. Preliminary research indicates that the wetter and warmer climate conditions may be associated with the occurrence of rapid lake drainage. However, this has not been confirmed.
4. This information is required for infrastructure development and pipeline construction and operation phases.
5. This baseline gap is linked to impact gaps that affect ground stability and infrastructure integrity.

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<sup>12</sup> Rapid Lake Drainage – rapid (hours, days) draining of a lake through natural processes. Occurs where lakes are surrounded by ice-rich ground (high ice content). The drainage is usually initiated by overflow of the lake, which in turn causes erosion of soils and melting of the surrounding ice-rich ground.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

### **Responsible and Contributing Organizations:**

The federal government (EC, DFO) could be responsible for gathering this baseline information, and universities and research institutions could assist in addressing this gap.

### **Origin of Gap:**

- Scientists' Workshop.

## **2.6.6 Baseline Gaps: Improved database (including grain size) on geomorphology settings at stream crossings is required**

### **Context:**

1. Baseline information on geomorphic conditions at stream crossings is required to enable a comparison with post construction conditions, and to determine potential impacts.
2. Baseline information is also required to determine unstable geomorphic conditions that may require avoidance or special construction techniques to be used.
3. Information on sediment size materials is required to determine appropriate pipeline burial depths, and is important for hydraulic modelling.
4. This information can be used for seismic activities, infrastructure development, field operations, and pipeline planning, design, engineering and construction phases.
5. These gaps are linked to work that would be required for fish and fish habitat/aquatic resources impact avoidance.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate.

## Action Plan

### **Responsible and Contributing Organizations:**

The federal government (NRCan, DFO, EC, DIAND) could be responsible for setting the context for this information. Project proponents could be responsible for gathering and filling these gaps. This information should be gathered as part of baseline information gathering prior to an environmental assessment.

### **Origin of Gap:**

- Scientists' Workshop

### **2.6.7 Baseline Gap: Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas**

#### **Context:**

1. Communities have expressed a concern over the lack of detailed information and understanding of baseline water quality and quantity regimes in the watersheds of the oil and gas development areas.
2. An understanding of the water regimes in the watersheds of development areas would assist in the proper regulation and management of these areas and protect the quality of these regimes.
3. This information is required for all of the oil and gas development scenarios.
4. This information can be used in the project planning, design and construction phases.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long-lead time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

Project proponents could gather this information as part of their baseline environmental studies. The federal government (DIAND, EC) could provide the context for the information to be collected, and retain the acquired information in a database.

### **Origin of Gap:**

- Community visits
- Norman Wells Workshop

## **2.6.8 Impact Gap: Requirement to understand long term environmental impacts to surface water as a result of oil and gas development activities in existing oil and gas development areas**

### **Context:**

1. By using the oil and gas developments in the Cameron Hills, Liard Plateau and Norman Wells areas as case studies, long term and cumulative impacts to surface water could be determined. If these impacts could be definitively linked to oil and gas activities, then lessons could be learned about potential impacts and the effectiveness of mitigation measures.
2. There is an opportunity to determine potential impacts that could be caused by long term oil and gas activities in an area, and determine the effectiveness of mitigation measures.
3. This information is relevant to all development areas.
4. This information gap would be most appropriate for production drilling and pipeline planning, design, construction and operation phases.
5. Communities have expressed concerns over the long-term impacts of development on surface water quality.
6. This gap is linked to cumulative effects initiatives, such as the CEAM Strategy and Framework program.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The federal government (DIAND and EC) could undertake this project in collaboration with the GNWT, project proponents, renewable resource boards, land and water boards, and community organizations.

This information could be gathered through a case study approach, targeting specific parameters to measure. Care must be taken to ensure that impacts identified could definitively be tied to oil and gas activities.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop



- Norman Wells Workshop
- Community visits

## 2.7 Fish and Fish Habitat

### 2.7.1 Baseline Gaps: Baseline Surveys

1. **Baseline Gap**: Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap:

#### Lakes<sup>13</sup>:

- Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant.
- Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio.
- Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor.

#### Rivers<sup>14</sup>:

- Gwich'in Settlement Area: Travaillant R. and Thunder R.
  - Sahtu Settlement Area: Oscar Ck, Donnelly R., Hare Indian R., and Loon R.
  - Deh Cho Region: Trail R. and Willow Lake R.
2. **Baseline Gap**: Need information on distribution of contaminants (associated with oil and gas development) in sediments and in harvested fish, especially for known spawning grounds, areas of fishing for human consumption, exploration areas and seeps.
  3. **Baseline Gap**: Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above in Gap 1.
  4. **Baseline Gap**: Aquatic surveys (which should include game fish, forage fish and invertebrates) need to be conducted at stream crossings.

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<sup>13</sup> These lakes are based on proximity to the proposed pipeline route (within 10 km of pipeline route), importance to communities, and lake size (assuming larger lakes are more likely to be of importance to communities, to contain harvested fish populations and have greater biodiversity)

<sup>14</sup> The selection of these rivers is based on: proximity to pipeline route, likelihood of suitability for spawning or being used as a migratory corridor for spawning, rearing or over-wintering migrations and existing information suggests important species occur in these rivers.

## Action Plan

### **Context:**

1. Species abundance and time series data are poor for most species.
2. Communities have raised concerns over the need to study inland lakes and the fish populations of these lakes
3. Fisheries surveys at stream crossings are needed to determine spatial and seasonal variability of species.
4. Some contaminants (e.g., PAHs from oil) information is available for the Mackenzie Valley; however, this information should be updated where relevant project development is anticipated.
5. This information would support all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is immediate for Gaps 1 and 3, and moderate for Gaps 2 and 4.

### **Responsible and Contributing Organizations:**

The federal government (DFO) could be responsible for gathering this information, with assistance from renewable resource boards, and project proponents.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.7.2 Baseline Gaps: Ecological Knowledge Gaps (also see Section 2.7.5)**

1. **Baseline Gap: Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1.**
2. **Baseline Gap: Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1.**
3. **Baseline Gap: Need to identify the factors that govern the abundance of economically important and rare species (following baseline data collection).**

## Action Plan

4. **Baseline Gap:** Need to identify the critical trophic linkages that may be affected by developments.

### **Context:**

1. Impacts due to development can be better determined by addressing these baseline gaps, which identify critical environmental information for fish.
2. The complex life cycles of economically important species and rare species are generally not well known. Development impacts cannot be determined without a better understanding of these species lifecycles, including the location of critical habitats (spatial and temporal), the critical environmental requirements to sustain life (i.e., in-stream physical requirements), and how disrupting other species may affect these important species.
3. Understanding this is required to ensure that impacts on aquatic habitats are not transmitted through the trophic pathways to higher level which are usually the commercially important species
4. This information would support all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is immediate for Gaps 1 and 2, moderate for Gap 3, and low for Gap 4.

### **Responsible and Contributing Organizations:**

The federal government (DFO) could be responsible for gathering this information, with assistance from renewable resource boards, project proponents, universities and research institutions.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

### **2.7.3 Impact Gaps: Monitoring Programs**

1. **Impact Gap:** Need to identify the impacts of projects on vital rates (reproduction, growth, mortality) and abundance of populations, and in harvest rates.
2. **Impact Gap:** Need to identify project-related changes in abundance and species composition of invertebrates.

## Action Plan

3. **Impact Gap: Need to identify project related spatial and temporal trends of contaminants (associated with oil and gas development).**

### **Context:**

1. A better understanding of how project related environmental changes and impacts affect species directly and collectively through the food web at all trophic levels is required.
2. This information would support all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The federal government (DFO and EC) and renewable resource boards could be responsible for gathering this information, with assistance from project proponents.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## 2.7.4 **Impact Gaps: Impact Knowledge Gaps**

1. **Impact Gap: In existing oil and gas development areas and along existing pipeline corridors, need to identify and quantify impacts on fish and fish habitat as a result of development.**
2. **Impact Gap: In existing oil and gas development areas and along existing pipeline corridors, need to determine what mitigation measures have been implemented and determine their effectiveness.**

### **Context:**

1. Existing and past projects can be assessed to determine the impacts that occurred, the effectiveness of applied mitigation techniques and the remaining residual effects, which will help to focus priority research areas.

## Action Plan

2. This information would support all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is immediate.

### **Responsible and Contributing Organizations:**

The federal government (DFO and EC) could be responsible for gathering this information, with assistance from universities and research institutions, and project proponents.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## **2.7.5 Impact Gap: Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells**

### **Context:**

1. Little information exists on sensitive fisheries areas along watercourses north of Norman Wells. Identifying sensitive areas would assist in planning and developing appropriate mitigation measures for sensitive areas that may be impacted by development activities such as damming.
2. Such information would be useful for hydraulic modelling to identify those areas that may require special engineering approaches.
3. This information is useful for the potential pipeline scenario.

### **Timing and Timeframe:**

- This information is needed in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate (prior to the pipeline construction phase).

