Beaufort Delta Cumulative Effects Project

Final Report

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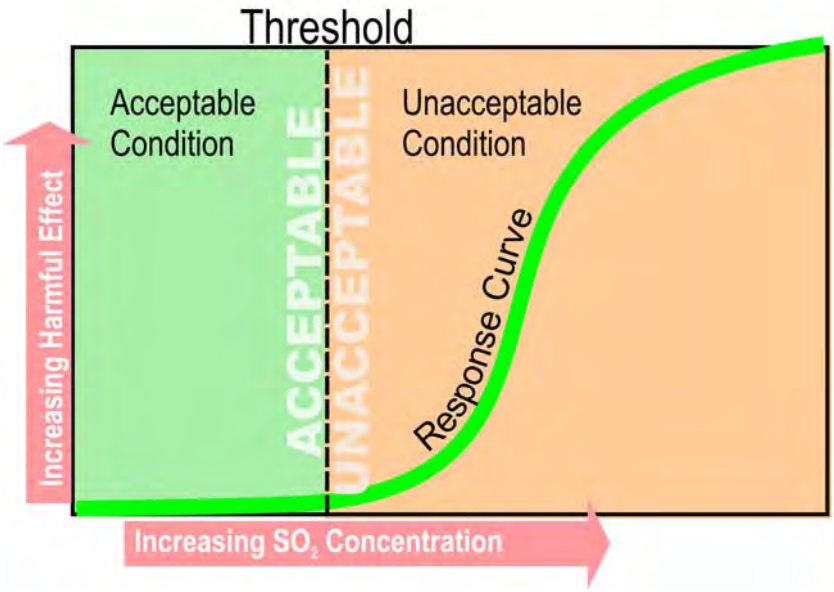

Beaufort Delta Cumulative Effects Project

Environmental Studies Research Funds

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EXECUTIVE SUMMARY

The potential for new and ongoing developments to result in adverse cumulative environmental and social effects is a growing concern in the North, and other parts of Canada. This is particularly true in the Beaufort Delta region.

As a result of these growing concerns, the Environmental Studies Research Funds (ESRF) commissioned a study to identify cumulative effects management tools for the Beaufort Delta region of the Northwest Territories. The study was conducted utilizing a blended research- and workshop-based approach.

Study Components

The study incorporated the following four components:

1. Identifying suitable Valued Components and associated cumulative effects indicators based on a review of relevant literature and information from the Beaufort Delta region;
2. Documenting the current state of each indicator and identifying candidate thresholds, carrying capacity, and/or Limits of Acceptable Change for each environmental and social indicator;
3. Convening a workshop of key stakeholders and agencies to provide feedback on the approach and the proposed suite of cumulative effects tools; and
4. Preparing a report describing the Valued Components, recommended indicators, candidate thresholds, carrying capacity, and/or Limits of Acceptable Change, and documenting the current state of each indicator.

Study Area

The Beaufort Delta study area was defined to include the Mackenzie River Delta (the Delta) and nearby upland and nearshore marine areas. This approximately 41,000 km^2 study area includes most known onshore and nearshore hydrocarbon discoveries, and overlaps two administrative areas established by land claims: the Inuvialuit Settlement Region (ISR) established by the *Western Arctic Claims Settlement Act* (Inuvialuit Final Agreement or IFA); and the Gwich'in Setlement Area (GSA) established by the *Gwich'in Comprehensive Land Claim Agreement* (Gwich'in Land Claim). The study area also contained seven relatively consistent physical divisions, or ecoregions.

Candidate Cumulative Effects Tools for the Beaufort Delta Region

The overall objectives of the ESRF Beaufort Delta Cumulative Effects Project is to identify a suite of candidate environmental and social Valued Components, indicators, and management thresholds that are of practical assistance in assessing and minimizing adverse cumulative effects in the region. These have been developed as components of an integrated cumulative effects framework incorporating socially-derived Tiered Thresholds and Limits of Acceptable Change. This framework is recommended to supplement the existing Beaufort Delta regulatory and resource management institutions and initiatives, and to reflect known regional values and concerns.

Although cumulative effects must ultimately be managed cooperatively at the regional scale, the emphasis of this study is consistent with the mandate of the ESRF, namely on local or operational level tools that would improve petroleum development decision making. As a result, the approach adopted here was to explicitly encourage linkages between project-specific and regional activities by adopting a suite of complementary indicators as a 'common language'.

Candidate '*Made for the Beaufort Delta*' indicators, tiered thresholds, and Limits of Acceptable Change provide a starting point for threshold application in this region. The next step, as experience in other jurisdictions clearly demonstrates, is to give all affected groups and individuals the opportunity to participate in threshold testing and refinement. This is because implementation is a shared responsibility that will be most effective when the above tools are accepted as both reasonable and based upon accepted science, traditional knowledge, and social values.

The suite of the candidate Valued Components, Indicators, Thresholds and Limits of Acceptable Change that are proposed for the Beaufort Delta region is provided in the table starting on the next page.

A workshop was held on October 5 and 6, 2004 in Inuvik, NWT, to review the proposed suite of Valued Components, indicators, and candidate thresholds/Limits of Acceptable Change, and to obtain input from key resource users and regulatory agencies. Participants indicated that there was general support for the proposed regional Management Objectives, Valued Components, Indicators and the management approach (i.e., thresholds and Limits of Acceptable Change linked to land use plans). They also indicated the regional social vision should be to 'improve existing social conditions', rather than 'not worsening social problems'. Participants also recommended that thresholds and indicators consider both positive and negative effects and opportunities for improvement, rather than focusing solely on negative effects. However, it was noted that workshop discussion was too limited in terms of time, and that comments should not be considered formal community endorsement of this approach.

Next Steps

Further work will be required to refine the framework and define project-specific, joint project, and cooperative regional impact management measures, including roles, responsibilities, and their relationship to current consultation, decision-making, and management processes. The candidate indicators and management thresholds presented here are intended to provide a clear basis for such discussions.

A number of steps are recommended before candidate thresholds and limits are implemented in the Beaufort Delta region. This refinement will require:

- Consultation to reach general agreement on the indicators to be used and definitions of acceptable change and threshold values;
- Modelling to help understand the economic, social, and ecological implications of proposed limits and thresholds;
- Development of a standard public database;

- Definition of standard methods to calculate indicator values using this database; and
- Identification of project-specific and cooperative actions including mitigation, monitoring, and research to be implemented when specific thresholds and limits are approached or exceeded.

Suite of candidate Valued Components, Indicators, Thresholds, and Limits of Acceptable Change proposed for the Beaufort Delta study area.

Candidate Valued Component	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Air	**Air quality** (ground level concentration of regulated emission parameters)	• **Critical**: no exceedance of regulated emission guideline or standard. Consider need for intermediate Target Thresholds in area(s) where pristine air quality is identified as a management objective or where regulatory guidelines/standards do not exist for an emission of interest.
Land	**Total area disturbed** (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	• **Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. • **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. • **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. • **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones. • **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear, and waterfowl) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.
	Core habitat available (ha and % of area available more than 1000 m from sites with intensive human or industrial use, including: industrial facilities, above ground pipelines, producing well sites, active camps and staging areas, airstrips, active seismic programs, cabins, and communities)	• **Target**: more than 40% on ICCP Category A and B lands and GLUP General Use Zones. • **Target**: more than 60% on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: more than 50% on ICCP Category A and B lands and GLUP General Use Zones. • **Critical**: more than 70% on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: more than 90% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.

Candidate Valued Component	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Land	**Total corridor density** (km/km^2; including all roads, trails, pipelines, seismic lines, power lines >3 m wide)	• **Target**: no more than 1.0 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. • **Target**: no more than 0.6 km/km^2 on ICCP Category C and D lands and Special Management Zones. • **Target**: no corridors on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. • **Critical**: no more than 1.2 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. • **Critical**: no more than 1.0 km/km^2 on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: no more than 0.2 km/km^2 on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
	Sensitive environmental features (ha and % of area disturbed in unique vegetation communities, rare plants, mineral licks, dens, nests, nesting colonies; Pingo Canadian Landmark)	• **Target**: no disturbance or activity within 250 m. • **Critical**: no net loss (taking into account mitigation or compensation). • **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where environmental values are the primary management objective.
	Grizzly bear mortality (number of grizzly bear mortalities from all industrial causes (management action, research, and illegal kill by industry worker) and legal/illegal harvest)	• **Target**: no industrial-associated mortality. • **Critical**: one industrial-associated mortality.
Freshwater	**Water quality** (ambient concentration of regulated discharge parameters).	• **Critical:** Canadian Water Quality Guidelines. • **Cautionary/Restrictive:** Monitoring at all approved discharges. Consider intermediate Target Thresholds where pristine water quality is a management objective and where defined guidelines do not exist for a particular parameter.
	Total land area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	• **Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. • **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. • **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. • **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones • **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones.**Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.

Candidate Valued Component	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Freshwater	**Total aquatic and riparian area disturbed** (ha and % of area disturbed by stream crossings, bank and bed alterations, and riparian clearing/disturbance)	• **Critical:** no net loss (taking into account mitigation, compensation or enhancement). • **Cautionary/Restrictive:** stream crossing density less than 0.25 crossings/km^2.
	Specialized environmental features (disturbance of spawning and overwintering areas)	• **Target**: no disturbance or activity within 250 m of overwintering and spawning areas of Rat River Dolly Varden char. • **Target**: no disturbance or activity within 100 m of designated overwintering and spawning areas. • **Critical**: no disturbance or activity within 100 m of overwintering and spawning areas of Rat River Dolly Varden char. • **Critical**: no net loss of designated overwintering and spawning areas.
	Char mortality (number of fish mortalities caused by all industry-related causes in addition to legal/illegal harvest)	• **Target**: cumulative industrial-associated mortality of Dolly Varden char no more than 1% of total annual allowable harvest. • **Target**: cumulative industrial-associated mortality of lake trout no more than 10% of recorded subsistence harvest during the previous year.
Nearshore Marine	**Total area disturbed** (ha and % of area disturbed by dredging, artificial islands, bottom-founded vessels or structures)	• **Target**: no more than 5% on ICCP Category C and D lands. • **Critical**: no more than 10% on ICCP Category C and D lands. • **Critical**: no more than 0.5% on ICCP Category E lands.
	Seasonal vessel and aircraft activity (ha and % of area by month in designated travel corridors and movement areas where low level flights and vessel activity could occur)	• **Target**: no more than 20% combined footprint on ICCP Category C and D lands. • **Target**: 0% on Beluga Management Zone 1 during beluga harvest. • **Target**: 0% on KIBS during the nesting season. • **Critical**: more than 30% combined footprint on ICCP Category C and D lands. • **Critical**: no more than 5% on Beluga Management Zone 1 during beluga harvest. • **Critical**: no more than 5% on KIBS during the nesting season.
	Specialized environmental features (disturbance of polar bear dens; % of KIBS and beluga whale Zone 1 area disturbed)	• **Target**: no disturbance or activity within 250 m of polar bear dens. • **Critical**: no disturbance or activity within 100 m of polar bear dens. • **Critical:** no more than 1% long-term disturbance within KIBS.
	Polar bear mortality (number of polar bear mortalities from all industrial causes [management action, research, and illegal kills by industry workers] and legal/illegal harvest)	• **Target**: no industrial-associated mortality. • **Critical**: one industrial-associated mortality.

Candidate Valued Component	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Traditional Culture and Land Use	**Significant cultural features** (including archaeology and heritage sites as well as cultural sites still in use: trapping, fishing, hunting and gathering locations; cabins; burial sites, historic trails; spiritual sites)	• **Target**: no disturbance or activity within 100 m. • **Critical**: no net loss (taking into account mitigation or compensation). • **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where cultural values are the primary management objective.
	Area unavailable for traditional use (assumed to include land area within 1000 m of highly visible sites and those with intensive industrial use, including: production facilities, active well sites, camps, above ground pipelines)	• **Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. • **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: no more than 20% on ICCP Category A and B lands and GLUP General Use Zones. • **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. • **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
Community Well-being	**Employment** (full- and part-time employment by community including project-specific projections)	• **Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) • **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Training (resident employee/contractor skill training and non-resident employee/contractor cross-cultural training)	• **Target**: all residents to complete at least two skill training programs and all non-residents to complete a cross-cultural training program every five years. • **Critical**: all resident employees/contractors to complete at least one skill training program and all non-residents to complete a cross-cultural training program every five years. • Consider merits of limits for community-based skills training.
	Community population (transient and permanent population increase by community including project-specific projections)	• **Target**: no more than 10% change from ten year average population growth/decline rate (final target limit to be defined by community) • **Critical**: no more than 25% change from ten year average population growth/decline rate (final critical limit to be defined by community)
Economy and Business	**Employment** (full- and part-time employment by community including project-specific projections)	• **Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) • **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Income (business and employment income (expenditures) by community including project-specific projections)	• **Target**: average household income higher than ten year average rate (final target limit to be defined by community) • **Critical**: average household income no lower than ten year average rate (final critical limit to be defined by community)

ICCP - Inuvialuit Community Conservation Plans GLUP - Gwich'in Land Use Plan
KIBS – Kendall Island Bird Sanctuary

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La possibilité que des projets de développement, en cours ou à venir, entraînent des effets négatifs cumulatifs sur l'environnement et la société est une préoccupation grandissante dans le Nord du Canada et ailleurs au pays, tout particulièrement dans la région du delta de Beaufort.

C'est pourquoi le Fonds pour l'étude de l'environnement (FEE) a commandé une étude dans le but de créer des outils pour gérer les effets cumulatifs dans la région du delta de Beaufort (Territoires du Nord-Ouest). L'étude a été menée selon une démarche hybride combinant des activités de recherche et des ateliers.

Composantes de l'étude

L'étude comprend quatre volets :

5. Une liste des composantes valorisées et des indicateurs d'effets cumulatifs correspondants, selon les documents pertinents et des renseignements obtenus dans la région du delta de Beaufort;
6. La description, avec preuve à l'appui, des conditions actuelles caractérisant chaque indicateur ainsi que des seuils et limites de capacité et/ou de changement acceptable proposés pour décrire chaque indicateur social et environnemental;
7. Un atelier réunissant les principales parties prenantes et organisations pour obtenir des commentaires sur la démarche et l'agencement proposé de mesures visant les effets cumulatifs;
8. Un rapport qui décrit les composantes valorisées, les indicateurs recommandés, les propositions de composantes valorisées, de limites de capacité et/ou de changement acceptable, ainsi que la description, avec preuve à l'appui, des conditions actuelles caractérisant chaque indicateur.

Secteur d'étude

Il a été établi que le secteur d'étude du delta de Beaufort comprend le delta du fleuve Mackenzie (le delta) ainsi que la zone sèche et le milieu marin littoral adjacents. Sa superficie d'environ 41 000 km^2 couvre la plus grande partie des découvertes d'hydrocarbures terrestres et littoraux ainsi que deux régions administratives établies en vertu d'accords de revendication territoriale. Ce sont la région désignée des Inuvialuit (RDI), établie en vertu du *Règlement des revendications des Inuvialuit de la région ouest de l'Arctique* (la Convention définitive des Inuvialuit, la CDI) et la région visée par le règlement de la revendication des Gwich'in (RVRG), établie en vertu de l'*Entente sur la revendication territoriale globale des Gwich'In* (la revendication territoriale des Gwich'in). Le secteur d'étude est divisé en sept régions relativement cohésives : ce sont les écorégions.

Mesures proposées visant la gestion des effets cumulatifs dans la région du delta de Beaufort

En entreprenant son projet sur les effets cumulatifs dans le delta de Beaufort, le FEE visait avant tout à dresser une liste des composantes valorisées aux niveaux social et environnemental, de leurs indicateurs

et des seuils à considérer dans leur gestion. Ainsi rassemblés, ces éléments devaient constituer un outil pratique pour évaluer et réduire au minimum les effets cumulatifs dans la région. Ils ont été établis dans le cadre d'un modèle intégré sur les effets cumulatifs qui comprend, pour les effets sociaux, des seuils gradués des effets et les limites de changement acceptable. On recommande que ce modèle soit intégré aux institutions et aux initiatives en place pour la réglementation et la gestion des ressources du delta de Beaufort, et qu'il représente les valeurs et les préoccupations connues dans la région.

Bien que les effets cumulatifs doivent en bout de ligne être gérés en collaboration au niveau régional, l'objectif de l'étude, à savoir la mise en place de mesures locales et opérationnelles qui mèneront à de meilleures décisions sur la mise en valeur des ressources pétrolières, s'inscrit dans le mandat du FEE. C'est pourquoi on a opté pour une démarche encourageant en toutes lettres les renvois entre les activités menées dans le cadre d'un projet et les activités menées à l'échelle régionale par l'adoption d'indicateurs complémentaires comme « vocabulaire commun ».

Les indicateurs, les seuils gradués et les limites de changement acceptable proposés ont été créés expressément pour le delta de Beaufort. Ils constituent un point de départ pour la mise en pratique des seuils dans la région. Ce qui s'est passé dans d'autres régions indique clairement que la prochaine étape est de permettre à tous les groupes et personnes touchés de mettre les seuils à l'essai et de les perfectionner. En effet, la mise en pratique est une responsabilité commune et son efficacité sera optimalisée si les outils susmentionnés sont considérés comme étant raisonnables et fondés sur des faits scientifiques acceptés, des connaissances traditionnelles et des valeurs sociales.

Un tableau illustrant l'ensemble proposé de composantes valorisées, d'indicateurs, de seuils et de limites de changement acceptable pour la région du delta de Beaufort figure à la page suivante.

On a tenu un atelier les 5 et 6 octobre 2004 à Inuvik (T.N.-O.), pour étudier les composantes valorisées, les indicateurs, les seuils et les limites de changement acceptable qui avaient été proposés et recueillir les commentaires des principaux utilisateurs des ressources ainsi que des organismes de réglementation. Les participants ont fait savoir qu'en général, la collectivité appuyait les objectifs de gestion régionale, les composantes valorisées et les indicateurs qui avaient été mis de l'avant ainsi que la démarche de gestion (établir un lien entre les seuils et les limites de changement acceptable et les plans d'occupation du sol). Selon les participants, la vision sociale régionale devait être « d'améliorer les conditions sociales » plutôt que de « ne pas aggraver les problèmes sociaux ». Ils ont aussi recommandé que les seuils et les indicateurs tiennent compte des effets positifs et négatifs ainsi que des points à améliorer au lieu d'être exclusivement axés sur les effets négatifs. Cependant il a été soulevé que trop peu de temps avait été alloué aux discussions lors de l'atelier et que les commentaires ne devraient pas être interprétés comme étant une approbation officielle de la présente démarche de la part de la collectivité.

Étapes suivantes

Le modèle d'évaluation devra être amélioré et on devra mieux définir les mesures de gestion propres à un projet, à un projet conjoint et les mesures de cogestion des effets régionaux. Ces mesures attribueront

rôles et responsabilités et définiront comment ces mesures se rapportent aux présents processus de consultation, de décision et de gestion. Les indicateurs et les seuils de gestion présentés visent à énoncer clairement le fondement de telles discussions.

Avant que les seuils et les limites proposés soient mis en place dans la région du delta de Beaufort, il est recommandé de prendre les mesures suivantes :

- Des consultations pour atteindre un consensus sur les indicateurs à adopter et la définition des changements acceptables et des seuils;
- La modélisation pour clarifier les répercussions économiques, sociales et écologiques des limites et des seuils proposés;
- La mise en place d'une base de données publique normalisée;
- La définition de méthodes standard pour calculer la valeur des indicateurs à l'aide de la base de données;
- Le choix de mesures coopératives et propres au projet, qui comprendront l'atténuation, la surveillance et la recherche, à mettre en place lorsque les seuils et les limites seront approchés ou dépassés.

Ensemble proposé de composantes valorisées, d'indicateurs, de seuils et de limites de changement acceptable pour la zone d'étude du delta de Beaufort.

Composante valorisée	Indicateur propre au projet	Seuil/ limite de changement acceptable
Air	**Qualité de l'air** (concentration au niveau du sol de rejets réglementés)	• **Seuil critique :** les rejets ne dépassent pas les quantités prescrites dans les directives ou les normes sur les émissions. Considérer la nécessité de seuils cibles intermédiaires si la pureté de l'air est un objectif de gestion ou en l'absence de réglementation sur les émissions de la substance préoccupante.
Terre	**Superficie totale de la zone perturbée** (en ha et en %, la superficie perturbée par les collectivités ainsi que les camps, emprunts, étangs d'eaux usées, pistes d'atterrissage, installations militaires ou industrielles, routes, pipelines, profils sismiques)	• **Seuil cible :** 10 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil cible :** 5 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil cible :** aucune perturbation sur les terres de catégorie E (PCCI) et les zones patrimoniales ou les autres zones de conservation (PGAT). • **Seuil critique :** 15 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil critique :** 10 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** 0,5 % ou moins des terres de catégorie E (PCCI) et des zones patrimoniales et autres zones de conservation (PGAT). Considérer les seuils propres à une espèce (p. ex., caribou, grizzli, sauvagine) et les seuils de précaution pour déclencher la surveillance des effets dans les secteurs où les valeurs environnementales constituent l'objectif de gestion prioritaire.
	Environnement habitable (habitat principal) (en ha et en %, la superficie habitable située à plus de 1000 m des lieux où se déroulent d'intenses activités humaines, ce qui comprend les activités industrielles, dont les installations industrielles, pipelines hors terre, environs de puits en exploitation, aires de rassemblement et camps en activité, pistes d'atterrissage, profils sismiques en utilisation, chalets et collectivités)	• **Seuil cible :** plus de 40 % des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil cible :** plus de 60 % des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** plus de 50 % des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil critique :** plus de 70 % des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** plus de 90 % des terres de catégorie E (PCCI) et des zones patrimoniales ou autres zones de conservation (PGAT). Considérer les seuils propres aux espèces (p. ex., caribou, grizzli, sauvagine) et les seuils de précaution pour déclencher la surveillance des effets dans les secteurs où les valeurs environnementales constituent l'objectif de gestion prioritaire.

Composante valorisée	Indicateur propre au projet	Seuil/ limite de changement acceptable
Terre	**Densité totale du corridor** (km/km^2, qui comprend la totalité des routes, sentiers, pipelines, profils sismiques et lignes électriques d'une largeur de plus de 3 m)	• **Seuil cible :** 1,0 km/km^2 ou moins sur les terres de catégories A et B (PCCI) et dans les zones d'usage général (PGAT). • **Seuil cible :** 0,6 km/km^2 ou moins sur les terres de catégories C et D (PCCI) et dans les zones de gestion spéciale (PGAT). • **Seuil cible :** aucun corridor sur les terres de catégorie E (PCCI) et les zones patrimoniales ou autres zones de conservation (PGAT). • **Seuil critique :** 1,2 km/km^2 ou moins sur les terres de catégories A et B (PCCI) et dans les zones d'usage général (PGAT). • **Seuil critique :** 1,0 km/km^2 ou moins sur les terres de catégories C et D (PCCI) et dans les zones de gestion spéciale (PGAT). • **Seuil critique :** 0,2 km/km^2 ou moins sur les terres de catégorie E (PCCI) et dans les zones patrimoniales ou autres zones de conservation (PGAT).
	Caractéristiques sensibles de l'environnement (en ha et en %, la superficie perturbée dans les secteurs comportant populations végétales uniques, plantes rares, minéraux à lécher, tanières, nids ou colonies de nidification, ainsi que sur le site canadien des pingos)	• **Seuil cible :** aucune perturbation ou activité dans un rayon de 250 m. • **Seuil critique :** aucune perte nette (en considérant les activités d'atténuation et de compensation). • **Précaution/restriction (seuil critique) :** Considérer la gestion des secteurs (p. ex., terres de catégorie E (ICCP), zones de conservation du patrimoine (PGAT)) là où les valeurs environnementales sont l'objectif de gestion prioritaire.
	Mortalité du grizzli (pertes de grizzlis dues à toute activité industrielle (mesure de gestion, recherche, braconnage par un ouvrier), à la chasse ou au braconnage)	• **Seuil cible :** aucune mortalité liée aux activités industrielles • **Seuil critique :** une mortalité liée aux activités industrielles
Eau douce	**Qualité de l'eau** (niveau de concentration ambiante en rejets réglementés)	• **Seuil critique :** recommandations canadiennes pour la qualité des eaux au Canada • **Prévention/restriction :** surveillance de tout rejet approuvé. Considérer les seuils cibles intermédiaires là où la pureté de l'eau est un objectif de gestion ou en l'absence de directives claires pour un paramètre.

Composante valorisée	Indicateur propre au projet	Seuil/ limite de changement acceptable
Eau douce	**Superficie totale de la zone terrestre perturbée** (en ha et en %, la superficie perturbée par les collectivités ainsi que les camps, emprunts, étang d'eaux usées, pistes d'atterrissages, installations militaires et industrielles, routes, pipelines et profils sismiques)	• **Seuil cible :** 10 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil cible :** 5 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil cible :** ne perturber aucune terre de catégorie E (PCCI) ni aucune zone patrimoniale ou autre zone de conservation (PGAT). • **Seuil critique :** 15 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT) • **Seuil critique :** 10 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** 0,5 % ou moins des terres de catégorie E (PCCI) et des zones patrimoniales ou des autres zones de conservation (PGAT).
	Superficie totale de la zone aquatique ou rivulaire perturbée (en ha et en %, la superficie perturbée par les passages de ruisseaux, l'altération des rivages et des lits ainsi que les perturbations ou le déboisement des rives)	• **Seuil critique :** aucune perte nette (en prenant en considération les mesures d'atténuation, de compensation et d'amélioration). • **Prévention/restriction :** moins de 0,25 passage de ruisseaux par km^2.
	Caractéristiques environnementales spéciales (perturbation des lieux de frai ou d'hivernage)	• **Seuil cible :** aucune perturbation ou activité dans un rayon de 250 m des zones d'hivernage et de frai de la Dolly Varden de la rivière Rat. • **Seuil cible :** aucune perturbation ou activité dans un rayon de 100 m entourant les zones de frai et d'hivernage désignées. • **Seuil critique :** aucune perturbation ou activité dans un rayon de 100 m entourant les zones de frai et d'hivernage de la Dolly Varden de la rivière Rat. • **Seuil critique :** aucune perte nette de zone d'hivernage et de frai désignée.
	Mortalité de la Dolly Varden (nombre de pertes de poissons dues aux activités industrielles (mesure de gestion, recherche, braconnage par un ouvrier), à la pêche et au braconnage)	• **Seuil cible :** le nombre total de pertes de Dolly Vardens associées aux activités industrielles ne dépasse pas 1% du nombre total de prises autorisées par année. • **Seuil cible :** le nombre total de pertes de touladis associées aux activités industrielles ne dépasse pas 10 % du nombre de touladis pêchés pour la subsistance au cours de l'année précédente.

