SECTION 17

CUMULATIVE EFFECTS SUMMARY

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Section 17 Abbreviations

Abbreviation	Definition
AAQS	Ambient Air Quality Standards
BSA	baseline study area
DAR	Developer's Assessment Report
Diavik Mine	Diavik Diamond Mine
Dominion Diamond	Dominion Diamond Ekati Corporation
e.g.	for example
Ekati Mine	Ekati Diamond Mine
ELC	Ecological Landscape Classification
ESA	effects study area
GDP	gross domestic product
GNWT	Government of the Northwest Territories
i.e.	that is
KLOI	Key Line of Inquiry
LSA	local study area
MDNN	mean distance to nearest neighbour
NWT	Northwest Territories
Project	Jay Project
RFD	Reasonably Foreseeable Development
SON	Subject of Note
TLU	Traditional Land Use
TOR	Terms of Reference
WRSA	waste rock storage area
VC	valued component

Section 17 Units of Measure

Unit	Definition
%	percent
>	greater than
ha	hectare
km	kilometre
km^2	square kilometre
kV	kilovolt
m^3	cubic metre

17 CUMULATIVE EFFECTS SUMMARY

17.1 Introduction

17.1.1 Context

This section summarizes the cumulative effects approach, methods, and results from the Key Lines of Inquiry (KLOIs) and Subjects of Note (SONs) for the biophysical and socio-economic components of the Jay Project (Project) Developer's Assessment Report (DAR). In the DAR, cumulative effects are identified, analyzed, and assessed in the KLOIs and SONs where applicable. The approach is the same as that used for the Project-specific effects analysis and residual impact classification and determination of significance. If significant adverse cumulative effects are identified, then the opportunity for technically and economically feasible additional mitigation is considered and applied to the assessment.

This section outlines the general, overall approach to the cumulative effects assessment that was used in the biophysical and socio-economic KLOIs and SONs and consideration in the residual impact clarification and determination of significance. Details that are specific to each KLOI and SON are provided in their respective sections (Sections 7 to 15 of the DAR).

17.1.2 Purpose and Scope

The Terms of Reference (TOR) for the Project require that each KLOI and SON be a stand-alone section, and that each assessment section address cumulative effects from past, present, and reasonably foreseeable future developments (Appendix 1A). The TOR also requires a combined summary of the cumulative effects discussions from the relevant biophysical and socio-economic KLOI and SON sections. This summary is also required to identify the committed means for Dominion Diamond Ekati Corporation (Dominion Diamond), on its own or cooperatively with others, to reduce or avoid any predicted cumulative effects.

The analysis and classification of cumulative effects for each KLOI and SON is presented in each respective section of the DAR. In Section 7.2 of the TOR, "impacts to the landscape" was also included in addition to the KLOIs and SONs previously identified. Potential cumulative effects to the landscape are not summarized in a separate section; however, potential changes to the landscape are assessed in the soils, vegetation, wildlife habitat, and terrain sections.

17.1.3 Definition of Cumulative Effects

Cumulative effects are those effects that result from a combination of a project with other past, present, and reasonably foreseeable future developments (MVRB 2004). They may be biophysical, socio-cultural or economic in nature (MVRB 2004). Cumulative effects represent the sum of all natural and human-induced influences on the physical, biological, social, cultural, and economic components of the environment through time and across space (Section 6.5.2). Certain changes may be human-related, such as increasing mineral development or implementing new policy, and other changes may be associated with natural phenomena such as extreme rainfall events and periodic harsh and mild winters. It is the goal of the cumulative effects assessment to predict the relative contribution of human-related influences on valued components (VCs) in context of natural factors.

Not every VC requires an analysis of cumulative effects. The key is to determine if the effects from the Project and one or more additional developments or activities overlap (or interact) with the temporal and spatial distribution of the VC. For certain VCs, there is little or no potential for cumulative effects because there is little or no overlap with other projects (e.g., surficial geology, soils, and terrain). For other VCs that are distributed, or that travel over large areas and can be influenced by a number of developments (e.g., caribou and socio-economics), the analysis of cumulative effects can be necessary and important. A cumulative effects assessment should use the following steps (MVRB 2004):

- Identify the VCs for the proposed project.
- Determine what other past, present, and reasonably foreseeable future developments could affect the VCs.
- Predict the effects of the proposed project in combination with these other developments.
- Identify ways to manage the combined effects.

In this DAR, cumulative effects are identified, analyzed, and assessed in the section for each VC, where applicable, and the methods follow the approach used for the Project-specific effects analysis (Section 6.5.1), and impact classification and determination of significance (Section 6.7).

17.2 Cumulative Effects Approach

17.2.1 Spatial Boundaries

Individuals, populations, and communities function within the environment at different spatial (and temporal) scales (Wiens 1989). In addition, the responses of physical, chemical, and biological processes to changes in the environment can occur across several spatial scales at the same time (Holling 1992; Levin 1992). Because the responses of physical, biological, cultural, social, and economic properties to natural and human-induced disturbance will be unique and occur across different scales, the DAR has adopted a multi-scale approach for describing baseline conditions (existing environment) and predicting effects from the Project on VCs. As indicated in the TOR, the spatial boundaries for analyzing and predicting cumulative effects from the Project and other developments should be appropriate for capturing the processes and activities that influence the geographic distribution and/or movement patterns specific to each VC (Appendix 1A).

For the DAR, baseline study areas (BSAs) were designed to characterize existing environmental conditions on a continuum of spatial scales from the Project site to broader, regional levels. Data collected at the Project site and local scales were used to provide precise measures of baseline environmental conditions and to predict the Project-related direct and indirect changes to VCs (e.g., changes to terrestrial and aquatic habitat from the physical footprint and from dust and air emissions). Data collected at larger scales were used to measure broader-scale baseline environmental conditions, and to provide regional context for the combined direct and indirect Project-related effects on VCs.

Baseline study areas do not necessarily represent the spatial boundaries for the effects analysis (i.e., effects study area [ESA] or effects assessment area). Selection of the boundaries for ESAs was based on the physical and biological properties of VCs. In addition, ESAs were designed to capture the maximum spatial extent of potential effects from the Project and other previous, existing, and reasonably foreseeable future developments. Effects from the Project on the biophysical environment are typically stronger at the local scale, while larger-scale effects are more likely to result from other ecological factors and human activities. For example, Project-specific effects on environmental components with limited movement (e.g., soil and vegetation) will likely be restricted to local changes from mining and associated infrastructure. Certain indirect changes to vegetation from dust deposition and air emissions may occur, but the effects should be limited to the local scale of the Project. For soil and vegetation VCs, and other VCs with similar physical and biological properties, the BSAs may be suitable for the analysis and assessment of incremental and cumulative effects from the Project and other developments.

For VCs with more extensive distributions, such as fish that can move within a watershed and wildlife species with large home ranges, effects from the Project have a higher likelihood of combining with effects from other human developments and activities at a regional scale. Watersheds may be influenced by multiple users that generate cumulative effects on aquatic resources. Similarly, larger animals (e.g., caribou and grizzly bear) that are influenced by the Project will likely encounter other human activities and developments in their daily and seasonal ranges. Consequently, effects from the Project could combine with influences from other developments in the individual's home range. In addition, the home ranges of several individuals may be affected, which results in cumulative effects on the population. For VCs that are distributed and move over large areas, the BSAs used to measure existing conditions around the Project are not sufficient for analyzing and assessing Project-specific and cumulative effects, and a larger study area is required. Similarly, the effects assessment area for the human environment considers both primary and potentially affected communities (Appendix 1A).

The rationale for the ESA for VCs is provided in each KLOI and SON. The overall environmental assessment study area for the Project is defined by the combined ESA for all VCs.

17.2.2 Temporal Boundaries

The DAR was designed to evaluate the short- and longer-term changes from the Project on the biophysical and human environments. In accordance with the TOR, the duration of effects may extend beyond specific phases of the Project; duration is dependent on the physical and/or biological properties of VCs (Appendix 1A). The temporal boundary of the Project is defined as having the following phases:

- construction (2016 to 2019);
- operations (2019 to 2029); and,
- closure (2030 to 2033; approximately four years).

Baseline studies associated with each VC identify temporal variation (e.g., annual or seasonal changes in water flow or habitat use, or trends over time in populations and employment) and other biophysical and socio-economic constraints relevant to the assessment of the Project.

For all VCs, residual effects were assessed for all phases of the Project, but not necessarily for each specific phase. For example, effects on wildlife will begin during the construction phase with the removal and alteration of habitat (resulting in direct and indirect changes), and the effects will continue through the operations phase and for a period after the closure phase until the effects are reversed (unless determined to be irreversible or permanent). Therefore, effects on wildlife were analyzed and predicted from construction through closure. This generated the maximum potential spatial and temporal extent of effects and provided confident and ecologically relevant impact predictions.

Alternately, for some other VCs, the assessment was completed for those phases of the Project where predicted effects would be expected to peak (e.g., most air quality effects from emissions occur during the initial period of operations due to open-pit mining), or at several key snapshot points in time within a Project phase or phases. An example is evaluating surface water quality predictions at specific times that represent key milestones throughout the life of the Project. For other VCs, the assessment of effects continued into post-closure (e.g., long-term water quality and hydrology predictions for Lac du Sauvage following the breaching of dike and reconnection at closure).

Similarly, the temporal boundaries identified for cumulative effects assessments are specific to the VCs being assessed. Temporal boundaries include the duration of residual effects from previous and existing developments that overlap with residual effects of the Project, and the period of time over which the residual effects from reasonably foreseeable developments will overlap with residual effects from the Project. The temporal boundaries considered for each VC are defined in the KLOIs and SONs.

17.2.3 Assessment Cases

For VCs that require cumulative effects analysis, the concept of assessment cases was applied to the associated spatial boundary of the assessment (i.e., the ESA) to estimate the incremental and cumulative effects from the Project and other developments (Table 17.2-1). The approach incorporated the temporal boundary for analyzing the effects from previous, existing, approved, and reasonably foreseeable developments before, during, and after the anticipated life of the Project (Section 6.3.2). Analyzing the temporal changes to the biophysical and human environments is fundamental to predicting the cumulative effects from development on VCs that move over large areas, such as caribou, fish, and traditional land users.

Table 17.2-1 Contents of Each Assessment Case

Base Case	Application Case	Reasonably Foreseeable Development Case
Range of conditions from little or no development to previous and existing developments[a] before the Project	Base Case plus the Project	Application Case plus reasonably foreseeable developments

a) Includes planned and approved projects.

The Base Case represents a range of conditions over time within the ESA before application of the Project (as do the Application Case and the Reasonably Foreseeable Development Case). Environmental conditions on the landscape before human development (e.g., mining, mineral exploration, outfitting, and transportation), which represent reference conditions, were considered independently within the Base Case, where possible (Appendix 1A, Section 4.1).

To prepare the Base Case, baseline studies were carried out to develop an understanding of the existing physical, biological, and social conditions that may be influenced by the Project. Other sources of existing and historical information were also reviewed. Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in VCs. Environmental selection pressures include both natural (e.g., weather, changes in gene frequencies, predation, and competition) and human-related factors (e.g., mineral development, forestry, and traditional and sport hunting and fishing). Depending on which selection pressures are currently driving changes to the VC and system, baseline conditions typically fluctuate within a range of variation through time and space. The fluctuations are generated by variation in natural factors (natural variation) and variation associated with human influences. Relative to ecological time and space, baseline conditions are in a constant state of change due to the push and pull of environmental selection pressures. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value within the distribution (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the trajectory of the VC and the system.