### **Responsible and Contributing Organizations:**

The federal government (DFO) could set the context for gathering this information, and project proponents could be responsible for gathering it on a project specific basis.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## **2.8 Vegetation and Forests**

### **2.8.1 Baseline Gap: Need landcover (vegetation) mapping including identification of terrestrial and wetland<sup>15</sup> vegetation types**

#### **Context:**

1. Communities and scientists identified the need to have a complete landcover inventory of the Mackenzie Valley. This is essential to understanding impacts and detecting landscape level changes as may occur from cumulative impacts. Mapping of some specific locations along the Mackenzie River and development areas has been conducted; however, this mapping does not provide a basis for assessing cumulative impacts.
2. Landcover/earthcover inventory work by Ducks Unlimited is underway (and in some areas completed) in the Sahtu and Gwich'in Settlement Areas, largely along the Mackenzie Valley. The Deh Cho Region and the Colville Hills area in the Sahtu have not been mapped.
3. The landcover inventory will provide an important information layer for the development of an ecological land classification system (see Section 2.8.2).
4. The information will also provide a basis for linking vegetation type to wildlife habitat preferences and requirements, and will provide a basis for documenting fire history and recovery rates and patterns of vegetation.
5. The mapping of wetlands will provide a basis on which groundwater-surface water interactions can be examined in the context of impacts due to development/construction.
6. This information is required for project design and siting
7. This information is needed for infrastructure development, field operations, and pipeline construction.

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<sup>15</sup> Consistency with existing classification systems (e.g., Canadian Wetland Classification System) and the recent compilation mapping of peatlands could be considered

## Action Plan

### **Timing and Timeframe:**

- Similar information to that being collected by Ducks Unlimited in the Sahtu and Gwich'in should be gathered for the Deh Cho and the Colville Hills area of the Sahtu in the short term.
- This information will take a short and long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The federal government (NRCan, EC) and the GNWT (RWED) could be responsible for jointly acquiring this information in co-operation with renewable resource boards and organizations such as Ducks Unlimited Canada. Local community members could be involved in gathering this information. Both scientific knowledge and TK needs to be collected.

### **Origin of Gap:**

- Community visits
- Norman Wells Workshop

## **2.8.2 Baseline Gap: An ecological land classification (ELC) system needs to be developed**

### **Context:**

1. Some classifications systems exist, but there is no standardized, NWT-wide system for the evaluation of land within an ecological framework. A common ecosystem classification is required to assist with protected area identification, biodiversity, environmental assessment of development activities and for sustainable forest harvesting and wildlife habitat conservation.
2. GNWT (RWED) is currently planning for the development of an ELC, which includes consideration of the NWT Protected Areas Strategy goals.
3. This information is required for the potential pipeline and projects in the oil and gas development areas.
4. This information can be used for seismic and drilling exploration, infrastructure development, and pipeline construction phases
5. This gap is related to the gap raised by communities for landcover/vegetation mapping in the Mackenzie Valley and to biodiversity conservation.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for setting the context of this work, for gathering the information, and for housing the information in a mapped Geographic Information System (GIS) format and database. Renewable resource boards could be responsible for assisting in gathering this information, augmented with support from project proponents and federal government (EC). Local community members and TK holders could also participate in this work.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community Visits
- Norman Wells Workshop

### **2.8.3 Baseline Gap: Need to identify and map locations of rare and medicinal plants**

#### **Context:**

1. Communities have indicated the need to compile TK about rare and medicinal plants and to map known occurrences of these species to avoid disturbance to these plants.
2. This information is required in order to protect these plants and areas from development activities, in particular, endangered species. This information will assist in the planning phases of construction and development.
3. An ethnobotany study is being conducted in the Inuvialuit Settlement Region. Similar studies could assist in addressing this gap.
4. This information is required for the design and siting of potential hydrocarbon projects.
5. This information is required for seismic exploration, exploration drilling, infrastructure development, and pipeline construction phases in order to avoid sensitive or important areas.



## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the Mackenzie Valley in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate both from the need to determine development routings and the need to obtain information from elders before they pass on.

### **Responsible and Contributing Organizations:**

The federal government (EC, NRCan) and the GNWT (RWED) could collaborate on collecting, recording and mapping baseline information, with assistance from renewable resource boards, social and cultural institutes, and land use planning boards and committees of the Gwich'in and Sahtu. University researchers may also contribute to this knowledge. Project proponents could be responsible for collecting and recording project specific information.

There is a need distinguish between the collection of scientific knowledge and TK. This information would have to be collected and documented in such a way so that listed species are not jeopardized (e.g., documentation should not include specific location of listed species).

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.8.4 Impact Gap: Need to document TK with respect to project effects on vegetation and forests**

### **Context:**

1. There is little information available about the long-term effects of project induced impacts to vegetation and forests in the Mackenzie Valley. TK about vegetation and forest resilience and response to burning, land clearing, and contamination (spills and leaks) impacts is lacking, and would be particularly useful in addressing this gap.
2. Scientific research could also be undertaken and both knowledge types could be combined to understand these effects.
3. This information is required for the environmental assessment, regulation and management of a potential pipeline and for oil and gas developments.
4. This information can be used for all phases of exploration, development and transmission.

## Action Plan

5. This information gap is linked to TK gathering initiatives underway in the Mackenzie Valley.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

Renewable resource boards, land use planning boards and committees, and community organizations could be responsible for setting the context and for gathering and analyzing this information, augmented by project specific TK collected by project proponents would be of assistance.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.8.5 Impact Gap: Need to determine long-term recovery rates of disturbed vegetation communities**

### **Context:**

1. There is some data available about re-vegetation and recovery rates from along the existing Enbridge pipeline. However, studies of the long-term recovery and re-colonization rates, or species presence in vegetation communities after disturbance are required from other areas of the Mackenzie Valley where different climatic conditions occur.
2. This information is required to establish appropriate rehabilitation strategies for disturbed sites for the potential pipeline and for projects in the oil and gas development areas.
3. This information can be used for seismic exploration, infrastructure development, field operations and pipeline construction phases of development.

### **Timing and Timeframe:**

- This information is needed in the short term, and can be collected in the short to medium term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

This information could be gathered by project proponents, with the federal government (EC) and GNWT (RWED) setting the context for these studies. TK and input from community members could assist in addressing this gap.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop
- Community visits
- Norman Wells Workshop

### **2.8.6 Impact Gaps: Native Seeds**

1. **Impact Gap: Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley.**
2. **Impact Gap: Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank<sup>16</sup>).**

### **Context:**

1. Communities and scientists have expressed concerns regarding the introduction of non-native plant species into development areas and their spread into undisturbed areas. More research into the use of native species may result in a reduced need for the use of non-native plant species for revegetation of disturbed sites.
2. This research will assist in understanding the suitability of various native plant species for re-vegetation
3. Native seeds and seedlings are currently not available for re-vegetation of disturbed areas so non-native species are typically used for erosion prevention and re-vegetation purposes.
4. This information is required for the potential pipeline and for projects in the oil and gas development areas.

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<sup>16</sup> The meaning of seed bank in this case context: usually a temperature- and humidity-controlled facility used to store seed (or other reproductive materials) for future use.

## Action Plan

### **Timing and Timeframe:**

- This information is needed in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is immediate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for setting the context for this initiative and project proponents could be responsible for collecting and establishing the seed bank. Assistance could be provided by renewable resource boards, universities, research institutions and the Museum of Nature. Local residents could be consulted and TK gathered to help in development of these native seed banks. It is important to recognize that revegetation success is dependent on site-specific conditions in addressing these gaps.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

### **2.8.7 Impact Gap: Need information for the Mackenzie Valley on non-native species, including current locations of non-native species, the means by which non-native species are introduced into an area, the potential for non-native species to invade areas and where they may become a concern**

#### **Context:**

1. Non-native species are often used as a nurse crop to provide short term coverage for erosion control purposes on disturbed areas allowing native species to become established. However, non-native species have the potential to spread into adjacent (undisturbed) areas, become invasive and have the potential to inhibit the establishment of native species. This can potentially alter native vegetation communities and traditional plant use areas.
2. Addressing this gap will assist in developing prevention measures against the introduction of non-native species in areas where they are unwanted, which is linked to biodiversity conservation efforts.
3. Communities and scientists have concerns about the locations of and how non-native species become introduced into undisturbed areas.
4. This information is required for the potential pipeline and for projects in the oil and gas development areas.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short and long lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could conduct the initial research on the introduction of non-native species and identify areas where non-native species may be of concern. Best practices and/or guidelines for the Mackenzie Valley to prevent the introduction of non-native species could be developed by the GNWT (RWED) and NEB and project proponents. The term non-native species needs to be clearly defined before addressing these gaps.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits

## **2.9 Mammals**

### **2.9.1 Impact Gap: Need to study the potential effects of habitat fragmentation on different wildlife species**

#### **Context:**

1. Communities raised the concern that there is little information about the effects of habitat fragmentation on wildlife.
2. Scientific research in other parts of Canada suggest that some wildlife species such as woodland caribou and some forest birds are particularly sensitive to habitat fragmentation.
3. Existing information about the potential effects to wildlife species from habitat disturbance and fragmentation needs to be evaluated for applicability to the Mackenzie Valley.
4. This information would support seismic exploration, field operations and pipeline construction phases.
5. This is linked to impact gaps caused by developments and their effects on landscapes, vegetation communities and habitat generally.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long-lead time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The federal government (EC) and GNWT (RWED) could be responsible for gathering this information, with support from renewable resource boards, universities and research institutions.