Composante valorisée	Indicateur propre au projet	Seuil/ limite de changement acceptable
Littoral marin	**Superficie totale perturbée** (en ha et en %, la superficie perturbée par le dragage, les îles artificielles ainsi que les embarcations et les installations coulées)	• **Seuil cible :** 5 % ou moins des terres de catégories C et D (CPPI). • **Seuil critique :** 10 % ou moins des terres de catégories C et D (CPPI). • **Seuil critique :** 0,5 % ou moins des terres de catégorie E (CPPI).
	Activités nautiques et aéronautiques saisonnières (en ha et en %, la superficie, par mois, des corridors et des secteurs de déplacement désignés qui pourraient être survolés en basse altitude ou traversés par des embarcations)	• **Seuil cible :** 20 % ou moins de la superficie totale des terres de catégories C et D (CPPI). • **Seuil cible :** 0 % de la zone 1 de gestion du beluga pendant la chasse au beluga • **Seuil cible :** 0 % de la ROIK pendant la saison de nidification. • **Seuil critique :** plus de 30 % de la superficie totale des terres de catégories C et D (CPPI). • **Seuil critique :** 5 % ou moins dans la zone 1 de gestion du beluga pendant la chasse au beluga • **Seuil critique :** 5 % ou moins de la ROIK pendant la saison de nidification.
	Caractéristiques environnementales spéciales (perturbation des tanières d'ours polaires, % de la superficie perturbée de la ROIK et de la zone 1 du beluga)	• **Seuil cible :** aucune perturbation ou activité dans un rayon de 250 m entourant les tanières d'ours polaires. • **Seuil critique :** aucune perturbation ou activité dans un rayon de 100 m entourant les tanières d'ours polaires. • **Seuil critique :** moins de 1 % de perturbations à long terme dans la ROIK.
	Mortalité des ours polaires (nombre de pertes d'ours polaires dues aux activités industrielles (mesure de gestion, recherche, braconnage par des ouvriers], la chasse et le braconnage)	• **Seuil cible :** aucune mortalité associée aux activités industrielles • **Seuil critique :** une mortalité associée aux activités industrielles.
Culture et usage traditionnel des terres	**Caractéristiques culturelles d'importance** (sites archéologiques et patrimoniaux, sites culturels fréquentés : lieux où se pratiquent piégeage, pêche, chasse et cueillette, chalets, lieux de sépulture, sentiers historiques et lieux spirituels)	• **Seuil cible :** aucune perturbation ou activité dans un rayon de 100 m. • **Seuil critique :** aucune perte nette (en considérant les mesures d'atténuation et de compensation). • **Prévention/restriction (seuil critique) :** considérer la gestion les secteurs (p. ex., terres de catégorie E (ICCP), zones de conservation du patrimoine (PGAT)) là où les valeurs environnementales sont l'objectif de gestion prioritaire.

Composante valorisée	Indicateur propre au projet	Seuil/ limite de changement acceptable
Culture et usage traditionnel des terres	**Zone non accessible pour les usages traditionnels** (toute zone située dans un rayon de 1000 m entourant un site très visible ou le lieu d'intenses activités industrielles, dont les installations de production, puits en exploitation, campements et pipelines hors terre)	• **Seuil cible :** 10 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil cible :** 5 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** 20 % ou moins des terres de catégories A et B (PCCI) et des zones d'usage général (PGAT). • **Seuil critique :** 10 % ou moins des terres de catégories C et D (PCCI) et des zones de gestion spéciale (PGAT). • **Seuil critique :** 0,5 % ou moins des terres de catégorie E (PCCI) et des zones patrimoniales et des autres zones de conservation (PGAT).
Bien-être de la collectivité	**Emploi** (emplois à temps plein et à temps partiel pour la collectivité, ce qui comprend les prévisions liées à un seul projet)	• **Seuil cible :** le taux d'activité sur le marché du travail dépasse la moyenne décennale (les limites de l'objectif final seront définies par la collectivité) • **Seuil critique :** le taux d'activité sur le marché du travail ne descend pas au-dessous de la moyenne décennale (la limite du seuil critique sera définie par la collectivité)
	Formation (formation professionnelle pour les résidents employés et entrepreneurs et formation aux relations interculturelles pour les non-résidents employés et entrepreneurs)	• **Objectif :** tous les cinq ans, les résidents complètent au moins deux programmes de formation professionnelle et les non-résidents complètent une formation sur les rapports interculturels. • **Seuil critique :** tous les cinq ans, les résidents, les employés et les entrepreneurs complètent au moins un programme de formation professionnelle et tous les non-résidents complèteront un programme de formation aux rapports interculturels. • Considérer les bienfaits des limites de la formation professionnelle locale.
	Aspect démographique (augmentation de la population permanente et temporaire par collectivité, ce qui comprend les prévisions liées à un seul projet)	• **Objectif :** la fluctuation de la population ne représente pas plus de 10 % du taux d'écart décennal moyen (les limites de l'objectif final seront définies par la collectivité) • **Seuil critique :** la fluctuation de la population ne représente pas plus de 25 % du taux d'écart décennal moyen (la limite du seuil critique sera définie par la collectivité)
Économie et commerce	**Emploi** (emplois à temps plein et à temps partiel par collectivité, ce qui comprend les prévisions liées à un seul projet)	• **Seuil cible :** le taux d'activité sur le marché du travail dépasse la moyenne décennale (la limite du seuil cible final sera définie par la collectivité) • **Seuil critique :** le marché du travail se maintient au-dessus de la moyenne décennale (la limite du seuil critique sera définie par la collectivité)
	Revenus (revenus d'emploi ou d'affaires (dépenses) par collectivité, ce qui comprend les prévisions liées à un seul projet)	• **Seuil cible :** le revenu familial moyen dépasse la moyenne décennale (la limite du seuil cible final sera définie par la collectivité) • **Seuil critique :** le revenu familial moyen se maintient au-dessus de la moyenne décennale (la limite du seuil critique sera définie par la collectivité)

PCCI - plans de conservation communautaires des Inuvialuit
PGAT – Plan Gwich'in d'aménagement territorial
ROIK – Réserve d'oiseaux de l'île Kendall

Glossary

Access corridor – a linear feature created by humans (road, trail, pipeline, power line, railway line, cut line) that may be used by pedestrians, vehicles, hunters, anglers, or animal predators.

Barrier – a barrier is present when it is not possible for animals to move across a corridor, and the habitat on either side of the corridor becomes isolated (e.g., a busy highway is a barrier for small ground-dwelling insects).

Cautionary Threshold – a threshold established to indicate the point at which additional or more intensive monitoring is required to document conditions or environmental and social response.

Core area – an area with minimal human impacts. Core areas are relatively undisturbed, 'unroaded' areas; they are often source areas for plant and animal populations or metapopulations.

Corridor – a reasonably uniform, linear feature that differs from its surrounding landscape. Corridors can occur naturally (e.g., river valley; windrow, aeolian ridge) or as the result of human disturbance (e.g., roads, cut lines and pipelines).

Critical threshold – a science-based target reflecting the continuous maximum amount of stress that an environmental or social system can support without long-term harm. When this threshold is reached or approached, restrictive management practices are formally adopted to reduce risk

Cumulative effects – changes to the environment caused by collective past, present, and future human actions; resulting from the combined effects of simple, routine activities and/or small or large projects.

Density-dependent – factors that affect population growth and parameters in relation to animal abundance. These depress population growth as animal abundance increases, and increase growth as animal abundance decreases. Examples include food availability and quality. Predation may be density-dependent or –independent.

Density-independent – factors that affect population growth and parameters regardless of animal abundance. Examples include natural environmental disturbances such as fire, floods, or severe weather. Predation may be density-dependent or –independent.

Disturbance – a natural or human action that affects physical, chemical, or biological conditions.

Disturbance feature – a corridor or patch created by natural random events (e.g., burn or flood) or human action (e.g., cut block, facility, community, road).

Disturbance trajectory – the calculated or predicted rate of natural or human disturbance.

Ecological resilience – the ability of a system or species to absorb natural and human disturbance without altering its fundamental structure (Weaver et al. 1996).

Ecological sink – an area with degraded habitat that has lower survival (or higher mortality) rates, causing local population declines. Although individual animals may continue to use this area, it creates a net loss to the population that may not be detectable for several generations.

Edge area - the area bordering patches and corridors where abiotic conditions (e.g., moisture, light, temperature, wind regimes) and biotic conditions (e.g., predation, mortality, competition, vegetation diversity and structure, species diversity and abundance) may be altered. Examples include the intersection between a cut block and forest or a trail and native grassland.

Fragmentation – the process of losing habitat continuity through temporary or permanent conversion of lands for human use (e.g., clearcutting forest, tilling native prairie for agriculture). Three general effects result from habitat fragmentation: (1) original habitat is lost, (2) remaining habitat patches decrease in size, and, (3) patches become increasingly isolated from one another.

Habitat – the environment in which an organism or biological population lives or grows.

Habitat alteration – habitat alteration occurs with disturbance of original habitat. *Temporary habitat alteration* occurs when pre-disturbance conditions are allowed to re-establish (e.g., forest regrowth after harvest). *Permanent terrestrial habitat alteration* occurs when different vegetation becomes established on the disturbed area (e.g., converting mixed wood forest to domestic grasses for hay production; introducing non-native species). *Permanent aquatic habitat alteration* occurs when substrate or channel conditions are modified, or where flow and sediment transport patterns are modified by upstream activities.

Habitat availability – the amount of usable habitat accessible to a particular species.

Habitat effectiveness – habitat quality, as perceived by a particular species. For instance, when a species uses the area around a man-made facility less than nearby areas of identical habitat, there has been a decrease in habitat effectiveness for that species.

Habitat loss – loss of habitat can occur in either terrestrial or aquatic ecosystems. *Terrestrial habitat loss* occurs when human activities disturb the soil or remove vegetation and regrowth is not allowed to occur (e.g., construction of a city, highway or industrial facility). *Aquatic habitat loss* occurs when water is removed, chemistry is substantially altered, or the structure of the waterbody is substantially altered.

Habitat suitability or quality – the ability of a habitat unit, in its current condition, to provide the life requisites of a species. This rating is irrespective of the numbers of that species that are currently using the habitat (RIC 1999).

Habitat unit – a defined terrestrial or aquatic unit with consistent abiotic and biotic conditions.

Human activity – all forms of human actions including land conversion and disturbance, damming, water withdrawal, pedestrian, vehicle and aircraft movements, harassment, harvest, and contaminant input.

Human capital - skills, education, experiences, and general abilities of residents or communities that facilitate the creation of personal, social, and economic well-being (NRTEE 2003).

Index or metric – a numerical value used to represent or monitor the condition of an abiotic or biotic resource.

Indicator - a characteristic of the social or ecological setting that is used to describe, measure, manage, and report on Valued Components.

Interior area – also referred to as core area in this report. Interior areas are those beyond the influence of edge effects.

Juvenile – an individual that is age 1 or older and has not reached maturity.

Landscape – an area of tens to hundreds of square kilometres that includes one dominant background ecosystem. The Beaufort Delta consists of a number of landscape types including the nearshore marine, delta, tundra and forest.

Limits of Acceptable Change - socially-defined endpoints or thresholds that reflect the desired balance between human activities and ecological and social sustainability.

Local population - A breeding group or stock with distinct genetic or life history attributes that interact on a regular basis. May also represent a component of a metapopulation or population found in a discrete or isolated area (Hanski et al. 1996).

Lowest observed effect level − concept from the field of ecotoxicology that represents the lowest concentration of a material used in a toxicity test that has a statistically significant adverse effect on the exposed population of test organisms compared to the controls. Also called lowest observed adverse effect level (LOAEL). This concept is also applicable to behavioural, physiological, and population response.

Management objective - regional statements of desired environmental and social conditions.

Matrix – the dominant background ecosystem or land-use type within a habitat mosaic. Within the matrix, patches and corridors are reasonably uniform areas and linear features that differ from their surroundings.

Metapopulation - a population of populations. This represents an abstraction of the population concept to a higher level. Metapopulations generally consist of a group of interacting but spatially discrete or isolated populations, subpopulations, or stocks. These subunits are linked by drainage networks but movement between subunits is infrequent and typically takes place across unsuitable habitat or over great distances (Hanski and Gilpin 1991; Dunham and Rieman 1999). An example of a fish metapopulation is a group of isolated headwaters populations found in the same watershed.

Natural capital – the environmental stocks and systems that provide us with the many natural materials and services that we rely on to sustain economic activity, including natural resources, land, and ecosystems (NRTEE 2003).

Patch – a reasonably uniform area that differs from its surrounding landscape. Patches can occur naturally (e.g., wetlands and burns) or as the result of human disturbance (e.g., cabins, wellsites, and clearcuts).

Population − a group of interacting individuals of the same species in a defined area distinguished by a distinct gene pool or distinct physical characteristics.

Pre-Tenure Plan – a plan prepared before land rights are issued that establishes general and specific management direction that rights holders will need to adhere to.

Reach − a defined watercourse channel section, tens to thousands of meters in length, with relatively consistent channel morphology, hydrology, and water chemistry.

Regional - an area more than hundreds of square kilometres that incorporates several landscapes.

Riparian - the banks and slopes next to streams, lakes and wetlands that are affected by elevated soil moisture levels for at least part of the year. These riparian areas protect water quality, stabilize banks, provide a continuous source of woody debris, nutrients, and food organisms, and regulate stream temperature.

Riparian clearings - cleared areas within 15 m of a waterbody, including linear corridors, communities and residences, industrial and commercial facilities and cutblocks.

Significant cultural features − archaeology or palaeontology site; camping, trapping, fishing or hunting locales; cabins; burial sites; historic trails and sites; mineral licks; berry picking and medicinal plant collecting areas; areas identified as cultural landmarks or spiritual significance.

Social capital – the ability and willingness of residents to work together for community goals.

Specialized habitat features − mineral licks, dens, wallows, nests.

Stream crossing - a road, trail, pipeline, powerline, or cutline crossing of a watercourse.

Subpopulation - a breeding group or stock with distinct genetic or life history attributes that interact on a regular basis. May also represent a component of a metapopulation or population found in a discrete or isolated area.

Subwatershed - a subset of a watershed, generally less than 1,000 km^2 in size.

Target threshold – a socially-defined or politically-defined goal for amount of stress on a system. This threshold is more protective than the critical threshold to provide a margin of safety. A target threshold can be characterized as the level that is politically and practically achievable and provides adequate long-term protection to the environment or resource of interest. When this threshold is reached, enhanced management practices are formally adopted to reduce risk or increase understanding of the system.

Threshold – the point which an indicator changes to an unacceptable condition, with acceptability defined either from an ecological or social perspective.

Tiered Thresholds - A series of progressive thresholds (i.e., cautionary thresholds, target thresholds, and critical thresholds) that reflect increasing degrees of concern or risk.

Valued component (VC) - an aspect of the environment that is considered important, on the basis of economic, social, cultural, community, ecological, legal or political concern. A VC is not an indicator in itself, although impacts on, or trends in, some characteristic of a VC may be used as an indicator.

Viable population – a self-sustaining population with a high probability of survival despite the foreseeable effects of demographic, environmental, and genetic stochasticity and of natural catastrophes.

Waterbody – a specific aquatic basins or channel (lake, pond, wetland, river, or stream).

Watercourse − a specific flowing channel (river or stream).

Watershed − a large drainage area, generally 1,000 to 10,000 km^2 in size, which flows directly into a large river such as the Mackenzie River.

ZOI – Zone of Influence; the distance to which a species is affected by an activity or disturbance.

List of Acronyms

BEMP - Beaufort Environmental Monitoring Project

BREAM - Beaufort Regional Environmental Assessment and Monitoring Program

BSIMPI - Beaufort Sea Integrated Management Planning Initiative

CAPP - Canadian Association of Petroleum Producers

CCME - Canadian Council of Environment Ministers

COSEWIC - Committee On the Status of Endangered Wildlife In Canada

CWS - Canadian Wildlife Service

DIAND - Indian and Northern Affairs Canada

DFO - Fisheries and Oceans Canada

EC - Environment Canada

EIA - Environmental Impact Assessment

EIRB - Environmental Impact Review Board

ESRF - Environmental Studies Research Funds

ESRF TAG - Environmental Studies Research Funds Technical Advisory Group

GIS - Geographic Information System

GLUP - Gwich'in Land Use Plan

GLWB - Gwich'in Land and Water Board

GNWT - Government of the Northwest Territories

GRRB - Gwich'in Renewable Resource Board

GSA - Gwich'in Settlement Area

GTC - Gwich'in Tribal Council

HTC - Hunters and Trappers Committee

ICCP - Inuvialuit Community Conservation Plans

ILA - Inuvialuit Land Administration

IRC - Inuvialuit Regional Corporation

ISR - Inuvialuit Settlement Region

KIBS - Kendall Island Bird Sanctuary

MEMP - Mackenzie Environmental Monitoring Project

MRBB - Mackenzie River Basin Board

MVEIRB - Mackenzie Valley Environmental Impact Review Board

MVLWB - Mackenzie Valley Land and Water Board

NEB - National Energy Board

NEI WLCE Thresholds Project - Northern Ecosystems Working Landscapes Initiative Integrated Cumulative Effect Thresholds Project

NWT - Northwest Territories

NWT CIMP - NWT Cumulative Impact Monitoring Program

RWED - GNWT Resources, Wildlife and Economic Development

USFWS - United States Fish and Wildlife Service

VC - Valued Component

WMAC (NWT) - Wildlife Management Advisory Council (NWT)

WMAC (NS) - Wildlife Management Advisory Council (North Slope)

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The support and advice provided by all of the TAG members listed in Section 1 of this report is also gratefully acknowledged. We also appreciated the leadership and direction from Mr. Chuck Brumwell and Dr. Laura Johnson (both with Environment Canada – EC), who were the Chairpersons of the ESRF TAG. Particularly noteworthy was Dr. Laura Johnson's contribution prior to her retirement. Administration support was provided for this project by ESRF staff, Mr. Jim McComiskey, Senior Technical Advisor, and Ms. Kym Hopper-Smith, Program Coordinator.

The following individuals also made valuable contributions to the project. Technical support for research and background writing was provided by Sasha Ostryck, Kevin Trapp, Kenton Friesen, and Janet Scott (Dillon) and Rhonda Gallelli (Salmo). Graphics were developed by Brian Zelt and Elizabeth Clement for Salmo, and Kevin Trapp (Dillon). Paul Schaap also served as Dillon's Technical Review Partner on this project. In addition to these staff, the roles of the key individuals who developed this report, organized and hosted the workshop in Inuvik, and managed the project are summarized in Section 1 of this report.

We also greatly appreciated the comments and valuable input of the following individuals who reviewed the draft report: Mike Fournier (EC); Lorraine Sawdon (EC); Theresa Braat (EC); Craig Machtane (CWS, EC); Kim Hawkins (Gwich'in Tribal Council); Jennifer McKay (DIAND), Bill Ross (University of Calgary); and Alan Ehrlich (International Association for Impact Assessment).

1 INTRODUCTION

Cumulative effects arise when numerous independent decisions contribute to regional social or environmental effects. The potential for new and ongoing developments to result in adverse cumulative effects is of increasing concern in the North, as in other parts of Canada.

Assessing, minimizing, and managing potential adverse cumulative effects have been the subject of an increasing number of studies. Many of these studies have concluded that a suite of coordinated regional, sub-regional, and local or project-specific tools must be adopted to effectively manage cumulative effects. At present, there is particular interest in developing methods to both measure and predict changes in the ecosystem and in incorporating traditional knowledge. With the rapid increase in development in the Beaufort Delta region, both onshore and in the nearshore marine environment, it is necessary to develop a practical set of tools for addressing the potential for cumulative impacts arising from oil and gas development and other activities in the area.

The Environmental Studies Research Funds (ESRF) was established under the *Canada Petroleum Resources Act* "to finance environmental and social studies pertaining to the manner in which, and terms and conditions under which, exploration, developmental, and production activities on frontier lands under this Act or any other Act of parliament, should be conducted". The ESRF identified cumulative effects as a research priority, and issued a Request for Proposals in March 2004 to complete a Cumulative Effects Project in the Beaufort Delta area.

The specified objectives of the ESRF Beaufort Delta Cumulative Effects Project are to:

1. Identify Valued Components (or VC) that are of importance to the people of the area;
2. Identify environmental and social indicators for each Valued Component that are of practical assistance in assessing and minimizing adverse cumulative effects in the Beaufort Delta region; and
3. Develop thresholds, carrying capacity, and/or limits of acceptable change for these indicators.

A consulting team comprised of Dillon Consulting Limited (Dillon) and Salmo Consulting Inc. (Salmo), partnered with Keano Social Analysts and Dynamic Ecosystems Ltd., was selected by the Technical Advisory Group (ESRF TAG) formed for this project. The ESRF TAG consisted of:

- Chuck Brumwell/Dr. Laura Johnston, Environment Canada, Scientific Authority;
- Ray Case, GWNT Resources, Wildlife and Economic Development;
- Roger Creasey, Shell Canada;
- Alan Ehrlich, International Association for Impact Assessment;
- Kim Hawkins, Gwich'in Tribal Council;

- Laurie McEachern/Meredith Seabrook, Indian and Northern Affairs Canada;
- Dr. Sheilagh Montgomery, Canadian Arctic Resources Committee;
- Carol Barsky, Canadian Association of Petroleum Producers;
- Dr. Bill Ross, University of Calgary; and
- Dr. Norm Snow, Joint Secretariat.

Key members of the consulting team were:

- Kerry Brewin (Dillon) – project management and coordination, workshop co-organization, report writing (workshop summary, and air, climate, freshwater and marine indicators), technical review;
- Terry Antoniuk (Salmo) – project management and senior technical advisor, workshop facilitation and plenary presentations, report writing (integrated cumulative effects management framework and regulatory regime, and marine and socio-cultural indicators), and senior technical review;
- Dr. Joan Ryan and Allice Legatt (Keano Social Analysts) – workshop facilitation, and background literature review (socio-cultural indicators);
- Nalini Naidoo (Dillon) – workshop co-organization and facilitation; and
- Bruce Greenfield (Dynamic Ecosystems) – report writing (land indicators).

Additional team members and their roles are acknowledged in the Acknowledgements section.

1.1 Methods

Two fundamentally different approaches were considered for this project: workshop-based and research-based. A multi-stakeholder, workshop-based approach has frequently been applied to develop cumulative effects management tools, particularly in northern ecosystems [e.g., Norman Wells Research and Monitoring Program (Boreal Ecology 1986); Beaufort Environmental Monitoring Project (BEMP; LGL et al. 1984; ESL et al. 1985); Mackenzie Delta Environmental Monitoring Project (MEMP; LGL et al. 1986, 1988); Beaufort Regional Environmental Assessment and Monitoring Program (BREAM; ESL 1992, Axys et al. 1992, 1993 and Axys 1994); NWT Cumulative Effects Assessment and Management Framework; Regional Sustainable Development Strategy for the Athabasca Oil Sands Area (AENV 1999)]. The advantage of the workshop-based approach is that it builds stakeholder support through education and involvement; generally, stakeholder support is mandatory if the tools are ultimately to be adopted and applied. However, as demonstrated by the examples provided above, the disadvantage of this approach is that it requires significant time and resources.

A research-based approach relies on existing information and the experience of the project team to develop appropriate cumulative effects management tools (e.g., Salmo et al. 2003). The advantage of this approach is that candidate tools can be identified more quickly and cost-effectively. Its primary disadvantage is that tools developed by independent specialists may not be perceived to reflect regional values, interests, decision-making processes, and constraints.

A blended approach that built on the research-based approach was adopted for the Beaufort Delta Cumulative Effects Project. The rationale is explained below:

- The project budget was not sufficiently large to support a multi-stakeholder workshop-based approach.
- The project team's experience working in the Beaufort Delta region and elsewhere suggests that key stakeholders need to be consulted if indicators, thresholds, and Limits of Acceptable Change are ultimately to be adopted to manage cumulative effects. A workshop to discuss concepts, verify data, and discuss draft recommendations and conclusions was concluded to be a reasonable compromise for the defined project scope.
- Incorporating a workshop to get initial feedback from regulatory agencies and resources users on a proposed suite of cumulative effects tools allowed the consulting team to consider inputs from stakeholders and regulatory agencies and identify a suite of tools that stakeholders and regulatory agencies are more likely to support.
- An extensive information base is available for this region, including the Inuvialuit Community Conservation Plans (ICCPs - communities of Aklavik 2000; Inuvik 2000; and Tuktoyaktuk 2000), resource management plans [(e.g., Beluga Management Plan (FJMC 2001); Draft Bluenose Caribou Management Plan (Nagy et al. n.d.)], assessment and monitoring reports (BEARP, BEMP, MEMP, BREAM), the Gwich'in Land Use Plan (GLUPB 2003), and information retained by the Gwich'in and Inuvialuit cultural centres. This information was used to identify Valued Components, indicators, thresholds, and Limits of Acceptable Change that reflect regional values and realities.
- Past work in the oil sands and boreal forest (Salmo et al. 2001, 2003) also demonstrates that, if properly conducted, an independent research-based project like the ESRF Cumulative Effects Project can provide valuable input to develop cumulative impact tools in the Beaufort Delta. However, this project cannot be expected to lead directly to threshold implementation. As all stakeholders contribute to cumulative effects, further work will ultimately be required to involve them so that the social, economic, and environmental implications of tool implementation are understood and accepted.
- Incorporating a workshop to get initial feedback from regulatory agencies, regional planning bodies, co-management boards, environmental assessment agencies and resource users on a proposed suite of cumulative effects tools will allow revisions to be made and help the consulting team identify a suite of tools that stakeholders and regulatory agencies are more likely to support.

The ESRF Beaufort Delta Cumulative Effects project included five components, discussed in more detail in the Sections 1.1.1 through 1.1.5:

1. Identifying suitable Valued Components and associated cumulative effects indicators based on a review of relevant literature and information from the Beaufort Delta region;
2. Documenting the current state of each indicator and identifying candidate thresholds, carrying capacity, and/or Limits of Acceptable Change for each environmental and social indicator;
3. Convening a workshop of key stakeholders to provide feedback on the proposed suite of cumulative effects tools;
4. Preparing a draft report describing the Valued Components, recommended indicators, candidate thresholds, carrying capacity, and/or Limits of Acceptable Change, and documenting the current state of each indicator; and
5. Preparing a final report incorporating feedback from the ESRF TAG.

1.1.1 Identify Valued Components and Indicators

A review of relevant literature and reports was completed to select a suite of Valued Components. The proposed Valued Components were reviewed with the ESRF TAG prior to initiating further work.

1.1.1.1 Selecting Indicators

Appropriate indicators for the Beaufort Delta region were identified based on a literature review and interviews with key stakeholders [e.g., Inuvialuit Regional Corporation (IRC); Inuvialuit Game Council; Inuvialuit Cultural Resource Centre; Joint Secretariat (JS); Fisheries Joint Management Committee; Wildlife Management Advisory Committee (NWT); Gwich'in Land Use Planning Board, Gwich'in Tribal Council (GTC); Gwich'in Renewable Resource Board (GRRB); Gwich'in Social and Cultural Institute; Mackenzie Valley Environmental Impact Review Board (MVEIRB), GNWT Resources, Wildlife and Economic Development (RWED); Indian and Northern Affairs Canada (DIAND); Environment Canada (EC); Fisheries and Oceans Canada (DFO); National Energy Board (NEB); and Canadian Association of Petroleum Producers (CAPP)].

Readily-available information pertinent to the Beaufort Delta was obtained and reviewed to ensure that subsequent work is focused on regional resources, issues, and values. Primary information sources for this component were the Inuvialuit Community Conservation Plans and the Gwich'in Land Use Plan. These documents describe community values, goals, and land use categories. They also identify focus species and resource management goals that are directly applicable to Valued Component and indicator selection. Explicit links to these community-based plans ensures that the ESRF Beaufort Delta Cumulative Effects Project reflects regional values and interests.