The Base Case describes the existing environment before the application of the Project to provide an understanding of the current physical, biological, and social conditions that may be influenced by the Project. Base Case conditions include the cumulative effects from all previous and existing developments and activities that are approved and assumed to take place within the ESA of a VC. For example, environmental and social effects from the construction and operations of Ekati Diamond Mine (Ekati Mine), Diavik Diamond Mine (Diavik Mine), Snap Lake Diamond Mine (Snap Lake Mine), and the Tibbitt to Contwoyto Winter Road were considered to be part of the existing conditions in the Base Case, if applicable to the VC ESA. Approved but not yet completed developments, such as the Lynx Project (Dominion Diamond 2013), the Gahcho Kué Project (De Beers 2010), NICO Project (Fortune 2011), and Nechalacho Project (Avalon 2014) were also identified for potential inclusion in the Base Case.

The Application Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project, in isolation from potential future land-use activities. Where relevant, this case was also used to identify the incremental changes from the Project that were predicted to occur between the Base and Application cases. The temporal boundary of the Application Case begins with the anticipated first year of construction of the Project, and continues until the predicted effects are reversed. For several VCs, the temporal extent of certain effects will likely be greater than the lifespan of the Project because the effects will not be reversible until beyond closure. For other VCs, the effects may be determined to be irreversible within the temporal boundary of the Application Case. Such effects may be permanent, or the duration of the effect may not be known, except that the duration is expected to be extremely long (say, more than 100 years past closure).

The Reasonably Foreseeable Development (RFD) Case includes the Application Case plus the cumulative effects of future projects. In accordance with the TOR (Appendix 1A), a scenario analysis was used to identify future projects and assess potential cumulative effects on VCs. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project; and,
- have the potential to change the Project or the effects predictions.

For the DAR, the scenario analysis used the maximum number of potential future projects that could occur within the effects study (assessment) area of VCs. The assessment did not evaluate different combinations of numbers, types, and locations of projects, but used a conservative approach that provides the maximum potential cumulative effects on a VC. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. Thus, the minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project, which like the Base Case, includes a range of conditions over time.

Unlike the analyses of cumulative effects for the Base and Application cases, which are largely quantitative, the analysis for the RFD Case is quantitative where possible and qualitative where necessary. The analysis was quantitative for those future projects that could be assigned a location and known or hypothetical physical footprint area on the landscape. Analysis was qualitative for developments for which this information was not available. For all RFDs, the DAR used the best and most current information available for the location, size, and type of activity associated with a project.

Although large parts of the analyses for the RFD Case were numerical, it is important to acknowledge the low level of confidence in predicting cumulative effects on VCs for this case. There were uncertainties associated with the exact location, physical footprint area, and activity level of a development, and the timing and rate of future developments in the ESA for each VC. There were also uncertainties in the direction, magnitude, and spatial extent of future fluctuations in ecological, cultural, and socio-economic variables, independent of effects from the Project and other developments. These uncertainties are discussed with respect to confidence in the effects predictions and determination of environmental significance.

A summary of the projects considered for each VC and for each assessment case is provided in Table 17.2-2.

Table 17.2-2 Assessment Cases Used for Each Valued Component

Valued Component	Base Case[a]	Application Case[b]	Reasonably Foreseeable Development Case[c]
Air Quality	• Ekati Mine • Diavik Mine	Jay Project	• No Reasonably Foreseeable Developments
Water Quality and Quantity	• Ekati Mine • Diavik Mine	Jay Project	• No Reasonably Foreseeable Developments
Fish and Fish Habitat	• Ekati Mine • Diavik Mine	Jay Project	• No Reasonably Foreseeable Developments
Terrain	Terrain does not include assessment cases; refer to Section 10 of the Developer's Assessment Report.		
Vegetation	• Ekati Mine • Diavik Mine	Jay Project	• No Reasonably Foreseeable Developments
Barren-Ground Caribou	• Ekati Mine • Diavik Mine • Snap Lake Mine • Gahcho Kué Project • Nechalacho Project • NICO Project • Tibbitt to Contwoyto Winter Road	Jay Project	• Jericho Mine • Lupin Mine • Hope Bay Project • Hackett River Project • Back River Project • Bathurst Inlet Port and Road • Izok Corridor Project • Courageous Lake Project • Indin Lake Project • Thaidene Nene (East Arm) National Park • The Tłı̨chǫ Road Route (from Highway 3 to Whatì) • Yellowknife Project • Hydroelectric Grid Expansion
Wildlife – Waterbirds and Raptors	• Ekati Mine • Diavik Mine	Jay Project	• No Reasonably Foreseeable Developments

Table 17.2-2 Assessment Cases Used for Each Valued Component

Valued Component	Base Case[a]	Application Case[b]	Reasonably Foreseeable Development Case[c]
Wildlife – Grizzly Bear and Wolverine	• Ekati Mine • Diavik Mine • Tundra Mine • Doris North Mine • Snap Lake Mine • Gahcho Kué Project • Tibbitt to Contwoyto Winter Road	Jay Project	• Jericho Mine • Lupin Mine • Hope Bay Project • Hackett River Project • Back River Project • Bathurst Inlet Port and Road • Izok Corridor Project • Courageous Lake Project • Hydroelectric Grid Expansion
Socio-Economics	• Ekati Mine • Diavik Mine • Snap Lake Mine • Gahcho Kué Project	Jay Project	• No Reasonably Foreseeable Developments
Cultural Aspects –TLU and Heritage Resources	Cultural Aspects includes effects on two valued components (VCs): Traditional Land Use (TLU) and Heritage Resources. Due to confidentiality, effects on Heritage Resources are managed through the Prince of Wales Northern Heritage Centre, and the TLU VC relies on the assessments conducted for other components (e.g., Wildlife). Refer to Section 15 of the Developer's Assessment Report.		

a) Range of conditions from little or no development to previous and existing developments before the Project (includes approved projects, i.e., the Lynx Project, the Gahcho Kué Project).

b) Base Case plus the Project.

c) Application Case plus Reasonably Foreseeable Developments (see Section 6.5.2.4).

Diavik Mine = Diavik Diamond Mine; Ekati Mine = Ekati Diamond Mine.

17.3 Air Quality

The air quality ESA is equivalent to the regional study area used for air dispersion modelling. The ESA for the Project measures 107 kilometres (km) by 111 km. The Project is nominally centered within the ESA. The ESA was selected to capture the cumulative effects associated with emissions from existing and approved industrial sources within the region, in combination with emission sources from the proposed Project.

The Base Case represents air quality conditions within the ESA before construction and operation of the Project. The Ekati Mine and Diavik Mine were included in the Base Case. The RFD Case does not apply for the air quality assessment because no future projects are located in the ESA (Table 17.2-2).

The assessment endpoint for air quality is compliance with the Northwest Territories Ambient Air Quality Standards ([NWT AAQS]; ENR 2014). Changes to air quality for the Application Case, as predicted by an air dispersion model, were compared against the NWT AAQS. The NWT AAQS were the most stringent ambient air quality criteria among the applicable criteria (e.g., Canada-Wide Standards, National Ambient Air Quality Objectives, and Canadian Ambient Air Quality Standards).

Potential pathways for effects on air quality include emissions of sulphur dioxide, nitrogen oxides, carbon monoxide, and particulate matter in two size ranges (2.5 microns in aerodynamic diameter and total suspended particulate). Sulphur dioxide, nitrogen oxides, and carbon monoxide emissions are primarily from construction equipment, mining operations, processing equipment, and the vehicle fleet. Particulate matter emissions are mainly from fugitive dust emissions from mining activities, material movement and storage, the drained lakebed, and haul roads.

Assessment of cumulative effects on air quality considered emissions from the Project, as well as the existing Ekati Mine and Diavik Mine. Magnitude is the primary criterion used to determine environmental significance for air quality, while other criteria such as geographic extent, duration, frequency, reversibility and likelihood are used as modifiers and to provide context when evaluating magnitude. The level of confidence in the predicted effects, established regulatory standards, and professional opinion are also included in the determination of the environmental significance.

The results of a residual impact classification indicate that the cumulative effects from the Project and other developments on air quality are not significant. Although the magnitude of the effects for individual compounds with the NWT AAQS ranged from negligible to high, the effects were all local in geographic extent as maximum air quality changes due to the Project and all modelled exceedances are within the local study area (LSA), medium term in duration, and reversible. Frequency varied from frequent to infrequent and likelihood was likely for certain effects and unlikely for others. When all residual impact criteria are considered collectively, the resulting impact of the Project and other developments on air quality is predicted to be not significant. This indicates that exceedances of the relevant NWT AAQS were consistently confined to the area immediately adjacent to Project activities, and/or where the changes to air quality that result in exceedances of the standards were reversible upon termination of Project activities.

Conservatism was built into the emission inventory, such as by assuming that equipment would operate at maximum capacity at all times. Dispersion models simplify atmospheric processes and can introduce uncertainty. However, model inputs are generally designed to conservatively model concentration and deposition values. Consequently, model results are likely to overestimate actual concentrations, which is preferable to underestimating them. Therefore, based on the conservatism of the emission inventory and modelling, it is unlikely that Project emissions and Project effects are underestimated, and the level of confidence in the prediction is high.

17.4 Water Quality and Quantity

The water quality and quantity KLOI considered potential changes to the VCs of hydrogeology, surface hydrology, and water quality from the Project. Residual cumulative effects were carried forward and assessed for the surface hydrology and water quality VCs.

The Project is situated within the Lac du Sauvage and Lac de Gras basins, which are part of the larger Desteffany Lake drainage basin.

- The ESA for surface hydrology was defined as the area where measurable effects on water levels and flows are anticipated to occur and includes Sub-Basin B (Christine Creek sub-basin), Sub-Basin C, Stream Ac35, Lac du Sauvage to the outlet, Lac de Gras to the outlet, the Koala watershed, and Desteffany Lake to the outlet.
- The ESA for water quality was defined as the area where measurable effects on water quality constituents are anticipated to occur and includes the Lac du Sauvage basin and tributaries draining into Lac du Sauvage, and downstream to the outlet of Lac de Gras.

The assessment endpoint for the water quality and quantity KLOI is the maintenance or suitability of surface water quality for healthy and sustainable aquatic and terrestrial ecosystems.

For surface hydrology and water quality, cumulative effects are considered in all assessment cases. Existing projects within the ESA under the Base Case include the Ekati Mine (in the Koala watershed of Lac de Gras and the Misery operations in Sub-Basin B of Lac du Sauvage), the Lynx Project (in the Lac de Gras watershed), and the Diavik Mine (in the Lac de Gras watershed). Similarly, as the Application Case is the existing and approved projects plus the Project, this case also includes the cumulative effects of these developments. There are no reasonably foreseeable developments in the surface hydrology and water quality ESAs (Table 17.2-2). The closest reasonably foreseeable development is the Courageous Lake project, located outside the Lac de Gras sub-basin and approximately 73 km to the southwest of the Project.

Primary pathways were evaluated for cumulative residual effects, after implementing environmental design features and mitigation, on the surface hydrology and water quality VCs. The pathways addressed activities under current conditions (Base Case), and during the construction, operations, and closure phases of the Project, and the post-closure period (Application Case). Cumulative effects to water quantity and quality were evaluated through the use of measurement indicators specific to each VC.