### **Origin of Gap:**

- Community visits
- Norman Wells Workshop
- Background Paper Report

## **2.9.2 Impact Gap: Need to study the behavioural responses of wildlife to development activities, including inter-species behaviour changes, i.e. changes in prey vulnerability**

### **Context:**

1. Behavioural responses of wildlife to development activities, including inter-species relationships (i.e., predator-prey relationships) have been studied in other areas. Addressing the above noted gap can be used to confirm that similar responses can be predicted for the Mackenzie Valley area.
2. Communities have raised concerns about how species behaviour and inter-species relationships may change due to development activity occurring in the oil and gas development areas.
3. This information is required for the oil and gas development areas, and along the potential pipeline corridor.
4. This information would support exploration, development and transmission phases.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long-lead time to gather.
- The urgency to fill this gap is moderate.

## Action Plan

### **Responsible and Contributing Organizations:**

The federal government (DIAND, EC, Parks Canada and other relevant departments) and GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards, universities and research institutions. The participation of TK holders could also benefit this work. Post-development monitoring programs by industry could also contribute to meeting this gap.

### **Origin of Gap:**

- Community visits
- Norman Wells Workshop

### **2.9.3 Baseline Gap: Need to research the baseline level of contaminants (associated with oil and gas development) in harvested wildlife species and assess the potential for release of contaminants**

#### **Context:**

1. Traditional harvesting is a large part of community life in the Mackenzie Valley. Concerns were raised over the potential for increased levels of hydrocarbon contaminants in the environment, their effects on wildlife species, and how bio-available contaminant levels in harvested species may be.
2. This information is required for all oil and gas development areas.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long-lead time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The federal government (EC), GNWT (RWED) and project proponents could be jointly responsible for gathering this information.

### **Origin of Gap:**

- Background Paper Report
- Community visits
- Norman Wells Workshop

## 2.9.4 **Baseline and Impact Gaps: Boreal Woodland Caribou**

1. **Baseline Gap: Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness for Boreal Woodland Caribou.**
2. **Impact Gap: Need information on factors affecting Boreal Woodland Caribou survival and responses to human activities.**

### **Context:**

1. Some studies have been initiated but these studies do not address all the gaps. TK on Boreal Woodland Caribou is limited and needs to be collected.
2. This information is required for Cameron Hills, Sahtu (NW), Colville Hills and for potential pipeline.
3. This information would be useful for all phases of oil and gas exploration, development and transmission in the oil and gas development areas identified and for the potential pipeline.
4. This information can build upon information obtained for northern Alberta (Boreal Caribou Committee)

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is immediate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards and project proponents. Communities in the vicinity of boreal woodland caribou home ranges should also be involved in these studies.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop



### **2.9.5 Baseline Gap: Northern Mountain Woodland Caribou - Need information on extent of occurrence, area of occupancy, population demographics and habitat use**

#### **Context:**

1. No studies have been conducted on Northern Mountain Woodland Caribou in the Peel or Liard Plateau areas so the importance of these areas to caribou currently cannot be assessed.
2. This information is required for the Peel and Liard Plateau oil and gas development areas.
3. This information would support seismic exploration, exploration drilling and field operation phases.

#### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

#### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards.

#### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

### **2.9.6 Baseline Gap: Bluenose West Caribou Herd - Information on movements and winter range use is needed**

#### **Context:**

1. This information is needed to assess the potential for effects resulting from disturbance. Studies are needed to build upon information available from studies undertaken in Alaska. Retrospective studies in Alaska have shown that barren-ground caribou are negatively impacted (cumulative) as a result of oil and gas development. Therefore it is important to understand where the caribou spend their year.
2. Potential effects of activities on the winter range of Bluenose West Caribou Herd has not been investigated.

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3. Need to understand and relate level of development intensity to caribou responses and the ability of populations to accommodate disturbance (population resilience). Require information on how these effects can influence harvest rates and a sustainable population.
4. This information is required for Colville Hills.
5. This information would be useful for exploration development and operation phases.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from communities, renewable resource boards, and project proponents.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

### **2.9.7 Baseline Gap: Furbearers - Estimates of furbearer distribution and abundance need to be developed based on habitat type, existing access and harvest data, with focus on key harvested species (lynx, marten, wolverine, beaver and muskrat)**

#### **Context:**

1. Some information exists, but not for all development areas. The current information is based mostly on fur harvest data. Communities have expressed interest in acquiring more information on all furbearer species.
2. This information in combination with fur harvest data is needed to assess potential for population level changes and identify necessary mitigation
3. This information is required for all oil and gas development areas and the potential pipeline
4. This information useful for all phases of oil and gas exploration, development and transmission.

## Action Plan

### **Timing and Timeframe:**

- This information should be gathered in the medium term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from communities and renewable resource boards.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Norman Wells Workshop
- Community visits

## **2.9.8 Baseline Gap: Dall's Sheep - Need information on population dynamics, health and abundance in the Liard Plateau**

### **Context:**

1. Communities have expressed concern over the lack of population dynamics, health and abundance information for Dall's Sheep in the Liard.
2. Population abundance in the Liard is dated. Responses of Dall's sheep to development activities has been studied but needs to be applied with current population and distribution data.
3. This information would be useful for seismic exploration and exploration drilling phases.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information with assistance from communities. Project proponents could also gather information related to their specific projects.

**Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Norman Wells Workshop
- Community visits

**2.9.9 Impact Gap: Information is needed on how linear developments contribute to re-colonization of Bison**

**Context:**

1. Bison populations are increasing in the lower Mackenzie Valley; information is required on how linear developments may influence/affect the population of Bison.
2. This information would provide background information for potential pipeline corridor management with respect to Bison re-colonization.
3. This information is needed for pipeline construction and operation phases.

**Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

**Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards.

**Origin of Gap:**

- Background Paper Report
- Scientist's Workshop

## 2.9.10 Baseline and Impact Gaps: Moose

1. **Baseline Gap: Need population abundance, trend and resilience data for Moose, including information on productivity, predation rates, and habitat status.**
2. **Impact Gap: Need information on effects of increased access resulting from development.**

### **Context:**

1. As development increases in the Mackenzie Valley, better information is required related to moose populations and impacts caused by development.
2. With the exception of the Sahtu, moose population data (population size, productivity and habitat status) are dated. Data on predation rates and effects of increased access are lacking in the vicinity of the five development areas.
3. This information would be required for all oil and gas development areas and the potential pipeline, with the exception of the Colville Hills area, where moose populations do not occur.
4. This information would be useful for all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## 2.10 Migratory Birds / Raptors

### 2.10.1 Baseline and Impact Gaps: Forest Birds

1. **Baseline Gap:** Information is required on population presence, density and inventory, and population-habitat association data of forest birds.
2. **Baseline Gap:** TK information on forest birds is required.
3. **Impact Gap:** Information is required on effects of rights-of-way on predation rates on forest birds.

#### **Context:**

1. Little research has been done on boreal forest bird populations and the effects of development where the area was previously undisturbed.
2. Some research on forest songbirds is being undertaken in the Liard Plateau oil and gas development area. This work should continue and be expanded to other development areas.
3. This information is required for all oil and gas development areas and for the potential pipeline.
4. This information would be useful for all phases of oil and gas exploration, development and transmission.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is moderate for Gaps 1 and 3 and immediate for Gap 2.

#### **Responsible and Contributing Organizations:**

The federal government (EC) could be responsible for gathering this information, with assistance from communities, renewable resource boards and research institutions.

#### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop
- Community visits
- Norman Wells Workshop

### **2.10.2 Baseline Gap: Waterfowl and Shore Birds - Need information on breeding behaviour and habitat use in the Mackenzie Valley**

#### **Context:**

1. Most research on waterfowl and shore birds has been completed in the Mackenzie Delta. Research is required in Mackenzie Valley especially small inland lakes adjacent to a potential pipeline corridor and in oil and gas development areas.
2. This information is required for all oil and gas development areas, and for the potential pipeline.
3. This information is needed for all phases of oil and gas exploration, development and transmission.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate.

#### **Responsible and Contributing Organizations:**

The federal government (EC) could be responsible for gathering this information, with assistance from renewable resource boards, research institutions and other organizations such as Ducks Unlimited.

#### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Norman Wells Workshop
- Community visits

### **2.10.3 Impact Gap: Raptors - Information is needed on how specific development activities affect nesting success rates and nest site abandonment**

#### **Context:**

1. Effects information is needed to appropriately predict and assess potential impacts on raptors.
2. This information would be useful for all phases of oil and gas exploration and development.

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### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards and project proponents. Focus should be on a potential pipeline, then oil and gas development areas.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

## **2.11 Biodiversity**

It should be recognized that the baseline and impact gaps identified for specific disciplines (e.g., vegetation, wildlife, fish) are in effect addressing biodiversity needs, in addition to the gaps identified below.