Other important information sources, many of which were identified by the ESRF TAG, included:

- Status reviews and resource management plans for the Beaufort Delta region [e.g., Inuvialuit Renewable Resources Conservation and Management Plan (WMAC and FJMC 1988; FJMC et al. 2000, FJMC 2001)];
- Reports on northern monitoring and cumulative effects programs (BEMP; MEMP; BREAM; Data Gaps Study (Kavik-Axys and LGL 2001); NWT CIMP (DIAND 2003, GeoNorth 2002, IER and Terriplan 2002); NWT Cumulative Effects Assessment and Management Framework (IER Terriplan 2002); Mackenzie River Basin Board; Western Kitikmeot-South Slave studies (GeoNorth and Axys 1997; Parlee and Lutsel K'e First Nation 1996; McLoughlin et al. 1999);
- Reports on sustainable development indicators developed elsewhere in Canada for sustainable forest harvest (CCFM 1995, 1997, 2003; CSA 1996; FMF 2003), sustainable development (NRTEE 2003), and social monitoring in the NWT (Parlee and Lutsel K'e First Nation 1996, 1999; GNWT HSS 2002a,b);
- Petroleum pre-tenure planning objectives, indicators, and targets (MSRM 2004);
- Reports on cumulative effect indicators and Limits of Acceptable Change (Merigliano et al. 1997; Axys 2000; Macleod 2002; Salmo et al. 2003, 2004);
- Published and grey literature on social, cultural, historical, economic, and environmental indicators; and
- Information from GIS databases made available through industry and regulatory agencies (e.g., GNWT RWED, and the JS).

1.1.2 Develop Candidate Thresholds and Limits of Acceptable Change

Setting a numerical value on indicators is one of the most challenging aspects of cumulative effect management (MSRM 2004). The literature reviews completed by Salmo and associates for the Deh Cho and northeast British Columbia (Salmo et al. 2003, 2004) provided a starting point to develop *'Made for the Beaufort Delta'* candidate thresholds and Limits of Acceptable Change.

A **Threshold** is defined as a point at which an indicator changes to an unacceptable condition, with acceptability defined either from an ecological or social perspective. In other words, they can be used to quickly provide a good idea of whether what is happening in the Beaufort Delta region is acceptable or unacceptable. Thresholds may be based on outcomes (e.g., desired habitat conditions) or inputs (e.g., disturbance intensity). Outcome-based thresholds are preferred because outcomes can be influenced by more than one input and it is the outcome that is important from a management perspective. Nevertheless, thresholds based on acceptable inputs are required when desired outcomes cannot be practically defined (Merigliano et al. 1997).

Limits of Acceptable Change are socially-defined endpoints or thresholds that reflect the desired balance between human activities and ecological and social sustainability. This concept acknowledges that precise thresholds may not exist and sets boundaries on the extent of change that will be permitted.

Candidate thresholds and Limits of Acceptable Change were derived from available information in a transparent manner so that their rationale is clear. The proposed threshold derivation process is described in detail in Section 4.4 of Salmo et al. (2003).

1.1.2.1 Document Current Conditions

Readily-available GIS data for the Beaufort Delta area were obtained and consolidated to document existing indicator conditions. Preliminary maps of current conditions were generated for use in the project report and workshop.

Datasets and maps used for determining current conditions are listed in Sections 2.2.5, 2.3.5, and 2.4.4. Assumptions used for calculating areas of disturbance features, and habitat and activity buffers (i.e., areas impacted by edge effects) are listed in tabular form in Appendix I.

This information was also used to confirm that the proposed indicators can be practically quantified and to validate the candidate thresholds and Limits of Acceptable Change.

1.1.3 Workshop

A workshop was held on October 5 and 6, 2004 in Inuvik, NWT, to review the proposed suite of Valued Components, indicators, and candidate thresholds/Limits of Acceptable Change, and to obtain input from key resource users and regulatory agencies (Dillon and Salmo 2004b). The workshop scope was confirmed during the initial meeting with the ESRF TAG. Fall was identified as the optimum timing for the workshop because it is a 'shoulder season' between the summer and early winter harvesting periods, and it was consistent with the project schedule.

The agenda and a non-technical summary (Dillon and Salmo 2004a) describing the proposed Valued Components, indicators, and candidate Limits of Acceptable change were distributed to all invitees approximately two weeks prior to the workshop. These reference materials were also reviewed and approved by the TAG ESRF before distribution.

The workshop attendance was 17 people during the October 5 session for community representatives and 44 people on October 6. A combination of large (i.e., plenary) and small group sessions (i.e., small breakout groups used to discuss environmental and socio-cultural topics) were used to focus discussions and encourage participation by all attendees.

As discussed in Dillon and Salmo (2004b – Appendix II), participants indicated that there was general support for the proposed regional Management Objectives, Valued Components, Indicators and the management approach (i.e., thresholds and Limits of Acceptable Change linked to land use plans). They

also indicated the regional social vision should be to 'improve existing social conditions', rather than 'not worsening social problems'. Participants also recommended that thresholds and indicators consider both positive and negative effects and opportunities for improvement, rather than focusing solely on negative effects. However, it was noted that workshop discussion was too limited in terms of time, and that comments should not be considered formal community endorsement of this approach.

Many participants in the break-out group that discussed socio-cultural indicators and thresholds felt that communities in the Beaufort Delta region have already surpassed many socio-cultural thresholds. In conjunction with discussions on indicators, the group struggled with the information some indicators would provide. The statistics of suicide, housing and education levels are examples of these discussions. Suggestions for additional indicators included:

- Weight gain (although at least one person suggested that weight gain could indicate both evidence of enough food and evidence of over-eating inappropriate food);
- Rate of violent crime and vandalism;
- Loss of language which can suggest better employment opportunities and loss of knowledge of identity and ancestry;
- Elder care and abuse; and
- Burn-out of individuals in responsible positions.

The environmental break-out group agreed with the approach and most of the proposed Valued Components, but some representatives felt that 'nearshore' should be expanded to include 'offshore'. The Terms of Reference for this study, however, specified that the consulting team focus on nearshore. Protected Areas was proposed and generally accepted as a Valued Component because of the perceived importance of these areas. This discussion group also suggested that access to land could also be included as a Valued Component, and that while the land-use zone/categories provided in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan need to be respected, other legislation and regulations (e.g., federal *Species At Risk Act*) are also important.

The small group discussion on environmental indicators also revealed that while there was general agreement with the approach, it is important to track harvest along with land use activities. Barriers to movements and seasonality are other factors that could be addressed by environmental indicators.

There was general support for the proposed framework linking tiered thresholds to land use categories in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan. Participants noted that there were several elements that would likely be required to achieve buy-in. These included:

- A scientific basis (e.g., changes need to be both monitored and measurable);

- Trusted and credible sources of information;
- Identifying acceptable thresholds and closing some of the data gaps for terrestrial communities (i.e., air and freshwater have relatively good standards in place);
- Integrating scientific knowledge with traditional knowledge;
- Recognizing that land use plans are subject to revision on an ongoing basis;
- Low community risk tolerance for adverse effects on some activities (e.g., harvest of caribou and beluga whale; and saying 'no' to development activities in some areas, should mean 'NO').

Additional details about feedback from the workshop can be found in Dillon and Salmo (2004b – Appendix II).

1.1.4 Draft Report Preparation

The existing literature was reviewed and summarized by members of the consulting team (see Section 1.0 and Acknowledgements). Feedback from the October 2004 workshop in Inuvik was also incorporated into the report as appropriate. Following the preparation of working drafts, the working drafts underwent two reviews by both the Senior Technical Advisor and Project Manager. Dillon's Technical Review Partners and Client Relationship Manager also reviewed the final working copy of the draft.

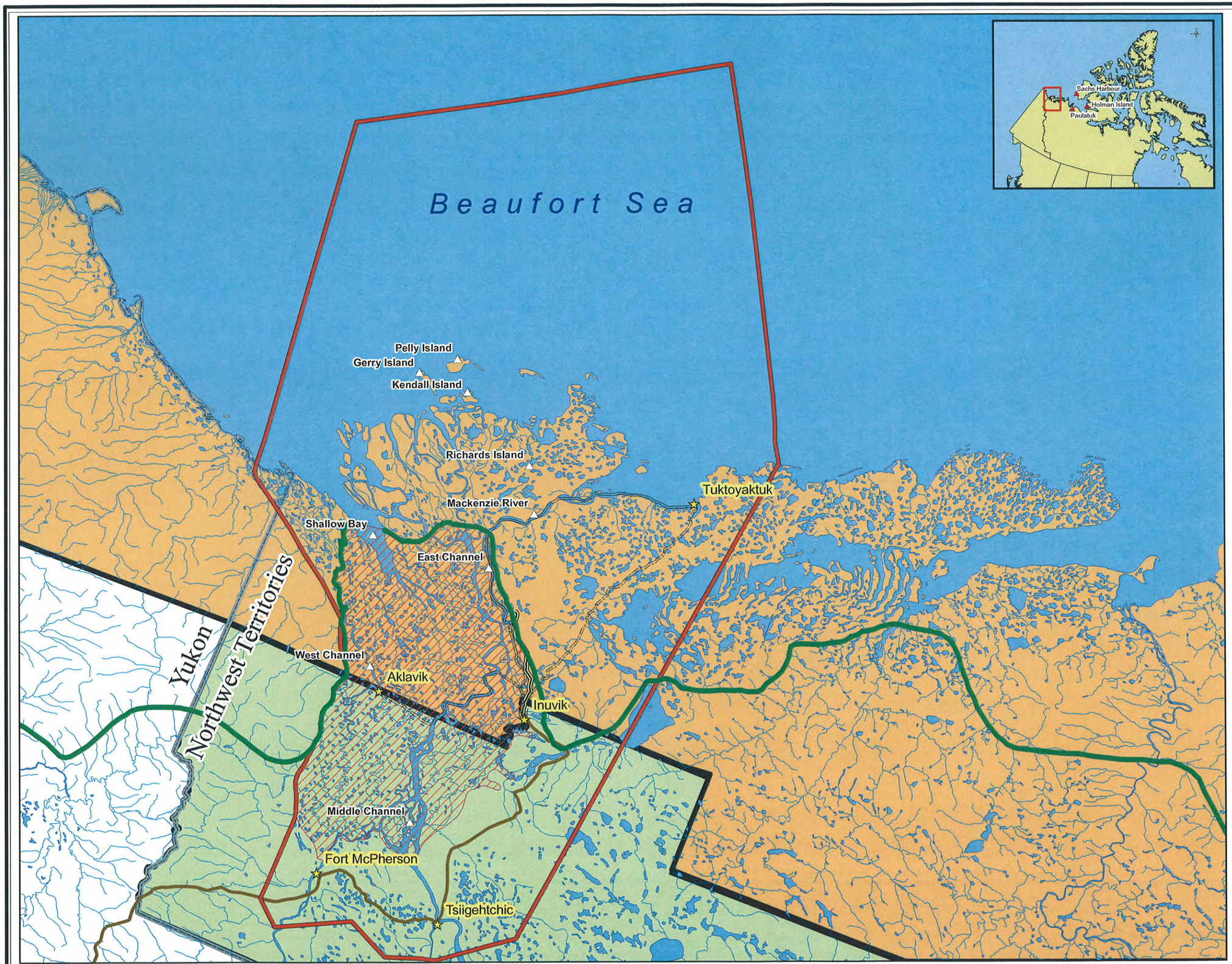
2 BEAUFORT DELTA SETTING

The Beaufort Delta study area was defined to include the Mackenzie River delta (the Delta) and nearby upland and nearshore marine areas (Figure 1). This study area includes most known onshore and nearshore hydrocarbon discoveries (LGL et al. 1986; Kavik-Axys et al. 2002). The approximately 41,000 km^2 study area can be subdivided into seven relatively consistent physical divisions, or ecoregions (Figure 2). The Nearshore marine zone covers about 42% of the study area. The Mackenzie Delta is the next largest ecoregion, covering just less than one fourth of the study area. The Tuktoyaktuk Coastal Plain and Great Bear Lake Plain cover 15% and 11% of the study area, respectively. The remaining ecoregions each comprised less than 5% of the study area.

The defined Beaufort Delta study area overlaps two administrative areas established by land claims: the Inuvialuit Settlement Region (ISR) established by the *Western Arctic Claims Settlement Act* (Inuvialuit Final Agreement or IFA); and the Gwich'n Settlement Area (GSA) established by the *Gwich'in Comprehensive Land Claim Agreement* (Gwich'in Land Claim). Five communities occur in the study area: Aklavik, Fort McPherson, Inuvik, Tsiigehtchic, and Tuktoyaktuk (Figure 1). The communities of Holman Island, Paulatuk, and Sachs Harbour are within the ISR, but outside of the study area.

Participants at the October 2004 workshop recommended that the study area be expanded to include all adjacent marine areas because their ecology and human use are intimately linked. They also noted that the communities of Holman Island, Paulatuk, and Sachs Harbour should have been included in this study and invited to the workshop because they are within the ISR; these recommendations, however, were beyond the study Terms of Reference provided to the consulting team. The discussion of nearshore marine indicators and thresholds included here (Section 5) is also directly relevant to deeper offshore areas. Similarly, the discussion of social-cultural indicators and Limits of Acceptable Change provided in Section 8 is also directly relevant to ISR communities outside the study area. As discussed further in Section 9 (Implementation), residents of Holman Island, Paulatuk, and Sachs Harbour should be consulted when the benefits and risks of candidate Limits are formally evaluated. Within the study area there are several protected and sensitive areas (Figure 3); these include such areas as the Kendall Island Bird Sanctuary, the Pingo Canadian Landmark, the Gwich'in Territorial Park and areas known to provide critical habitats for marine and terrestrial wildlife. With the study area, lands within the GSA and the ISR are also categorized by priority land uses (Figure 4).

Cumulative effect indicators, targets, and limits must reflect existing conditions, issues, and regulatory realities if they are to be effective. An overview of current and historical conditions in the study area is provided below. It is intended to help explain why the candidate Valued Components and indicators discussed in Section 3 and later were selected. The setting discussion is provided under the general headings Air and Climate (Section 2.1), Nearshore Marine (Section 2.2), Land (Section 2.3), Freshwater (Section 2.4), and Socio-cultural (Section 2.5). Each section discusses key issues or species; sensitive and protected areas; and available information sources. Section 2.6 summarizes relevant aspects of the



Legend

- Beaufort Delta Study Area
- Inuvialuit Settlement Region (ISR)
- Gwich'in Settlement Area (GSA)
- Mackenzie Inner Delta
- Northern Limit of Trees
- Place Names
- Communities
- Existing Pipelines
- Rivers
- Waterbody

Roads

- All Season Surface
- Winter Access Only

0 20 40 80 Kilometers

Scale 1 : 1,500,000

Projected Coordinate System: Canada Albers Equal Area Conic

Client	Produced by
ESRF	DILLON CONSULTING

Title

Figure 1. Beaufort Delta Study Area

Data Source

World Wildlife Fund - Digital Atlas September 2002
Gwich'in Land Use Plan - June 2002

Project Name

ESRF Beaufort Delta Cumulative Effects Project

Project Number	Date
04-3429	March 15, 2006

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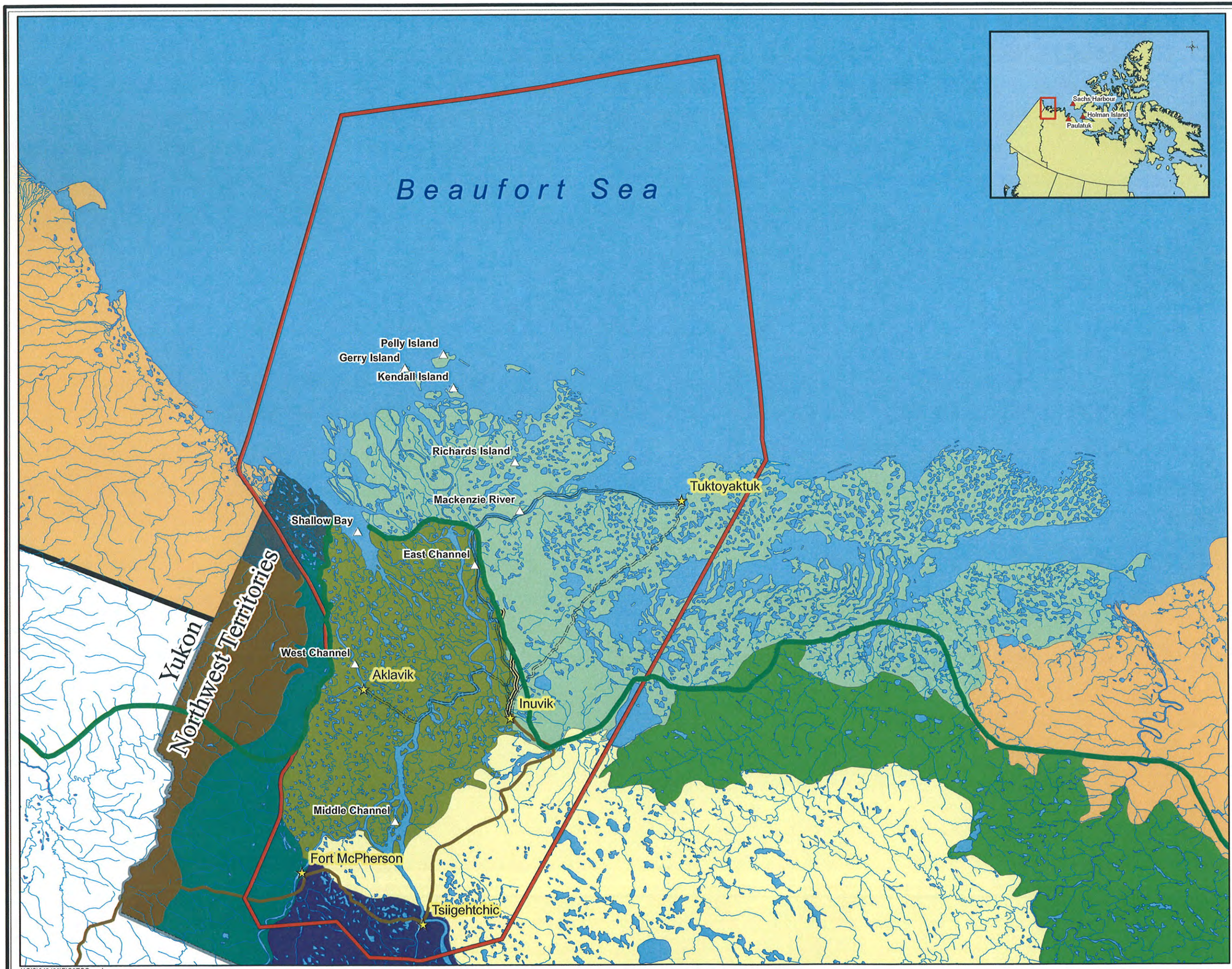

Legend

- Beaufort Delta Study Area

Ecoregions

- British-Richardson Mountains
- Dease Arm Plain
- Fort MacPherson Plain
- Great Bear Lake Plain
- Mackenzie Delta
- Peel River Plateau
- Tuktoyaktuk Coastal Plain
- Yukon Coastal Plain
- Nearshore Marine
- Northern Limit of Trees
- Communities
- Place Names
- Existing Pipelines
- Rivers

Roads

- All Season Surface
- Winter Access Only

N W E S

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Scale 1 : 1,500,000

Projected Coordinate System: Canada Albers Equal Area Conic

Client	Produced by
ESRF	DILLON CONSULTING

Title

Figure 2. Beaufort Delta Ecoregions

Data Source

World Wildlife Fund - Digital Atlas September 2002
Gwich'in Land Use Plan - June 2002

Project Name

ESRF Beaufort Delta Cumulative Effects Project

Project Number	Date
04-3429	March 15, 2006

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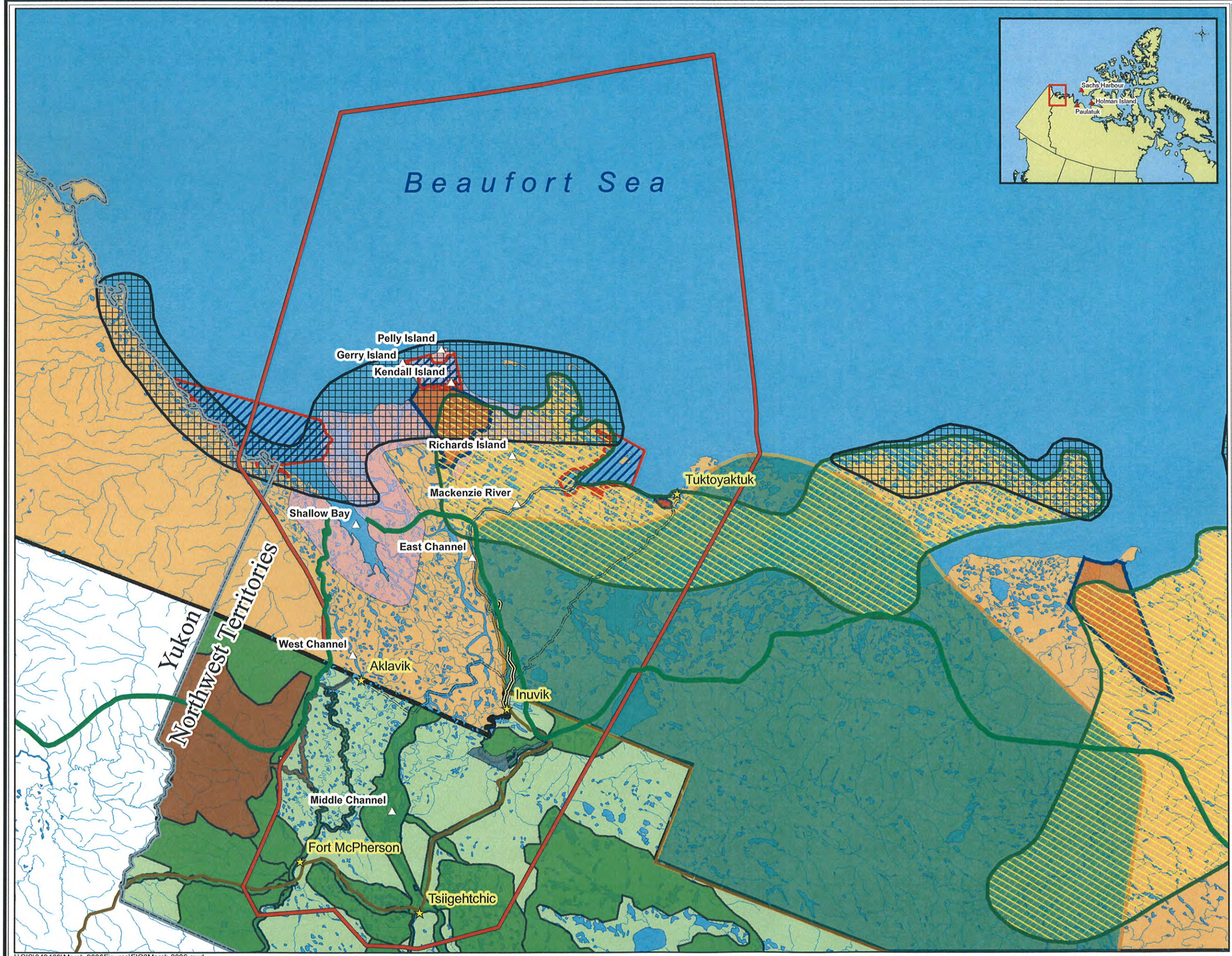

Legend

- Beaufort Delta Study Area

Inuvialuit Settlement Region

- Polar Bear Denning Areas
- Critical Grizzly Bear Denning Areas
- Beluga Management Zone 1A
- Kendall Island Migratory Bird Sanctuaries
- Mackenzie River Delta Migratory Bird Habitat
- Bluenose-West Caribou Herd Winter Range
- Pingo Canadian Landmark
- Inuvialuit Settlement Region (ISR)

Gwich'in Settlement Area

- Gwich'in Special Management Zone
- Gwich'in Conservation Zone
- Gwich'in Heritage Conservation Zone
- Gwich'in Territorial Park
- Gwich'in Settlement Area (GSA)
- Northern Limit of Trees
- Communities
- Place Names
- Existing Pipelines
- Waterbody
- Rivers

Roads

- All Season Surface
- Winter Access Only

N W E S

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Scale 1 : 1,500,000

Projected Coordinate System: Canada Albers Equal Area Conic

Client	Produced by
ESRF	DILLON CONSULTING

Title

Figure 3. Beaufort Delta Sensitive and Protected Features

Data Source
World Wildlife Fund - Digital Atlas September 2002
Gwich'in Land Use Plan - June 2002
ISR Community Conservation Plans - 2000

Project Name
ESRF Beaufort Delta Cumulative Effects Project

Project Number	Date
04-3429	March 15, 2006

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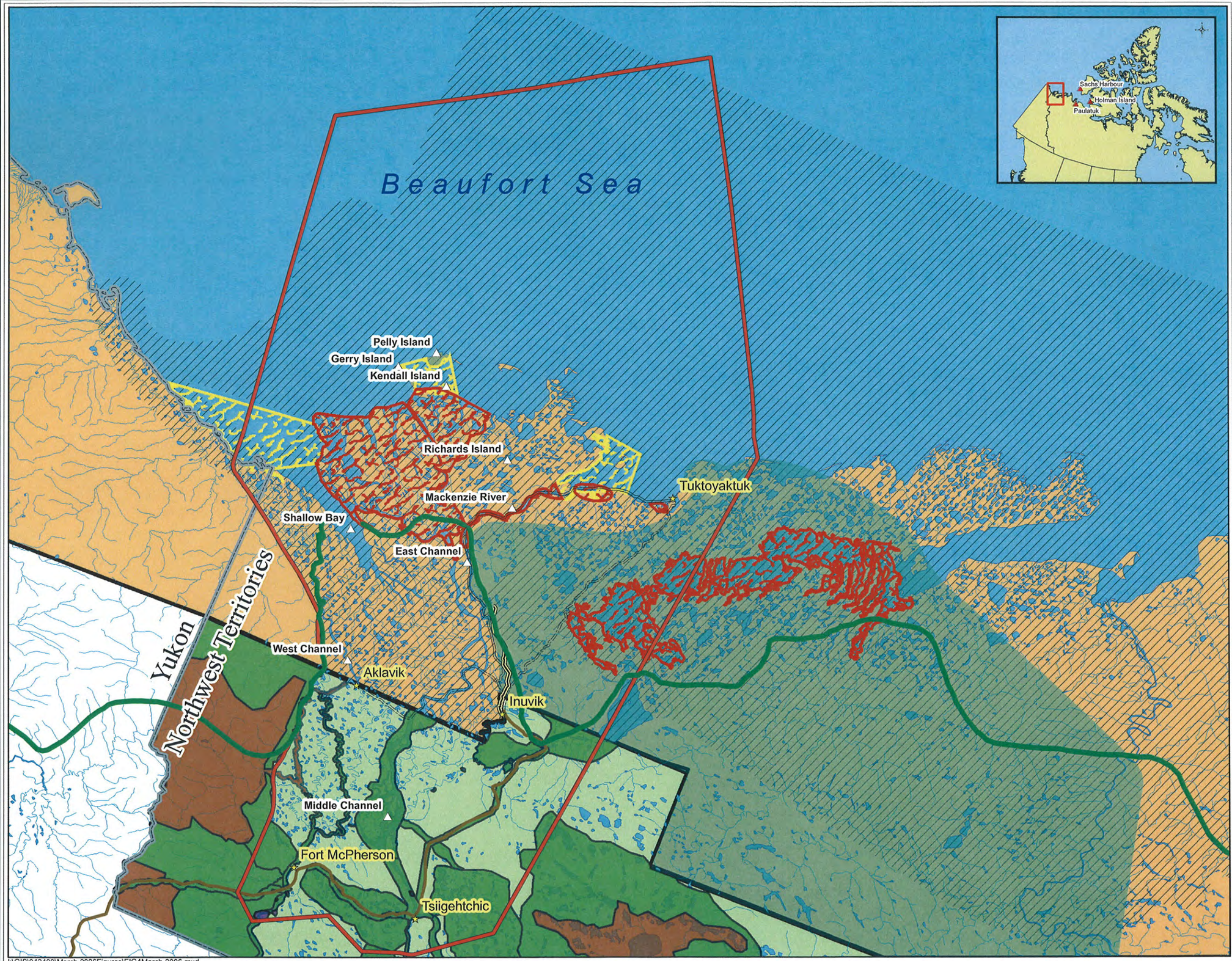

Legend

- Beaufort Delta Study Area

Inuvialuit Settlement Region

- Category B
- Category C
- Category D
- Category E

Gwich'in Settlement Area

- Gwich'in Special Management Zone
- Gwich'in Conservation Zone
- Gwich'in Heritage Conservation Zone
- Gwich'in Settlement Area (GSA)
- Northern Limit of Trees
- Communities
- Place Names
- Inuvialuit Settlement Region (ISR)
- Gwich'in Settlement Area (GSA)
- Existing Pipelines
- Waterbody
- Rivers

Roads

- All Season Surface
- Winter Access Only

N W E S

0 20 40 80 Kilometers

Scale 1 : 1,500,000

Projected Coordinate System: Canada Albers Equal Area Conic

Client	Produced by
ESRF	DILLON CONSULTING

Title

Figure 4. Beaufort Delta Management Plan Areas

Data Source

World Wildlife Fund - Digital Atlas September 2002
Gwich'in Land Use Plan - June 2002
ISR Community Conservation Plans - 2000

Project Name

ESRF Beaufort Delta Cumulative Effects Project

Project Number	Date
04-3429	March 15, 2006

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regulatory regime in the study area. Common names of plants and animals are used in the report. A list of common and scientific names for the Beaufort Delta region is included in Appendix I.