For surface hydrology, measurement indicators used to determine residual effects included changes to flows or water level at lake outlets. These changes were determined by comparing modelled conditions under the Base Case to modelled conditions under the Application Case, accounting for alterations in watershed hydrology through diversions and water management (e.g., containment), and operational discharges (e.g., treated effluent discharges from the Diavik Mine and Project discharges of Misery Pit minewater to Lac du Sauvage). Limited hydrological data is available before the first mine (Ekati) within the study area; therefore, long-term records for the Coppermine River at Desteffany Lake, Point Lake, and above Copper Creek were used to represent both reference and baseline (or existing) conditions for the watersheds. The baseline conditions were determined to be representative of the Base Case conditions as: the cumulative site footprints of the Ekati and Diavik mines are very small relative to the Lac de Gras watershed; flow diversions in smaller lakes and streams in the Lac de Gras watershed do not have a measurable effect on water levels or discharges at Lac du Sauvage and Lac de Gras; and, the effect of water management activities and altered runoff coefficients of the Ekati and Diavik mines are small compared to the natural inflows and discharges from terminal watershed lakes, Lac du Sauvage, Lac de Gras, and Desteffany Lake.

For water quality, measurement indicators used to determine residual effects included changes to water quality or sediment quality constituents relative to a screening threshold (i.e., site-specific water quality objectives, aquatic life guidelines, drinking water guidelines, other reasonable toxicological limits, or existing condition concentrations). Predicted water quality in the Application Case was compared to the screening threshold to determine if there was the potential for impairment to the uses of water by aquatic life and humans (i.e., human consumption). Predicted water quality in the Application Case was also compared to existing conditions, and reference (pre-development) conditions where data were available, to evaluate the absolute range of changes. Current and existing water and sediment quality data include water and sediment quality in the present day (i.e., reference plus changes due to mining activities). There is no evidence of change in water quality in Lac du Sauvage as a result of previous or existing mining activities; however, there is evidence of change in water quality in Lac de Gras. The data available for the water quality ESA before the development of the first mine (Ekati Mine) are limited; therefore, existing conditions was used as the Base Case but where available, a comparison to reference conditions was included.

Residual effects to surface hydrology were predicted for construction, operations, and closure phases of the Project, and the post-closure period. The main focus of the assessment was the effect of major Project activities (e.g., dewatering, diversions, operational water management, back-flooding in closure) on discharge and water levels at the outlets of Lac du Sauvage, Lac de Gras, and Desteffany Lake as compared to Base Case (baseline) conditions (Section 8.5.6.1). The effects from the Ekati Mine Misery operations were considered in the assessment.

A summary of the residual cumulative effects to surface hydrology include:

- Discharges and water levels at the outlet of Lac du Sauvage are predicted to be similar to baseline during early operations and post-closure.
- Discharges and water levels are predicted to increase relative to baseline during construction and late operations at the outlet of Lac du Sauvage, and to increase relative to baseline during dewatering at the outlets of Lac du Sauvage, Lac de Gras, and Desteffany Lake.

- Discharges and water levels at the outlet of Lac de Gras and Desteffany Lake are predicted to be similar to baseline during construction, construction dewatering, early operations, late operations, and post-closure.
- Discharges and water levels are predicted to decrease relative to baseline during closure at the outlets of Lac du Sauvage, Lac de Gras, and Desteffany Lake.
- Changes in Koala watershed discharges related to the closure of the Ekati Mine site are minor and temporary; post-closure conditions in the Koala watershed are expected to be similar to natural runoff and drainage conditions.

The duration of effects from each Project phase on surface hydrology are predicted not to extend past the duration of each Project phase. Discharges and water levels are predicted to be similar to baseline by 2035 and in post-closure at the outlets of Lac du Sauvage, Lac de Gras, and Desteffany Lake.

Project activities will be managed to protect source water and downstream areas against adverse effects, such as, channel scouring and erosion of shorelines. This includes actively managing pumped dewatering flows to accommodate natural changes through wet or dry conditions, and completing back-flooding in accordance to approved withdrawal rates from source lakes. Mitigation efforts will focus on limiting potential adverse effects on fish habitat due to Project activities, as well as reducing cumulative effects to source lakes and downstream watersheds.

There is a high level of confidence in overall predicted changes to surface hydrology at a watershed scale for Lac du Sauvage, Lac de Gras, and Desteffany Lake. Future modelling will be completed during detailed design to indicate whether reduced transfer rates will be required at certain times to limit impacts on the downstream hydrological regime. It is anticipated that Dewatering Plans describing this information will be provided to the Wek'eezhii Land and Water Board in a similar manner to the established operating requirements of the Ekati Mine Water Licence.

For water quality, cumulative residual effects were predicted for operations through closure phases and the post-closure period; the analyses considered the Project plus existing operations (details in Section 8.5.5 and summarized in Section 8.5.6). During the operations phase of the Project, there is a reduction in the extent of existing mining operations within the ESA. The effects of deposition of dust and metals air emissions on lakes is expected to be minor and restricted to lakes within close proximity to the Project, and will only last for the operations phase of the Project. Acidification of lakes from air emissions is predicted to be negligible.

The release of mine water is predicted to change water quality in Lac du Sauvage (Project) and Lac de Gras (Project and cumulative effects), but at all times and at all assessment locations in the lakes, concentrations are predicted to be less than the screening thresholds. Changes to water quality in Lac du Sauvage are driven primarily by Project activities, but changes to water quality in Lac de Gras are the result of incremental effects of the mine water discharge to Lac du Sauvage from the Project and the release of mine water from existing developments. In both lakes, these releases are predicted to change water quality from existing conditions, but concentrations throughout operations, closure, and into post-closure are not predicted to increase above site-specific objectives, protection of aquatic life guidelines, drinking water guidelines, other aquatic life guidelines, or chronic benchmarks during any

Project phase or at any assessment location. As a result of these changes to water quality, cumulative effects to the health of aquatic biota or as a drinking water source are negligible.

The Mine Water Management Plan is designed to mitigate Project and cumulative effects on receiving water quality by using the mined-out Misery pit to store mine water. The extended timeframe for storage of mine water in the Misery Pit with no discharge is a key environmental component of the Mine Water Management Plan, as it defers mine water discharge until after the scheduled closure of the Diavik mine (reducing cumulative effects in Lac de Gras). This approach also provides an opportunity for the collection and evaluation of site-specific data on mine water quality and quantity.

Based on predicted water quality during the Project phases relative to screening thresholds (i.e., magnitude), long-term water quality (i.e., duration), geographical extent (to the outlet of Lac de Gras or slightly further), and no potential effects to aquatic health, it is concluded that the Project will not have a significant adverse effect on the maintenance or suitability of water to support a healthy and sustainable ecosystem. There is a high degree of confidence in the predictions of environmental significance from the incremental and cumulative impacts on water quality and quantity. Methods used to predict effects on surface hydrology and water quality incorporated conservative assumptions to address uncertainty and improve confidence of effects predictions.

17.5 Fish and Fish Habitat

Cumulative effects within the ESAs for the VCs of fish and other aquatic life were assessed by analyzing habitat quantity and quality changes from previous and existing developments and the Project at the scale of Lac de Gras, Lac du Sauvage, and selected tributaries (Section 9.4). Cumulative (indirect) effects to habitat quantity and quality through changes to surface hydrology and water quality in the ESAs for fish and other aquatic life considered model predictions and methods for the assessment of effects to surface hydrology and water quality (Section 8.5).

For fish and other aquatic life, cumulative effects are considered in all assessment cases. Previous and existing developments considered in the Base Case were the Ekati Mine (including the Lynx Project) and the Diavik Mine downstream of Lac du Sauvage in Lac de Gras (Table 17.2-2). No previous or existing footprints overlap with tributary stream habitats to Lac de Gras and Lac du Sauvage. As the Application Case is the existing and approved projects plus the Project, this case also includes the cumulative effects of these developments. An RFD Case was not considered for fish and other aquatic life VCs because there are no potential RFD projects within the ESAs. The closest reasonably foreseeable development is the Courageous Lake project, located outside the Lac de Gras sub-basin and approximately 73 km to the southwest of the Project.

The cumulative effects analysis for the fish and other aquatic life VCs also considers the cumulative effects related to surface hydrology and water quality (Section 8). Natural factors, such as climate change and population processes that influence population abundance and distribution, were also considered in the assessment and in the prediction confidence and uncertainty.

The assessment endpoints for fish and fish habitat were self-sustaining and ecologically effective populations of Arctic Grayling, Lake Trout, and Lake Whitefish, which would maintain the ongoing fisheries productivity for local Aboriginal groups in the Northwest Territories (NWT) and Nunavut.
The assessment endpoint for aquatic life other than fish was ongoing support of fisheries productivity.

Seven primary pathways were evaluated for cumulative residual effects on the ongoing fisheries productivity in Lac du Sauvage and Lac de Gras (Section 13.4). These pathways are:

- The construction of the horseshoe dike and Jay Pit within Lac du Sauvage will result in the direct loss or alteration of habitat, affecting fish and other aquatic life within Lac du Sauvage and Lac de Gras.
- The dewatering of the diked area will result in the direct loss or alteration of habitat in Lac du Sauvage, affecting fish and other aquatic life within Lac du Sauvage and Lac de Gras.
- Dewatering Lac du Sauvage within the diked area will require removal of fish from the area.
- The construction of the horseshoe dike and diversion channel may alter access to tributary stream habitats to Lac du Sauvage, resulting in habitat loss for Arctic Grayling, Lake Trout, and Lake Whitefish.
- Operational activities and discharge (e.g., discharge of treated domestic wastewater, altered drainage, runoff from facilities, including waste rock storage areas, pit inflows, dike seepage, release of nitrogen compounds from blasting residues, fine processed kimberlite management) may change surface water quality and affect fish and other aquatic life in Lac du Sauvage and Lac de Gras.
- Pumping water to back-flood the Jay Pit and diked area of Lac du Sauvage may affect water levels and riparian habitat in Lac du Sauvage and Lac de Gras, and water levels, flows, and riparian habitat in the Lac du Sauvage - Lac de Gras Narrows, affecting fish and other aquatic life.
- Reconnection of the back-flooded area of Lac du Sauvage to the remaining watershed and post-closure releases of water (e.g., Misery Pit overflow and seepage, waste rock storage area runoff, Long Lake Containment Facility discharge) may change long-term water quality in Lac du Sauvage and Lac de Gras and affect fish and other aquatic life.

The evaluation of the significance of cumulative effects on fish and aquatic life VCs considered the set of primary pathways as a whole. Significance was not explicitly assessed for each pathway. Instead, the relative contribution of each pathway was used to determine the significance of the Project and other developments on the assessment endpoint.

Cumulative effects on fish and other aquatic life will primarily result from habitat losses (i.e., Project footprint effects) due to construction of the Jay horseshoe dike and dewatering of the diked area in Lac du Sauvage where the mine pit will be located. Habitat losses may also occur when tributary streams are diverted during operation of the Sub-Basin B Diversion Channel. The cumulative direct loss of lake habitat from the Project plus previous and existing developments is expected to be less than 1 percent (%) of lake habitat in the ESA (i.e., Lac du Sauvage and Lac de Gras), relative to the reference condition (i.e., pre-development conditions). The incremental and cumulative direct loss of stream habitat from the application of the Project is expected to be less than 1.6% of the length of selected tributary habitats in the ESA, relative to the reference condition. Dominion Diamond will engage with Fisheries and Oceans Canada and local Aboriginal communities during the permitting phase of the Project on the development of an offsetting plan to counterbalance for losses in fish habitat productivity.