### **2.11.1 Baseline Gap: Need TK that conveys information about biodiversity**

#### **Context:**

1. TK conveys a wide range of information, and may include valuable information about biodiversity. Biodiversity information has been identified in TK from the Dogrib region, but not specifically for other regions of the Mackenzie Valley.
2. Communities have expressed interest and raised concerns over the need to develop a better understanding of the balance of nature and how the biological and physical components are related and dependent on each other, and how these relate to biodiversity.
3. This information is required for the potential pipeline and for projects in the oil and gas development areas.
4. This information can be used for all phases of oil and gas exploration, development and transmission in the Mackenzie Valley.



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### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The renewable resource boards and community organizations could be responsible for setting the context for, and for gathering TK. This could be augmented by project specific TK gathered by project proponents.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop
- Norman Wells Workshop
- Community visits

## **2.11.2 Baseline Gap: Genetically distinct species sub-populations of 'species at risk' need to be identified**

### **Context:**

1. There is little information available on genetically distinct sub-populations of species at risk in the Mackenzie Valley. This information is important for understanding the vulnerabilities of species at risk.
2. Local genetic variation reflects local adaptation within a species, and is an important part of biodiversity. Identifying these sub-populations will contribute to our knowledge of the local/regional ecosystem, and would also influence project planning and approval decisions.
3. This gap is linked to a limited number of studies that have been undertaken by the federal and territorial governments. It is also linked to federal legislation, the *Species At Risk Act*.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is low.

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### **Responsible and Contributing Organizations:**

The GNWT (RWED) - could be responsible for gathering this information. Assistance could be provided by universities, research institutions and federal government departments (EC, DFO, and DIAND).

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop

### **2.11.3 Impact Gap: Methodologies for assessing impacts to biodiversity need to be improved**

#### **Context:**

1. The assessment of impacts on biodiversity is a relatively new requirement in federal legislation, and processes to undertake such assessments need to be refined to do this. A variety of approaches are currently used, but none are particularly suitable
2. This gap is linked to all baseline gaps related to species abundance, diversity and ecological processes.
3. This is required for the potential pipeline and projects in the oil and gas development areas.
4. This information is needed for infrastructure development and pipeline construction phases.

#### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

Environmental assessment regulators and practitioners from government (EC, DFO, GNWT-RWED), universities, research institutions and project proponents could collaborate on developing and improving biodiversity impact analysis techniques and methodologies. Scientific and TK sources could be used to address this gap.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.12 Air**

### **2.12.1 Baseline Gaps: Air Quality Monitoring**

1. **Baseline Gap: Need to upgrade air quality monitoring stations at Inuvik, Norman Wells, and Fort Liard to measure for particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>), nitrogen oxides (NO<sub>x</sub>), volatile organic chemicals (VOCs), and ground level ozone (O<sub>3</sub>). The current acid precipitation station at Snare Rapids would provide true background concentrations (unaffected by any emission sources), but needs to be expanded such that it can measure TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, NO<sub>x</sub>, VOCs, O<sub>3</sub> as well as hydrogen sulphide (H<sub>2</sub>S) and sulphur dioxide (SO<sub>2</sub>).**
2. **Baseline Gap: Baseline air quality monitoring for TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, NO<sub>x</sub>, VOCs, O<sub>3</sub>, H<sub>2</sub>S, and SO<sub>2</sub> needs to be established at other locations where emission producing equipment, such as compressor stations, are proposed.**
3. **Baseline Gap: Using the above noted stations, need to establish baseline air quality conditions and to use these data for modelling air emissions.**

### **Context:**

1. To establish appropriate baseline of air quality data, there is a need to upgrade existing air-monitoring facilities and expand the air-monitoring network.
2. Airshed baseline monitoring - is required to determine local ambient air quality conditions, background levels of parameters, and airshed dynamics. This monitoring is also used in modelling air emissions to assist in project design and facility siting.
3. The air quality monitoring facilities are used for ongoing trend monitoring, impact assessment, and cumulative effects assessment.
4. The air quality parameters that require measurement are related to emissions from oil and gas activities.
5. Air quality monitoring stations do not currently exist between Norman Wells and Fort Liard.
6. Communities have raised concerns over downwind effects of flaring to vegetation, animals, water and fish, and the persistence of contaminants. There is general uncertainty surrounding the effects of flaring on the biological environment in northern regions.

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7. This information is required for the potential pipeline, and for potential and existing gas production sites in Colville Hills, Liard Plateau and Cameron Hills oil and gas development areas.
8. This information can be used for exploration and production drilling, field operations and pipeline operation development phases.

### **Timing and Timeframe:**

- This information is needed in the short term (establishing baseline) and long-term (ongoing monitoring for trends and impacts).
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED), with assistance from the federal government (EC), could be responsible for updating and expanding the air quality-monitoring network and establishing parameters and approaches. Project proponents could collect baseline data, conduct modelling and implement monitoring.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.12.2 Baseline Gap: Requirement for meteorological data sufficient to allow for point-source and multiple-source dispersion modelling studies of contaminant releases from oil and gas exploration and development sites.**

### **Context:**

1. Stations at Inuvik, Norman Wells, and Fort Liard monitor meteorological parameters, but provide site-specific information for these areas and are not necessarily useful for extrapolation to other locations. Snare Rapids does not monitor meteorological parameters.
2. These data are required in anticipation of future applications, since several years of valid data are needed to establish baseline and future meteorological regimes.
3. This information is required for the potential pipeline, and for potential and hydrocarbon development areas.
4. This information can be used for exploration and production drilling, field operations and pipeline operation development phases.

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### **Timing and Timeframe:**

- This information is needed in the short term (establishing baseline) and long-term (ongoing monitoring for trends and impacts)
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The GNWT (RWED), federal government (EC) and the proponent could participate in selecting additional sites where meteorological data are required, and the proponent could be responsible for collecting site specific monitoring data.

### **Origin of Gap:**

- Background Paper Report

### **2.12.3 Impact Gaps. Biological Indicators of Air Quality**

1. **Impact Gap: Need to research the sensitivity of wildlife and vegetation species to air quality changes, and determine which species would be good indicators of poor air quality.**
2. **Impact Gap: Need to research the appropriate ambient air quality standards for wildlife.**

### **Context:**

1. Addressing these gaps will provide information on potential impacts to the biological environment due to air quality.
2. Little is known about air quality impacts on wildlife. The sensitivity of some plant forms, particularly lichen, are well studied in southern regions, but the applicability to northern regions is not fully understood.
3. This information is required for the potential pipeline and for projects in the Norman Wells, Liard Plateau and Cameron Hills oil and gas development areas.
4. This information can be used for production drilling and pipeline operation phases.

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### **Timing and Timeframe:**

- This information is needed in the short term.
- This information will take a short lead-time to gather.
- The urgency to fill these gaps is low.

### **Responsible and Contributing Organizations:**

The GNWT (RWED) and federal government (EC) could be responsible for setting the context and gathering this information. During post development monitoring, project proponents could collect and continue to report project specific information. Renewable resource boards, universities and research institutions could assist in developing biological indicators.

### **Origin of Gap:**

- Background Paper Report
- Scientists' workshop

## 2.13 Climate Change

This section outlines gaps directly related to climate change. There are other gaps noted in this report that are linked to the understanding of climate change effects (see Sections 2.3.2, 2.4.1, 2.4.3, 2.6.4, and 2.6.5).

### **2.13.1 Baseline Gap: Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions**

#### **Context:**

1. Arctic regions, including the Mackenzie Valley, will be particularly affected by the temperature and climate changes which will contribute to such effects as increased risk of forest fire, widespread thinning and disappearance of permafrost, and changes in snow pack and precipitation. These effects in turn will contribute to changes in vegetation, wildlife and other ecological patterns and functions.
2. An understanding of potential changes to the physical environment will assist in understanding potential changes to the biological environment.

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3. This information is required to distinguish project-related impacts from climate change induced effects. The results would be applicable to the assessment and monitoring of the potential pipeline and for projects in the oil and gas development areas.
4. Communities have raised concerns over the possible effects of climate change, and want to better understand what they might be.
5. This gap is linked to biodiversity baseline and impact gaps.
6. This information can be used for production drilling, infrastructure development, field operations and pipeline design and operation phases.

### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate.