This summary of the Beaufort Delta setting provides background information for readers who are not intimately familiar with the Beaufort Delta region. Readers who do not require background information on resources, communities, and regulatory matters should proceed to Section 3.

2.1 Air and Climate

Emissions from industrial facilities, vessels, aircraft, vehicles, communities, and cabins have the potential to cause cumulative effects on air quality and noise in the Beaufort Delta region.

2.1.1 Air Quality

Air quality affects human, plant, and animal physiology and health. Kavik-Axys et al. (2003) reported that air quality in the region is relatively pristine, but that there has been relatively little research on existing conditions. RWED established an air quality monitoring station in Inuvik in September 2003 that monitors sulphur dioxide, hydrogen sulphide, nitrogen oxide, and fine particulates (RWED 2003). Results from 2003 indicate only background concentrations of sulphur dioxide and hydrogen sulphide; levels of nitrogen oxides and fine particulate are well below the NWT and national standards. Overall, like other parts of the NWT, the results confirm that air quality in the region continues to be very good.

RWED has also established ambient air quality standards that apply to the Beaufort Delta region (RWED 2003). Both short- and long-term standards have been developed to provide adequate protection for acute and chronic exposure. The standards for sulphur dioxide, ground level ozone, total suspended particulates, and fine particulate matter are used to assess the acceptability of emissions from existing and proposed developments, and to report on the state of air quality in the territory (e.g., RWED 2000b, 2001a, 2002a, 2003; available online at: www.gov.nt.ca/RWED/eps/environ.htm). A draft Air Quality Code of Practice for the Upstream Oil and Gas Industry, developed by RWED (2002a), discusses design considerations and modeling requirements.

2.1.2 Climate

The Beaufort Delta region is considered an Arctic desert (BMMDA n.d.). EC (2004) maintains records for climate normals from 1971 to 2000 at Inuvik and Tuktoyaktuk. Selected ambient temperature, precipitation, and wind data are provided in Table 1. As discussed in Sections 2.2, 2.3, and 2.4, the Mackenzie River has a warming influence on landforms, vegetation, and freshwater and marine areas within the Beaufort Delta region. Climatic data indicate that inland areas near Inuvik are slightly warmer and receive almost twice as much precipitation as the coastal community of Tuktoyaktuk. Snow and ice cover the lakes and channels of the Mackenzie Delta for up to eight months of the year.

Table 1 Climate normals from 1971 to 2000 at Inuvik and Tuktoyaktuk and selected ambient temperature, precipitation and wind data. Data extracted from EC (2004).

Parameter	Inuvik	Tuktoyaktuk
Mean monthly temperature in January (^{o}C)	-27.6	-25.9
Mean monthly temperature in July (^{o}C)	14.2	10.9
Mean annual temperature (^{o}C)	-8.8	-10.2
Average number of frost free days	106.7	95.5
Average annual rainfall (mm)	117.0	70.2
Average annual snowfall (mm)	167.9	69.2
Average annual precipitation	248.4	139.3
Most frequent wind direction	East	Not provided
Average wind speed (km/h)	9.7	Not provided
Extreme windchill (^{o}C - year)	-67.0 - 1968	-66.4 - 1968

Although long term wind data across the study area are limited, BMMDA (n.d.) also report that higher winds are often experienced along the coast, but inland areas are relatively calm for long periods of time.

BMMDA (n.d.) report that the Delta region in 1999 was 4.3^{o}C warmer than normal long-term temperatures. Some studies indicate that although decadal warming has occurred in the region during April to mid-August, cooling trends in some months have also occurred (i.e., mid-November to January; Whitfield et al. 2004). However, there is evidence to suggest warming temperature trends are occurring in and beyond the region; for example, there is evidence of local changes in multi-year ice distribution, first-year ice thickness, and ice-break-up dates. Nichols et al. (2004) reported the changes observed in these parameters throughout the 1990s were without precedent and are well outside the normal range of variability.

The GNWT has committed to working with governments and organizations to develop an equitable approach to Canada's international commitment under the Kyoto protocol (RWED 2001b). A ‘Made-in-the-NWT’ strategy to help control greenhouse gas emissions is being developed in consultation with government agencies, municipalities, industry and the public.

2.1.3 Noise

The Beaufort Delta area has been described as quiet relative to most developed parts of Canada (IORVL 2004). The Mackenzie Gas Project collected information for baseline noise levels at several sites, including one in the Mackenzie Delta near Inuvik (IORVL 2004). They indicated the acoustic environment was dominated by sounds of nature and that ambient sound levels were low and in the range of 35 dBA. They also indicated that anthropogenic sources of noise were localized and intermittent, and included:

- vehicle traffic (including snowmobiles);
- barge and boat traffic;
- air traffic; and
- oil and gas exploration activities.

The GNWT has an air quality Code of Practice (a consultation draft) that pertains to noise and endorses the Alberta Energy and Utilities Board Guide 38 (AEUB 1999). The defined sound control principles of the NWT Code of Practice (RWED 2002a) are that:

- sound level increases be kept to a minimum;
- quality of life for neighbors of energy facilities is not impaired;
- wildlife are not adversely affected; and
- indoor sounds levels not change significantly, particularly as they affect normal sleep patterns.

2.2 Land

The Beaufort Delta region includes diverse landforms and features that influence soils, vegetation, and wildlife. Terrestrial resources are also influenced by the Mackenzie River that flows between mountains on both the east and west sides of the valley. The river and associated Delta contain many channels along with approximately 25,000 lakes and interspersed land. As the river nears the Beaufort Sea, the landscape flattens out into an alluvial plain to meet the Sea. Although discontinuous permafrost lies beneath much of the region, upland areas are underlain by continuous permafrost. Pingos occur near the community of Tuktoyaktuk and elsewhere to a lesser degree. Tundra – treeless plains with dwarf plants and permafrost soils – is found along the coast, upland areas, and the lower Mackenzie River Delta. Taiga, generally referring to northern, slow-growing, coniferous forest, is found in the upper Delta and along larger valleys.

Seasonal flooding of the Delta alters the succession of plant communities, and in turn, provides a variety of habitats for wildlife, birds, and insects. Most species of birds and some wildlife species found in the Beaufort Delta region are migratory.

Human and industrial activities can have both direct and indirect cumulative effects on land, plants, and wildlife. These include: changes in landforms and permafrost; loss and alteration of vegetation communities; and disturbance, altered movement, and increased mortality of wildlife.

2.2.1 Landforms and Permafrost

The greatest topographic relief occurs in the Richardson Mountains that lie on the west side of the Delta, and the Caribou Hills to the east. The flat fluvial deposits of the Delta have been built up over the last 12,000 to 13,000 years since the retreat of the glaciers by sedimentation from the Mackenzie River. The depth of this sediment reaches 70 to 80 m in some places (Marsh 1998), and provides nutrient-rich soil for plant growth. The deposition process is still underway, with flood events adding material each year. Thousands of meandering channels of various sizes run through the Delta, providing a naturally complex landscape that constantly changes due to the influences of annual flood events and of Beaufort Sea tides and storm surges. As new channels are cut through the Delta, deposition of sediment creates new terrestrial and aquatic features on the landscape.

Permafrost is ground that remains at or below 0^{o}C for at least two years and has important effects on land stability and vegetation communities in the Beaufort Delta region. Although this region is within the continuous permafrost zone, the river's warming effect on the land results in permafrost that is highly variable in thickness and ice content. In upland and coastal areas permafrost is continuous, has high ice content, and may create the ice-cored hills known as pingos. There is no permafrost directly beneath lakes and channels that exceed 2 m in depth (talik); however, in other areas of the Beaufort Delta, permafrost extends from near surface to depths greater than 500 m (Marsh 1998; review in Kavik-Axys et al. 2002b).

The melting of permafrost due to changes in climate in the Beaufort Delta region is a topic recently visited and monitored by many agencies, including the Geological Survey of Canada. Changes to the Arctic coastline, slumping ground, failing slopes and erosion have been documented as a result of permafrost melting. The Terrain Sciences Division of the Geological Survey of Canada also has a comprehensive program to study permafrost in the Mackenzie Delta and Beaufort coastal areas; this research has been in response to knowledge requirements in anticipation of hydrocarbon exploration, development and transportation (see http://sts.gsc.nrcan.gc.ca/permafrost/regional.html).

Pingos, some as high as 50 m, are unique and valued; the Inuvialuit Land Administration Manual of Rules and Procedures contains a section prohibiting vehicle access to pingos or areas within 100 m of them (ESWG 1996). The Ibyuk Pingo, second highest in the world and estimated to be more than one thousand years old, is located near Tuktoyaktuk – a region containing over 1400 of the formations (Mackay 1990). Ice wedges are also found in the region. The Pingo Canadian Landmark has been designated as a protected area within this region, under the *National Parks Act* and the *Western Arctic (Inuvialuit) Claims Settlement Act*. The landmark is approximately 4 km southwest of Tuktoyaktuk and covers approximately 16.4 km^2 (Tuktoyaktuk ICCP 2000).

There has been a general increase in active layer depth of about 15 cm throughout the Mackenzie Valley since 1990 (Gartner Lee et al. 2003).

Cumulative effects on landforms and permafrost can occur as a result of surface disturbance that alters topography or thermal regime. Changes in active layer depth and permafrost melting can be caused by disturbance of the protective vegetative mat, construction of gravel pads, and increased traffic during winter.

2.2.2 Vegetation

The Mackenzie River warms the land in the Delta, causing the treeline to extend further north than in other areas of the NWT. The Beaufort Delta contains a wide range of vegetation types; plants in the region provide food shelter and are used for traditional and medicinal purposes. Habitat types for vegetation include upland, coastal plain, delta, and estuarine/coastal waters. In some instances, vegetation is controlled or initiated by fire; in others, by seasonal flooding. Vegetation communities are often found in various stages of succession due to these influences and the mosaic of landforms in the region.

Within the "National Ecological Framework for Canada" (ESWG 1996), most of the Delta is classified as the Mackenzie Delta Ecoregion within the Taiga Plains Ecozone (Figure 2). In general, this ecoregion is treeless; however, the Mackenzie River provides a warming influence that results in the Delta being

mainly treed with open, stunted stands of predominantly white spruce, as well as some black spruce and tamarack. Ground cover consists of dwarf birch, willow, various other low shrubs, lichen, moss and grasses. More poorly drained sites host sedges, cotton grass and sphagnum mosses (ESWG 1996). Along the river, regular flooding and the resulting sedimentation controls the distribution of vegetation.

The coastal areas along the Beaufort Sea are a part of a different ecozone known as the Southern Arctic Ecozone, more specifically the Tuktoyaktuk Coastal Plain Ecoregion (Figure 2). This part of the region lies beyond treeline. ESWG (1996) describes this coastal area, covering the outer Mackenzie Delta and the Tuktoyaktuk Peninsula as having low, shrubby tundra vegetation such as dwarf birch, willow, and tussocks of sedge and cotton grass

The GRRB has undertaken or co-managed several projects related to traditional and current uses of the forests and plant communities within the GSA. The Gwich'in Social and Cultural Institute also completed an ethno-botany study related to the use of plants for traditional medicine and other uses.

The Inuvialuit Community Conservation Plans for Aklavik, Tuktoyaktuk and Inuvik list over 500 species of vascular plants that occur in the Beaufort Delta region, as well as many species of non-vascular plants such as ferns, mosses, lichen and liverwort. Appendix I lists those that the Inuvialuit Community Conservation Plans indicate are used by local people for food or other purposes. In addition, there are several vascular plants that have been listed both by the Inuvialuit Community Conservation Plans and by McJannet et al. (1995) as being rare in the NWT. These authors define rare as being low in numbers or very restricted in range due to either biological characteristics, being near the limit of its' geographic range, or other reasons. They also note that rare taxa should also be regarded as vulnerable to human activity.

A few additional species considered rare in the NWT are found in the Beaufort Delta region (McJannet et al. 1995); these include: Mackenzie's sedge which exists in coastal brackish marshes; tundra fescue which is generally found on dry tundra, and Huron tansy, which is found in boreal areas along sandy riverbanks.

2.2.3 Wildlife

Terrestrial mammals, birds, insects, and one amphibian make the Beaufort Delta their home – either year-round or seasonally as they migrate through the area. Due to exploration and development activities in the region as well as to fulfill resource management goals, the communities in the region have been preparing management plans and species conservation summaries. Appendix I notes the species of mammals that are described in detail and have Species Conservation Summaries within the Inuvialuit Community Conservation Plans.

In addition to the 13 species in Appendix I, there are another 20 terrestrial mammals listed in the Inuvialuit Community Conservation Plans. These include an additional: six carnivore species (polar bear,

coyote, wolverine, least weasel, long-tailed weasel and river otter); two ungulate species (Dall's sheep and muskox); two lagomorph species (Arctic hare and snowshoe hare); and ten rodent species (hoary marmot, Alaska vole, yellow-cheeked vole, brown lemming, Greenland collared lemming, meadow vole, northern flying squirrel, porcupine, tundra redback vole, and tundra vole).

2.2.3.1 Grizzly Bear

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) list grizzly bear as a 'Species of Special Concern', a category formerly known as 'vulnerable' (RWED 2000a). Grizzly bear are widely distributed throughout the Beaufort Delta region.

High priority is placed on researching grizzly bear populations in the Mackenzie Delta, as this will assist with setting harvest quotas for residents of the region. The goal as outlined in the Inuvik Inuvialuit Community Conservation Plan is to see the population of grizzly bear at a level that could sustain an annual harvest of three percent of the total population. For now, many researchers are, or have already undertaken research, and there is a co-management plan for the species (Nagy and Branigan 1998). The GRRB is also currently developing a management plan for grizzly bear.

Grizzly bears have a low reproductive rate, and are, therefore, vulnerable to declines in their population by overharvest, killing in defense, being illegally killed, or by loss of habitat due to development activities (Nagy and Branigan 1998). McLoughlin and Messier (2001) note that grizzly bear require a very large space to roam and live (an average of 1154 km^2 for male grizzly bears on the Tuktoyaktuk Peninsula; Nagy and Branigan 1998), and conclude that development activities far from the core of their home range may affect them. Grizzly bears on the tundra are more susceptible to displacement than those that live in forested areas, due to less available cover (McLellan 1990). The ICCPs discuss the need to identify and protect key grizzly bear habitat from disruptive land uses.

2.2.3.2 Moose

Moose provide a valuable food source for residents of the Mackenzie Delta communities. Currently, a Moose Management Plan for the GSA is being developed by the GRRB, Renewable Resource Councils, and RWED. It has not yet been determined if low moose densities on the GSA are natural, or whether this is due to other causes. Habitat studies, aerial surveys and browse surveys have also been conducted to help better understand the species and its' distribution and sensitivity in the region. Moose feed extensively on aquatic vegetation, thus making the Mackenzie Delta attractive habitat. Moose have been observed north of the treeline on the Delta, and winter further south in areas of coniferous forest (Martell et al. 1984).

The Inuvialuit Community Conservation Plans indicate that there has been a possible decline in moose numbers over the past several decades. The priority for research is to survey population and productivity of moose occasionally, and there is a non-quantified goal to maintain the moose population at a level that will allow a maximum sustained yield. These plans also discuss the need to identify and protect key moose habitat from land uses deemed disruptive.

2.2.3.3 Caribou

Both barren-ground and woodland caribou are present in the Beaufort Delta region. The barren ground ecotype generally calves north of treeline while the woodland ecotype is associated with boreal taiga, forests, and mountains. Caribou (particularly barren-ground) are identified as a highly-valued food resource in the ICCPs and Gwich'in Land Use Plan that was also historically important for clothing and tools.

Three barren-ground caribou herds use the Beaufort Delta region: the Porcupine herd west of the Delta; and the Cape Bathurst and Bluenose-West herds east of the Delta.

The Porcupine caribou herd home range is approximately 250,000 km^2 and overlaps the Yukon, NWT, and Alaska. One wintering concentration area is the Richardson Mountains west of the Mackenzie Delta. Estimated population size of the Porcupine herd peaked at 178,000 animals in 1989 (PCMB n.d.). Unlike other Alaskan and Beaufort Delta barren-ground caribou, the Porcupine herd has decreased by about 3.6% per year since this peak and is expected to reach the lowest levels ever recorded during 2005-2010 (USGS n.d.; www.absc.usgs.gov/1002/section3part2.htm). This herd is harvested by residents of seventeen communities and is co-managed by the Porcupine Caribou Management Board according to the International Porcupine Caribou Agreement. Management principles identified in the herd management plan include: the herd and its habitat remain healthy and viable; some habitats such as calving grounds are essential for the long-term survival of the herd and must be protected; and understand and recognize subsistence harvest needs and allocate sustainable harvest fairly (PCMB n.d.).

Barren-ground caribou east of the Mackenzie River and north of Great Bear Lake have been divided into three herds based on fidelity to calving grounds. The range of the Bluenose-East herd is entirely outside the Beaufort Delta study area. The Cape Bathurst herd calves on the Cape Bathurst peninsula, ruts east of Husky Lakes, and winters in the Tuktoyaktuk Peninsula-Husky Lakes area within the Beaufort Delta study area. The Bluenose-West herd calves west of Bluenose Lake in Tuktut Nogait National Park and adjacent areas to the west, ruts in the Anderson River area, and winters in the Tuktoyaktuk Peninsula area south to the Sahtu Settlement Area. Some individuals of the Bluenose-West herd winter in the Beaufort Delta study area (Figure 3). In 1992, there were about 88,000 to 106,000 caribou in the combined Cape Bathurst and Bluenose-West herds (Nagy et al. n.d.).

The Cape Bathurst and Bluenose-West herds are harvested by residents of the Beaufort Delta study area. The Bluenose-West herd is also harvested by Sahtu Dene and Métis residents in seven other communities. These herds are cooperatively managed by Inuvialuit, Gwich'in, Sahtu Dene, Métis, and Nunavut land claim wildlife management boards, and territorial and federal government agencies. Management principles identified in the draft co-management plan include: maintaining healthy and viable herds for the future; recognizing the social, cultural, and economic value of the herds and their habitat; and understanding and recognizing subsistence harvest needs and allocating sustainable harvest fairly (Nagy et al. n.d.).

Boreal ecotype woodland caribou are found south of the treeline in the Beaufort Delta study area. Investigations of boreal caribou ecology in this area were initiated in late winter 2002. Preliminary data suggest that calving occurs in poorly drained, open black spruce dominated habitats and females appear to use areas adjacent to seismic lines less than expected (Nagy et al. 2003); this is consistent with data from southern herds of the same ecotype (Dzus 2001; Gunn et al. 2002; Thomas and Gray 2002). Unlike southern herds, however, observed calf survival in the Beaufort Delta area was high (J. Nagy, pers. comm.).

Boreal ecotype woodland caribou are classified as 'sensitive' by the NWT and 'threatened' by COSEWIC (2002) because populations have declined throughout most of the range. These barren ground caribou herds have not been classified as a species at risk by either jurisdiction. Barren-ground caribou populations such as the Porcupine herd are more likely to be limited in numbers by range conditions (Russell et al. 1993), while woodland caribou herds are primarily limited by predators or harvest (Dzus 2001; Adamczewski et al. 2003). Cumulative effects of increased activity, including petroleum exploration and development, have been identified as one of the primary threats for both ecotypes (Nagy et al. 2003; PCMB n.d.).

2.2.3.4 Birds

There are over 450 species of birds in Canada – more than 130 of which are known to occur in the Beaufort Delta alone (ARI 2002, Martell et al. 1984). Ducks, geese, tundra swans, loons, ptarmigan, Sandhill Cranes, eagles, falcons, hawks, owls, woodpeckers, and numerous Passeriformes (perching birds) use the variety of habitat types found in the Beaufort Delta region for migration, molting or breeding. The Delta itself is a crucial funneling area for migratory birds each year, as they make their way north towards their nesting grounds (ARI 2002).

Several species of birds in the Beaufort Delta are listed as 'sensitive' in RWED (2000a), meaning that they are not currently at risk of becoming extinct or extirpated, but they may require management action so they do not become listed as 'at risk'. The Anatum Pergrine Falcon is listed as a species of 'special concern' with COSEWIC (RWED 2000a). All 'listed' species are identified in Appendix I. This appendix also summarizes habitat and management details from the Inuvialuit Community Conservation Plans.

EC's website identifies habitat loss or alteration and human access as the primary cumulative impact sources to migratory birds. The Beaufort Delta region is identified as an area of concern over the next decade (www.pnr-rpn.ec.gc.ca/nature/migratorybirds/sb/dc31s03.en.html).

2.2.3.5 Insects

Insects (terrestrial and aquatic) are recognized in the Inuvialuit Community Conservation Plans as an important base to the food chain, as well as providing other functions such as pollination and organic matter decomposition. Insects such as mosquitoes affect the behavior or patterns of habitat use of many

wildlife species. Key habitat for insects that are limited in their North American distribution is identified in the Inuvialuit Community Conservation Plans as:

- unglaciated areas where dolomite or limestone is common;
- the west side of the Richardson Mountains in the 'White Mountains' area; and
- south-facing slopes dominated by pasture sage.

2.2.3.6 Amphibians

Martell et al. (1984) indicate that only one species of amphibian, the wood frog, is found in the Beaufort Delta region. This is the northern limit of the species distribution. The status of the wood frog is 'secure' in the NWT (RWED 2000a).

2.2.4 Sensitive and Protected Features

2.2.4.1 Inuvialuit Settlement Region Category E Lands

Category E lands and waters (Figure 4) identified in the Inuvialuit Community Conservation Plans for Inuvik, Aklavik and Tuktoyaktuk are considered to contain lands or waters that are of extreme importance to terrestrial wildlife and habitat. Development is not permitted in these areas and the lands and waters are to be managed to eliminate potential damage and disruption to the greatest extent possible. There are no Category E land areas that are protected for terrestrial wildlife or vegetation.

2.2.4.2 Pingo Canadian Landmark

The Pingo Canadian Landmark is a protected area that contains one of the greatest concentrations and some of the largest pingos in the world. It is legislatively protected under both the *National Parks Act* and Inuvialuit Final Agreement (Figure 3).

2.2.4.3 Kendall Island Bird Sanctuary (KIBS)

Migratory Bird Sanctuaries are created under the *Migratory Birds Convention Act*. The Canadian Wildlife Service (CWS) of EC regulates the amount and type of human activity within these protected areas. The primary purpose of sanctuaries is for protection of migratory birds and their habitats.

The KIBS (Figure 3) was established in 1961 to protect breeding and staging waterfowl, particularly a colony of Lesser Snow Geese that was originally restricted to the sanctuary area. KIBS currently supports large numbers of several waterfowl species.

As a general policy, EC permits a variety of activities in northern protected areas, provided that they do not pose a threat to the resident birds and their habitat. KIBS overlies two natural gas Significant Discovery Licences, and EC has implemented a 1% disturbance threshold for KIBS. This threshold includes all long-term disturbances, defined as altered, disrupted, removed, covered, or degraded habitat

which cannot be restored to its natural state within three years (CWS Memorandum of Understanding dated 21 May 2004). An industry study concluded that foreseeable petroleum development could be accommodated within this direct disturbance threshold (Connon et al. 2002).

2.2.4.4 ISR Category C and D Lands

In additional to the above described areas, there are also Category C and D areas (Figure 4) which are protected due to their importance to terrestrial wildlife and vegetation. Category C and D areas are lands that are deemed to have renewable resources of particular significant or sensitive during specific times of (Category C), or throughout (Category D), the year. These lands are managed so as to eliminate, to the greatest extent possible, potential damage or disruption.

Category C and D lands described in the Inuvialuit Community Conservation Plans include the: Spring, Summer, Fall and Winter Caribou Harvesting areas (Category C); Spring, Summer, and Fall Goose Harvesting areas (Category C); Winter Wolverine Harvesting areas (Category C), Harrowby Bay Key Migratory Bird Terrestrial Habitat (Category D); Critical Grizzly Bear Denning areas (Category C); Mainland Coastal Polar Bear Denning Areas (Category C); Kugaluk River Estuary (Category D); Husky Lakes (Category D); KIBS (Category D); Coastal Zones of the Tuktoyaktuk Peninsula, Liverpool Bay, Wood Bay and Baillie Islands (Categories C and D); Mackenzie River Delta Key Migratory Bird Habitat (Category C); Mackenzie Bay and Shallow Bay (Categories C and E); Inner Mackenzie Delta (Category C); Eastern North Slope, East of the Babbage River (Category D); and Cape Bathurst Caribou Core Calving and Post-Calving Grounds (Category D).