Prior to dewatering, a fish-out will be conducted to remove fish from the diked area. The detailed fish-out plan will be developed thorough engagement of local Aboriginal groups and Fisheries and Oceans Canada. As the predicted number of fish to be removed is small compared to the entire population in Lac du Sauvage and Lac de Gras (i.e., less than 1%), this would not affect self-sustaining and ecologically effective populations of fish VCs.

Although increased concentrations of some metals, major ions, and total dissolved solids in Lac du Sauvage and Lac de Gras are predicted as a result of the Project, these changes in water quality are predicted to result in negligible cumulative effects to aquatic health in Lac du Sauvage and Lac de Gras. As a result, adverse cumulative effects to Arctic Grayling, Lake Trout, and Lake Whitefish health are unlikely, and thus, no effects would be expected to the self-sustaining and ecologically effective populations of these VCs.

The effect of increased nutrient concentrations during operations is expected to result in a general increase in productivity at lower trophic levels in the main basin of Lac du Sauvage, and a similar but less pronounced cumulative effect in the eastern part of Lac de Gras. Large shifts in the composition of plankton and benthic invertebrate communities are not expected. However, the biomass of phytoplankton, zooplankton, and benthic invertebrates will likely increase during operations when these communities take advantage of the increased nutrient supply. Following closure, plankton and benthic invertebrate communities are expected to return to baseline conditions. Due to the increased food base, there may also be a minor increase in growth and reproduction rates in the fish valued components (VCs). However, effects will be limited primarily to Lac du Sauvage during the late operations phase and potentially into closure.

A short-duration impact (less than four years) on downstream habitat is predicted during pumping from Lac du Sauvage to back-flood the Jay Pit and the diked area at closure. During anticipated low flow time periods, such as winter months, pumping rates may be reduced and pumping rates may be managed, which will further reduce downstream cumulative effects to the Lac du Sauvage and Lac de Gras outlets. Habitat connectivity will be maintained for fish passage between the two lakes (i.e., the stream that drains from Lac du Sauvage into Lac de Gras, known locally as "the Narrows").

In the impact classification, the magnitude of residual cumulative impacts for all primary pathways was low. The geographic extent for the pathways was regional, with the exception of a local effect within Lac du Sauvage for the permanent footprints from the construction of the horseshoe dike and the Jay Pit, and the effects of the construction of the horseshoe dike and diversion channel on access to tributary stream habitats for fish VCs.

The duration of impacts for most pathways will range from short-term to long-term. The effects of the fish-out (i.e., increased mortality) and habitat losses during operations would be reversible upon dike breaching and reconnection. The dike will be breached when water quality within the diked area meets pre-defined acceptability criteria for mixing with the lake. The dike will also be breached at multiple locations, and remnant portions of the dike will remain in Lac du Sauvage post-closure, resulting in permanent loss of less than 1% of the area of Lac du Sauvage and Lac de Gras. Remaining dike material will resemble shoals and islands, potentially providing functions for spawning, rearing, and foraging fish. The diversion channel will also be reclaimed and the natural channel will be reconnected to Lac du Sauvage.

When the dike is breached, recolonization of the back-flooded area is expected to occur immediately from adjacent habitat areas and will likely be populated by fish of all species and life-stages. Fish from adjacent habitat areas in Lac du Sauvage are expected to immediately move into the area and fully exploit the restored habitat within a few years of closure. Initial minor increases in growth and reproduction rates of fish VCs are expected as a response to reduced densities and access to available habitat behind the dike. Population recovery for fish VCs is expected to occur within a few years, and should be no longer than one generation time of fish VCs for populations to approach densities in other regions of Lac du Sauvage and Lac de Gras, in part, because measurable changes to populations within the ESA are expected to be minor and may not occur at all.

Although Arctic ecosystems can be slow to recover from disturbance, the resilience in the current state of fish populations in the ESA suggests that the impacts from direct habitat loss and mortality due to the Project and previous and existing developments should be reversible in the long term.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from the Project and other developments will not have a significant adverse effect on the self-sustaining and ecologically effective populations of Arctic Grayling, Lake Trout, and Lake Whitefish, and ongoing fisheries productivity.

Confidence in the assessment prediction is based on the low magnitudes of the incremental and cumulative changes of measurement indicators from the Project and other developments. As a general approach for addressing uncertainty, conservatism was adopted at various steps of the assessment to overestimate impacts. There is moderate uncertainty for the classification of the duration of effects, in part because of the uncertainty inherent in making long-term predictions in ecological systems. The assessment conservatively predicted that most residual effects will be reversible within one generation of the fish VCs following closure, even though it is plausible that most effects will be reversed by the end of closure or shortly thereafter.

17.6 Terrain

The purpose of the terrain assessment was to describe the existing geotechnical stability of the area proposed for mine rock management, and the geotechnical stability of all engineered structures under a range of climate, seismic, and precipitation scenarios. Included in the Terrain SON is the cumulative area of disturbance from previous, existing and future waste rock storage areas.

The terrain ESA is approximately 142 square kilometres (km^2), or 14,170 hectares (ha). The ESA includes the Ekati Mine and the Project footprint plus a 500 m buffer. Terrain is a VC with measurement indicators, but no explicit assessment endpoint (Table 17.2-2). Project-specific changes in the measurement indicators for terrain were determined. The measurement indicators for the terrain VC were soil quantity and distribution, surface hydrology, permafrost distribution, quantity and distribution of terrain units, and topography and slope stability. The changes in measurement indicators were carried forward to other assessments and applied to VCs with assessment endpoints, as described in Section 6.2. Although soil quantity and distribution and surface hydrology are included in the terrain section, the incremental and cumulative changes to these measurement indicators are analysed in detail in Appendix 11A and Section 8, respectively.

Waste rock and overburden excavated from the Jay Pit and waste generated during dike construction will be stored at the Jay waste rock storage area (WRSA). The existing Ekati Mine Waste Rock and Ore Storage Management Plan (WROMP) will be expanded to incorporate the Jay WRSA. The existing WRSAs at the Ekati Mine include the Panda/Koala/Beartooth WRSA, the Fox WRSA, and the Misery WRSA, which cumulatively cover 1,031 ha of the ESA. The Jay WRSA will cover approximately 250 ha, resulting in a cumulative WRSA area within the ESA of 1,281 ha. The future Pigeon WRSA that is currently under construction will cover an area of approximately 48 ha when complete. The cumulative area that will be occupied by previous, existing and reasonably foreseeable WRSAs is predicted to be 1,329 ha.

17.7 Vegetation

The vegetation ESA is approximately 5,933 km^2 (593,274 ha), and includes both unaffected (i.e., reference) areas, as well as areas influenced by the Project. The cumulative effects analysis for vegetation consists of the Base Case and Application Case (the maximum point of development of the Project). No reasonably foreseeable developments are located in the vegetation ESA (Table 17.2-2). The closest reasonably foreseeable development was the Courageous Lake Project approximately 73 km southwest of the Project, which is outside the ESA. Therefore, the RFD case was not included in the vegetation assessment.

The Base Case represents a range of conditions over time within the vegetation ESA, before application of the Project. Environmental conditions on the landscape before human development, which represent reference conditions, were considered independently within the Base Case. The Base Case also describes the existing conditions that may be influenced by the application of the Project, which is represented by the 2014 baseline condition. Cumulative effects within the ESA were assessed by analyzing changes to vegetation measurement indicators from previous and existing developments, and the Project.

Vegetation VCs were plant populations and communities; listed plant species and listed plant habitat potential; and traditional use plants and traditional use plant habitat potential. The assessment endpoint for vegetation VCs is self-sustaining and ecologically effective plant populations and communities. Details regarding incremental and cumulative effects analysis for each VC are available in each VC section. One primary pathway was evaluated for cumulative residual effects from development on self-sustaining and ecologically effective plant populations and communities (Section 11.4). This pathway is:

- Direct loss, alteration, and fragmentation of vegetation from the Project footprint.

17.7.1 Abundance and Distribution of Plant Communities

The cumulative changes from direct habitat loss associated with the previous and existing developments was calculated to be approximately 4,916 ha (0.8%) of the Ecological Landscape Classification (ELC) units within the ESA relative to the reference condition. The cumulative reduction in vegetation from application of the Project and other developments is predicted to remove 6,048 ha, or approximately 1.2%, of the mapped units in the ESA. The largest magnitudes of cumulative reductions of ELC land cover types are 203 ha (3.7%) of Esker Complex and 49 ha (2.3%) of Boulder Complex (>80% rock). Cumulative reductions of Heath Tundra 30% to 80% Boulder (1,032 ha), Heath Tundra 30% to 80% Bedrock (160 ha), Bedrock Complex (17 ha), Tussock/Hummock (578 ha), and Sedge Wetland (175 ha) are predicted to be no greater than 1.4% each relative to the reference condition in the ESA.

In addition to direct habitat loss, the application of the Project will result in the fragmentation of the existing landscape. With the application of the Project, the number of patches is expected to decrease from 263,572 for 2014 baseline conditions to 263,082 (loss of 490 patches) for the Application Case; the mean patch size is expected to decrease by less than 0.1 ha. The cumulative change in number of patches from the Project and previous and existing disturbance is a decrease of 1,792 patches and a decrease in mean patch size of 1.3 ha. The mean distance to nearest neighbour (MDNN) for the Esker Complex map unit is expected to decrease by approximately 0.3 m relative to 2014 baseline conditions. Heath Tundra 30-80% Boulders, Heath Tundra, and Deep Water map units are expected to decrease in distance by less than 1 m relative to 2014 baseline conditions. The MDNN for the remaining map units is expected to increase in distance by less than 1 m relative to 2014 baseline conditions.

Although fragmentation can change plant population and community processes, it is expected that associated plant populations and communities in the ESA will be able to accommodate disturbances associated with the Project. The Project footprint does not support isolated plant populations and communities that are endemic to the region. Project-related disturbances are expected to occur once, and although the effect will be permanent for the Project footprint, the net incremental change in ELC units from loss and fragmentation in the ESA will be confined to the Project footprint (local scale). The previous and existing disturbances, although spread out across the ESA, are also localized and small. The magnitude of regional cumulative effects of the Project and previous and existing disturbances on the relative abundance and quality of plant populations and communities will be negative in direction but low in magnitude (approximately 1.2% of the mapped units in the ESA).

No significant adverse effects are predicted for the ability of plant populations and communities to remain self-sustaining and ecologically effective as a result of the Project in combination with previous and existing developments in the ESA. Confidence in this prediction is high because the majority of these ecosystems are well distributed in the ESA, and plant species within already uncommon map units are expected to be adapted to the patchy nature of their habitats.