### **Responsible and Contributing Organizations:**

The federal government (NRCan, DIAND, EC) and GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards, universities and research institutions. Existing information on species responses to climate change need to be evaluated and modelled with current climate predictions and monitoring of species responses needs to be enhanced. Scientific and TK information could be used to address this gap.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

## **2.13.2 Impact Gaps: Climate Change Effects on the Physical Environment**

1. **Impact Gap: Along the Mackenzie Valley pipeline right-of-way, the impact of climate change on shallow ground temperatures (less than 5 m) requires assessment, especially in widespread and sporadic discontinuous permafrost zones.**
2. **Impact Gap: The impact of climate changes on forest fire frequency along the entire length of the Mackenzie Valley and the risk to infrastructure development needs to be assessed.**

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3. **Impact Gap: The impact of climate change on ice thickness in rivers and lakes for ice bridges and winter roads along the entire length of the Mackenzie Valley.**
4. **Impact Gap: The impact of climate change on snow conditions and associated winter trafficability associated with hydrocarbon developments including drilling and pipeline development.**
5. **Impact Gap: The impact of climate change on regional hydrology.**

### **Context:**

1. Climate change may have an impact on shallow ground temperatures, which could potentially affect permafrost distribution. This will be especially important for the widespread and sporadic discontinuous permafrost zones.
2. Increased fire frequency, and changes in snow pack and ice thickness may occur as a result of climate change. Increased fire frequency, and changes in snow pack may cause changes to insulating properties to permafrost, which may create ground stability issues. Changes in snow pack may also enhance potential changes to lake and river ice thickness as a result of climate change.
3. The potential for regional fluctuations in hydrological systems in the Mackenzie Valley could impact terrestrial and aquatic ecology. This should be considered for the climate change scenarios described above and the resulting impacts on the environmental conditions in the Mackenzie Valley.
4. These potential effects to the physical environment may have impacts on the biological environment: vegetation (e.g., loss through fire, community shifts, food quality) and fish and wildlife movement (e.g., expansion of home ranges, particularly northward).
5. The intent is to gather environmental baseline information and develop and monitor climate change indicators over a time interval that will produce meaningful results.
6. This information can be used for all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This information is needed in the short term.
- This information will take a long lead-time to gather.
- The urgency to fill these gaps is moderate.

### **Responsible and Contributing Organizations:**

The federal government (NRCan, EC, DIAND) and GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards, universities and research institutions.



### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

### **2.13.3 Impact Gaps: Permafrost Response to Climate Change / Pipeline Integrity**

1. **Impact Gap: Need to document spatial and temporal variability in permafrost response to climate change.**
2. **Impact Gap: Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas.**
3. **Impact Gap: Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change.**

### **Context:**

1. Climate change may influence thaw settlement and frost heave, frozen/thawing slope processes and stability, river processes and stability. In turn these could affect infrastructure integrity. Changes to permafrost may also have an impact on hydrology and ecosystems. In the last 5-7 years numerous studies have begun to examine and report on the sensitivity of permafrost soils and processes to climate change in the Mackenzie Valley. In addition, a network of active layer and ground temperature monitoring sites has been developing in the Valley and is documenting recent changes, but gaps in the network exist. As well, the development of predictive models of terrain sensitivity, has been a focus of attention.
2. The speed and extent of any change in the permafrost regime caused by climate change needs to be assessed and the effect it will have on pipelines.
3. This information is required for a potential Mackenzie Valley pipeline and for the Cameron Hills, Liard Plateau and Norman Wells oil and gas development areas where pipelines are used.
4. This information can be used for production drilling, infrastructure development, field operations and pipeline design and operation phases.

### **Timing and Timeframe:**

- Information on permafrost response to climate change should continue to be gathered and summarized at existing sites in the short term – to document regional and temporal variability in

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permafrost response. Gaps in the monitoring network will take long term to fill. Development of predictive models should continue over the long term

- This information will take a short and long lead-time to gather.
- The urgency to fill these gaps is immediate to address engineering design needs and environmental impact mitigation, and moderate to track climate change caused permafrost variability.

### **Responsible and Contributing Organizations:**

This information could be gathered by the federal government (NRCan, DIAND), and augmented by project specific information gathered by project proponents. Universities and other research institutions (e.g., ESRF) could also participate in gathering information. Any existing information on changing permafrost conditions and resulting pipeline integrity issues should be analyzed and reported along with these results of new research.

These information gaps are linked to permafrost baseline gaps that relate to determining and mapping ground temperature and ground ice conditions, and to permafrost impact gaps related to effects of a chilled gas pipeline on permafrost and long-term drilling waste sump stability. They are also linked to the increased risk of pipeline integrity failure due to climate change and a change in permafrost conditions.

### **Origin of Gap:**

- Background Paper Report
- Scientists' Workshop
- Community visits
- Norman Wells Workshop

### **2.13.4 Impact Gap: Need to continue analyses on the effects of vegetation removal (e.g., rights-of-way) on permafrost conditions in the context of climate change**

#### **Context:**

1. Fifteen years of monitoring along the Norman Wells pipeline, and several other studies in the Mackenzie Valley and western Arctic dealing with the effect of vegetation disturbance on ground thermal regime are available. Also, measures to restrict thermal disturbance, in particular insulation with wood chip on slopes, have been undertaken and the effectiveness assessed. However, the effects on permafrost when climate change is considered on top of vegetation removal are not well understood.
2. Fire frequency is predicted to increase as a result of climate change and the effects of vegetation loss due to forest fires on permafrost and permafrost processes (e.g., slope stability) is not well

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understood. In addition, the effects of forest fire on areas where vegetation has already been removed could also be an issue.

3. This information is required for pipeline planning, design, environmental assessment, construction, and operation phases.

### **Timing and Timeframe:**

- This gap should be addressed in the short term.
- This information will take a long lead-time to undertake.
- The urgency to fill this gap is moderate.

### **Responsible and Contributing Organizations:**

This baseline information could be gathered by the federal government (NRCan, DIAND, NEB), the GNWT (RWED) and augmented by project specific information gathered by project proponents. Existing information should be analyzed and reported along with the results of new research.

### **Origin of Gap:**

- Scientists' Workshop
- Background Paper Report

### **2.13.5 Impact Gap: Require research on the potential impact of climate change scenarios on the terrestrial and aquatic ecology in the Mackenzie Valley and the linkage of these predicted changes with the environmental conditions that will be assessed for any hydrocarbon development**

#### **Context:**

1. Potential impacts of climate change on the ecological environment should be considered in developing long-term impact predictions where hydrocarbon development takes place.
2. This information can be used for all phases of oil and gas exploration, development and transmission.

### **Timing and Timeframe:**

- This gap should be addressed in the long term.
- This information will take a long lead-time to undertake.
- The urgency to fill this gap is low.

### **Responsible and Contributing Organizations:**

The federal government (EC, DFO) and GNWT (RWED) could be responsible for gathering this information, with assistance from renewable resource boards, universities and research institutions.

### **Origin of Gap:**

- Background Paper Report

## **2.14 Land and Resource Use/ Harvesting/Protected Areas**

### **2.14.1 Baseline Gaps: Protected Areas Strategy**

1. **Baseline Gap: A specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the ISR<sup>17</sup> to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas which would contribute to ecoregion representation goals.**
2. **Baseline Gap: Detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each site, will then be needed for each potential candidate protected area.**

### **Context:**

1. The opportunity to establish representative network of core protected areas in the ecoregions facing hydrocarbon development pressures has not commenced. There are currently no sites specifically identified for ecoregion representation though the NWT-PAS and the NWT-PAS *Mackenzie Valley Five-Year Action Plan* provide a process for doing so. Given that establishing protected areas has generally taken considerable time and that detailed biophysical data is often poor, there is a need to prioritize action in the Mackenzie Valley according to areas under development pressure.
2. The NWT-PAS *Mackenzie Valley Five-Year Action Plan* identified a need to document and map ecological, cultural and non-renewable resources within the Mackenzie Valley to fulfil both Goal 1 and Goal 2 of the NWT-PAS. This information would be made available to communities, Aboriginal organizations and other NWT-PAS partners.
3. The other information and research gaps identified throughout this report, if filled, will assist in addressing this gap, by providing background information on which assessments can be conducted. This will in turn facilitate the realization of the NWT-PAS goals.

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### **Timing and Timeframe:**

- This information should be gathered in the short term.
- This information will take a short lead-time for Gap 1 and long lead-time for Gap 2 to gather.
- The urgency to fill these gaps is immediate.

### **Responsible and Contributing Organizations:**

This work will be done in partnership with the federal government (DIAND, DOE, Parks, NRCan, DFO), the GNWT (RWED), the PAS Secretariat, PAS Implementation Advisory Committee, the land use planning boards or committees, the renewable resource boards, Environmental Non-Government Organizations and communities could be responsible for, or contribute to addressing this gap as is required.

### **Origin of Gap:**

- Background Paper Report

## 2.15 Cumulative Effects

The following gaps related to cumulative effects are focussed on the regional aspect of cumulative effects. The requirement for cumulative effects assessments at the project-specific level was considered in developing the research and information gaps outlined in this report.

### **2.15.1 Impact Gap: Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline which can be used to determine significance and impact thresholds**

#### **Context:**

1. In the Mackenzie Valley, a series of minor actions have taken place. Many of these actions have been recorded in the LIMS (Land Information Management System) database held by DIAND. It is possible to use this information supplemented by information from other departments and agencies to undertake preliminary cumulative effects analysis
2. It is possible with this existing data to get an overview of the current level of impact and establish some criteria for avoiding potential cumulative impacts especially for sensitive species like caribou.

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<sup>17</sup> This work also needs to be undertaken in the ISR as described in the NWT-PAS *Mackenzie Valley Five-Year Action Plan*. The ISR is not included in the study area identified for this biophysical gap analysis project.

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3. This gap is linked to the CEAM Strategy and Framework, and NWT Cumulative Impact Monitoring Program (CIMP).

### **Timing and Timeframe:**

- This information should be gathered in the short term and long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate for potential pipeline and moderate for other areas.