2.2.4.5 GSA Conservation Zones

The Gwich'in Land Use Plan designates lands where regulatory agencies may not issue licences, permits, or authorizations for a variety of new activities (e.g., oil and gas developments, mineral and aggregate extraction, transportation, power development). The eastern boundary of Conservation Zone A (Rat, Husky and Black Mountain) adjoins the Beaufort Delta study area (Figure 4). In addition to providing critical habitats for Dolly Varden char, this Zone also provides important migration habitat for the Porcupine caribou herd, and lambing and rutting habitat for Dall's Sheep.

2.2.4.6 GSA Special Management Areas

Special Management Zones in the GSA (Figure 4) are lands and waters where a variety of land uses are possible provided the conditions outlined in the Gwich'in Land Use Plan are met and the appropriate regulatory approvals are obtained. The Plan places additional conditions on uses that are designed to protect resources that are valued by the communities.

The Special Management Zones established to protect terrestrial resources, and at least partially within the study area include the: Porcupine Caribou; Stoney Creek; Frog Creek and Lake; Campbell Hills; Mackenzie Islands; Mouth of the Arctic Red River; Cardinal Lakes; Mackenzie River; Arctic Red River; and Transportation.

2.2.5 Data Available

Digital data on sensitive and protected features, and ISR Management Zones, was obtained directly from the Joint Secretariat. The accuracy of this CCP GIS digital dataset was not determined in this study.

Digital Data for the Gwich'in Land Use Plan was received under a license agreement with Dillon, and the Gwich'in Land Use Planning Board. The digital files were created in June 2002; the accuracy of this dataset was not determined in this study.

Information databases were also provided by RWED. RWED's NWT Species Infobase dataset was accessed through a data release and restriction agreement between Dillon and RWED. RWED also provided a digital GIS database to Dillon with information related oil and gas exploration activities within the study area (i.e., seismic activity) after permission was obtained by the oil and gas companies (that had provided the information to RWED) so that Dillon could use the data for this project.

Digital data on petroleum exploration features and other disturbance features was obtained from the Northwest Territories Digital Atlas published in September 2002 by the World Wildlife Fund. No efforts were made to determine the accuracy of this dataset. This was supplemented by a spreadsheet provided by the NEB that contained locations of existing oil and gas exploration wells in the study area, and datasets on the National Energy Board Interactive Mapping Tool (http://216.58.105.202/map.htm).

2.3 Freshwater

The major influencing feature of the coastal and delta areas of the Beaufort Delta Region is the Mackenzie River. With a drainage area of approximately 1.8 million km^2, the Mackenzie River drains approximately one fifth of Canada, and provides the single largest contribution of freshwater to the Canadian Arctic Coast. The Delta, at the mouth of the Mackenzie River, is approximately 13,000 km^2, and can be classified into three basic units:

- The channel system which covers approximately 15-20% of the total surface area of the delta;
- The basin system which covers 40-50% of the delta and is primary composed of ponds and as many as 24,000 lakes; and
- The delta plain which is comprised of areas above the normal flood level; this unit supports mature spruce forest, and due to its reduced flooding frequency receives relatively little sediment deposition, and is not as dynamic as the channel or basins systems.

2.3.1 Water Quality and Quantity

Clean water is a valuable ecological and social resource, and the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan place a high priority on maintaining acceptable water quality in the Beaufort Delta region. Water quality and quantity have been used as federal environmental indicators (e.g., CCFM 1997; NRTEE 2003).

Various factors cause water levels in the Mackenzie River and adjoining channels to change seasonally and annually. Peak discharges typically occur in late May to early June and may exceed 14,000 cubic metres/sec (m^3/s), while the mean discharge and summer discharges are approximately 9,730 m^3/s and 8,500 m^3/s, respectively (MacKay 1963). After freeze-up occurs, water levels decrease and remain low for the duration of winter. Spring ice jams can cause a rapid increase in levels and flooding in many areas. During the summer water levels can rise in response to rainstorm events in the Delta as well as further upstream. In the northern section of the Delta, tidal activity can also have minor effects on water levels. Storm surges of about 1.5 m have been known to raise water levels as far upstream as the community of Tsiigehtchic (www.bmmda.nt.ca/mackenzie_delta.htm).

Changes in flow also affect water quality. For example, turbidity and total suspended solid levels generally increase with increases in flow levels, as the highly erodable banks of the Mackenzie River channels release increased sediment loads into the river.

Clearings, road and trail networks, muskeg drainage, and waste discharge are also known to cause both direct and indirect effects on water quality and flow. Changes can result from the combined effects of small routine activities as well as large industrial and residential disturbances (Furniss et al. 1991; Newcombe and MacDonald 1991; McGurk and Fong 1995; Waters 1995; Anderson et al. 1996; Trombulak and Frissell 2000: Angermeier et al. 2004). In addition to natural fluctuations in the quality and quantity of water that occur as a result of annual and seasonal variations in precipitation and

temperature, disturbance events such as fires and insect damage (CCFM 1997; Minshall et al. 1997; Carignan et al. 2000) from by human activities can also influence water quantity and quality.

2.3.2 Aquatic Habitat

Most freshwater habitats in the region are ice-covered from early October to May. Due to the extremely cold ambient temperatures and long winter, only those habitats that do not freeze to the bottom and provide a suitable oxygen levels throughout the ice-cover area are able to provide fish with overwintering habitats. For example, deep perennial spring-fed pools are known to provide important overwintering habitat for Dolly Varden char (Sekerak et al. 1992; Harwood 2001).

Freshwater habitats in the Beaufort Delta include a complex system of large and small channels, lakes and ponds that are important to a variety of freshwater, anadromous and semi-anadromous fish species. In the channels, substrates are typically fine-grained. The extensive channels in the Delta are also prone to erosion, particularly during high flows and warmer temperatures. This erosion contributes to highly dynamic channel migration. Before draining into the Beaufort Sea, the river deposits sand and silt into the channels, lakes and sandbars of the vast Mackenzie Delta.

The smaller channels provide important habitat for whitefish species, smelt and inconnu, while the larger channels are more important for larger adult fish and provide feeding and overwintering habitats. These channels also provide vital migration routes in the spring and fall for anadromous and semi-anadromous species.

The thousands of small and large lakes and ponds throughout the Delta, depending on their size and depth, also provide important foraging and overwintering habitat for a variety of fish species and life stages. For example, broad whitefish are common in many of the large and small freshwater lakes throughout the Delta Region. The majority of the lakes and ponds, however, are less than 3 m deep, and therefore, are subject to freezing solid and are unlikely to overwinter fish.

Sekerak et al. (1992) divided aquatic habitats in the Beaufort Delta region into eight overwintering habitat types:

1. Perennial springs: occur in the mountain and foothill regions and provide overwintering and incubation habitat; low, but constant groundwater flows throughout the year; water quality good, but occasionally mineralized; winter stream temperatures 2-4^{o} C; and most common overwintering habitat for Arctic char.
2. Upland lakes: predominantly in the southeast portion of the study area; water quality variable, but generally good to excellent; poor connection to other waterbodies; infrequently used by anadromous fishes; and provide important fisheries for communities of Inuvik and Tsiigehtchic.

3. Moderate rivers: predominantly in southeastern portion of study area; water quality poor to moderate; small flow volumes and only contain intermittent flow or unfrozen water in isolated pools during the winter; and fisheries are predominantly utilized by community of Tsiigehtchic.
4. Major rivers: substantial flow volumes throughout the winter with good to excellent water quality; mainstem Mackenzie River and major channels of Peel River and lower Arctic Red River; good connections to adjacent waterbodies; and provide important fisheries for the communities of Aklavik and Fort McPherson.
5. Inner delta lakes and minor channels: small to moderate volumes; located in the active Mackenzie Delta downstream from the Arctic Red River; subjected to annual flooding and turbid summer flows; connections to other waterbodies is often seasonal during high flows; and provide important fisheries for communities of Aklavik and Fort McPherson.
6. Outer delta lakes and minor channels: located in the outer delta and the Tuktoyaktuk Peninsula; many drain directly into marine environments; not subjected to annual flooding of the Mackenzie River; usually small to moderate flows available; good connections to adjacent waterbodies, but sometimes seasonal; used by a wide variety of anadromous fishes; and provide important fisheries for the communities of Tuktoyaktuk and Inuvik.
7. Estuarine coastal (discussed in Section 2.4 Nearshore Marine).
8. Nearshore marine (discussed in Section 2.4 Nearshore Marine).

Small ephemeral waterbodies found in the study area provide seasonal flows during the spring/summer melt or during moderate to large precipitation events. Due to their seasonal nature, they only provide temporary habitat for fish in connected permanent waterbodies. In more southern environments, ephemeral streams can provide critical habitats (e.g., spawning habitats for spring spawning salmonids); they also transport sediment, nutrients, and woody debris from upper portions of a watershed to downstream habitats that are more frequently used by fish. Although little published information on fish use in small ephemeral streams in the Beaufort Delta was located, they likely also provide movement corridors between seasonally isolated lakes and ponds.

2.3.3 Fisheries

More than 40 species of freshwater and anadromous fish have been identified in the Mackenzie River watershed (Cott and Moore 2003). Appendix I lists thirteen of these species and describes the habitat where they are found, their spawning periods, and their status. Although information the life histories of these species, in more southern climates is available, relatively little is known about the life histories and distribution of many of these migratory species in the Arctic (Cott and Moore 2003).

Fisheries in the study area are managed by the GRRB and the Fisheries Joint Management Committee (FJMC) in the GSA and ISR, respectively.

The Inuvialuit Harvest Study (JS 2003) shows that a number of salmonid species (e.g., cisco and herring, Dolly Varden char, and whitefish species), as well as burbot and northern pike, provide important subsistence fisheries. Although other species like Arctic grayling, char, lake trout, and cod are captured, they typically account for a very low percentage of the overall catch. The dominant species in the catch are broad whitefish, cisco/herring, inconnu, lake (humpback) whitefish, burbot, and to a lesser extent Dolly Varden char in the communities of Aklavik and Inuvik.

2.3.3.1 Inconnu (a.k.a. Coney and sruh)

Inconnu are the only fish species in the Beaufort Delta for which an integrated management plan is available (FJMC et al. 2000). Both migratory and non-migratory stocks occur. The Inconnu Management Plan was developed to manage migratory inconnu stocks in the lower Mackenzie River and nearshore marine waters of the Beaufort Delta region. Lake dwelling, non-migratory stocks are not managed by this plan.

Inconnu stocks in the lower Mackenzie River Basin Delta are migratory and have complex anadromous life histories that are not fully understood (Day 1998). Although Day (1998) cautions that limited scientific information is available on their stock structure and migrations, he notes that traditional knowledge on migration stock structure and general biology is generally consistent with scientific data.

The migration patterns of freshwater and anadromous inconnu in the Mackenzie River system have been summarized by Howland (1997) and FJMC et al. (2000). Spawners leave their overwintering areas prior to spring break-up and begin a summer-long migration to upstream spawning sites. Spawning occurs in late-September/early-October in major rivers such as the Peel and the Arctic Red rivers, and is also thought to occur in the Mackenzie River and some of its smaller tributaries. Inconnu require silt-free water and gravel-boulder areas for spawning. With few exceptions, inconnu in the lower Mackenzie River do not migrate beyond the Ramparts Rapids near Fort Good Hope. Following spawning, most individuals rapidly move back downstream to the Mackenzie Delta (Howland 1997).

Day (1998) suggests that inconnu inhabiting the lower Mackenzie River are comprised of at least three distinct spawning stocks: one that spawns in the Peel River and utilize the West Channel of the Mackenzie Delta for migration; and two that spawn either in the Arctic Red River or near the Ramparts and probably only utilize the East and Middle channels.

Inconnu are an important food source for people and their dogs in the Beaufort Delta region, but like the harvests of other fish species, harvests of inconnu are considerably lower when compared to 20 or more years ago (FJMC et al. 2000). Peak subsistence harvests typically occur in July and October during upstream pre-spawning and downstream post-spawning migrations (Day 1998). Harvest data for

Gwich'in communities suggests 3000-6000 fish are harvested annually between July and November (MacDonald 1998a,b in FJMC et al. 2000). The Inuvialuit Harvest Study (JS 2003) indicates that timing and size of the harvest is similar in the communities of Aklavik, Inuvik and Tuktoyaktuk. Although commercial and recreational fisheries for inconnu exist (Anderson 1995; Day 1998), they are substantially smaller than the subsistence fishery.

Management actions identified for inconnu include:

- Focusing research on quantifying critical habitat requirements for all life stages and identifying stock specific locations for spawning, feeding and overwintering;
- Protecting known critical habitats;
- Requiring land developments within land claim areas to undertake extensive fisheries survey work to ensure that the development is not destroying valuable fish habitat and to understand potential negative effects on transboundary stocks; and
- Restricting certain types of work to specific times of the year.

2.3.3.2 Broad Whitefish

Although a management plan has not been finalized, broad whitefish are the second species for which an Integrated Fisheries Management Plan is proposed. Discussions towards this began in 2001. Based on total harvest, they are the most important subsistence fish in the Beaufort Delta region, except possibly for cisco species in the Tuktoyaktuk area (JS 2003), and are harvested from rivers, creeks, and lakes throughout the region (Greenland and Walker-Larsen 2001; JS 2003).

Although often considered an anadromous species, non-migratory lake-dwelling stocks also occur in the Mackenzie River basin. They typically spawn in gravel areas found in rivers throughout the area during October and November. Post-spawning fish are thought to gradually migrate downstream throughout the winter. They are found in rivers more than lakes. Important overwintering areas occur in the East Channel and in several harbours and bays along the coast. Greenland and Walker-Larsen (2001) also identify the Peel, Mackenzie, Arctic Red, and Aklavik rivers, mouths of Caribou River and Bear Creek, and Travaillant Lake area, as important habitats for broad whitefish.

Community concerns about broad whitefish are similar to concerns about other fish species and wildlife in general (e.g., contaminants, pollution, water quality, and habitat protection; Greenland and Walker-Larsen 2001). Conservation measures for broad whitefish identified in the Inuvialuit Community Conservation Plans are to:

- only harvest what is needed; and
- identify and protect important habitats from disruptive land uses.

2.3.3.3 Dolly Varden Char

Dolly Varden char are an anadromous species that utilize clean, ground-fed, gravel-bottom, mountain streams for spawning. They are highly sought after by community residents (JS 2003). Dolly Varden are considered a 'sensitive' species by RWED (2000a), but they also indicate that because the species is at the northern limit of their range in the region, small numbers are expected. Unless otherwise indicated, the following information on Dolly Varden char was taken from the Inuvialuit Community Conservation Plans, the Gwich'in Renewable Resource Board website <www.grrb.nt.ca/charrPro.html>, and Harwood (2001).

Fish Hole, Fish Creek, Shingle Point and the Rat, Big Fish, and Babbage rivers, as well as the Mackenzie River near Inuvik, provide important habitats for Dolly Varden char. In the ISR, Dolly Varden occur to the west of the Mackenzie River in the Big Fish, Babbage, and Firth rivers. A small anadromous population from the Vittrekwa River would also likely migrate past sites where fishing for the Rat River population occurs.

The Rat River watershed west of the Mackenzie Delta is thought to be the only system that supports Dolly Varden char in the GSA. Char in this watershed spawn and overwinter in Fish Creek, a small tributary of the Rat River that is considered critical habitat (Greenland and Walker-Larsen 2001). Most of the spawning activity in Fish Creek occurs in mid-September in six small pools located in a one kilometre stretch of the river. These pools are spring-fed and remain unfrozen for most of the winter. The same pools are used as overwintering habitat by the adult char. They can spend up to eight or nine months of the year in these pools.

Although some documents indicate the Rat River stock is thought to be declining, Harwood (2001) indicates that the population size has been relatively stable. The main threats to the population are overharvest and habitat degradation. The Rat River stock is an important food resource for the Gwich'in and Inuvialuit, and average annual harvest (1990 -1999) was estimated at about 13% of the estimated population size; yearly harvests range from 2,000-3,500 fish. The communities of Aklavik and Fort McPherson developed and implemented the Rat River Fishing Plan in 1995. The Plan recommended that annual harvest be limited to a maximum of 2000 fish/year. Voluntary compliance with the Plan reduced community harvest in 1999 and 2000 to fewer than 2,000 and 1,500 fish/year, respectively. Other plans with similar harvest targets have subsequently been developed and implemented (i.e., Aklavik RRC et al. 2000, and the West Side Char Fishing/Management Plan to cover stocks utilized by Aklavik).

The potential for habitat alteration and/or degradation of sensitive spawning and overwintering habitats represent threats to Dolly Varden. Conservation measures for Dolly Varden stocks in the study area are designed to ensure harvest is sustainable and to identify and protect critical habitats.

2.3.3.4 Burbot (a.k.a. Loche)

Burbot are also an important fish species to communities in the Mackenzie Delta area. Unlike most other freshwater species, burbot typically spawn in mid-winter (January-March) under the ice. Spawning

generally occurs in depths of 3 m or less and over sand or gravel in shallow bays. Most burbot spawning occurs in lakes, but it also occurs in some gravel shoals in rivers. Burbot undertake seasonal movements to tributary rivers in late winter and early spring and into deeper waters in the summer.

There are no management plans in place for burbot and their populations are generally thought to be stable. They are also locally common throughout the study area. Conservation measures identified for burbot in the Inuvialuit Community Conservation Plans are to: only harvest what is needed; and identify and protect important habitats.

Important habitats in the study area include the mouths of creeks in the fall and fresh and brackish waters of Kugmallit Bay in the winter and spring.

2.3.3.5 Lake Trout

Although total harvest of lake trout in the Beaufort Delta region is relatively low, they are highly valued and more community residents fish for lake trout than any other species (JS 2003). Like other top predators, lake trout are sensitive to overharvest and ecological disturbances. The communities place a high research priority on documenting the biology and habitat requirements of lake trout in the area and in monitoring water quality where they are harvested. The priority given to lake trout was emphasized at the October 2004 workshop in Inuvik.

Lake trout are most common in large deep lakes, but are also occasionally found in large rivers and brackish water (e.g., Husky Lakes) in the Beaufort Delta region. They spawn in the fall (generally around early September) over lake shoals or along the windswept shorelines of islands.

There is no management plan for lake trout, but the HTC Bylaw requires a minimum 11 cm mesh size on nets. Conservation measures identified for lake trout in the Inuvialuit Community Conservation Plans are to only harvest what is needed, and identify and protect important habitats.

2.3.3.6 Other Fish Species

There are a number of other fish species (Appendix I) that are important to communities in the study area. These species may be less appropriate as cumulative effect indicators because:

- They are less important as a source of food, or have a lower profile, among people living in communities in the study area;
- They are considered locally and/or regionally abundant (e.g., Arctic cisco and least cisco);
- They are not subject to specific management plans; and
- Their habitat requirements generally overlap with one or more of the sensitive species discussed above.

Some fish species ranked as 'sensitive' by RWED are occasionally found in the study area, but their range is typically outside of the study area (e.g., Arctic char whose nearest known population is in the Hornaday River east of the community of Paulatuk; Harwood 1999). Arctic cisco and least cisco are also 'sensitive' species, but are considered 'abundant' in the study area. Additional conservation measures for least cisco are that there should be no drilling in areas where they concentrate for spawning and migration and all oil-related activities should be closely monitored.

Arctic grayling are locally common in some clear upland streams, but only occur occasionally in the Mackenzie River which is often highly turbid. This species is particularly sensitive to cumulative effects of angling induced by access creation, but it not an important food or recreational species in the Beaufort Delta region (JS 2003). In the western Arctic, Arctic grayling are more common in groundwater springs on the Yukon North Slope and in most rivers to the east of the Mackenzie River. In these upland areas where oil and gas development overlaps Arctic grayling habitats, this species could provide a good indicator of cumulative effects.

2.3.4 Sensitive and Protected Features

All documented spawning and overwintering areas for fish (e.g., groundwater-fed pools in Fish Creek used by Dolly Varden char), as well as areas where fish concentrate for spawning or migrations, should be considered sensitive features that need protection from habitat degradation. Water quality and quantity are also important to fish and fish habitat and need to be protected. For example, although water usage in the lower Mackenzie River would not be expected to impact water quantity or fish habitat, even small water withdrawals during low flow periods from small perennial springs could impact important overwintering habitats used by fish.

2.3.4.1 Inuvialuit Settlement Region Category E Lands

Category E lands and waters identified in the Inuvialuit Community Conservation Plans are considered to contain lands or waters that are of extreme importance to fish and fish habitat (Figure 4). Development is not permitted in these areas and the lands and waters are managed to eliminate potential damage and disruption to the greatest extent possible. These Category E Lands that are protected for fishery-related concerns include:

- Mackenzie Bay and Shallow Bay within Beluga Management Zone 1a – This area provides: important overwintering areas for anadromous whitefish and cisco; and feeding and nursery areas for young fish.
- Fish Hole/Cache Creek and Big Fish River – These areas are west of Aklavik in a zone along both sides of Cache Creek and include Fish Hole, the riparian corridor associated with the Big Fish River, the Big Fish River watershed, and Canoe Lake. Although closed to fishing, the area was historically an important fishing area. It provides critical overwintering and spawning habitat for non-anadromous and anadromous Dolly Varden char.

2.3.4.2 Inuvialuit Settlement Region Category C and D Lands

Designated Category C and D lands (Figure 4) within the ISR also have fisheries-related concerns. Category C and D areas are lands or waters that are deemed to have renewable resources of particular significance or sensitivity during specific times of (Category C), or throughout (Category D), the year. These lands are managed to eliminate, to the greatest extent possible, potential damage or disruption. These are described in the Tuktoyaktuk, Inuvik and Aklavik Inuvialuit Community Conservation Plans and include the: Spring, Summer, Fall and Winter Fishing areas (Category C); Fish Lakes and River (Category C); Husky Lakes (Category D); Coastal Zones of the Tuktoyaktuk Peninsula; Liverpool Bay; Wood Bay and Baillie Islands (sub-divided into Categories C and D); the Central Mackenzie Estuary (Category D); the Inner Mackenzie Delta (Category C); and the Eastern North Slope, east of Babbage River (Category D).

2.3.4.3 Gwich'in Settlement Area Conservation Zones

The Gwich'in Land Use Plan designates lands where regulatory agencies may not issue licences, permits, or authorizations for a variety of new activities (e.g., oil and gas developments, mineral and aggregate extraction, transportation, power development). The eastern boundary of Conservation Zone A (Rat, Husky and Black Mountain) adjoins the Beaufort Delta study area (Figures 3 and 4). This area provides important spawning, rearing and nursing habitat for Dolly Varden char.

2.3.4.4 Gwich'in Settlement Area Special Management Zones

Special Management Zones in the GSA are lands and waters where a variety of land uses are possible, provided the conditions outlined in the Gwich'in Land Use Plan are met and the appropriate regulatory approvals are obtained. The Plan places additional conditions on uses that are designed to protect resources that are valued by the communities.

The Special Management Zones established to protect freshwater resources within (or partially within) the study area include: Stoney Creek; Peel River and Channel; Frog Creek and Lake; Campbell Creek; Campbell Hills; Mackenzie Islands; Rengleng River; Mouth of the Arctic Red River; Cardinal Lakes; Mackenzie River; and Arctic Red River (Figures 3 and 4).

2.3.5 Data Available

Digital data on sensitive and protected features, and ISR Management Zones, was obtained directly from the Joint Secretariat. The accuracy of this CCP GIS digital dataset was not determined in this study.

Digital Data for the Gwich'in Land Use Plan was received under a license agreement with Dillon and the Gwich'in Land Use Planning Board. The digital files were created in June 2002; the accuracy of this dataset was not determined in this study.

Information databases were also provided by RWED. RWED's NWT Species Infobase dataset was accessed through a data release and restriction agreement between Dillon and RWED. RWED also

provided a digital GIS database to Dillon with information related oil and gas exploration activities within the study area (i.e., seismic activity) after permission was obtained by the oil and gas companies (that had provided the information to RWED) so the data could be used for this project.

Due to the highly dynamic nature of river channels in the Delta, the GIS datasets provided to the consulting team failed to provide sufficient detail to show seasonally active channels, and appeared to only illustrate large channels with surface flow throughout the years. Consequently, the datasets provided did not allow some calculations to be made (e.g., stream crossing densities).

2.4 Nearshore Marine

The Mackenzie River freshwater plume influences physical and chemical conditions of the nearshore marine area. Sea ice is the dominant feature in the Beaufort Sea between mid-October and mid-June and three ice zones are commonly identified. The Grounded (Landfast) Ice Zone includes single year ice that is attached to the coastline and usually extends seaward to depths of 20 m by late winter. The Polar Pack zone includes multi-year ice that does not melt completely during summer. Shearing between the fixed landfast ice and moving pack ice occurs in the dynamic Transition or Seasonal zone; this varies in width depending on polar pack ice movements (Dome et al. 1982; North/South 2002).

The Nearshore Marine area defined for this study is restricted to the Grounded (Landfast) Ice or Mackenzie Shelf zone (Figure 1). Petroleum exploration and development and associated dredging is the only anticipated offshore land use, and most past and proposed activities are located in the grounded ice zone (ESL 1992). Vessel and aircraft traffic, offshore petroleum exploration and development, spills, and harvesting have the potential to cause cumulative effects on habitat and wildlife in the nearshore marine area.

2.4.1 Habitat

Bottomfast ice forms to a depth of about 2 m by late winter; this extends as much as 20 to 30 km from the delta front (Solomon 2003). Bottomfast ice areas provide fish and marine mammal habitat during the open-water season.

Floating ice is found between depths of 2 m and 15 m, and grounded ice between depths of 15 m and 20 m. The floating ice zone includes a comparatively warm band of brackish water (to water depths of about 10 m) that is present along the coast of the Beaufort Delta region because of summer heating of nearshore waters and inflow from the Mackenzie River and smaller watercourses. Small islands offshore the Mackenzie Delta and Tuktoyaktuk Peninsula provide summer habitat for waterfowl and winter polar bear denning habitat.

2.4.2 Marine Wildlife

The nearshore marine area is important for beluga (white) whale, waterfowl, and seabirds during the open-water period, for polar bear and seals during winter, and for fish throughout the year.

2.4.2.1 Beluga Whale

Beluga whales that concentrate in the Mackenzie River estuary during summer are part of a larger population that winters in the Bering Sea. This stock is hunted in three concentration areas (Shallow Bay, Kugmallit Bay, and East Mackenzie Bay) by Inuvialuit from Aklavik, Inuvik, and Tuktoyaktuk (FJMC 2001). These areas tend to be warmer, more turbid, less saline, and shallower than the rest of the estuary (North/South 2002). The hunting of belugas for use as human and dog food has a long history in this area (Harwood et al. 2000). Management direction for beluga whale habitat and harvest is provided in the Beaufort Sea Beluga Whale Management Plan (Beluga Management Plan; FJMC 2001).

A summary of recent Beaufort Sea beluga whale research and monitoring is provided in Norton and Harwood (2001). The Beaufort Sea stock size was estimated to be approximately 19,600 individuals in 1992 (Harwood et al. 1996). Hunter-based beluga monitoring programs conducted in the Mackenzie Delta since 1973 indicate that current harvest levels are sustainable (Harwood et al. 2000).

Beluga migrate through areas where oil and gas exploration activities have occurred and where petroleum production and transportation activities are proposed for the future. Such activities could affect beluga and beluga harvest either directly (e.g., underwater noise, oil spills) or indirectly (e.g., changes in salinity or integrity of ice, timing of break-up; LGL et al. 1984; FJMC 2001). The following guidelines for development activities are identified in the Beluga Management Plan:

- Protect beluga, beluga habitat, and beluga harvesting;
- Provide guidelines and information to assist [regulators] in their evaluation of development proposals which may affect beluga, beluga habitat, or beluga harvesting; and
- Provide guidelines to assist industry in preparing developmental proposals.