17.7.2 Listed Plant Species and Listed Plant Habitat Potential

Two territorial listed vascular plant species and five non-vascular plants species were documented during the 2014 field program, specifically one forb (Pallas' buttercup), one graminoid (Richardson's sedge), one bryophyte (tiny fork-moss), and four lichens (Kamchatka Iceland moss lichen, umber monk's hood lichen, silver-rimmed crottle lichen, and cushion coral lichen) (Section 11.2.2.2.1). All of these observations were in Shallow Water, Sedge Wetland, and microsites including rocky crevices and ecotones (i.e., transition area between two vegetation types). Microsites can occur within any mapped unit in the ESA; Shallow Water (high potential habitat) and Sedge Wetland (moderate potential habitat) are widely distributed and abundant in the ESA.

Of the area directly disturbed by the Project, 36 ha of ELC units with high listed plant habitat potential will be disturbed during construction, resulting in a decrease of 0.1% relative to 2014 baseline conditions. Habitat units with moderate potential for listed plants will decrease by approximately 43 ha (0.2%). The largest cumulative change through application of the Project and previous and existing developments is within the moderate plant potential ELC map units (1.7%) relative to the reference condition. The magnitude of the cumulative change within the high potential map units is 0.9% relative to the reference condition.

For cumulative effects of the Project to have a significant effect on self-sustaining and ecologically effective listed plant populations and communities, all preferred habitats for listed species would have to be permanently removed, or individual patches would have to become isolated to the extent that they would no longer be resilient to other environmental pressures or changes. Not all areas that were assessed to be disturbed by the Project are expected to be disturbed during construction; therefore, the effects from direct loss of listed plant species and the loss or alteration and fragmentation of preferred habitat were overestimated. The cumulative effects of the Project and previous and existing disturbances on the relative abundance of listed plant populations and communities are negative and regional, but low in magnitude (approximately 2.6% of the high and moderate potential mapped units in the ESA).

With mitigation (e.g., avoidance as practicable), it is expected that the residual effect of the Project to listed plant populations would be low in magnitude, because if a patch of listed plants is removed, it could be measurable at the regional level, but would not be predicted to alter the state of self-sustaining and ecologically effective listed plant populations. However, it is unknown whether previous and existing disturbances in the ESA have removed other patches of listed plant species; therefore, the cumulative effects on listed plants are considered moderate in magnitude to be conservative. Incremental and cumulative changes to listed plant habitat from the Project and other developments are predicted to not have significant adverse effects on listed plant populations and communities to remain self-sustaining and ecologically effective. Confidence in this prediction is moderate because of limited knowledge about the reproductive capacity and resilience of the observed listed species, and the level of occurrence of these species in the ESA; however, there is a large amount of suitable habitat for listed plant species in the region.

17.7.3 Traditional Use Plants and Traditional Use Plant Habitat Potential

There are 11 traditional use plants known to occur within the ESA. Local and traditional knowledge studies identified that many plants and berries are harvested in the ESA, within the traditional lands that overlap the Project footprint. The ELC map units predicted to contain the most traditional use species are Heath Tundra 30% to 80% Bedrock, Heath Tundra 30% to 80% Boulders, and Heath Tundra, which are also the most abundant habitats in the ESA compared to other land cover types.

Relative to the reference condition, previous and existing developments have removed approximately 2,829 ha (0.9%) of the high potential ELC units for traditional use plants and 580 ha (0.9%) of moderate potential units within the ESA. During the Application Case, 507 ha of ELC units with high traditional use plant habitat potential will be disturbed by the Project, resulting in a decrease of 0.2% relative to 2014 baseline conditions. Habitat units with moderate listed potential will decrease by approximately 177 ha (0.3%). The cumulative reduction in land cover types through application of the Project and previous and existing developments is predicted to remove 6,048 ha or approximately 1.2% of the mapped units in the ESA. The magnitude of the cumulative changes to high and moderate traditional use plant habitat potential will be 1.0% and 1.1% of the ESA, respectively, relative to the reference condition. The permanent loss from the Project footprint is expected to be 1,132 ha (0.2% of the ESA).

The Project footprint does not support isolated traditional use plant populations and communities. Project-related disturbances are expected to occur once, and although the effect will be permanent, the net incremental change in traditional use plants and traditional use plant habitat in the ESA will be confined to the Project footprint. The cumulative effects from the direct loss, alteration, and fragmentation of traditional use plant habitat from the Project and previous and existing developments are expected to be adverse, regional, and low in magnitude. The effects are predicted to not have a significance influence on self-sustaining and ecologically effective traditional use plant populations and communities. The scale of residual effects from the Project interactions, independently or combined, should not be large enough to cause irreversible changes at the population and community level and decrease the resilience of traditional use plant populations and communities. Confidence in this prediction is high because the majority of the traditional use plant species and the land cover types that support them are well distributed throughout the ESA.

17.8 Barren-Ground Caribou

Three primary pathways were evaluated for cumulative residual effects from development on self-sustaining ecologically effective barren-ground caribou populations (Section 12). These pathways included:

- Direct loss and fragmentation of habitat from the Project footprint causes changes in caribou abundance and distribution.
- Sensory disturbance (lights, smells, noise, dust, viewscape) and barriers to movement causes changes to caribou distribution and behaviour, and changes to energetics and reproduction.
- Increased traffic on the Misery Road and Jay Road and the above-ground power line along these roads may create barriers to caribou movement, change migration routes, and reduce population connectivity.

The caribou ESA is an amalgamation of the four seasonal ranges of the Bathurst herd and is 305,780 km^2. Effects of habitat loss, fragmentation, and change in habitat quality were analyzed separately for each seasonal range and their cumulative effects considered. Although the Project is not within the winter range, the assessment of cumulative effects required that changes in all seasonal ranges be considered. The ESA was based on the seasonal ranges of the Bathurst herd because this herd has the greatest likelihood of interacting with the Project, relative to the Ahiak and Beverly herds. In addition, current knowledge and relevant information regarding caribou research in the North Slave Region is focused on the Bathurst herd. Potential Project-related effects predicted for the Bathurst herd are anticipated to be representative and to provide conservative estimates of effects for the Ahiak herd (i.e., the effects for the Bathurst herd will likely overestimate effects for the Ahiak herd).

The cumulative direct habitat loss from the Project and previous, existing, and reasonably foreseeable future developments is predicted to be less than 0.6% of the area in each seasonal range. Based on a conservative approach to the analyses that overestimated footprint areas and considered human disturbance features to be irreversible, the effects of fragmentation on caribou across the seasonal ranges are expected to be low. For all seasonal ranges, changes in fragmentation metrics from the reference condition to the RFD Case were less than 2.3%, with the exception of burns in the winter range (number of patches increased by 5% and mean distance between burn patches increased by 3.5%). However, fragmentation of burn patches should not affect range value to caribou. Overall, fragmentation effects have less influence than direct habitat loss when there is a large proportion of natural habitat on the landscape (i.e., greater than 30%; Fahrig 1997, 2003; Andrén 1999; Flather and Bevers 2002; Swift and Hannon 2010), which is the expected state of the barren-ground caribou ESA resulting from the Project and other developments. Thus, caribou are predicted to be resilient to these small changes in physical habitat loss, and there should be no measurable effect on population abundance and distribution across the seasonal ranges.

Most of the cumulative effects of development on caribou seasonal ranges are related to modelled changes in habitat quality from the combined influences of sensory disturbance mechanisms (e.g., dust, noise, lights, viewscape, and general human activity). In the analysis of habitat quality, conservative assumptions and conditions were applied to spatial and temporal variables so that the predicted effects on caribou would not be underestimated. The Project and previous, existing and approved developments were determined to reduce the amount of preferred habitat (includes physical footprints and zones of influence that decrease habitat quality) by 0.9% on the spring range (includes the calving grounds), 5.5% on the post-calving range, 6.1% on the autumn range, and 5.4% on the winter range. The proximity of the Project to existing Ekati Mine operations resulted in declines of preferred habitat from 0.0% to 0.2% among seasonal ranges. With the addition of uncertain, future developments (i.e., reasonably foreseeable) there was an increase in the loss of high quality habitat, particularly on the post-calving and autumn ranges. For the RFD Case, preferred habitat could be decreased by 1.7% in the spring range, 13.3% in the post-calving range, 12.0% in the autumn range, and 5.9% in the winter range.

The analysis of changes in caribou behaviour from sensory disturbance also included the use of an ecologically conservative and applicable energetic model to predict effects on calf production (Sections 12.4.2.3 and 12.5). Results indicated that encounters with development and insect harassment can have negative effects on adult female body condition in the autumn and reduce parturition rates the following spring. However, the key variable in the model is insect harassment. Even with the maximum previous, existing and future developments on the landscape (RFD Case), female caribou would have to increase their encounter rate with zones of influence by approximately 14 to19 times to result in no calf production the following spring. In contrast, when insect harassment is high, the predicted decline in parturition rate may be as large as 32%, with average insect harassment the decline in parturition is 16%, and with low insect harassment there is a 5% decline in calf production. Insect harassment, particularly oestrid flies, has been shown to have adverse effects on female body condition and calf production (Hagemoen and Reimers 2002; Weladji et al. 2003; Bergerud et al. 2008). In a recent study by Witter et al. (2012), Bathurst caribou spent more time walking than feeding when insect abundance was high, but feeding intensity (ratio of time eating to total time eating and searching) remained similar regardless of insect abundance. Feeding intensity appeared to be related more to seasonal changes in vegetation abundance (and likely quality) (Witter et al. 2012).

Changes in habitat quality from sensory disturbance associated with human developments are predicted to have a measurable effect on the abundance and distribution of caribou across the seasonal ranges. Effects on distribution (and local abundance) are expected to be detectable within 15 km of operating mine sites and 5 km of winter and all-season road corridors. Effects from sensory disturbance on habitat quality and calf production are anticipated to be reversible in the long term (perhaps 5 to 10 years following the end of closure of a project), and should be within the resilience limits and adaptive capacity of the Bathurst herd. When human activities are present, caribou are known to alter their behaviour to avoid disturbed landscapes. Initially, the response of caribou to roads is avoidance, but over time they can become habituated to the presence of roads and traffic (Haskell and Ballard 2008; ERM Rescan 2014a,b; Johnson and Russell 2014).

Deflections in animal movement from increased traffic on the Misery and Jay roads could adversely affect migration and connectivity of the Bathurst caribou herd. The expansion of the Ekati Mine monitoring program during migration periods will identify concentrations and movements of animals that may interact with the roads. Stockpiling of ore, modifications to traffic patterns, and the implementation of road closures are expected to provide opportunities for caribou to move across the roads, and limit effects to migration and maintain population connectivity. Qualitative analysis predicted that the presence of the power lines should result in negligible changes to caribou movements and distribution relative to increased traffic on the Misery and Jay roads (Section 12.4.2.2.2). Natural environmental factors that operate over large scales of space and time will likely have greater influences on seasonal distributions of caribou than the incremental and cumulative impacts from the Project and other developments. For example, studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer, or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000; Tyler 2010).

Elders from communities have expressed concerns about mining developments affecting the timing and routes of caribou migration. Although future development is uncertain, the Izok Corridor and Bathurst Inlet Port and Road are reasonably foreseeable projects (Section 6.5.2.4) that could affect caribou abundance, distribution, and population connectivity by increasing habitat loss and fragmentation, and decreasing habitat quality and calf production. The Izok Corridor and Bathurst Inlet Port and Road may act as barriers to animal movement within the northern portion of the Bathurst caribou range. If developed, these all-season roads will be within the spring, post-calving, and autumn ranges of the herd, and on or encroaching on the calving grounds. If these projects are developed, then it is anticipated that temporary modifications to traffic patterns and road closures would be implemented to mitigate effects to migratory movements and population connectivity.