### **Responsible and Contributing Organizations:**

The federal government (DIAND) with assistance from the GNWT (RWED) could be responsible for gathering this information. The information gathering should be consistent with the CEAM Strategy and Framework and NWT CIMP initiatives.

### **Origin of Gap:**

- Background Paper Report

## **2.15.2 Baseline Gap: Need to gather regional baseline information for the purposes of cumulative effects assessment**

### **Context:**

1. Adequate regional baseline information is required for input into cumulative effects assessments.
2. The information is also necessary to distinguish between the human impacts and natural variation in the environment.
3. This information is required for potential pipeline development and for projects located in oil and gas development areas.
4. This gap is linked to the CEAM Strategy and Framework, and NWT CIMP.

### **Timing and Timeframe:**

- This information should be gathered in the long term.
- This information will take a long lead-time to gather.
- The urgency to fill this gap is immediate for pipeline and moderate for other areas.

## Action Plan

### **Responsible and Contributing Organizations:**

The federal government (DIAND) with assistance from the GNWT (RWED) could be responsible for gathering this information. The information gathering should be consistent with the CEAM Strategy and Framework and NWT CIMP initiatives.

### **Origin of Gap:**

- Background Paper Report

### 3. Information Management

The management of the information required to fill the gaps identified in this report will be a critical step to ensuring that the users of this information are able to use it to capacity, but also in an efficient manner. A system for information management should be designed, in which the following should be considered:

- Standards or guidelines that facilitate a consistent approach to gathering and recording information to enable a level of comparability between data sets should be developed. Different standards or guidelines would need to be developed for different types of information.
- The development of a centralized library/database to house northern information should be considered.
- Communication with communities.
- Mechanisms for sharing the information with participating parties should be developed.
- Where appropriate the information should be made publicly available and mechanisms should be put in place to allow ease of access to the information.
- GIS storage and presentation of information would be a useful means of making the information more widely available and useful.
- Where possible, co-ordinated information gathering and analysis effort should be carried out.
- Specific timeframes should be established.
- Information tracking and monitoring systems should be put in place.
- Opportunities to link site-specific information gathering and results with other regional initiatives and past or existing research should be considered (e.g., CEAM Strategy and Framework, ecological land classification, climate change research in the Mackenzie Delta and along the existing Enbridge pipeline corridor).
- Database(s) of project-specific information should be maintained by government and updated on a regular basis.
- Responsibilities for the on-going management of the various types of information should be designated.
- Changing environmental conditions should be considered (e.g., climate change).
- Information required to be kept confidential should be identified (e.g., nesting sites, species at risk locations) and means to keep it confidential established.
- TK is considered proprietary information, and therefore should be gathered and recorded by qualified individuals, and retained by the appropriate institutions. Project proponent should co-ordinate their TK gathering and collection efforts in relation to project applications with these appropriate institutions in an effort to efficiently and effectively gather information. Any TK used in relation to a project application should be properly recorded and archived by the appropriate institution so it is not lost. Gathering this information should support existing TK gathering efforts in the Mackenzie Valley.



# Appendix A

## Summary of Gaps and Level of Priority

## Appendix A. Summary of Gaps and Level of Urgency to Address the Gaps

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
<b>Community Identified Gaps</b>	2.1.1	<p><u>Capacity and Process Gaps: Traditional Knowledge (TK)</u></p> <ol style="list-style-type: none"> <li>1. <u>Capacity Gap:</u> Increased human and financial resources, tools and training in communities and regions for collecting, recording, archiving and using TK from all regions in the Mackenzie Valley is required.</li> <li>2. <u>Process Gap:</u> Need to advance work on how to link TK with scientific knowledge to better understand impacts to the biophysical environment and baseline environment characteristics.</li> <li>3. <u>Process Gap:</u> Need to create a consistent process for accessing TK and governing the use of TK.</li> </ol>	Gaps 1 to 3: Moderate
	2.1.2	<p><u>Baseline Gap:</u> Requirement for improved information base (mapping, data) of traditional land use areas and cultural sites before large-scale developments are allowed to proceed</p>	Immediate
	2.1.3	<p><u>Baseline, Impact and Communications Gaps: Cumulative Impacts</u></p> <ol style="list-style-type: none"> <li>1. <u>Baseline Gap:</u> Need to identify the induced (spin-off) impacts from development in undisturbed areas and the cumulative impacts from accessory developments.</li> <li>2. <u>Impact Gap:</u> Need to identify the cumulative impacts from past and existing oil and gas exploration and development activities in the Mackenzie Valley.</li> <li>3. <u>Communications Gap:</u> Need improved communications between communities and government regarding past and current information (e.g., mapping) that is available and accessible on seismic lines, seismic exploration activities and exploration drilling sites held by the federal government (National Energy Board – NEB and DIAND)</li> </ol>	Gaps 1 to 3: Low
	2.1.4	<p><u>Process and Communications Gaps: Research and Monitoring Programs in Communities</u></p> <ol style="list-style-type: none"> <li>1. <u>Process Gap:</u> Need improved community involvement in monitoring programs and post-development studies.</li> <li>2. <u>Communications Gap:</u> Need better co-ordination, organization and communication about research and other initiatives including taking results back to the community.</li> </ol>	Gaps 1 & 2: Moderate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.1.5	<p><u>Communications Gaps</u>: Communications and Community Awareness</p> <ol style="list-style-type: none"> <li>1. <u>Communication Gap</u>: Training, workshop or other information is required to improve understanding in communities about all phases of the oil and gas industry.</li> <li>2. <u>Communication Gap</u>: Training, workshop or other information is required to facilitate a better understanding in communities of the EIA, regulatory and management processes as related to the oil and gas industry.</li> </ol>	Gaps 1 & 2: Immediate
<b>Terrain and Surficial Geology – Database and Mapping</b>	2.2.1	<u>Baseline Gap</u> : Need to gather TK and/or interpret TK as it may relate to terrain and surficial geology	Immediate
	2.2.2	<p><u>Baseline Gaps</u>: Surficial Geology Mapping</p> <ol style="list-style-type: none"> <li>1. <u>Baseline Gap</u>: Need surficial geology mapping at a scale of 1:100,000 or more detailed for the development areas especially Colville Hills, Peel Plateau, Liard Plateau and Cameron Hills and along the potential pipeline route south from Great Bear River.</li> <li>2. <u>Baseline Gap</u>: Need to map the surficial deposit thickness, terrain hazards and slope stability conditions in the Mackenzie Valley.</li> </ol>	Gaps 1 & 2: Immediate
	2.2.3	<u>Baseline Gap</u> : Update and verify granular resources information in terms of location, quantity and quality parameters	Immediate (particularly for potential pipeline)
<b>Terrain and Surficial Geology – Geotechnical Considerations</b>	2.3.1	<u>Baseline Gap</u> : Need to assess the earthquake potential in the oil and gas development areas in the Mackenzie Valley, particularly in the Liard Plateau area	Moderate: Liard Plateau  Low: other oil & gas development areas
	2.3.2	<p><u>Impact Gaps</u>: Slope Movement Mechanics</p> <ol style="list-style-type: none"> <li>1. <u>Impact Gap</u>: Need to assess forest fire as a landslide trigger along the potential pipeline route</li> <li>2. <u>Impact Gap</u>: Need to assess susceptibility of slope destabilization caused by right-of-way thawing</li> <li>3. <u>Impact Gap</u>: Need to assess creep of frozen ground as a cause of pipeline deformation</li> <li>4. <u>Impact Gap</u>: Need to assess slope failures in the Liard Plateau and Peel Plateau</li> </ol>	Gaps 1 to 3: Immediate  Gap 4: Moderate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.3.3	<u>Baseline Gap</u> : Need to document the general locations of terrain and soils that are susceptible to instability due to thaw (also see Section 2.2.2, Gap 2)	Immediate: potential pipeline  Moderate: oil and gas areas
	2.3.4	<u>Impact Gap</u> : Identify environmental impacts and appropriate mitigation measures related to soil compaction and rutting	Moderate
<b>Permafrost</b>	2.4.1	<u>Baseline Gap</u> : Need to establish ground temperature and ground ice conditions, particularly along the potential pipeline corridor between Inuvik and Norman Wells.	Immediate
	2.4.2	<u>Impact Gap</u> : Need to understand the effects of frost heave on the integrity of a chilled pipeline in permafrost	Immediate
	2.4.3	<u>Impact Gaps</u> : Drilling Waste Fluid (Mud) Containment Sumps  1. <u>Impact Gap</u> : Need to establish the long-term viability and best practices of using permafrost excavated pits (sumps) for containing drilling muds.  2. <u>Impact Gap</u> : Need to research alternatives to using sumps for projects in the Mackenzie Valley.  3. <u>Impact Gap</u> : Identify the locations and conditions of existing sumps in the Mackenzie Valley, and determine which sumps need clean-up or remediation, and how this would be done.	Gaps 1 to 3: Immediate <sup>1</sup>
<b>Hydrogeology</b>	2.5.1	<u>Baseline Gap</u> : Need to characterize (quality/quantity) near surface groundwater flow along the potential pipeline corridor	Moderate to Immediate: driven by project timing  Immediate: for Travailant Lake area
	2.5.2	<u>Impact Gap</u> : Need to identify the effects of permafrost degradation and creation (e.g., frost bulb development) on groundwater flow regimes along the potential pipeline corridor and at stream crossings	Immediate