The Beluga Management Plan divides the Beaufort Sea into four management zones that reflect the intensity of management required. Guidelines provided for each zone are intended to provide specific guidance to managers and regulators in the evaluation of any development proposals. Zones include:

- Zone 1a: Traditional Harvesting/Concentration Areas;
- Zone 1b: Occasional or Potential Harvesting Areas;
- Zone 2: Mackenzie Shelf waters;
- Zone 3: Deeper Canadian waters; and
- Zone 4: International waters.

2.4.2.2 Seals

Ringed and bearded seals, reside throughout the year in the Beaufort Sea. Ringed seals are the most widespread mammal in the Beaufort Sea and are important in the marine food chain. They consume fish and invertebrates and are the main prey of polar bears. Bearded seals are much less common in this region. Both species use the sea ice platform during the late winter to early spring pupping and mating season, and sea ice is a critical habitat component. Coastal waters offshore of the Yukon appear to be important feeding areas in late summer when ringed seals tend to form large feeding aggregations (NMFS 2002a, b; JS 2003; www.taiga.net/wmac/researchplan/reports/seal.html; www.beaufortseals.com).

Research being conducted on ringed seal ecology, movements, and response to industrial activity in the southeastern Beaufort Sea is summarized at www.beaufortseals.com. Seal populations exhibit large natural fluctuations. Although the exact size of the ringed seal population in this area is not known, it is believed to be stable.

Late spring aerial surveys have shown that significant numbers of both species can be found basking on the ice in the area presently being considered for offshore gas exploration activity (www.beaufortseals.com). Some seals are harvested by residents of Tuktoyaktuk. Stakeholders have expressed concern that petroleum activities could reduce the size of ringed and bearded seal populations, although BEMP and BREAM concluded that open-water effects are unlikely (LGL et al. 1984; Axys et al. 1992). Climate change and oil spills were considered to be the primary cumulative effects concern for ringed seals in Alaska (NMFS 2002a, 2002b) and off the Alaskan North Slope (NRC 2003).

2.4.2.3 Polar Bear

Based on a status report prepared by Stirling and Taylor (1999), polar bear are listed as a species of 'special concern' by COSEWIC (2002). Polar bears in the Beaufort Delta area belong to the southern Beaufort Sea population consisting of about 1,800 animals; the population is thought to be stable or possibly slowly increasing. This population is harvested subject to a joint management agreement between the Inuvialuit and Alaskan Inupiat. Polar bear management is also subject to an agreement between the United States and Canadian governments and an international agreement (Stirling and Taylor 1999; Kavik-Axys and LGL 2001). Polar bear are highly valued for guided sport hunts and subsistence harvest.

Polar bear are most abundant in the Transition Zone where densities of seals are highest. The small islands offshore the Mackenzie Delta and Tuktoyaktuk Peninsula are thought to be suitable for maternity denning (reviewed in Kavik-Axys and LGL 2001).

Polar bear have a slow reproductive rate and are vulnerable to overharvest and changes in ice patterns caused by climate change (NRC 2003). Polar bears and harvest could be affected by: disturbance of pregnant females seeking or occupying offshore or coastal maternity dens; human-bear encounters leading to bear mortality; disturbance from industrial facilities and activities; changes in break-up patterns caused by ice breakers or artificial islands; and oil spills (LGL et al. 1984; Kavik-Axys and LGL

2001; NRC 2003). Climate change and oil spills are considered to be the primary cumulative effects concerns (NRC 2003).

2.4.2.4 Fish

The band of warm, fresh to brackish water in the nearshore marine area is biologically important to freshwater, anadromous, and marine fish species. The most common freshwater and anadromous fish species that use the nearshore marine area are broad whitefish, lake whitefish, Arctic cisco, least cisco, and inconnu (a.k.a. coney). Common marine species include Pacific herring, saffron cod, Arctic cod, and rainbow smelt.

Depending on wind direction, speed and duration, coastal upwellings can occur which may disrupt the continuity of the freshwater band and associated habitat for freshwater and anadromous species. During winter, freshwater and anadromous fish overwinter in coastal rivers and deltas, while marine species move into deeper offshore waters (Sekerak et al. 1992; Kavik-Axys and LGL 2001; North/South 2002). Whitefish, cisco, and herring are important components of subsistence harvest (JS 2003).

Fish in nearshore marine areas could be affected by dredging, petroleum exploration and production islands and structures, water intakes, discharges from vessels and production facilities, and increased harvest (LGL et al. 1984; Axys et al. 1992).

2.4.2.5 Waterfowl and Seabirds

Areas of the outer Mackenzie Delta support high densities of nesting, brood-rearing, moulting, and staging waterfowl, gulls, terns, and shorebirds (reviewed in Kavik-Axys and LGL 2001). Nearshore marine areas are used during spring and fall staging and summer moulting. More than 100 species of birds have been recorded, including several species of concern ('Endangered' - Eskimo curlew; 'Special Concern' - Ivory gull; and 'Threatened' - Ross' gull; North/South 2002).

The KIBS was established in the outer Delta in 1961 to protect the staging and breeding grounds of many waterfowl species, particularly Lesser Snow Geese. The sanctuary is 600 km^2 and includes many flat islands, as well as a portion of Kendall Island.

Moulting and staging waterfowl and seabirds could be affected by aircraft overflights, vessel traffic, facility and flare noise, and oil spills (LGL et al. 1984; Axys et al. 1992; Kavik-Axys and LGL 2001).

2.4.3 Sensitive and Protected Features

Designated sensitive and protected features in the nearshore marine zone are shown in Figure 3 and land use planning zones are shown in Figure 4.

Beluga Management Zone 1 areas are considered sensitive or specialized nearshore marine areas because they are to be managed as protected areas (FJMC 2001). As part of the Beaufort Sea Integrated Management Planning Initiative (BSIMPI), the Inuvialuit, DFO, and industry have agreed to work

together to change the designation of Zone 1(a) waters to 'Marine Protected Areas' under the federal *Oceans Act* (Figures 3 and 4).

Other unique nearshore marine features in the Beaufort Delta region include polar bear denning habitat on small islands offshore the Mackenzie Delta and Tuktoyaktuk Peninsula and the KIBS in the outer delta (Figure 3).

In additional to the above described areas, there are also Category C and D areas which have been identified in the Tuktoyaktuk, Inuvik, and Aklavik Inuvialuit Community Conservation Plans due to their importance to marine wildlife. Category C and D areas are lands that are deemed to have renewable resources of particular significance or sensitivity during specific times (Category C), or throughout the year (Category D). These include the: Spring and Fall Seal Harvesting areas (Category C); Spring, Summer, and Fall Goose Harvesting areas (Category C); Winter Seal and Polar Bear Harvesting areas (Category C); Mainland Coastal Polar Bear Denning Areas (Category C); Kugaluk River Estuary (Category D); and Coastal Zones of the Tuktoyaktuk Peninsula, Liverpool Bay, and Wood Bay and Baillie Islands (Categories C and D). These lands are managed to eliminate, to the greatest extent possible, potential damage or disruption (Figure 4).

2.4.4 Data Available

No digital land use or habitat base data for the nearshore marine area were located. Digital data on sensitive and protected features and marine wildlife was obtained from directly from the ISR Joint Secretariat. The accuracy of this GIS digital dataset was not validated for this study.

Physical and habitat information is available in a numerous hard copy and electronic reports, of which the most integrated version is the 'Environmental Atlas for Beaufort Sea Oil Spill Response' (Dickins et al. 1987). Relevant references are cited throughout this reports and full citations and/or internet locations are provided in Section 9.

Digital data on petroleum exploration features and other disturbance features was obtained from the Northwest Territories Digital Atlas published in September 2002 by the World Wildlife Fund. No efforts were made to determine the accuracy of this dataset. This was supplemented by a spreadsheet provided by the NEB that contained locations of existing oil and gas exploration wells in the study area, and datasets on the National Energy Board Interactive Mapping Tool (http://216.58.105.202/map.htm).

2.5 Socio-Cultural

The Beaufort Delta region is the traditional home to the Gwich'in and Inuvialuit, who are two of the most northerly aboriginal peoples in North America. The traditional lands of the Gwich'in extend east from the interior of Alaska, through the Yukon, and into the Mackenzie valley. Residents of the study area continue to maintain close cultural ties to other Gwich'in people in other regions. Gwich'in culture is closely tied to the land and caribou, moose, whitefish, and furbearers, and all are important both culturally and economically. The traditional lands of the Inuvialuit include coastal and adjacent inland areas of the Beaufort Sea and Amundsen Gulf, as well as the western edge of the Arctic Islands, including Banks and Victoria islands. At the time of European contact, the Inuvialuit were divided into six distinct tribal groups, each with its own main village. Inuvialuit culture is rooted in the land and water, and caribou, whales, seals, fish, and muskox providing food, clothing, and other necessary materials (Beaufort-Delta Self Government, n.d.).

Like other northern regions, communities within the Beaufort Delta have mixed, subsistence-based economies in which the harvesting of traditional foods is important for food, income, and culture (Usher 2002; Usher et al. 2003). The contemporary mixed economy includes both a subsistence-based economy based on whaling, hunting, fishing, and gathering[1], and a market economy that provides wage employment. The two economies not only co-exist within the community, but also within individual households (Staples 1997; Usher et al. 2003). In other words, rather than the creation of class-divided communities, most households integrate the procurement of country food with wage labour and commercial production (Usher et al. 2003).

Northern people are adaptive and may actively choose to participate in both the cash economy and subsistence activities (Freeman 2001; NRC 2003). This flexibility has allowed the mixing of economies since the introduction of trading and whaling more than 100 years ago (Hart 2001; Hart and Amos 2004). During the 1950s and 1960s social scientists argued that hunting and gathering and associated lifestyles would disappear as more commercial products and wage employment became prevalent (Murphy and Steward 1956; Graburn 1969). Trapping, which anchored the economy for the first half of the twentieth century, is now a small contributor to the regional economy (GLUPB 2003). The importance of subsistence fishing has declined in recent years, in part because of a decline in the number of people who keep dog teams. Traditionally, fish was fed to dogs (MRBB 2004). Nonetheless, harvesting continues to be a widespread and valued activity (Freeman 2001; Usher 2002).

Fur trading and whaling introduced epidemics of influenza, tuberculosis, measles, and other diseases that caused dramatic population changes. Over the last fifty years residents have attempted to adapt to

[1] These include: beluga whales, bowhead whales, caribou, geese and ducks (snow geese, white-fronted goose, brant, Canada goose, widgeons, mallards, scoters, pintail, oldsquaw), gulls, polar bears, ringed seals, bearded seal, broad whitefish, least cisco or lake herring, humpback or lake whitefish, Arctic cisco (herring), inconnu, pacific herring, lake trout, lake trout, Arctic char, sculpin, sucker, northern pike, northern pickerel, rock cod, flounder, loche, Arctic grayling (Hart and Amos 2004).

ongoing significant changes to the socio-cultural and economic environment (Freeman 2001; Beaufort-Delta Self-government 2004; IRC 2004). The dual economy – and introduced churches, residential schools, and government programs – have created 'boom and bust' cycles in the area (e.g.: Distant Early Warning line construction in the 1960s; onshore oil and gas exploration in the 1970s; and offshore oil and gas exploration in the 1980s). Each of these new economic activities brought increased income and new skills, however, all have been short-lived.

One of the most disruptive policies was the removal of young people from their families to attend residential schools where aboriginal language and culture were not allowed. As a result, several generations were not socialized in their own cultures or communities; consequently, they lacked the parenting skills to raise a family. According to the both Gwich'in and Inuvialuit representatives at the Inuvik ESRF October 2004 workshop, this experience underlies many of the social problems in the region (Dillon and Salmo 2004b – Appendix II).

Another external influence affecting Beaufort Delta communities was the environmental/animal rights movement. This affected fur markets, contributed to the difficulties currently experienced by fur trappers, and continues to threaten indigenous whaling (Freeman 2001: Beaufort Delta Self-government 2004; IRC 2004; NWT CIMP 2004a,b; Gwich'in Self Government Report). As shown in Table 2, both trapping and whaling continue to be culturally significant activities (e.g., there has been a ten percent increase in the number of people who earn income from trapping over the last decade). Freeman (2001) discusses the continual importance of whaling to the Inuvialuit.

Northern aboriginal communities in the Beaufort Delta are said, once again, to be under great pressure to adapt. Currently, the area is poised for major developments with the proposed natural gas production and associated Mackenzie Valley Pipeline. Based on past experience, it is likely that the proposed petroleum development will provide training and employment for some local people, but local communities have a number of concerns that include: increased crime; increased substance abuse associated with increased wages and exposure to the 'rig pig' culture; and the impacts associated with large numbers of transient workers to the region.

On the other hand, given that both the Gwich'in and Inuvialuit are participating directly in proposed petroleum development through the Aboriginal Pipeline Group, it is likely that capacity building will increase at least in terms of training. Several interviewees and participants in the October 2004 workshop also noted that land claims settlements had provided residents with more direct involvement and participation in decision-making for activities taking place within their settlement areas. Through Land Claim Agreements, the Inuvialuit and Gwich'in have increased their authority over at least some of their traditional lands.

Table 2 Statistical data for Beaufort Delta study area communities.

Statistic [1]	Aklavik	Fort McPherson	Tsiigehtchic	Tuktoyaktuk	Inuvik	NWT
Population size (2003)	656	808	207	909	3,435	
Traditional Activities						
% of population who continue to hunt and fish - 2003	49.3%	37.4%	44.1%	56.9%	32.6%	36.7%
% of population who consume country food – 2003	56.9%	78.1%	60.2%	71%	30.1%	28.4%
% who earned from trapping – 1993/2003	7.9% 21.1%	12.8% 12.9%	19.0% 13.8%	13.4% 8.4%	6.9%/ 7.2%	5.9%
% who earned from Arts and Crafts – 1993	17.7%	16.9%	17.0%	17.0%	9.7%	
% of aboriginal population who speak mother tongue - 2004	19.0%	22.7%	24.2%	28.3%	17.6%	44.0%
Education and Employment						
Labour force participation rate - 2004	42.5%	57.1%	63.4%	62.1%	80.9%	75.6%
% of population with high school or post-secondary education	37.6%	38.0%	42.8%	36.6%	73.1%	67.5%
% of population with at least high school who are employed	66.7%	64.7%	79.0%	65.6%	85.7%	81.7%
% of employed population with > than high school	28%	15.7%	25.3%	32.9%	46.2%	38.8%
Income						
Average household income in 2002	$51,141	$57,248	$45,760	$58,733	$85,280	$87,143
% of households with <$25K income in 2002	35.3%	28.6%	40%	29.2%	16.3%	15.3%
% of households with >$60K income in 2002	29.4%	33.3%	nd	33.3%	58.7%	59.9%
Average personal income 2002	$25,137	$26,971	$24,673	$29,933	$43,829	$42,047
Housing – 2004 Survey						
% of households with >6 people in 2004	10.5%	14.5%	13.3%	16.1%	6%	7%
% of households in core need of housing in 2004	32.3%	32.7%	30.1%	31.9%	13.1%	16.3
Suicides – 2001 survey						
Number of suicides in 2001	2	1	0	3	0	8
Crime - 2003 survey						
Property Crime Rates per 10,000 persons	1,204	1,374	nd	1,162	949	679
Violent crimes per 10,000 person	869	1,300	nd	1,505	859	722

[1] – Source: NWT Bureau of Statistics 2004. Combination of data from three summaries: 2004 NWT Socio-Economic Scan 2004a; Statistics Quarterly 2004b; and Northwest Territories 2004c. Most recent figures provided for categories (i.e., 2002 unless indicated otherwise).

People continue to gather, in the their home, at community events and on the land to tell stories drawing strength as they hunt, fish, trap, collect medicine plants and berries. Each of these activities includes a spiritual connection to the land and a reciprocal responsibility.

2.5.1 Community

Currently, Métis, Dene, Inuit from other regions, and non-native people reside in most of the communities along with the Inuvialuit and Gwich'in. Métis people are descendents of fur traders and the Saami reindeer herders who brought herds to the Inuvialuit area (Hart 2001). People in Inuvik tend to be sojourners from local communities employed by governments and businesses.

Aboriginal people residing within the Beaufort Delta region continue to engage in both traditional activities and wage employment when it is available. Between the four smaller communities, 46.9% of the population hunts, and fish provide 66.5% of the population with country food and materials to produce traditional clothing and art. Art and handicraft sales provide income for just over 17% of the population. Reindeer were brought to the region in the early part of this century and there is still private reindeer herding enterprise. According to available statistics, Inuvik has few people harvesting (Table 2); however, individuals return to their home community to participate in harvesting activities.

Table 2 shows the percentage of individuals with high school or post-secondary education and employment is higher in Inuvik than the rest of the NWT and significantly higher than the other communities in the study area. Likewise 46% of those residing in Inuvik with less than high school are employed, compared to fewer than 39% in other parts of the NWT. It is interesting to note that there has not been a substantial increase in the percentages of individuals with high school education or with employment over the last 13 years for which the GNWT has statistics (42.5% in 1991 vs. 45.6% in 2004; Beaufort-Delta Self Government, n.d.; NWT Bureau of Statistics 2004).

Average family income in the study area was $59,632 in 2002, with Inuvik households averaging the highest (i.e., $85,280); and Tsiigehtchic households averaging the least at $45,760. The average household income of $55,220 in the four smaller communities is substantially lower than the Territorial average of $87,143, whereas the percentage of individuals hunting and fishing and providing country food to the population is significantly higher when compared to the overall NWT average. Although the consumption of country food lowers cash requirements to purchase imported food, the regional Food Price Index of 155 is much higher than in Yellowknife (100). This is particularly true in Inuvik where harvesting and consumption of country food is lowest (Table 2).

In 2004, 22.4% of the aboriginal population in the study area spoke an aboriginal language, which is almost half the overall NWT average of 44%. The number of aboriginal speakers has dropped by half over the last 20 years (from 41.9% to 19.5% of the aboriginal population).

Throughout the study area, 28.2% of households are in need of housing, compared to 16.3% in the NWT. Although statistics indicate that Inuvik has less stress on the housing market, community representatives at the October 2004 workshop stated that their community has a serious housing problem.

Communities in the Beaufort Delta region display more symptoms of community stress when compared to the Territorial average. Although the causes of suicides are unknown, the Beaufort-Delta region experienced five of the eight suicides for the last year (2001) that the NWT Bureau of Statistics released data. The study area also has significantly more violent and property crimes, with 1,158[2] violent crimes per 10,000 and 1172[2] property crimes per 10,000, compared to the overall NWT averages of 679 per 10,000 and 722 per 10,000, respectively (2003 figures).

The historical demographics of the five communities in the study area are discussed below.

2.5.1.1 Aklavik

Aklavik, with a population of 656 people in 2003 (NWT Bureau of Statistics 2004) is located on the Peel Channel of the Mackenzie Delta about 100 km from the Beaufort Sea. Traditionally, the Inuvialuit and Gwich'in met in this location to resolve issues of land use and to share resources. Relationships are cordial and it continues to be an important location for the Inuvialuit, Ehdiitat Gwich'in as well as Métis. In the early 1920s, it became the Delta trading post and was the government and commercial centre in the western Arctic.

In the late 1950s, the federal government became concerned that Aklavik would be washed away by flooding and melting permafrost and created Inuvik as the place for relocation. Many people, however, remained in Aklavik. Eventually the government provided the community with a school and health clinic, and a handicraft workshop was built contributing to the revival of its economy.

Today, local businesses in Aklavik include a bed and breakfast and a store. The cash economy is provided by wage employment by government, local stores and community administration and services. Aklavik is an excellent trapping area with the percentage of active trappers almost tripling in the last decade (Table 2). Oil and gas exploration has stimulated some employment and business development in recent years (GNWT Community Survey; Beaufort-Delta Self-Government n.d.).

Aklavik people have access to major health services in Inuvik. There are scheduled daily flights from Inuvik. Travel is by boat and air in summer. In winter, people can fly or can drive on the ice road that is open for about three months. Snowmobiles are important for travel, hunting and fishing.

Table 2 provides current demographic information for traditional activities, education, employment, income, housing, and crime and suicide rates. Additional information is available through the GNWT Bureau of Statistics 2004.

[2] This number does not include the figures for Tsiigehtchic, which are not available.

2.5.1.2 Fort McPherson (Tetl'it Zheh)

Fort McPherson is located on the Dempster Highway about 120 km south of Inuvik - an hour and half drive. Fort McPherson was originally established as a trading post in 1840 and then became a missionary outpost in 1860. In 1903 an RCMP detachment post was built (Beaufort-Delta Self-Government n.d.; GNWT Community Survey).

Traditionally, the Tetlit Gwich'in moved between the Richardson Mountains and the river valleys to hunt caribou and moose and to fish, particularly for whitefish. They also have an extensive hunting area in the Yukon. Since the mid-1800s the economy has been mixed with the current economy based on hunting, trapping and oil exploration (Beaufort Delta Self-government n.d.). Wage income also comes from the local Co-op store and gas bar. The McPherson First Nation has a road contract with GNWT to maintain the road from the Mackenzie River to the summit of the Dempster Highway. Other employment includes the school, nursing centre, cultural centre, band and hamlet offices, the local Co-op and Gas Bar stores, and the community-operated McPherson tent and canvas shop that employs about 15 people.

In 2003 the population of Fort McPherson had dropped to 808 people, consisting primarily of Tetlit Gwich'in; approximately 100 people in the community are either non-aboriginal, Métis, or Inuvialuit. A language and cultural centre was established in 1988. At the time, people estimated that only 17 local speakers of Gwich'in were left — mainly elders. A recent survey by the GNWT found an increase of aboriginal speakers to almost quarter of the population. The language and cultural centre provided the motivation for reclaiming the language and some of the centre staff have developed curriculum for the school which now has an immersion program in Gwich'in.

2.5.1.3 Inuvik

Inuvik is the largest community in the region, with a population of 3,435 with 40% Inuit[3], 20% Dene, and 40% non-aboriginal people. The federal government built Inuvik as the regional centre in the late 1950s replacing Aklavik as the centre and providing most of the services: a regional hospital, RCMP headquarters, bank, schools and post office. Inuvik is the shopping centre for surrounding communities and a winter festival is held there annually. It has hosted an internationally renowned arts festival for the last decade. Inuvik is also the communication hub and a staging area for petroleum exploration in the study area (NWT Bureau of Statistics 2004).

Inuvik is the communication, business and government centre for the region. The town has several stores and a variety of services including a library with public internet facilities, and natural gas service from a nearby reservoir. The airport has three main airlines and a variety of independents that fly charters and transport people and goods to the outlying communities and the rigs. Offices of many aboriginal and co-management bodies established by the Inuvialuit and Gwich'in land claims are located in Inuvik.

[3] Probably a large percentage are Inuvialuit, however, statistics do not indicate percentages.

Inuvik has a mixed economy, but to a lesser degree than other communities in the region (Table 2). The Inuvialuit, Gwich'in and Métis residing in Inuvik tend to be transient in the sense that they return to their own communities for hunting and fishing and for important cultural events. Their basic social roots remain with extended families in their communities of origin.

2.5.1.4 Tsiigehtchic

Tsiigehtchic is a small community on the banks of the Mackenzie River at the mouth of the Arctic Red River. The permanent community was constructed at a traditional fishing location and fishing camps continue to be used along the rivers. Tsiigehtchic was also a spring gathering place where people traditionally gathered to dance, play drum games and tell stories about their winter out on the land. Many of these activities continue.

The 207 people who live here are known as the Gwich'a Gwich'in and speak a slightly different dialect of Gwich'in that is mutually understood by other speakers. Residents have a mixed economy with an emphasis on hunting, trapping and fishing.

Tsiigehtchic has the highest percentage of households earning less than $25,000 in the study area. Information is not available for the percentage over $60,000; however, it is assumed that the percentage is lower than for other communities in the region.

The community has a church, a school and a health centre that provides some wage income. Several people work in Inuvik and return to the community on the weekends. A few residents were employed with the offshore exploration sector during the 1980s. The community has a store, but no airport so people traveling there must fly to Fort McPherson or Inuvik, and then travel by road to the community. Residents also travel extensively by boat in the summer.

The Gwich'in Social and Cultural Institute headquarters is located here and employs three local people. The Institute has been quite active in producing a series of elders' stories especially associated with Gwich'in place name and plants, as well as a dictionary (Kritsch and Andre 1998).

2.5.1.5 Tuktoyaktuk

This community is located at Kugmallit Bay on the Beaufort Sea, east of the Mackenzie Delta. Tuktoyaktuk is the oldest and largest Inuvialuit community with a population of 990 people. After the loss of many people due to diseases brought to the area by American whalers between 1880 and 1910, many Alaskan Dene and Inupiat settled in Tuktoyaktuk. Currently, its inhabitants are primarily Inuvialuit with a few Dene and Métis also residing there. In 1928, Herschel Island residents were relocated to Tuktoyaktuk where more services were available. A freight office was opened in the late 1950s to handle the freight going to the Distant Early Warning-Line (DEW Line) stations operated by the US Army (Beaufort-Delta Self-government n.d.).

Traditional activities included beluga whaling, caribou hunting, fishing, and trapping. In recent decades, the community has experienced more wage employment and business opportunities from hydrocarbon

exploration activities and development of a port facility with industrial camps in the 1980s. These activities continue to be important, but fewer people engage in them. Like other communities, people are employed at the stores, school and health centre. As Table 2 shows, more Tuktoyaktuk residents are involved in the making and selling of arts and crafts than in the other communities.

The local economy is mixed; however, it has the highest proportion of residents that both harvest (56.9% continuing to hunt and fish) and consume country food (71% of the households consume country food) in the region. Yet they maintain participation in the labour force on par with the smaller communities in the region. Tuktoyaktuk also has the highest ratio of aboriginal speakers (NWT Bureau of Statistics 2004).

Social well-being indicators (crime and suicide rate) suggest that community residents suffer more stress than other regional residents. Tuktoyaktuk experienced three of the eight suicides in the NWT during 2001. Tuktoyaktuk also seems to experience greater violent crimes and property crimes than other communities in the region. During 2003 they experienced a violent crime rate of 1,505 and a property crime rate of 1,162 per 10,000 persons compared to the overall NWT crime rates, respectively, of 679 and 722 per 10,000 persons during the same period (NWT Bureau of Statistics 2004).

2.5.2 Data Available

Population data for communities in the Beaufort Delta region was accessed from several key sources. These included the following surveys, estimates, and/or databases from the:

- GNWT Bureau of Statistics (www.stats.gov.nt.ca):
  - 2004 NWT Community Survey;
  - 2002 NWT Alcohol and Drug Survey;
  - 2002 NWT Population Survey;
  - 2002 Regular Employment and Harvesting;
  - 2000 NWT Housing Needs Survey;
  - 1999 NWT Labour Force Survey;
  - 2004 NWT Socio-Economic Scan;
  - Employment and unemployment estimates (since 1984);
  - NWT crime and justice estimates; and
  - National Population Health Survey;
- Department of Health and Social Services:
  - NWT Health Status Report 1999;
  - NWT family violence data base (since 1987); and
  - NWT suicide database;
- Energy, Mines and Resources Secretariat, 1986:
  - Beaufort Region Cumulative Monitoring Indicator Catalogue; and
- Statistics Canada; and
  - National Population Health Survey.