Overall, the weight of evidence from the analysis of the primary pathways predicts that incremental and cumulative changes to measurement indicators from the Project and other developments should have no significant adverse effect on self-sustaining and ecologically effective barren-ground caribou populations. The confidence in this prediction is higher for the Application Case than the RFD Case. Barren-ground caribou populations have natural cycles of high and low numbers, and their distributions change through time (Adamczewski et al. 2009; Tłı̨chǫ Government and ENR 2010; Tyler 2010; Festa-Bianchet et al. 2011). Resilience in caribou herds likely fluctuates with population size so that the ability to recover from natural and human disturbances is greater when caribou are increasing and at high numbers (Bergerud et al. 2008; Gunn 2009). Although estimates are uncertain, a 2014 reconnaissance survey suggests a large decline in the Bathurst herd since 2012 (Boulanger et al. 2014b). Still, confidence in the predictions for the RFD Case is based on the consistent low effect sizes (i.e., magnitudes of change) that were determined from the incremental and cumulative changes from the Project and other developments for habitat quantity and habitat quality, and energetics. Although each development likely influences the local movement and distribution of caribou across their seasonal ranges, there is no strong mechanism causing an adverse and long-term or permanent change in population survival and reproduction rates. The implementation of temporary modifications to traffic patterns and road closures is predicted to mitigate effects to migration and maintain connectivity for self-sustaining and ecologically effective barren-ground caribou populations.

17.9 Wildlife and Wildlife Habitat

Cumulative effects within the ESAs for wildlife were assessed by analyzing habitat quantity and quality changes from previous and existing developments and from RFDs (if applicable) (Table 17.2-2). The ESA for the assessment of effects on waterbirds and raptors was 5,933 km^2. The grizzly bear and wolverine ESA was approximately 200,000 km^2. Natural factors that influence populations were also included in the assessment. The assessment endpoint for wildlife VCs was self-sustaining and ecologically effective populations.

Wildlife VCs assessed in the cumulative effects analysis were waterbirds, raptors, grizzly bear, and wolverine. Species at risk are defined as species recommended by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be protected under Canada's *Species at Risk Act* (SARA), as well as species currently protected under the SARA. Effects to short-eared owl and peregrine falcon were assessed as part of the raptor VC; grizzly bear and wolverine were assessed separately as per the TOR.

The following sections summarize the results of the cumulative effects analysis of primary pathways. Details regarding incremental and cumulative effects analysis for each VC are available in their respective sections (Sections 13.4.2, 13.4.3, 13.4.5, and 13.4.6).

17.9.1 Waterbirds and Raptors

Two primary pathways were evaluated for cumulative residual effects from development on self-sustaining and ecologically effective waterbird and raptor populations (Section 13.4). These pathways are:

- Direct loss and fragmentation of wildlife habitat from the Project footprint may cause changes in abundance and distribution of waterbirds and raptors.
- Sensory disturbance (lights, smells, noise, dust, viewscape) may cause changes to habitat quality, and the movement and behaviour of waterbirds and raptors, and influence population abundance and distribution.

Cumulative effects were limited to disturbance through the Application Case for waterbirds and raptors because no reasonably foreseeable developments were present in the bird ESA. Previous and existing developments in the bird ESA included the Ekati and Diavik mines (Table 17.2-2). The magnitude for both primary pathways was low. The area of the cumulative changes from direct habitat loss associated with the Project and previous and existing developments is expected to be approximately 6,048 ha (1%) of the birds ESA relative to the reference condition. Cumulative direct disturbance since reference conditions is estimated to alter high and good suitability habitats by 4,586 ha for waterbirds and by 235 ha for raptors, which is 0.9% of available high and good suitability habitat for each VC. Overall, the magnitude of cumulative changes to habitat area and configuration (e.g., number and distance between similar patches) from the Project and previous and existing developments are estimated to be approximately 1% relative to a reference landscape.

In addition to direct habitat loss, indirect changes from sensory disturbance of developments (e.g., lights, dust, noise, viewscape) may influence raptor and waterbird abundance and distribution by altering movement and behaviour among habitats at the population scale (Habib et al. 2007; Bayne et al. 2008; Boulanger et al. 2012). For waterbirds, the Project and previous and existing developments are expected to reduce high and good quality staging habitats by 8,623 ha (4.2%) and 3,709 ha (4.5%), respectively. Cumulative changes from the Project and other developments are predicted to reduce high and good breeding habitats by 4,816 ha (4.9%) and 3,709 ha (4.5%), respectively. For raptors, the cumulative direct and indirect changes from the Project and previous and existing developments is expected to reduce high and good suitability habitat by 355 ha (3.5%) and 614 ha (4.0%) of that available during the reference condition.

Most bird species within the ESA are migratory, and will be influenced by the Project and other developments for four to five months each year during spring to autumn. Arctic ecosystems are slow to recover from disturbance; therefore, the duration of directly disturbed habitats is anticipated to be reversible in the long term following reclamation. The cumulative direct disturbance impacts from the terrestrial footprint were conservatively assumed to be irreversible (for example, the permanent presence of the WRSA). Sensory disturbance impacts associated with exploration, mining activities, and roads on waterbird and raptor populations are anticipated to be reversible over the long term.

The resilience in the current state of waterbird and raptor populations in the ESA suggests that the impacts from the Project and from previous and existing developments should be reversible.
Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from the Project and other developments should have no significant adverse effect on self-sustaining and ecologically effective waterbird and raptor populations. There is a high degree of confidence in the predictions of environmental significance from the incremental and cumulative impacts on waterbirds and raptors. Methods used to predict effects on waterbirds and raptors incorporated conservative assumptions to address uncertainty and improve confidence of effects predictions.

17.9.2 Grizzly Bear and Wolverine

Three primary pathways were evaluated for cumulative residual effects from development on self-sustaining and ecologically effective grizzly bear and wolverine populations (Section 13.4). These pathways are:

- Direct loss and fragmentation of wildlife habitat from the Project footprint may cause changes in abundance and distribution of grizzly bear and wolverine.
- Sensory disturbance (lights, smells, noise, dust, viewscape) may cause changes to habitat quality, and the movement and behaviour of grizzly bear and wolverine, and influence population abundance and distribution.
- Increased traffic on the Misery Road and Jay Road, as well as the above-ground power line along these roads may create barriers to wolverine, grizzly bear, and caribou movement, which may affect wolverine and grizzly bear population connectivity, abundance, and distribution.

Previous and existing projects in the grizzly bear and wolverine ESA included the Ekati, Diavik, Tundra, Doris North, and Snap Lake mines, the Gahcho Kué Project, and the Tibbitt to Contwoyto Winter Road. Reasonably foreseeable developments in the grizzly bear and wolverine ESA included the Jericho and Lupin mines; the Hope Bay, Hackett River, Back River, Izok Corridor, and Courageous Lake projects; the Bathurst Inlet Port and Road; and the Hydroelectric Grid Expansion (Table 17.2-2).

The cumulative impacts from the Project and other developments should not have a significant influence on self-sustaining and ecologically effective grizzly bear and wolverine populations. For all primary pathways influencing the abundance and distribution of grizzly bear and wolverine, cumulative impacts were determined to be regional in geographic extent, which implies that a portion of the population is affected, but not the whole population. The magnitude for the primary pathways affecting grizzly bear and wolverine ranged from low to moderate. The likelihood of impacts occurring is expected to be highly likely for the three primary pathways, which would not change the expected magnitude and duration (or environmental significance). The frequency of most impacts is anticipated to occur periodically or continuously throughout the life of the Project.

Cumulative direct disturbance from the Project and from previous, existing, and reasonably foreseeable developments in the grizzly bear and wolverine ESA is predicted to be 48,375 ha, or 0.4% relative to the reference condition. Changes to landscape metrics for suitable wolverine and grizzly bear habitats were predicted to be less than or equal to 1.5% from the reference condition to the RFD Case. Fragmentation can influence individual, population, and community processes, but fragmentation effects have less influence than habitat loss when there is a large proportion of natural habitat on the landscape (Fahrig 1997, 2003; Andrén 1999; Flather and Bevers 2002; Swift and Hannon 2010), as occurs within the grizzly bear and wolverine ESA.

Cumulative changes to wolverine and grizzly bear habitat quality are predicted to be larger than changes to habitat loss and fragmentation. Cumulatively, previous, existing, and reasonably foreseeable developments, including the Project, are predicted to remove 9.3% of suitable spring to autumn habitats for wolverine. The removal of high- and good-quality wolverine winter habitat from the reference condition through reasonably foreseeable developments is predicted to be 12.3%. Approximately 7.4% of the cumulative 12.3% decrease of suitable winter habitat is due to seasonal ice roads such as the Tibbitt to Contwoyto Winter Road and access roads to mine sites (i.e., 59.9% of the area within the ZOIs in the ESA is due to winter roads).. Disturbance from these roads is considered temporary because winter roads are only active for 8 to 12 weeks every year.

Previous, existing, and reasonably foreseeable human developments (including the Project) are predicted to remove from 7.1% (spring) to 8.5% (autumn) good- and high-quality grizzly bear habitats, relative to the reference condition.

The Izok Corridor and Bathurst Inlet Port and Road projects are reasonably foreseeable developments that could affect grizzly bear and wolverine abundance, distribution, and population connectivity by increasing habitat loss and fragmentation, and by decreasing habitat quality.

The Hydroelectric Grid Expansion is a future project that proposes to connect the existing Snare and Taltson grids using a 240 kilovolt (kV) transmission line around the west side of Great Slave Lake and to expand the grid to service the diamond mines. The expansion of the hydroelectric grid would likely have little influence on wolverine and grizzly bear habitat and populations. Most effects would occur during construction and would be related to local avoidance due to sensory disturbance from human activities (e.g., helicopters for tower and conductor installation, temporary work camps). Changes in grizzly bear and wolverine population abundance and distribution associated with direct habitat loss and fragmentation from towers would likely be ecologically non-measurable. However, changes in caribou abundance and distribution could negatively influence wolverine and grizzly bear populations. Expansion of the hydroelectric grid could change caribou habitat use and distribution if animals avoid or restrict movements near the transmission lines (Vistnes and Nellman 2008; Tyler et al. 2014). The Izok Corridor and Bathurst Inlet Port and Road projects are located in the spring, post-calving, and autumn ranges of the Bathurst caribou herd, and would be predicted to adversely influence caribou habitat, abundance and distribution. Changes in caribou abundance and distribution could negatively influence wolverine and grizzly bear populations by altering the temporal and spatial availability of prey for these carnivores (i.e., a decrease in ecological effectiveness).

Arctic ecosystems are slow to recover from disturbance; therefore, the cumulative direct disturbance impacts from the terrestrial footprint (for example, the permanent presence of the WRSA) were conservatively assumed to be irreversible. Sensory disturbance impacts associated with influences of exploration, mining activities, and roads on wildlife populations are anticipated to be reversible over the long term.

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The resilience in the current state of the wolverine and grizzly bear populations in the ESA suggests that the impacts from the Project and existing and future developments should be reversible. Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from the Project and other developments should not have a significant adverse effect on self-sustaining and ecologically effective grizzly bear and wolverine populations.