<sup>1</sup> Need for funding this research is low due to the ongoing study of sumps for the Mackenzie Delta - this study is not considering the question of alternatives to using sumps. Research into alternatives to using sumps is immediate and required.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
Surface Water	2.6.1	<p><u>Baseline and Impact Gaps:</u> Background Hydrocarbon Levels</p> <ol style="list-style-type: none"> <li><u>Baseline Gap:</u> Need to determine natural background hydrocarbon levels (e.g., polycyclic aromatic hydrocarbons – PAHs) in streams and lakes in oil development areas and along potential oil pipeline corridors.</li> <li><u>Impact Gap:</u> Need to research how stream and lake water quality is affected by natural hydrocarbon seeps.</li> <li><u>Impact Gap:</u> Need to determine how background hydrocarbon levels in streams and lakes can be distinguished from those resulting from exploration and development activities.</li> </ol>	Gaps 1 to 3: Moderate
	2.6.2	<u>Baseline Gap:</u> Existing hydrologic models need to be adapted to Mackenzie Valley conditions	Moderate
	2.6.3	<u>Baseline Gap:</u> Additional hydrometric <sup>2</sup> data for tributaries of the Mackenzie River is required	Moderate (project driven)
	2.6.4	<u>Baseline Gap:</u> Expansion of the snow survey data collection program is required	Low
	2.6.5	<u>Baseline Gap:</u> Requirement to understand the natural processes that lead to rapid lake drainage <sup>3</sup> and identify areas where there is potential for this phenomenon to occur in relation to oil and gas activities	Low
	2.6.6	<u>Baseline Gaps:</u> Improved database (including grain size) on geomorphology settings at stream crossings is required	Moderate
	2.6.7	<u>Baseline Gap:</u> Need to determine the baseline water quality and quantity regimes by improving upon the available data in oil and gas development areas	Immediate
	2.6.8	<u>Impact Gap:</u> Requirement to understand long term environmental impacts to surface water as a result of oil and gas development activities in existing oil and gas development areas	Moderate

<sup>2</sup> Measurement of water, usually water quantity measurements such as flow and water levels.

<sup>3</sup> Rapid Lake Drainage – rapid (hours, days) draining of a lake through natural processes. Occurs where lakes are surrounded by ice-rich ground (high ice content). The drainage is usually initiated by overflow of the lake, which in turn causes erosion of soils and melting of the surrounding ice-rich ground.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
<b>Fish and Fish Habitat</b>	2.7.1	<p><u>Baseline Gaps:</u> Baseline Surveys</p> <ol style="list-style-type: none"> <li><u>Baseline Gap:</u> Need abundance and distribution information on fish and invertebrates, and the following lakes and rivers should be considered in addressing this gap: <ul style="list-style-type: none"> <li>Lakes<sup>4</sup>: <ul style="list-style-type: none"> <li>Gwich'in Settlement Area: North Caribou, Caribou, Hill, Sandy, Tregnantchiez, unnamed lake (67 51'N; 131 33'W), and Travaillant.</li> <li>Sahtu Settlement Area: Tutsieta, Yeltea, Loon, Ontadek, Chick, and Mio.</li> <li>Deh Cho Region: Eentsaytoo, Goodall, McGill, unnamed lake (61 05'N; 120 30'W), and Trainor.</li> </ul> </li> <li>Rivers<sup>5</sup>: <ul style="list-style-type: none"> <li>Gwich'in Settlement Area: Travaillant R. and Thunder R.</li> <li>Sahtu Settlement Area: Oscar Ck, Donnelly R., Hare Indian R., and Loon R.</li> <li>Deh Cho Region: Trail R. and Willow Lake R.</li> </ul> </li> </ul> </li> <li><u>Baseline Gap:</u> Need information on distribution of contaminants (associated with oil and gas development) in sediments and in harvested fish, especially for known spawning grounds, areas of fishing for human consumption, exploration areas and seeps.</li> <li><u>Baseline Gap:</u> Need to gather information on the ecological characteristics of inland lakes and the natural variability, vital rates and status of fish populations (pre-pipeline) in these lakes, particularly for the lakes listed above in Gap 1.</li> <li><u>Baseline Gap:</u> Aquatic surveys (which should include game fish, forage fish and invertebrates) need to be conducted at stream crossings.</li> </ol>	<p>Gaps 1 &amp; 3: Immediate</p> <p>Gaps 2 &amp; 4: Moderate</p>

<sup>4</sup> These lakes are based on proximity to the proposed pipeline route (within 10 km of pipeline route), importance to communities, and lake size (assuming larger lakes are more likely to be of importance to communities, to contain harvested fish populations and have greater biodiversity)

<sup>5</sup> The selection of these rivers is based on: proximity to pipeline route, likelihood of suitability for spawning or being used as a migratory corridor for spawning, rearing or over-wintering migrations and existing information suggests important species occur in these rivers.

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.7.2	<p><u>Baseline Gaps:</u> Ecological Knowledge Gaps (also see Section 2.7.5)</p> <ol style="list-style-type: none"> <li><u>Baseline Gap:</u> Need to identify important spawning, rearing and over-wintering habitats for fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1.</li> <li><u>Baseline Gap:</u> Need to identify the key migration (spatial/temporal) corridors and habitats for harvested fish and invertebrates, particularly for the lakes and rivers listed in Section 2.7.1, Gap 1.</li> <li><u>Baseline Gap:</u> Need to identify the factors that govern the abundance of economically important and rare species (following baseline data collection).</li> <li><u>Baseline Gap:</u> Need to identify the critical trophic linkages that may be affected by developments.</li> </ol>	<p>Gaps 1 &amp; 2: Immediate</p> <p>Gap 3: Moderate</p> <p>Gap 4: Low</p>
	2.7.3	<p><u>Impact Gaps:</u> Monitoring Programs</p> <ol style="list-style-type: none"> <li><u>Impact Gap:</u> Need to identify the impacts of projects on vital rates (reproduction, growth, mortality) and abundance of populations, and in harvest rates.</li> <li><u>Impact Gap:</u> Need to identify project-related changes in abundance and species composition of invertebrates.</li> <li><u>Impact Gap:</u> Need to identify project related spatial and temporal trends of contaminants (associated with oil and gas development).</li> </ol>	Gaps 1 to 3: Moderate
	2.7.4	<p><u>Impact Gaps:</u> Impact Knowledge Gaps</p> <ol style="list-style-type: none"> <li><u>Impact Gap:</u> In existing oil and gas development areas and along existing pipeline corridors, need to identify and quantify impacts on fish and fish habitat as a result of development.</li> <li><u>Impact Gap:</u> In existing oil and gas development areas and along existing pipeline corridors, need to determine what mitigation measures have been implemented and determine their effectiveness.</li> </ol>	Gaps 1 & 2: Immediate
	2.7.5	<u>Impact Gap:</u> Need sensitivity mapping in particular for fish habitat and other important environmental attributes of the Mackenzie River and its tributaries north of Norman Wells	Immediate (prior to pipeline construction phase)
<b>Vegetation and Forests</b>	2.8.1	<u>Baseline Gap:</u> Need landcover (vegetation) mapping including identification of terrestrial and wetland <sup>6</sup> vegetation types	Immediate
	2.8.2	<u>Baseline Gap:</u> An ecological land classification (ELC) system needs to be developed	Immediate

<sup>6</sup> Consistency with existing classification systems (e.g., Canadian Wetland Classification System) and the recent compilation mapping of peatlands could be considered

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.8.3	<u>Baseline Gap</u> : Need to identify and map locations of rare and medicinal plants	Immediate (both from need to determine development routings and need to obtain information from elders)
	2.8.4	<u>Impact Gap</u> : Need to document TK with respect to project effects on vegetation and forests	Immediate
	2.8.5	<u>Impact Gap</u> : Need to determine long-term recovery rates of disturbed vegetation communities	Immediate
	2.8.6	<u>Impact Gaps</u> : Native Seeds  1. <u>Impact Gap</u> : Need to research the use of native plant species (seeding and natural recovery) and their success for re-vegetation of disturbed land in the Mackenzie Valley.  2. <u>Impact Gap</u> : Need to develop methods/standards for obtaining a native seed supply, and identify facility needs for storing the seed (seed bank <sup>7</sup> ).	Gaps 1 & 2: Immediate
	2.8.7	<u>Impact Gap</u> : Need information for the Mackenzie Valley on non-native species, including current locations of non-native species, the means by which non-native species are introduced into an area, the potential for non-native species to invade areas and where they may become a concern	Moderate
<b>Mammals</b>	2.9.1	<u>Impact Gap</u> : Need to study the potential effects of habitat fragmentation on different wildlife species	Immediate
	2.9.2	<u>Impact Gap</u> : Need to study the behavioural responses of wildlife to development activities, including inter-species behaviour changes, i.e. changes in prey vulnerability	Moderate
	2.9.3	<u>Baseline Gap</u> : Need to research baseline level of contaminants (associated with oil and gas development) in harvested wildlife species and assess the potential for release of contaminants	Moderate
	2.9.4	<u>Baseline and Impact Gaps</u> : Boreal Woodland Caribou  1. <u>Baseline Gap</u> : Need information on extent of occurrence, area of occupancy, population structure and demographics, and habitat use and effectiveness for Boreal Woodland Caribou.  2. <u>Impact Gap</u> : Need information on factors affecting Boreal Woodland Caribou survival and responses to human activities.	Gaps 1 & 2: Immediate

<sup>7</sup> The meaning of seed bank in this case context: usually a temperature- and humidity-controlled facility used to store seed (or other reproductive materials) for future use.



Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.9.5	<u>Baseline Gap</u> : Northern Mountain Woodland Caribou - Need information on extent of occurrence, area of occupancy, population demographics and habitat use	Low
	2.9.6	<u>Baseline Gap</u> : Bluenose West Caribou Herd - Information on movements and winter range use is needed	Immediate
	2.9.7	<u>Baseline Gap</u> : Furbearers - Estimates of furbearer distribution and abundance need to be developed based on habitat type, existing access and harvest data, with focus on key harvested species (lynx, marten, wolverine, beaver and muskrat)	Moderate
	2.9.8	<u>Baseline Gap</u> : Dall's Sheep - Need information on population dynamics, health and abundance in the Liard Plateau	Low
	2.9.9	<u>Impact Gap</u> : Information is needed on how linear developments contribute to re-colonization of Bison	Low
	2.9.10	<u>Baseline and Impact Gaps</u> : Moose  1. <u>Baseline Gap</u> : Need population abundance, trend and resilience data for Moose, including information on productivity, predation rates, and habitat status.  2. <u>Impact Gap</u> : Need information on effects of increased access resulting from development.	Gaps 1 & 2: Moderate
<b>Migratory Birds / Raptors</b>	2.10.1	<u>Baseline and Impact Gaps</u> : Forest Birds  1. <u>Baseline Gap</u> : Information is required on population presence, density and inventory, and population-habitat association data of forest birds.  2. <u>Baseline Gap</u> : TK information on forest birds is required.  3. <u>Impact Gap</u> : Information is required on effects of rights-of-way on predation rates on forest birds.	Gaps 1 & 3: Moderate  Gap 2: Immediate
	2.10.2	<u>Baseline Gap</u> : Waterfowl and Shore Birds - Need information on breeding behaviour and habitat use in the Mackenzie Valley	Moderate
	2.10.3	<u>Impact Gap</u> : Raptors - Information is needed on how specific development activities affect nesting success rates and nest site abandonment	Moderate
<b>Biodiversity</b>	2.11.1	<u>Baseline Gap</u> : Need TK that conveys information about biodiversity	Immediate
	2.11.2	<u>Baseline Gap</u> : Genetically distinct species sub-populations of 'species at risk' need to be identified	Low
	2.11.3	<u>Impact Gap</u> : Methodologies for assessing impacts to biodiversity need to be improved	Immediate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
Air	2.12.1	<p><u>Baseline Gaps:</u> Air Quality Monitoring</p> <ol style="list-style-type: none"> <li>1. <u>Baseline Gap:</u> Need to upgrade air quality monitoring stations at Inuvik, Norman Wells, and Fort Liard to measure for particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>), nitrogen oxides (NO<sub>x</sub>), volatile organic chemicals (VOCs), and ground level ozone (O<sub>3</sub>). The current acid precipitation station at Snare Rapids would provide true background concentrations (unaffected by any emission sources), but needs to be expanded such that it can measure TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, NO<sub>x</sub>, VOCs, O<sub>3</sub> as well as hydrogen sulphides (H<sub>2</sub>S) and sulphur dioxide (SO<sub>2</sub>).</li> <li>2. <u>Baseline Gap:</u> Baseline air quality monitoring for TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, NO<sub>x</sub>, VOCs, O<sub>3</sub>, H<sub>2</sub>S, and SO<sub>2</sub> needs to be established at other locations where emission producing equipment, such as compressor stations, are proposed.</li> <li>3. <u>Baseline Gap:</u> Using the above noted stations, need to establish baseline air quality conditions and to use these data for modelling air emissions.</li> </ol>	Gaps 1 to 3: Moderate
	2.12.2	<u>Baseline Gap:</u> Requirement for meteorological data sufficient to allow for point-source and multiple-source dispersion modelling studies of contaminant releases from oil and gas exploration and development sites.	Moderate
	2.12.3	<p><u>Impact Gaps:</u> Biological Indicators of Air Quality</p> <ol style="list-style-type: none"> <li>1. <u>Impact Gap:</u> Need to research the sensitivity of wildlife and vegetation species to air quality changes, and determine which species would be good indicators of poor air quality.</li> <li>2. <u>Impact Gap:</u> Need to research the appropriate ambient air quality standards for wildlife.</li> </ol>	Gaps 1 & 2: Low
Climate Change	2.13.1	<u>Baseline Gap:</u> Need to develop an understanding of the range and type of climate change scenarios along the entire Mackenzie Valley, including hydrocarbon development areas such that the impact on the physical environment (land/vegetation, water and permafrost) can be evaluated for environmental assessment predictions	Immediate

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
	2.13.2	<p><u>Impact Gaps:</u> Climate Change Effects on the Physical Environment</p> <ol style="list-style-type: none"> <li>1. <u>Impact Gap:</u> Along the Mackenzie Valley pipeline right-of-way, the impact of climate change on shallow ground temperatures (less than 5 m) requires assessment, especially in widespread and sporadic discontinuous permafrost zones.</li> <li>2. <u>Impact Gap:</u> The impact of climate changes on forest fire frequency along the entire length of the Mackenzie Valley and the risk to infrastructure development needs to be assessed.</li> <li>3. <u>Impact Gap:</u> The impact of climate change on ice thickness in rivers and lakes for ice bridges and winter roads along the entire length of the Mackenzie Valley.</li> <li>4. <u>Impact Gap:</u> The impact of climate change on snow conditions and associated winter trafficability associated with hydrocarbon developments including drilling and pipeline development.</li> <li>5. <u>Impact Gap:</u> The impact of climate change on regional hydrology.</li> </ol>	Gaps 1 to 5: Moderate
	2.13.3	<p><u>Impact Gaps:</u> Permafrost Response to Climate Change / Pipeline Integrity</p> <ol style="list-style-type: none"> <li>1. <u>Impact Gap:</u> Need to document spatial and temporal variability in permafrost response to climate change.</li> <li>2. <u>Impact Gap:</u> Need to continue development of predictive models of permafrost thermal changes, distribution changes and terrain sensitivity, with focus on improving the scale/resolution, as well as moving from the pipeline corridor to the development areas.</li> <li>3. <u>Impact Gap:</u> Need to understand impacts to pipeline integrity as a result of changes to permafrost from climate change.</li> </ol>	Gaps 1 to 3:  Immediate: to address engineering design needs and mitigation  Moderate: to track climate change caused permafrost variability
	2.13.4	<u>Impact Gap:</u> Need to continue analyses on the effects of vegetation removal (e.g., rights-of-way) on permafrost conditions in the context of climate change	Moderate
	2.13.5	<u>Impact Gap:</u> Require research on the potential impact of climate change scenarios on the terrestrial and aquatic ecology in the Mackenzie Valley and the linkage of these predicted changes with the environmental conditions that will be assessed for any hydrocarbon development	Low

Topic	Report Section	Gap Statement	Urgency to Fill Gap(s)
<b>Land and Resource Use/ Harvesting/Protected Areas</b>	2.14.1	<p><u>Baseline Gaps:</u> Protected Areas Strategy</p> <ol style="list-style-type: none"> <li>1. <u>Baseline Gap:</u> A specific study to document and analyze baseline biophysical data along a proposed pipeline corridor and in the hydrocarbon regions south of the ISR<sup>8</sup> to identify unique landscapes, unusual features, rare, threatened or endangered species and associated habitat, areas of high biodiversity or other important biological and cultural resource use areas that will contribute to identifying potential protected areas which would contribute to ecoregion representation goals.</li> <li>2. <u>Baseline Gap:</u> Detailed non-renewable, ecological and cultural resource assessments i.e., specific studies for each site, will then be needed for each potential candidate protected area.</li> </ol>	Gaps 1 & 2: Immediate
<b>Cumulative Effects</b>	2.15.1	<u>Impact Gap:</u> Need to undertake preliminary cumulative effects analysis of each development area to establish a baseline which can be used to determine significance and impact thresholds	Immediate: for potential pipeline  Moderate: for other areas
	2.15.2	<u>Baseline Gap:</u> Need to gather regional baseline information for the purposes of cumulative effects assessment	Immediate: for potential pipeline  Moderate: for other areas

<sup>8</sup> This work also needs to be undertaken in the ISR as described in the NWT-PAS *Mackenzie Valley Five-Year Action Plan*. The ISR is not included in the study area identified for this biophysical gap analysis project.