- Regulatory Regime

2.5.3 Inuvialuit Settlement Region

2.5.3.1 Environmental Impact Screening and Review Process

Under the terms of the Inuvialuit Final Agreement, the Environmental Impact Screening Committee screens all development proposals on Crown lands within the ISR to determine if there is potential for significant negative environmental impact (see Appendix I). Projects in the offshore are also screened by the Environmental Impact Screening Committee, in response to a request from the Inuvialuit Game Council. Projects which may have significant negative impact are referred to the Environmental Impact Review Board (EIRB) or other equivalent environmental review processes for a public assessment and review. The EIRB has the authority to conduct a detailed public review and make recommendations to the competent governmental authority, with respect to proposed developments.

Support for the Environmental Impact Screening Committee and EIRB is provided by the JS.

2.5.3.2 Inuvialuit Land Administration

The Inuvialuit Land Administration (ILA) manages and administers access to Inuvialuit 7(1)(a) and 7(1)(b) lands. Although they may also be referred to the Environmental Impact Statement Screening Committee by the Inuvialuit, development proposals on private lands are screened by the ILA.

All applications submitted to the ILA are distributed to the local Hunters and Trappers Committees (HTCs) and Community Corporations for review and comment. Final approval of applications is made by the ILA Committee who generally will not grant permits without the support and approval of the HTC and Community Corporation. ILA has the authority to attach a variety of conditions on development proposals on Inuvialuit 7(1)(a) and 7(1)(b) lands to ensure that land and resources are not harmed and that the Inuvialuit benefit. Further information is available in the ILA 'Rules and Procedures'.

2.5.3.3 Co-management Bodies

The Inuvialuit Final Agreement created three new co-management bodies: the Wildlife Management Advisory Council (NWT) (WMAC (NWT)), the Wildlife Management Advisory Council (North Slope) (WMAC (NS)), and the FJMC. The WMAC (NWT) provides advice to appropriate government ministers and Inuvialuit agencies on all matters relating to wildlife policy and the management, regulation and administration of wildlife, habitat and harvesting in the NWT portion of the ISR. The WMAC (NWT) also advises government on wildlife-related issues of park planning and management. The WMAC (NS) fills a similar role as the WMAC (NWT), however, its focus is on the Yukon North Slope. In addition to providing advice to government ministers, the WMAC (NS) is also expected to provide advice to the Porcupine Caribou Management Board, the EIRB and other groups. The FJMC assists Canada and the Inuvialuit in a similar fashion, managing the area's marine mammals and marine and freshwater fisheries. The FJMC also coordinates delivery of the HTC registration system for fishing by non-beneficiaries on private land.

The Inuvialuit Final Agreement created the Inuvialuit Game Council and provided for the creation of a HTC in each of the six Inuvialuit communities. The Inuvialuit Game Council is intended to represent the collective or entire Inuvialuit interest in wildlife and to advise the government, often through the WMAC (NWT) and the FJMC. The HTC is, among other things, responsible for local resource allocation and is expected to encourage and promote Inuvialuit involvement in conservation, research, management, enforcement and utilization.

Support for these organizations is provided by the JS.

2.5.4 Gwich'in Settlement Area

2.5.4.1 Co-Management Bodies

The Gwich'in Land and Water Board, Mackenzie Valley Environmental Impact Review Board, Gwich'in Land Use Planning Board, and GRRB are co-management bodies established by the Gwich'in Land Claim.

The Gwich'in Land and Water Board (GLWB) is a regional panel of the Mackenzie Valley Land and Water Board (MVLWB) that is responsible for the management of land and water use, and the deposit of waste into waters, in the GSA. They issue, amend, or renew land use permits and water licences on government lands (crown land) and on Gwich'in Settlement Lands.

The Mackenzie Valley Environmental Impact Review Board (MVEIRB) is responsible for environmental and socio-economic assessment and public review of developments throughout the Mackenzie Valley. If a proposed development may have significant adverse environmental impacts, or is of public concern, it is referred to the MVEIRB for an environmental assessment. In the GSA, a proposed development can be referred to the Review Board by the Gwich'in Tribal Council (GTC), local government or a department or agency of the federal or territorial government if the development will have an impact within their boundaries, as well as by the regulatory group involved such as the GLWB.

The socio-economic mandate of the MVEIRB is broader than that of most review bodies, and it is charged with considering any "impact on the environment …as well as on wildlife harvesting, and includes any effect on the social and cultural environment or on heritage resources" (Canada 1998: 36).

The Gwich'in Land Use Planning Board is responsible for developing, reviewing proposals for exceptions and amendments to the Gwich'in Land Use Plan which was approved by the Government of Canada, the GTC, and the GNWT in 2003. The Board is also responsible for implementing and monitoring the Plan, including reviewing it every five years.

The GRRB is the main group dealing with wildlife, fish and forests in the GSA. Their role is to conduct research and propose policies to protect wildlife and wildlife habitat, as well as Gwich'in harvesting

rights on the land. The GRRB works with Gwich'in community groups (Renewable Resource Councils or RRCs) to manage wildlife, fish and forests.

The GRRB conducts wildlife, fish and forest research and the Gwich'in Harvest Study. They are currently working to develop wildlife management plans and a forest management plan for the GSA.

2.5.4.2 Gwich'in Tribal Council Land Administration

The GTC has lands staff that focus on the administration and management of Gwich'in owned private land. The GTC Land Administration Department also reviews and comments on land use and water applications issued through the GLWB, the Yukon Lands Division, and comments on environmental reviews conducted by the Yukon Environmental and Socio-economic Assessment Board.

The GTC Land Administration has developed the Land Management and Control Guidelines including a fee schedule to assist with the administration and management of Gwich'in private lands. Pit Management Plans have also been developed for Gwich'in owned quarries. Lands Administration staff process authorizations or leases for use and/or access to private lands for: commercial and residential leases; seismic activities; type II research; oil and gas exploration; tourism; grazing; rights-of-way; campsites; and commercial timber harvesting.

2.5.5 Federal Agencies

Several federal agencies regulate activities on Crown lands within the ISR and GSA or issue permits required by federal legislation. These include: DIAND, who regulates land use; DFO, who regulates activities that could affect fish and fish habitat; and, EC, who manages activities that could affect migratory birds, species at risk, federal habitat areas, and offshore waste disposal.

3 INTEGRATED CUMULATIVE EFFECTS FRAMEWORK

Management of cumulative effects is largely focused on defining where and how human activities can be continued without irreversible impacts on the environment and human systems. Experience in western and northern Canada and elsewhere (Axys 2000; Axys et al. 2003; Macleod 2002; Salmo et al. 2003, 2004; MSRM 2004) suggests that the most practical approach to assess and minimize cumulative effects is to adopt a management framework that focuses on a suite of complementary 'Valued Components' and associated 'indicators' linked to pre-defined 'thresholds' or 'Limits of Acceptable Change' (Figure 5). These frameworks provide specific guidance for project planning and assessment that also supports longer term resource monitoring, management and reporting.

Figure 5 Integrated cumulative effects assessment and management framework that links management objectives with measurable indicators and targets that can be measured at the local or operational level.

This section describes aspects of Management Objectives, Valued Components, indicators, and thresholds or Limits of Acceptable Change most relevant to cumulative effects assessment in the Beaufort Delta region.

The emphasis of this study is consistent with the mandate of the ESRF, namely on local or operational level tools that would improve project assessment, decision-making, and program implementation for petroleum development. The project review or environmental impact assessment (EIA) processes described earlier in Section 2.6 take cumulative effects into account when recommending approval or rejection of projects or activities and may suggest measures to mitigate these effects. EIA is, therefore, a key component of a cumulative effects management framework – for some recent proposals, the EIA process has become the focal point for cumulative effects issues (Kavik-Axys 2002a).

In reality, such local or operational level tools must be linked to cooperative strategic or regional cumulative effects management initiatives if they are to successfully deal with cumulative effects. This is because management of cumulative effects is normally beyond the control of project proponents and involves the mandates of multiple regulators and agencies. The use of common Valued Components, indicators, and thresholds is thought to be the best way to establish explicit and consistent links between the local and regional levels and thereby coordinate activities.

3.1 Management Objectives

Management objectives are defined here as "regional statements of desired environmental and social conditions". These help guide regulators, managers, and service providers by providing a '*vision*' of desired outcomes. This vision is used to establish Limits of Acceptable Change and thresholds.

3.1.1 Inuvialuit Settlement Region (ISR)

Management objectives for the ISR are provided in the *Western Arctic Claims Settlement Act* (Inuvialuit Final Agreement or IFA) and Inuvialuit Community Conservation Plans. These include:

1. All land uses in the ISR must recognize conservation of the renewable resource base as the foremost priority;
2. All parts of the environment are interconnected, so they must be managed together. Conservation, stable economic development, and sound resource management can only be achieved if all parties work toward a common goal;
3. Renewable and non-renewable resource development in the ISR should be of maximum benefit to community residents;
4. Priority activities to be protected in the ISR are hunting, fishing, trapping, tourism, and arts and crafts manufacturing; and
5. The Inuvialuit place a high priority on maintaining air and water quality and the health of the resources.

Inuvialuit Community Conservation Plans translate these objectives into five land use categories:

- **Category A**: lands and waters where there are no known significant and sensitive cultural or renewable resources. Lands and waters shall be managed according to current regulatory practices;
- **Category B**: lands and waters where there are cultural or renewable resources of some significance and sensitivity, but where terms and conditions associated with permits and leases shall assure the conservation of these resources;
- **Category C**: lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year. These lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption;
- **Category D**: lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year. As with Category C, these lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption; and
- **Category E**: lands and waters where cultural or renewable resources are of extreme significance and sensitivity. There shall be no development on these areas. These lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption. This category recommends the highest degree of protection in this document.

3.1.2 Gwich'in Settlement Area

Management objectives for the GSA provided in the Gwich'in Comprehensive Land Claim Agreement (Gwich'in Land Claim), and the Gwich'in Land Use Plan (GLUPB 2003) include:

1. Protecting and enhancing the existing and future social, cultural, and economic well-being of the Gwich'in;
2. Protecting and conserving the wildlife and environment of GSA for present and future generations; and
3. Integrating planning and management of wildlife and wildlife habitat with the planning and management of all types of land and water use in the GSA.

The Gwich'in Land Use Plan translates these objectives into three land use categories:

- **General Use Zones**: areas where all land uses are possible with the necessary approvals from the current regulatory system. This zone of the Land Use Plan imposes no conditions for proposed uses and activities in these areas;
- **Special Management Zones**: areas where all land uses are possible as long as conditions outlined in the Land Use Plan are met and approvals through the regulatory system are obtained. The additional Land Use Plan conditions are designed to protect valued resources identified by communities or other organizations during the planning process. The conditions

are tailored to address local concerns and the local environment. Regulatory authorities may not issue a license, permit, or authorization in Special Management Zones unless the proposed use is in conformity with the Gwich'in Land Use Plan. This zone places no restrictions on traditional uses protected by the Gwich'in Land Claim; and

- **Conservation Zones / Heritage Conservation Zones**: lands where the following new uses, and activities relating to these uses, are not permitted, and regulatory agencies may not issue a permit for these activities:
  - Oil and gas exploration and development;
  - Mineral exploration and development requiring a permit;
  - Sand, gravel, and rock extraction;
  - Transportation;
  - Waste disposal;
  - Communication;
  - Power development; and
  - Commercial renewable resource activities.

The Gwich'in Land Use Plan was developed from community input and is subject to review every five years. Any changes are subject to community involvement and cumulative effects assessment information can be added during these reviews as it becomes available.

3.1.3 Other Cumulative Effects Initiatives

Ongoing cumulative effects initiatives were also considered for the Beaufort Delta region cumulative effects management framework. Participants at the October 6, 2004 Inuvik workshop indicated that a successful framework should build on, not replace, other existing or proposed initiatives (Dillon and Salmo 2004b – Appendix II).

3.1.3.1 NWT Cumulative Effects Assessment and Management Strategy and Framework

The NWT Cumulative Effects Assessment and Management Strategy and Framework consists of nine linked components necessary for managing cumulative effects. These components are:

1. Vision and objectives;
2. Land use planning (e.g., Gwich'in Land Use Plan and Inuvialuit Community Conservation Plans);
3. Baseline studies and monitoring [e.g., NWT CIMP and West Kitikmeot Slave Study (WKSS)];

4. Research (e.g., WKSS and ESRF);
5. Audit and reporting (e.g., MRBB State of the Aquatic Ecosystem Report);
6. Project-specific screening, environmental assessment, and review;
7. Regulation and enforcement (e.g., co-management bodies; Inuvialuit Land Administration, Gwich'in Land Administration, NEB, DIAND);
8. Information management; and
9. NWT CEAMF coordination.

3.1.3.2 NWT Cumulative Impact Monitoring Program

The NWT Cumulative Impact Monitoring Program (NWT CIMP) is a community-based monitoring program that incorporates scientific and traditional knowledge to document environmental change from cumulative impacts. NWT CIMP has identified 12 Valued Components linked to specific indicators. These indicators will be used in State of the Environment and Knowledge Reporting, and ultimately, linked to thresholds or Limits of Acceptable Change (DIAND 2003).

The NWT CIMP Valued Components and indicators were considered as suitable candidates for the Beaufort Delta framework.

3.1.3.3 Arctic Borderlands Ecological Knowledge Coop

The Arctic Borderlands Ecological Knowledge Co-op is a cross-border ecological monitoring program involving a variety of state, territorial and federal government agencies, co-management boards, Inuvialuit and First Nation peoples, stakeholder organizations and academics that focuses on the range of the Porcupine Caribou herd (i.e., the north end of the Yukon Territories, northeast Alaska, and the northwest corner of the mainland NWT which includes the western edge of the Mackenzie Delta). The Arctic Borderlands Ecological Knowledge Co-op originated in 1994 when interested parties started an ecological monitoring program for the northern Yukon. It is a not-for-profit society with a Board of Directors that is elected annually. The Arctic Borderlands Ecological Knowledge Co-op is operated as cooperative venture between aboriginal organizations, co-management groups, and federal and territorial government agencies. Participating communities include Aklavik, Arctic Village, Fort McPherson, and Old Crow. Annual reports are available at www.taiga.net/coop/index.html.

The Arctic Borderlands Ecological Knowledge Co-op's objectives are to:

- monitor and assess ecosystem changes in the range of the Porcupine Caribou Herd and adjacent coastal and marine areas;
- encourage use of both science-based studies and studies based on local and traditional knowledge in ecological monitoring and ecosystem management;

- improve communications and understanding among governments, aboriginal and non-aboriginal communities and scientists with regard to ecosystem knowledge and management; and
- foster capacity-building and training opportunities in northern communities in the context of the above-listed goals.

The Arctic Borderlands Ecological Knowledge Co-op uses approximately 75 indicators that are divided into three categories (i.e., climate, nature and people). More information on the Arctic Borderlands Ecological Knowledge Co-op, the indicators they have chosen, and the rationale for their indicators, can be found at www.taiga.net/coop/index.html.

3.1.3.4 Mackenzie River Basin Board State of the Aquatic Ecosystem Report

The Mackenzie River Basin Board (MRBB) was created as a forum for cooperative water management. Its 13 members represent the governments of Canada; BC; Alberta; Saskatchewan; the NWT; and Yukon; as well as aboriginal peoples throughout the Basin. This Board is unique because of its inter-jurisdictional partnerships, the participation of aboriginal members, and its focus on maintaining the ecological integrity of the whole Basin, comprising over one-sixth the area of Canada.

The MRBB recently completed a State of the Aquatic Ecosystem report (www.mrbb.ca/reports.asp) that documents current conditions in the Basin based on a suite of indicators. This report concludes that aquatic systems in the Basin are generally healthy, but that climate change and altered flow regimes represent challenges that warrant further investigation.

3.1.3.5 NEI Working Landscapes Integrated Cumulative Effect Thresholds Project

The four year Northern Ecosystems Initiative Working Landscapes Integrated Cumulative Effect Thresholds project (NEI WLCE Thresholds project) is a multi-stakeholder project consisting of nine independent, but coordinated, studies undertaken by academic, government, and private consulting representatives with recognized expertise in cumulative effects assessment, thresholds, models, and decision-making processes.

The NEI WLCE Thresholds project will develop a complementary suite of technical, communication, and implementation tools using one or more northern case studies. These tools will be designed to help northern stakeholders define appropriate and socially-acceptable thresholds or Limits of Acceptable Change for valued ecosystem and social components. The suite of tools includes:

- suitable cumulative effect indicators for ecological and social systems;
- science-based ‘dose-response curves’ that relate changes in human activity intensity to indicator condition;
- ‘integrated land management models’ to help stakeholders evaluate options and trade-offs;

- community-based implementation processes; and
- communication materials for workshops, presentations, and technical publications.

The integrated cumulative effect management framework proposed for the Beaufort Delta region is consistent with that envisioned for the NEI CE Thresholds project.

3.1.4 Development Scenarios

A guiding principle for project-specific cumulative effects assessment and management is that the level of effort should be proportional to the project's potential to create negative effects (Kavik-Axys 2002c).

Although the concept of developing gas resources in the Mackenzie Delta is over 30 years old (e.g., Taglu, Parsons Lakes and Niglintgak anchor fields were discovered in 1971, 1972 and 1973, respectively – IORVL 2004), relatively little development has occurred in the area to date. The GIS databases reviewed for this project documented 129 onshore exploration wells and hundreds of kilometres of seismic lines. At present, there is only one producing well; this provides natural gas to the community of Inuvik via a 50 km pipeline. The Mackenzie Gas Project application identified a total of 266 wells in a much larger study area, corresponding to an average exploration well density of approximately one well/552 km^2 (IORVL 2004).

The most current development scenarios described for the Mackenzie Delta is provided in Mackenzie Gas Project Environmental Impact Statement (IORVL 2004). It indicates the amount of development will increase dramatically if the MPG project is approved. The Mackenzie Gas Project proposes to develop a pipeline and gathering system from the Mackenzie Delta that will interconnect with the Enbridge Pipeline at Norman Wells. Proposed facilities in the Mackenzie Delta include: production wells and facilities at each of the three largest onshore natural gas fields (i.e., the anchor fields - Niglintgak, Taglu, and Parsons Lake); gathering pipelines to transport natural gas and associated natural gas liquids from the fields to a gas processing facility near Inuvik; a pipeline to transport natural gas liquids from the Inuvik gas processing facility to connect with the Enbridge system at Norman Wells: a pipeline to transport natural gas from the Inuvik gas processing facility to connect with the TransCanada Pipeline system in Alberta; and associated access and development infrastructure.

A study by Gilbert Lausten Jung Associates (in IORVL 2004) to identify the gas supply for the Mackenzie Gas Project estimated the three anchor fields contained 161 Gm^3 of natural gas, or approximately 80% of the recoverable onshore natural gas in the Mackenzie Gas Project study area. They indicated that 78 Gm^3 of offshore natural gas reserves have been discovered in the nearshore (<30 m depth) Beaufort Sea waters. Gilbert Lausten Jung Associates also estimated that there was another 180 Gm^3 of undiscovered onshore natural gas and 54 Gm^3 of undiscovered offshore natural gas. The study concluded that there were sufficient gas resources for a 34 Mm^3/d pipeline for 25 years, based on what it expected was a reasonable pace of exploration and development.

3.1.4.1 Beaufort Delta Regional Objectives

Management objectives identified in existing guidance documents demonstrate the priority placed on environmental protection, sustainable economic development, and integrated management in the Beaufort Delta region. Many residents would prefer to be able to continue to make choices between the wage economy, the subsistence economy, and a blend of both (Kavik-Axys 2002c). Management goals were interpreted to provide the following regional *vision* for the Beaufort Delta Cumulative Effects Project:

1. Valued Components and Indicators should reflect the strong linkage between environmental conditions and community well-being;
2. Indicators should be selected to help integrate environmental and socio-economic assessment, resource management, economic development, social service provision, and cultural programs;
3. Environmental thresholds or Limits of Acceptable Change should be conservative (i.e., precautionary) in areas with sensitive or valued resources to reflect the priority placed on renewable resource conservation and sustainable use; and
4. Social Limits of Acceptable Change should accommodate increased community and regional economic development while improving existing social conditions.

Participants at the October 6, 2004 Inuvik workshop agreed that the above *vision* was an appropriate starting point for cumulative effects assessment and management in the region.

3.1.4.2 Valued Components

Limited time and resources make it impractical for resource managers and proponents to consider all environmental and social factors in equal detail. Representative ecological and social components are commonly used to summarize information and help focus assessment and management activities (Beanlands and Duinker 1983; Kelly and Harwell 1990; Noss 1990; Cairns et al. 1993; ELI 2003).

The NWT CIMP defines a Valued Component as:

> "… an aspect of the environment that is considered important, on the basis of economic, social, cultural, community, ecological, legal or political concern. A Valued Component is not an indicator in itself, although impacts on, or trends in, some characteristic of a Valued Component may be used as an indicator." (DIAND 2003).

A suite of complementary Valued Components is generally believed to be more appropriate for both project and resource management purposes because a single component is not capable of tracking all pertinent factors (Beanlands and Duinker 1983; Kelly and Harwell 1990; Noss 1990; Cocklin et al 1992a,b; Cairns et al 1993; FEARO 1994; Shoemaker 1994; Smit and Spaling 1995; Griffith 1998; Hegmann et al 1999; Schiller et al. 2001; GRI 2002; Macleod 2002).

No standard, widely-accepted suite of cumulative effects Valued Components exists. There is considerable scientific debate concerning the comparative merits of three approaches for land and resource management: 1) indicator species (fine-filter); 2) groups, guilds, or communities (coarse-filter); and 3) generalized biodiversity indicators (e.g., ecosystem - Murphy and Wilcox 1984; Wallis de Vries 1995; Noss et al. 1996; Lambeck 1997; Simberloff 1998; Caro and O'Doherty 1999; Andelman and Fagan 2003; Carignan and Villard 2002; Olsen et al. 2004; Roberge and Angelstam 2004).

A large number of Valued Components have been identified for past and current northern research and monitoring initiatives (Table 3). In most cases, selected Valued Components are species, or species groups, whose distribution and abundance are of management interest because they are harvested, at risk, and/or sensitive to disturbance.

The research and monitoring indicators provided in Table 3 generally reflect regional or strategic components of the cumulative effects management framework shown earlier in Figure 5. In contrast, the emphasis of the Beaufort Delta Cumulative Effects Project is on local or operational tools that are compatible with, and can be linked to, these research and monitoring initiatives.

Further to the advice provided by the ESRF TAG, a suite of eight ecosystem-scale Valued Components were chosen for the Beaufort Delta Cumulative Effects Project (Table 4). The following selection criteria were used:

- A small number of easily understood Valued Components known to be important to regional residents, managers, and regulators (e.g., identified in Inuvialuit Community Conservation Plans, approved regional resource management plans, social monitoring plans, or other relevant northern initiatives);
- The suite of Valued Components reflects overall environmental and social conditions in the region;
- Valued Components can be easily measured or described with one or more practical indicators (e.g., wildlife habitat conditions rather than abundance or population parameters);
- Valued Components allow key cumulative effect pathways to be considered (e.g., air emissions, aircraft traffic, increased demand on community services and manpower, and link between environmental conditions and social well-being);
- Valued Components can be evaluated at multiple scales (e.g., local, sub-regional, regional); and
- Compatible with Valued Components adopted by the NWT CIMP.

The broad Valued Components selected meet the criteria described above and are thought to be clear and readily-understandable.

Table 3 Valued Components selected for northern research and monitoring initiatives.

Initiative	Valued Components				
	Air	**Nearshore Marine**	**Land**	**Freshwater**	**Social**
Beaufort Environmental Monitoring Program (BEMP; LGL et al. 1984)	• Air quality	• Bowhead whale • White whale • Ringed & bearded seal • Polar bear • Eiders & diving ducks • Birds • Brant • Broad whitefish • Arctic cisco	• N/A	• N/A	• Harvest
Mackenzie Environmental Monitoring Program (MEMP; LGL et al. 1986)	• Air quality	• Snow geese • Raptors • Ducks • Loons • Polar bear	• Landscape quality • Caribou • Grizzly bear • Moose • Arctic & red fox • Beaver • Muskrat • Marten • White whale • Wolverine	• Water quality • Broad & lake whitefish • Inconnu • Arctic cisco • Burbot • Arctic char • Pike • Lake trout	• Harvest
Norman Wells Research and Monitoring Program (Boreal Ecology 1986)	• Air quality • Air emissions	• N/A	• Raptors • Snow goose • Thermal regime & ground stability • Revegetation & restoration • Furbearers • Large mammals	• Water quality • Fish habitat • Fish quality & condition	• Renewable resource harvesting
Ecological Monitoring and Assessment Network (EMAN; Geomatics 1999)	• Air quality • Mean temperature • Snow/ice phenology	• Rare species • Community biomass • Structural diversity • Gross pathology • Community productivity	• Rare species • Exotic pecies • Species richness • Species diversity • Community biomass • Community productivity • Nutrient storage	• Water quality • Stream flow • Lake level • Sediment • Rare species • Community biomass • Structural diversity • Gross pathology • Community productivity	• N/A

Initiative	Valued Components				
	Air	**Nearshore Marine**	**Land**	**Freshwater**	**Social**
Beaufort Regional Environmental Assessment and Monitoring Program (BREAM; Axys et al. 1992)	• Air quality	• Bowhead whale • Ringed seal • Polar bear • Beluga whale • Bearded seal • Common eider • Thick-billed murre • Phalaropes • Black brant • Ducks • Raptors • King eider • Black guillemot • Epontic (under-ice) organisms	• Coastlines • Landscape quality • Arctic fox • Grizzly bear • Moose • Muskrat • Wolverine • Black Bear • Red fox • Caribou • Beaver • Marten • Mink • Lynx • Snow geese • Loons • Phalaropes • Ducks • Raptors • Tundra swans • Ravens	• Surface & groundwater quality • Broad whitefish • Inconnu • Lake trout • Burbot • Arctic cod • Pacific herring • Arctic cisco • Lake whitefish • Pike • Arctic char • Arctic grayling • Fish quality	• Harvest
West Kitikmeot Slave Study (WKSS; GeoNorth and Axys 1997)	• Air quality	• N/A	• Permafrost • Eskers • Vegetation • Caribou • Wildlife habitat • Grizzly bear • Musk oxen • Wolf	• Water quality • Water quantity • Arctic grayling • Lake trout • Arctic char	• Cultural & heritage sites • Aboriginal land uses • Commercial land use • Human health • Community wellness
Independent Environmental Monitoring Agency (IEMA 2001)	• Air quality	• N/A	• Wildlife habitat • Caribou • Grizzly bear • Wolf • Wolverine • Upland breeding birds • Raptors	• Water & sediment quality • Water flows & quantities • Aquatic communities • Fish	• Traditional knowledge
Cumulative Impact Monitoring Program (NWT CIMP; DIAND 2002)	• Air quality • Climate	• N/A	• Snow, ground ice & permafrost • Moose • Caribou • Other wildlife • Vegetation	• Water & sediment quality • Water quantity • Fish habitat • Fish quality • Fish population	• Fish harvest • Human health & community wellness

Initiative	Valued Components				
	Air	Nearshore Marine	Land	Freshwater	Social
Arctic Borderlands Ecological Knowledge Co-op	• Weather	• N/A	• Berries • Caribou • Birds • Muskox • Rabbits • Bears & wolves • Ground squirrels • Moose • Muskrat • Wolverine • Lynx	• Fish	• Trapping • Human Activity

3.1.4.3 Indicators

An indicator is defined as here as:

> "a characteristic of the social or ecological setting that is used to describe, measure, manage, and report on Valued Components".