17.10 Socio-Economics

The approach to cumulative social and economic effects is, in some respects, different from that taken by the physical and biological disciplines. When describing conditions and trends beyond present day, a socio-economic impact assessment considers all reasonably foreseeable projects. While some projects may have been announced, or are in the planning process, they are not necessarily considered to be reasonably included in predictions of future conditions, from an economic standpoint. Rather, only projects with proven economics (e.g., funding, approvals) and a strong, real likelihood of proceeding are considered in the interest of providing a meaningful projection of future social and economic conditions. A project's effects are then described, first incrementally, and then in conjunction with the Base Case projects (Table 17.2-2). The assessment of a project's effects is, therefore, inherently cumulative in nature.

Several projects included by the physical and biological disciplines were considered too speculative to include in the socio-economic impact assessment. The potential Prairie Creek Mine, NICO Mine, and Nechalacho Mine have completed DARs. Passing these regulatory requirements has not, however, led to the immediate development of the projects due to other preventative factors, including issues of low commodity prices, missing infrastructure, and capital financing. These factors are significant enough that any one may indefinitely keep a project from being developed. It is, therefore, not possible to estimate a reasonable scope of development or timeframe for projects of this nature. To include such projects in the socio-economic cumulative scenario would skew the discussion to a highly speculative scenario.

Some other projects, while potentially having a cumulative interaction with far-reaching biophysical VCs, would not interact with the Project in terms of economics and social impacts. These projects will not likely affect the LSA communities because of their distance from the Project is great, or because the projects will be required to maximize hiring from another study area (i.e., Nunavut).

The projects considered in the cumulative scenario of the socio-economic impact assessment include the existing Ekati, Diavik, and Snap Lake mines, and the Gahcho Kué Project. The Gahcho Kué Project is included because of its advanced stage of development, initial staging of materials and construction activities, and its financially viability (i.e., the current price of diamonds). It is also reasonable to assume that Mountain Province Diamonds Inc. and De Beers Canada Inc. will be in a position to finance the development of the project once the licensing is in place.

An initial screening was completed to identify VCs of the socio-economic and cultural environments that have the potential to be influenced by cumulative effects from the Project and other developments (Table 17.10-1). All VCs have the potential to be influenced by cumulative effects.

Table 17.10.1 Identification of Residual Project Effects that have Potential Cumulative Effects

Key Line of Inquiry	Valued Component	Residual Project Effect	Potential Cumulative Effect
Maximizing Benefits and Minimizing Impacts to Communities	Population Demographics	• The Project would maintain the Base Case population from 2019 to 2025, and soften the trend of out-migration from the NWT to southern communities from 2026 to 2030. • Project-induced out migration from rural LSA communities to Yellowknife (urban).	Yes
	Economy	• Capital expenditure would add to the economic activity in the NWT, including investment. • The Project would contribute to the GDP of the NWT. • The Project would result in personal income tax, corporate tax and other taxes and revenues to the NWT. • The Project would discourage out-migration from the territory as a result of the closure of the existing Ekati mine, thereby stabilizing inflation and avoiding deflation.	Yes
	Employment and Incomes	• The Project would maintain local employment during construction and operations. • The Project would postpone spikes in unemployment rate. • The Project would maintain incomes for the local labour force, and add to labour income in the NWT.	Yes
	Education and Training	• Project employment educational requirements could lead to increased interests in completing education and educational attainment. • The Project would continue to provide community contributions and tax revenue to the GNWT, thereby supporting educational funding. • The Project would maintain some level of demand for mining-related educational services in the NWT. • Project training will continue to build capacity in the labour force, thereby strengthening the NWT population's ability to participate in the labour force.	Yes

Table 17.10.1 Identification of Residual Project Effects that have Potential Cumulative Effects

Key Line of Inquiry	Valued Component	Residual Project Effect	Potential Cumulative Effect
Maximizing Benefits and Minimizing Impacts to Communities (continued)	Health and Wellbeing	• Project health and safety training (e.g., defensive driving, first aid) could improve safety awareness, and provide skills for treatment of minor injuries. • Project medical and counselling services would benefit the physical and mental health of employees and their families. • Rotational employment would provide time for traditional harvesting in the two week off period. • Rotational work would require employees to be away from their communities during the two week on period, preventing them from participating in community events and volunteering. • Preferential hiring of women and Aboriginals would build capacity in these groups, and provide employment, thereby reducing their vulnerability. • Employment income would provide support for traditional harvesting activities. • Employment income would contribute to income disparity between employee families and families not benefiting from employment.	Yes
	Physical Infrastructure	• Project-related construction traffic may increase traffic volumes on the Tibbitt to Contwoyto Winter Road. • The Project would use existing air infrastructure in point of hire and fly point communities to transport workers and goods to and from site. • Project construction and operations could generate waste and increase demand for waste management.	Yes
	Non-Traditional Land Use	• The Project may affect the availability of wildlife for hunting in the LSA. • The Project may affect the availability of fish for fishing in the LSA. • Project-related noise may have an effect on hunting, fishing and land-based tourism in the LSA. • Project-related visual effects may have an effect on hunting, fishing and land-based tourism in the LSA.	Yes

LSA = local study area; NWT = Northwest Territories; GNWT = Government of the Northwest Territories; GDP = gross domestic product; e.g. = for example.

Population Demographics

The cumulative effect of the reasonably foreseeable mining projects on population demographics will be positive and significant, in that employment demand from the mines will retain residents, preventing out-migration from the territory. These projects will, together, provide incomes that will facilitate the intra-territorial migration of people from rural LSA communities to Yellowknife. While potentially positive for those who choose to migrate, out-migration from rural LSA communities where populations are small would be noticeable, and could alter community structures. The cumulative effect on population demographics is, overall, considered significant.

Economy

The reasonably foreseeable mining projects will include labour and capital expenditures, contributions to the territorial gross domestic product (GDP), and payment of taxes and revenues to the Government of the Northwest Territories (GNWT). Mining has not resulted in substantial changes to inflation over the past two decades. Cumulatively, the reasonably foreseeable mining projects will act to soften deflation. Overall, the cumulative effect on the economy is of the NWT is considered significant.

Employment and Incomes

Local employment opportunities will be maintained by the reasonably foreseeable mining projects. This would, cumulatively, postpone spikes in unemployment for the duration of mining operations, and would maintain incomes for the local labour force. Overall, the cumulative effect on employment and incomes in the NWT is considered significant.

Education and Training

The mining industry in the NWT, including the reasonably foreseeable projects, is expected to cumulatively support public interest in educational attainment in the hopes of obtaining skilled employment at the mines. The industry will also continue to provide tax revenue to the GNWT and community educational contributions (e.g., scholarships). The operations of the NWT mines will, in the future, maintain demand for skilled labour, and thus mining-related education programs. Training received at the mines will build capacity in the labour force. Overall, the cumulative effect on education and training in the NWT is considered significant.

Health and Well-being

It is difficult to disentangle socio-economic change due to mining from change due to other forces, particularly for changes to less tangible socio-economic indicators such as health and well-being. It is, therefore, difficult to establish a direct correlation between the mining industry alone and broad trends in health and well-being in the NWT.

It is not unreasonable; however, to suggest potential changes to specific indicators of health and well-being in the current environment as a result of employment and incomes from the mining industry over the next two decades. These predictions do not take into consideration other factors and influences on health and well-being (e.g., personal choices, potential government initiatives). As a result, the discussion of the health and well-being cumulative effects is, to a large extent, speculative.

The mining industry will continue to, cumulatively, provide health and safety training (e.g., first aid, defensive driving) that may improve health and safety awareness in the NWT, and basic medical skills for the treatment of minor injuries to employees and their families. The reasonably foreseeable mines are expected to provide medical services to employees on site, as well as counselling programs to employees and their families. These services would reduce demand for physical and mental health services in the NWT.

Rotational employment would provide time needed for activities on the land, but would also remove employees from their communities for extended periods of time, interfering with community involvement and volunteering activities.

The Socio-Economic Agreements for the reasonably foreseeable mines outline hiring targets for Aboriginal employees, and the proponents of the mines encourage the employment of women in non-traditional roles. Cumulatively, the mines will build labour capacity in these populations, thereby reducing their vulnerability to income inequality.

Employment incomes earned at the reasonably foreseeable mines would support traditional harvesting activities, but would also continue to contribute to the income disparity between employee families and families not benefiting from employment.

Overall, the cumulative effect on health and well-being in the NWT is considered significant.

Infrastructure

The reasonably foreseeable mining projects would require the transportation of waste, materials, and workers, which would act cumulatively to place pressure on existing physical infrastructure, particularly roads, waste disposal, and air transportation. These types of infrastructure are currently in place in the NWT, and mining projects would pay fees in their support. Overall, the cumulative effect on physical infrastructure in the NWT is considered not significant.

Non-Traditional Land Use

The Project would act cumulatively with other mines (particularly the Diavik Mine) to affect the availability of wildlife and fish for guided outfitting (hunting) and fishing-based tourism. These projects would also generate noise and visual disturbances, degrading wilderness character in their vicinity, and thus affect other land-based forms of tourism. Given the limited nature of non-traditional land use in the area around the Project, the cumulative effect on the non-traditional land use LSA is considered not significant.

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17.11 Cultural Aspects

The assessment of cultural aspects of the human environment considered effects on two VCs: Traditional Land Use (TLU) (representing traditional activities), and Heritage Resources. Cumulative effects on Heritage Resources are managed by the GNWT through the Prince of Wales Northern Heritage Centre because of the confidential nature of heritage sites. However, the documentation of heritage sites through the Project-specific site surveys has resulted in positive effects on the heritage resources record of the GNWT.

The TLU VC was selected because TLU practice has been demonstrated as providing an important link to the maintenance of Northern Aboriginal culture, spirit, and identity (Dezé 2009). Assessment endpoints for the TLU VC are the continued opportunities to traditionally harvest wildlife, fish, and plants, and to use the land in other culturally important ways. Multiple measurement indicators were considered for each assessment endpoint; assessment endpoints sometimes shared measurement indicators. Measurement indicators included: changes to the availability of traditional resources; direct disturbance of preferred areas; changes in access to preferred areas; indirect disturbances such as viewscape, light, and noise; social and economic factors that may affect continued participation in TLU activities; and increased concerns related to human and ecological health. Several of these indicators relied upon the assessments conducted for other components in the DAR (e.g., wildlife and wildlife habitat assessment).

For traditional use of land and resources, there are no established thresholds or standards for most measurement indicators, and effects on TLU are not quantifiable in the same way as many biophysical disciplines. Therefore, Base Case effects are described as the existing environment and are based on the reported observations about TLU available in reviewed public literature.

Cumulative effects on TLU are part of a process of interdependent social and cultural change and individual responses to that change, which causes the determination of the exact extent of effects due to development to be difficult. As a result, the assessment of potential cumulative effects on TLU is conducted qualitatively.

It is predicted that cumulative effects will likely result in negative effects on traditionally used resources, the loss of a portion of preferred use areas, and result in changes in access. Cumulative effects are also expected for sensory disturbances, increased concerns regarding human and ecological health, and social and economic factors that may affect the continued participation in TLU activities. These effects are generally considered to be negative in nature. However, some effects may have both negative and positive dimensions due to differing individual responses to these changes.

While negative cumulative effects are predicted for TLU, these effects are not predicted to result in a substantial reduction or alteration in the overall patterns of TLU activities or in associated traditional lifestyle and cultural practice. Therefore, cumulative effects are not expected to significantly affect the assessment endpoints for the TLU VC.

17.12 Means to Reduce or Avoid Predicted Cumulative Effects

Dominion Diamond is committed to keeping the footprint as small as practical to ensure safe operations of the mine and limit disturbance to the natural vegetation communities. Dominion Diamond will implement monitoring of the Bathurst caribou herd to track migratory movements via (i) satellite radio-collars (relying on information provided by GNWT), (ii) aerial reconnaissance surveys for caribou approaching the roads, and (iii) road surveys. The data collected during these monitoring activities will be used to test effects predictions and the success of proposed mitigation for increased traffic on the Misery Road as part of determining the cumulative effects of the project on caribou. In addition, Dominion Diamond funds the Independent Environmental Monitoring Agency in accordance with the Environmental Agreement.

In addition to Ekati Mine-related effects monitoring programs, Dominion Diamond has participated or contributed to regional wildlife monitoring initiatives intended for conservation and management including the GNWT's Barren-ground Caribou Management Strategy (GNWT-ENR 2011) and the Bathurst Range Plan Working Group. One initiative that is supported in part by Dominion Diamond is the Bathurst caribou aerial surveys used to determine herd composition, cow:calf ratios, and population estimates. Dominion Diamond is also involved in the Zone of Influence Working Group (includes Diavik Diamond Mines Inc., De Beers Canada Inc. and Avalon Rare Metals Inc.), which is tasked with determining the most effective methods for future monitoring of caribou distribution near mine sites. These programs provide data to support cumulative effects assessment and management by the GNWT.

Similarly, Dominion Diamond has participated or contributed to regional wildlife monitoring initiatives (in collaboration with other mines (e.g., Diavik) such as:

- gray wolf den monitoring;
- regional scale grizzly bear and wolverine hair snagging studies occurring in the North Slave Region;
- the North America Breeding Bird Survey; and,
- plans to contribute raptor nest monitoring for the Canadian Peregrine Falcon Survey, which will next occur in 2015.

The Mine Water Management Plan provides for secure storage of mine water in the mined-out Misery Pit, and defers the need for discharge to the local receiving environment (Lac du Sauvage) for approximately five years into the open-pit operation. This approach reduces aquatic cumulative effects in Lac de Gras (given the current published shut down of the Diavik Mine in 2023). Data collected as part of the mine water monitoring program will be used to assess the need for adaptive management should trends in mine water quantity and quality differ from expectations. Mine water sources and effluent will be monitored through internal programs and the expansion of the Water Licence Surveillance Network Program.

The receiving environment will be monitored through the expansion of the Water Licence Aquatic Effects Monitoring Program (AEMP). The AEMP will be designed to monitor effects on the aquatic environment related to changes in hydrology, surface water quality, sediment quality, plankton, benthic invertebrates and fish (fish health, fish tissue chemistry) (Appendix 9C). Sites will be identified to be representative of near-field and far-field conditions, and consideration of potential cumulative effects associated with the Ekati and Diavik mines. The Ekati Mine Aquatic Response Framework will also be expanded to incorporate the Project. This framework provides a mechanism for ensuring review of monitoring information against pre-defined thresholds, and implementation of adaptive management response actions as appropriate.

As described in the Ekati Mine Interim Closure and Reclamation Plan (ICRP), back-flooding of pits at the Ekati Mine will be completed in accordance with approved withdrawal rates to protect source water and downstream areas against adverse effects. Dominion Diamond will also manage water withdrawals to limit cumulative effects on Lac de Gras in terms of water level and local hydrological regime, and potential effects on fish habitat in Lac de Gras and downstream in the Coppermine River.

Many socio-economic effects are considered positive, and so are not actively reduced or avoided. Rather, Dominion Diamond will continue to maximize benefits via employment and employee support. Where there is potential for a negative socio-economic effect, the Project will employ environmental design and socio-economic management practices aimed at reducing or avoiding the effect. Socio-economic management practices, policies, and strategies to maximize northern benefits are discussed in Section 14 of the DAR (Section 14.1.3).

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17.13 References

Adamczewski JZ, Boulanger J, Croft B, Cluff D, Elkin B, Nishi J, Kelly A, D'Hont A, Nicholson C. 2009. Decline of the Bathurst Caribou Herd 2006-2009: A technical evaluation of field data and modeling. Draft technical report December 2009. GNWT.

Andrén H. 1999. Habitat Fragmentation, the Random Sample Hypothesis, and Critical Thresholds. Oikos 84(2): 306-308.

Avalon (Avalon Rare Metals Inc.). 2014. Application for New Land Use Permit – MV2004D0001. Mackenzie Valley Land and Water Board, Yellowknife, NWT, Canada.

Bayne EM, Habib L, Boutin S. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. Conserv Biol 22:1186-1193.

Boulanger J, Gunn A, Adamczewski J, Croft B. 2011. A Data-Driven Demographic Model to Explore the Decline of the Bathurst Caribou Herd. J Wildlife Manage 75: 883-896.

Boulanger J, Poole KG, Gunn A, Wierzchowski J. 2012. Estimating the Zone of Influence of Industrial Developments on Wildlife: a Migratory Caribou Rangifer tarandus groenlandicus and diamond mine case study. Wildlife Biol 18: 164-179.

Boulanger J, Croft B, Adamczewski J. 2014. An Estimate of Breeding Females and Analyses of Demographics For The Bathurst Herd of Barren-ground Caribou: 2012 Calving Ground Photographic Survey. Integrated Ecological Research Unpublished File Report No. 142 for Environment and Natural Resources, GNWT. 81 pp.

Dezé (Dezé Energy Corporation Ltd.). 2009. Taltson Hydroelectric Expansion Project Developer's Assessment Report. Dezé Energy, Yellowknife, NWT, Canada.

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

Dominion Diamond (Dominion Diamond Ekati Corporation). 2013. Project Description Proposed Development of the Lynx Kimberlite Pipe. September 2013.

ENR (Environment and Natural Resources, Government of the Northwest Territories). 2014. Guideline for Ambient Air Quality Standards in the Northwest Territories. Yellowknife, NWT, Canada, 5 pp.

Fahrig L. 1997. Relative effects of habitat loss and fragmentation on population extinction. J Wildl Manage 61: 603-610.

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Ann Rev Ecol Evol Systematics 34:487-515.

Ferguson MAD, Messier F. 2000. Mass emigration of Arctic tundra caribou from a traditional winter range: population dynamics and physical condition. J Wildlife Manage 64:168-178.

Flather CH, Bevers M. 2002. Patchy reaction-diffusion and population abundance: the relative importance of habitat amount and arrangement. Amer Nat 159:40-56.

Fortune (Fortune Minerals Limited). 2011. Developer's Assessment Report. Fortune Minerals Limited NICO Project. Environmental Assessment 0809-004. Submitted to the Mackenzie Valley Review Board. Yellowknife, NWT, Canada

Habib L, Bayne EM, Boutin S. 2007. Chronic Industrial Noise Affects Pairing Success and Age Structure of Ovenbirds *Seiurus aurocapilla*. J Appl Ecol 44: 176-184.

Holling CS. 1992. Cross-scale morphology, geometry and dynamics of ecosystems. Ecol Monogr 62:447-502.

Levin SA. 1992. The problem of pattern and scale in ecology. Ecology 73:1943-1967.

Messier F, Huot J, Hanaff DL, Luttich S. 1988. Demography of the George River caribou herd: Evidence of population regulation by forage exploitation and range expansion. Arctic 41:279-287.

MVRB (Mackenzie Valley Review Board). 2004. Mackenzie Valley Environmental Impact Review Board: Environmental Impact Assessment Guidelines. Yellowknife, NWT, Canada.

Swift TL, Hannon SJ. 2010. Critical thresholds associated with habitat loss: a review of the concepts, evidence, and applications. Biol Rev 85: 35-53.

Tłįchǫ Government and ENR (Department of Environment and Natural Resources). 2010. Revised Joint Proposal on Caribou Management Actions in Wek'eezihii. Submitted to Wek'eezhii Renewable Resource Board.

Tyler, N. J. C.. 2010. Climate, snow, ice, crashes, and declines in populations of reindeer and caribou (Rangifer tarandus L.). Ecological Monographs 80: 197 – 219

Tyler N, Stokkan KA, Hogg C, Nellemann C, Vistnes AI, Jeffery G. 2014. Ultraviolet vision and avoidance of powerline lines in birds and mammals. Conserv Biol 3: 630-632.

Vistnes I, Nellemann C. 2008. The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. Polar Biol 31:399-407.

Wiens JA. 1989. Spatial scaling in ecology. Funct Ecol 3:385-397.

17.14 Glossary

Term	Definition
Application Case	Base Case plus the Project; represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project.
Base Case	Describes the existing environment before the application of the Project to provide an understanding of the current physical, biological, and social conditions that may be influenced by the Project. Existing conditions include the cumulative effects from all previous and existing developments and activities that are approved, and are either under construction or not yet initiated in the ESA of a VC.
Baseline Study Area (BSA)	Study area that characterizes existing environmental conditions on a continuum of spatial scales from the Project site to broader, regional levels.
Cumulative Effects	Those effects that result from a combination of the Project with other past, present, and reasonably foreseeable future developments (MVRB 2004).
Developer's Assessment Report (DAR)	A stand-alone report that describes the development, the environmental setting, predicts impacts and proposes mitigations. The report is submitted to the MVRB for the purpose of an environmental assessment.
Effects Study Area (ESA)	The area where direct effects from the Project are expected to occur; selection of the boundary for ESAs was based on the physical and biological properties of VCs.
Ecological Landscape Classification (ELC)	An ecological mapping process that involves the integration of site, soil, and vegetation information.
Heritage Resources	Includes, but not limited to, archaeological and historical sites, burial grounds, palaeontological sites, historic buildings, and cairns.
Key Line of Inquiry (KLOI)	An area of concern that identified in the TOR as requiring rigorous analysis and detail to be included in the DAR. Key Lines of Inquiry are identified to ensure a comprehensive, detailed analysis of the issues that were identified as bringing about potential significant public concern regarding the proposed development. Each KLOI is a stand-alone section in the DAR and requires more detail than a topic identified as a SON.
Local Study Area (LSA)	Defines the spatial extent directly or indirectly affected by the project.
Subject of Note (SON)	An area of concern that need to be considered by the developer in the DAR but are of lower priority than the KLOIs. Requires a sufficient analysis to demonstrate whether the development is likely to cause significant adverse impacts. Each SON is a stand-alone section in the DAR.
Reasonably Foreseeable Development (RFD) Case	Application Case plus reasonably foreseeable developments. includes the Application Case plus the cumulative effects of future projects.
Residual Effects	Effects that remain after mitigation has been applied.
Terms of Reference (TOR)	The Terms of Reference identify the information required by government agencies for an Environmental Impact Assessment.
Traditional Knowledge	Knowledge systems embedded in the cultural traditions of regional, indigenous, or local communities. It includes types of knowledge about traditional technologies, the environment and ecology.
Traditional Land Use	Use of the land by Aboriginal groups for harvesting traditional resources such as wildlife, fish or plants, or for cultural purposes such as ceremonies or camping.
Watershed	The area drained by a river or stream; see also drainage basin.
Valued Component (VC)	Represents physical, biological, cultural, and economic properties of the social-ecological system that is considered to be important by society.