In other words, it can be used to quickly provide a good understanding of the overall environmental and social conditions in the Beaufort Delta region. Indicators help land users and managers speak a 'common language' when they assess the cumulative effect risk. Indicators are commonly used in 'State of the Environment' reporting for the same reasons.

Selection of appropriate indicators is a critical step that has received extensive discussion in guidance documents and published literature (Beanlands and Duinker 1983; Noss 1990; Cocklin et al. 1992a, b; Cairns et al 1993; FEARO 1994; Shoemaker 1994; Smit and Spaling 1995; Griffith 1998; Hegmann et al. 1999; Schiller et al. 2001; Carignan and Villard 2002; GRI 2002; Macleod 2002; reviewed in Appendix 1 of Salmo et al. 2003). As with Valued Components, a suite of complementary indicators is generally believed to be more appropriate for both project and resource management purposes, because a single indicator is not capable of tracking all pertinent factors.

Table 4 Valued Components for the Beaufort Delta region.

VC	Rationale
Air	• Includes air quality, noise, and climate. • Air quality identified as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk, MEMP (LGL et al. 1986), NWT CIMP (DIAND 2003) and Deh Cho (Salmo et al. 2004). • Established indicators allow air resources to be readily considered.
Nearshore Marine	• Includes landfast ice areas and associated marine wildlife. • Provides important habitat for VCs identified in ICCPs for Aklavik, Inuvik, Tuktoyaktuk, and BEMP (ESL al. 1985). • Indicators can track cumulative effects on habitat, resource access, and animals.
Freshwater	• Includes lakes, streams, water quality, and fish in the Mackenzie Delta and upland areas. • Affects human, plant, and animal health. • Water quality and fish identified as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk, MEMP (LGL et al. 1986), NWT CIMP (DIAND 2003), Deh Cho (Salmo et al. 2004), and federal reporting (NRTEE 2003). • Established indicators allow cumulative effects on water resources, resource access, and fish to be considered.
Land	• Includes soil, permafrost, vegetation, and terrestrial wildlife in tundra areas. • Affects soil, vegetation, and terrain stability and provides unique landscape features (e.g. pingos). • Terrestrial species used as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk, MEMP (LGL et al. 1986), NWT CIMP (DIAND 2003) and Deh Cho (Salmo et al. 2004). • Indicators can track cumulative effects on terrestrial resources, resource access and wildlife.
Sensitive and Protected Areas	• Includes Category E lands identified by ICCPs, Gwich'in Conservation Zones, and areas protected by territorial and federal legislation. • Indicators can track cumulative effects on resource access, plants, animals and habitat.
Cultural Relationship to the Land, Traditional Culture and Land Use	• Includes social, cultural, heritage and archaeological resources, traditional resource use, and stewardship responsibilities. • Traditional resource use and culture identified as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk, and West Kikikmeot Slave Study (DIAND 2003). • Established indicators have been used in the NWT to monitor cumulative effects on traditional use and culture (GeoNorth & Axys 1997).
Community Well-being	• Includes demographics, income and cash flow, education and training, mental and physical health, infrastructure, and crime. • Identified as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk, West Kikikmeot Slave Study (GeoNorth & Axys 1997) and Deh Cho (Salmo et al. 2004). • Established indicators have been used in the NWT to monitor individual, family, and community well-being (e.g., GeoNorth & Axys 1997; GNWT 2000).
Economic & Business Opportunities	• Includes wage employment and business opportunities. • Community benefits identified as a VC in ICCPs for Aklavik, Inuvik and Tuktoyaktuk 2000), West Kikikmeot Slave Study (GeoNorth and Axys 1997) and Deh Cho (Salmo et al. 2004). • Established indicators have been used in the NWT to monitor economic benefits and resource use (e.g., GNWT 2000).

VC – Valued Component ICCP - Inuvialuit Community Conservation Plan

The following criteria were used to select a suite of cumulative effect indicators for the Beaufort Delta region (Noss 1990; Schiller et al. 2001; Macleod 2002; NRTEE 2003):

- Clear and understandable by communities, resource users, and managers;
- Are currently monitored or easy and cost-effective to collect, measure or calculate;
- Applicable to small through large projects (e.g., small proposals reviewed by the Inuvialuit Environmental Impact Screening Committee or MVLWB through large development proposals reviewed by the Inuvialuit EIRB or MVEIRB);
- Provide information on desired ecological or social conditions and values (i.e., Valued Components);
- Provide information for multiple Valued Components or support integrated evaluations of multiple Valued Components;
- Applicable to a broad geographic area and long time frames;
- Capable of providing a continuous assessment from low through intensive land use;
- Reasonable understanding of potential cumulative effects exists;
- Able to differentiate between project-induced and natural changes; and
- Taken as a suite, indicative of overall ecological and social conditions.

3.1.5 Specific versus Generalized Indicators

Both issue-specific and generalized environmental indicators have been identified or proposed in the scientific literature. Issue- or species-specific approaches use indicators of interest to resource managers (e.g., caribou recruitment rate), or social service agencies (e.g., teen pregnancy rate). These indicators will continue to be an integral part of the cumulative effects management framework (Griffith 1998), but are frequently impractical for small project reviews, because it is difficult to predict project-specific effects on these metrics.

Generalized indicators are most commonly used to track regional trends of environmental and social conditions (e.g., habitat alteration and loss, traditional harvest participation rate; Griffith 1998). These indicators are the most practical for social and land management purposes – particularly project-specific assessments – because they can be easily estimated and also reflect cumulative effects. However, they may not adequately protect culturally important sites or rare features (ELI 2003).

Both issue-specific and generalized indicators are needed for cumulative effects assessment and management in the Beaufort Delta region.

3.1.6 Quantitative versus Qualitative Indicators

There are two general types of social indicators: 1) quantitative or objective metrics drawn from census and economic data; and 2) qualitative or subjective indicators normally developed from community surveys or interviews. Both types have associated strengths and weaknesses.

Quantifiable, objective indicators are very useful for describing and monitoring economic and social conditions. Researchers and institutions interested in large scale responses and evaluations believe that if chosen correctly, such data can be robust and defensible, trends can be documented, and the metrics can be compared across regions or jurisdictions.

Scientifically objective social data is difficult to apply consistently because numerical indicators do not completely describe or allow understanding of the local context that gave rise to these specific socio-economic conditions. For example, the crime rate in the NWT is calculated statistically and is supposed to be objective. In reality, what is considered a crime often varies between communities, as well as in court cases and judgments (Ross 1992; Ryan 1995). Furthermore, scientific or statistical findings are often difficult to correlate with a community's assessment of quality of life especially when the culture and values of that community may differ significantly from the researchers (e.g., Murdie et al. 1992; Beckley and Burkosky 1999). For these reasons, it is generally accepted by anthropologists, sociologists and social evaluators that social and cultural impacts are viewed differently by those who are from the region and those who reside in the region for a limited period (e.g., Schmidt-Thomé and Jarva 2003). Therefore, it is vital, if realistic interpretations of social conditions are to be made, that local information be collected in conjunction with quantitative data (Barnaby and Emery 2002; Petts et al. 2003).

When choosing a suite of indicators, one must consider how to best balance issues of audience, data availability, validity, reliability, and comparability. For this reason, the GNWT (2000) has committed to supplement statistical data by including attitudinal survey information into their annual reporting on community health and well-being for BHP Billiton Diamonds Inc. (BHP) point of hire communities.

> **Both quantitative and community-based (qualitative) indicators will ultimately be needed for cumulative effects assessment and management in the Beaufort Delta region.**

Recommended cumulative effects indicators for the Beaufort Delta region, and the rationale for their selection, are discussed by Valued Component in Sections 4 through 8.

3.1.6.1 Thresholds, Limits, and Targets

Indicators provide information about the likelihood of negative cumulative effects, but provide no direct measure of the acceptability of those impacts. In this report, management thresholds are defined as:

> 'technically or socially-based standards that identify the point at which an indicator changes to an unacceptable condition'.

In other words, they can be used to quickly provide a good idea of whether what is happening in the Beaufort Delta region is acceptable or unacceptable. Lack of thresholds is identified as a current constraint to cumulative effects assessment in the region (DIAND and EC 2001; Kavik-Axys 2002a). The MVEIRB recently recommended that a land use threshold be adopted to minimize risk of cumulative effects on boreal caribou in the Deh Cho Territory (MVEIRB 2004a). Land use targets have also been identified for special management areas within the Muskwa-Kechika Management Area (MSRM 2004).

Thresholds may be based on outcomes (e.g., desired habitat conditions) or inputs (e.g., land use intensity). Outcome-based thresholds are preferred because outcomes can be influenced by more than one input and it is the outcome that is important from a management perspective. Nevertheless, thresholds based on acceptable inputs are required when desired outcomes cannot be practically defined (Merigliano et al. 1997).

Some of the best examples of science-based thresholds are air and water quality criteria developed by the federal government (e.g., CCME 2004). These are based on observed or modeled dose-response relationships; an example is shown in Figure 6 where the air quality threshold represents the concentration that causes detectable effects on a sensitive receptor (e.g., reduced growth of lichen).

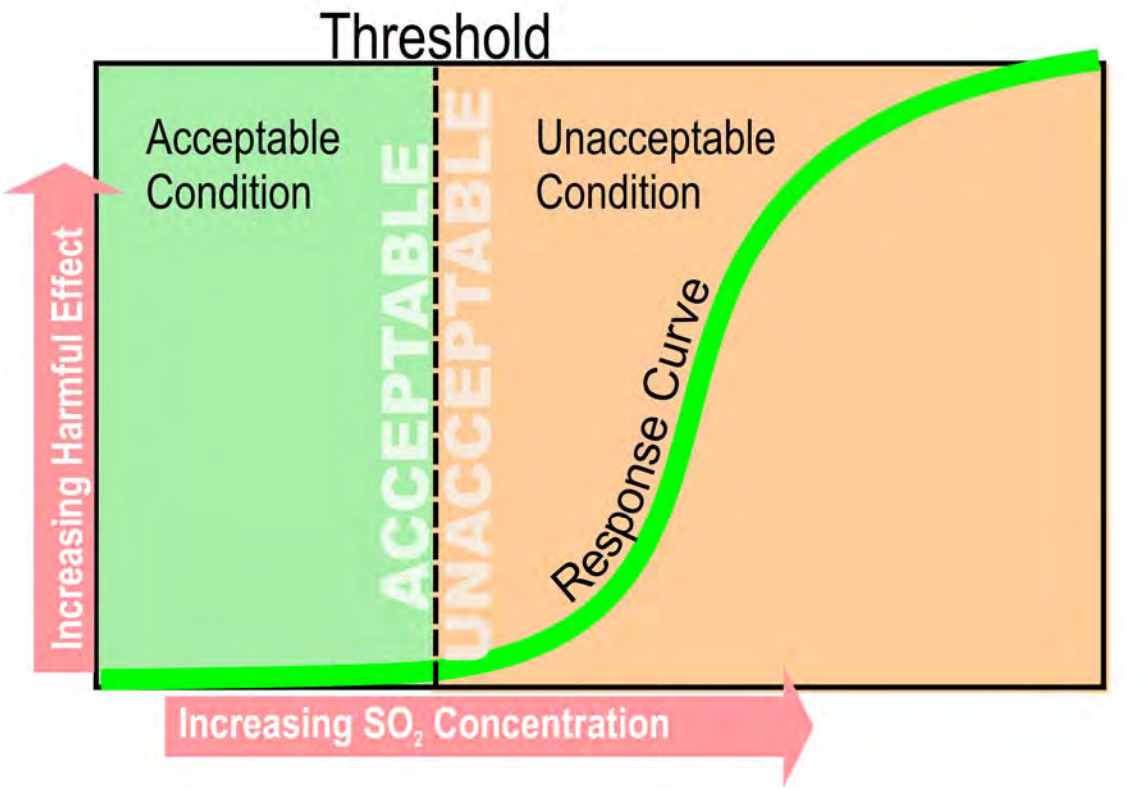

Figure 6 Theoretical dose-response relationship showing an effect threshold where an acceptable condition becomes unacceptable.

Established air and water quality criteria demonstrate both the inherent value and the practicality of thresholds for cumulative effects assessment and management. The perceived regulatory advantage of thresholds is that they allow development activities to proceed without detailed review until the defined threshold is reached. Once the threshold is reached, extra review or regulation is necessary (Zeimer 1994). Harmonized thresholds are one of the best ways of managing cross-jurisdictional resources because they create a common language and common 'rules of the road'. As such, thresholds can also provide a framework for market-based tools such as trade-able land use credits.

In spite of these perceived benefits, identification of quantitative thresholds is one of the most challenging aspects of land and resource management because they must be technically defensible, politically acceptable, and administratively efficient. Identification of specific ecological thresholds is difficult because effects differ with the averaging period used, type of exposure, the ecological setting, as well as species and life stage. This inherent scientific uncertainty has most frequently been addressed by building in a safety margin where the threshold is set below the lowest detected effect concentration (Bull 1991).

In most cases, as shown in Figure 7, the risk of adverse cumulative environmental effects (here represented by native vs. non-native species abundance) increases with the amount of human activity or disturbance. There is no distinct break-point that distinguishes acceptable and unacceptable conditions (Bayne et al. 2004). Similarly, there are no clear social thresholds because responses to – and perceptions of – change differ among individuals, communities, organizations, and cultures, and there are many viewpoints on what constitutes an unacceptable 'adverse' effect. Social responses may be linked to different expectations. For example, some individuals or communities may place a priority on economic growth, while others wish to maintain traditional cultural patterns. Social perceptions of development can vary significantly between cultures (Schmidt-Thomé and Jarva 2003). Political acceptability of thresholds, therefore, depends on how well they are perceived to balance community, regional, territorial, and national values, interests, and expectations.

Two approaches – Limits of Acceptable Change and Tiered Thresholds – have been adopted to address these technical and political challenges to defining acceptable and unacceptable conditions.

3.1.7 Limits of Acceptable Change

Limits of Acceptable Change are defined here as:

> 'socially-defined endpoints or thresholds that reflect the desired balance between human activities and ecological and social sustainability'.

This concept acknowledges that precise thresholds may not exist and sets boundaries on the extent of change that will be permitted.

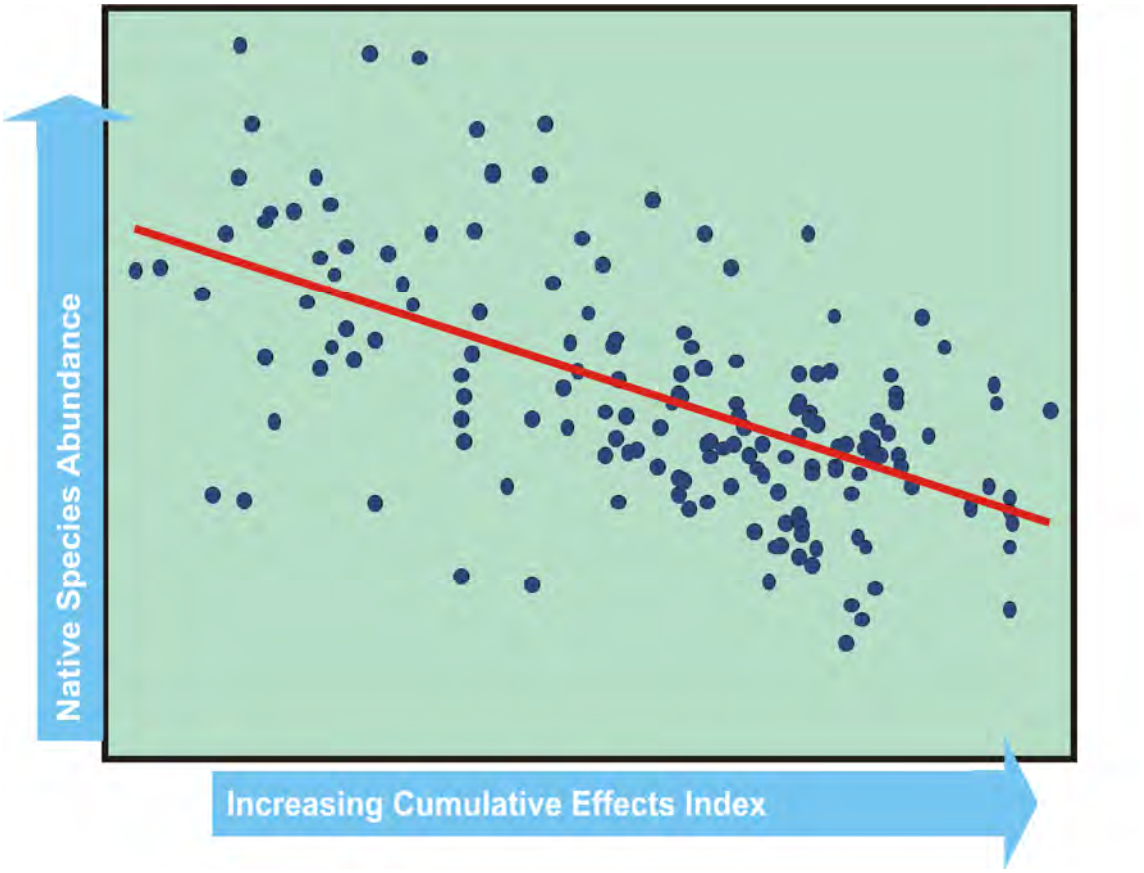

Figure 7 Dose-response curve showing inverse relationship between cumulative disturbance and relative abundance of native mammal community (from Bayne et al. 2004).

The Limits of Acceptable Change system was originally developed for wilderness management (Clark and Stankey 1979; Stankey et al. 1985) and has begun to be applied to non-recreational issues (McCool and Cole 1997; Cole and Stankey 1998). This approach assumes that outcome-based thresholds are preferred because it is the outcome that is important, and because outcomes can be influenced by more than one input. The following summary is derived from Stankey et al. (1984, 1985) and Cole and Stankey (1998), except where noted.

The Limits of Acceptable Change system attempts to identify "How much use is too much?" by turning the question around and asking "How much change is acceptable?" A critical component of the Limits of Acceptable Change system is that limits be defined in a collaborative process where decisions reflect the input of affected stakeholders. Judgments of acceptability require not only the viewpoints of managers and scientists, but of residents and land users as well. Limits of Acceptable Change uses scientific information to help define what is acceptable, not as the sole factor (Stankey et al. 1984).

One challenge is that individuals often value and desire different things, and the relationship between land use and perceived quality varies accordingly. Limits of Acceptable Change frameworks address this by defining perceived quality across a spectrum of uses such as protected areas through to industrial zones (Stankey et al. 1984; Cole and Stankey 1998). Limits are established as follows:

- Identify what special features or qualities are important in the area;
- Describe land use classes where different resource, social, and managerial conditions will be maintained;
- Select indicators that allow resource and social conditions to be described and measured;
- Inventory existing resource and social conditions; and
- Specify standards for resource and social conditions in each land use class.

The Limits of Acceptable Change system was recommended by Macleod (2002) for cumulative effects management in the NWT, and is considered to be directly relevant to the Beaufort Delta region. Limits of Acceptable Change can be directly linked to the Land Use Categories in the Inuvialuit Community Conservation Plans and Land Use Zones in the Gwich'in Land Use Plan.

3.1.8 Tiered Thresholds

'Tiered thresholds' are a series of progressive thresholds that reflect increasing degrees of concern or risk. Tiered thresholds were originally developed to manage deposition of acidic air pollutants (Bull 1991, 1992). This approach provides an integrated framework that relates two or more quantitative thresholds to appropriate management and regulatory responses.

Tiered thresholds have been recommended for fisheries management (Auster 2001), resource management in the NWT (Macleod 2002), activities in the oil sands area of Alberta (AENV 1999, 2001), and the west-central Alberta airshed (AENV and CASA 1999). Candidate tiered ecological and land use thresholds have been developed for cumulative impact management in northeastern British Columbia (Salmo et al. 2003) and the Deh Cho territory (Salmo et al. 2004).

Figure 8 illustrates a three-tiered system based on the Clean Air Strategic Alliance model for management of potential acidification input. The three threshold tiers established by the Clean Air Strategic Alliance are described in the following subsections.

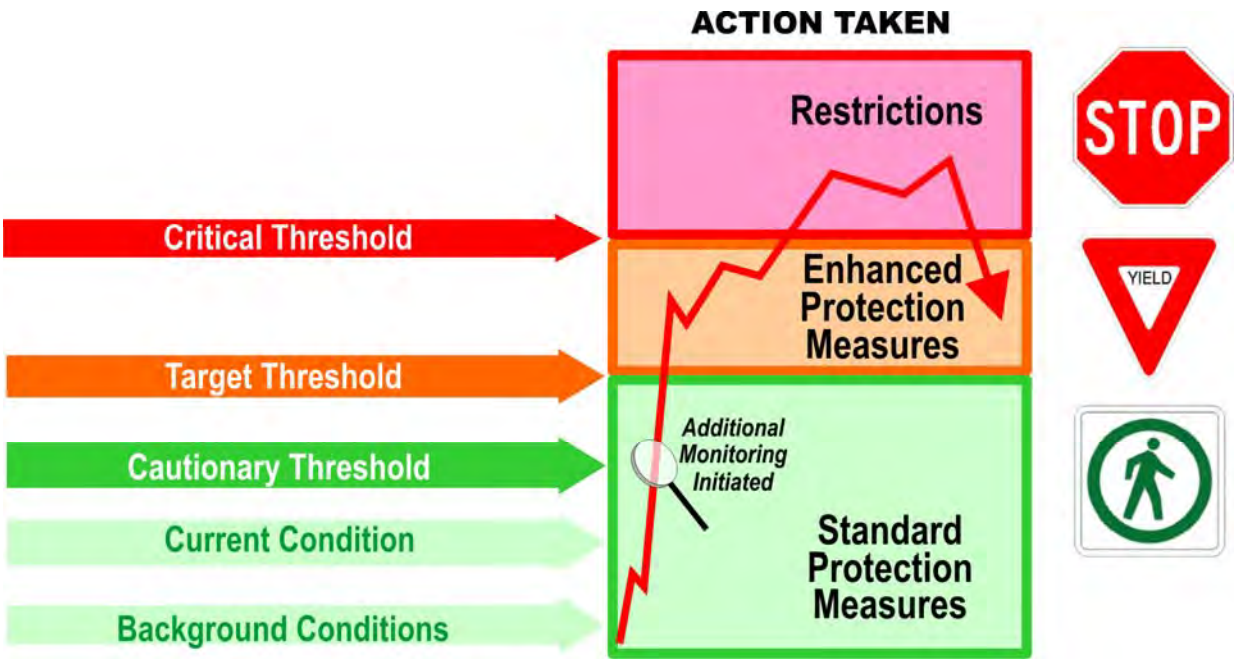

Figure 8 Application of tiered thresholds to management actions.

3.1.8.1 Critical Thresholds

A 'Critical Threshold' is the continuous maximum amount of stress that an ecological or social system can support without sustaining long-term harm (Bull 1992). To establish a critical threshold, a Level of Acceptable Change must be defined. Once the acceptable protection level is defined, a science- or value-based threshold is calculated from the best available information. This calculation is based on known cause and effect relationships like that depicted in Figures 6 and 7 (Bull 1991, 1992).

Critical thresholds have been defined in a variety of ways. For example, the critical threshold may be based on predicted risk of population extinction (Lande 1987), predicted probability of population survival (Lamberson et al. 1992), or the probability and severity of an undesirable effect (Francis and Shotton 1997). The Clean Air Strategic Alliance defined thresholds using 'levels of protection', where a 100% level of protection meant protection for all ecosystems, while a 90% level of protection meant that 10% of ecosystems or species might experience stress above their critical load (AENV and CASA 1999). Based on these definitions, the Clean Air Strategic Alliance defined Critical Thresholds as providing a 95% level of protection for sensitive, moderately sensitive, and low sensitivity soils.

When the Critical Threshold is reached or approached, restrictive management practices are formally adopted. These can include pre-defined protection and recovery measures mandated through the review and approvals process. Examples include implementation of economic instruments that discourage emissions use, retrofitting of 'Best Available Technology', and use of predefined recovery responses like activity restrictions (AENV and CASA 1999).

3.1.8.2 Target Thresholds

A 'Target Threshold' reflects a politically or socially-defined goal for the amount of stress on a system. It incorporates economic, social, and technological considerations and should ideally be below the critical threshold to provide a margin of safety. A Target Threshold can be characterized as the level that is politically and practically achievable and provides adequate long-term protection to the environment or resource of interest.

The Target Threshold may reflect a precautionary management philosophy or technical uncertainty associated with predictions of the Critical Threshold. In Alberta, the Clean Air Strategic Alliance defined the target acid deposition threshold loads at approximately 90% of the critical load (AENV and CASA 1999).

When this threshold is reached, enhanced management practices are formally adopted. These can include expanded environmental monitoring and applied research, voluntary use of 'Best Available Demonstrated Technology', and implementation of enhanced protection or recovery methods like 'No Net Habitat Loss' or restrictive harvest regulations (AENV and CASA 1999). Where existing disturbance levels exceed the critical threshold, the target threshold may be set at, or above, the critical threshold load, or a series of diminishing target threshold loads may be applied over time to progressively reduce stress to levels below the critical threshold (AENV and CASA 1999).

3.1.8.3 Cautionary Thresholds

A 'Cautionary Threshold' is established to indicate when additional or more intensive monitoring is required. This concept was established by the Clean Air Strategic Alliance (AENV and CASA 1999) to ensure that sufficient local data existed to confirm scientific predictions of both target and critical thresholds.

When this threshold is reached, issue-specific monitoring is initiated to document environmental conditions or responses. No other management or mitigation actions are required, but activities must comply with established regulatory guidelines and best industry management practices. Routine environmental and activity monitoring is also conducted to confirm that best management practices are being applied (AENV and CASA 1999).

Where there is not enough information to determine how much stress a social or environmental system can sustain, a decision can be made to define an interim threshold between the cautionary and target thresholds. Final thresholds would then be established only after further monitoring, research, and stakeholder consultation.

3.1.8.4 Beaufort Delta Region Framework

An integrated cumulative effects management framework incorporating socially-derived thresholds and Limits of Acceptable Change can be instituted to supplement the existing Beaufort Delta region regulatory framework. Tiered thresholds can be related to existing land use designations to reflect

increasing degrees of concern or risk (e.g., conservative or protective tiered thresholds for Category E Lands in the ISR known to include cultural or renewable resources of extreme significance and sensitivity; Figure 9). Because these land use designations are the result of extensive stakeholder consultation, they are assumed to provide the most appropriate foundation to define acceptability in this region.

The primary strength of tiered thresholds is the formal link between the thresholds and impact management. This provides a framework to gather data on actual responses and modify project review and management actions as appropriate. A secondary benefit is that tiered thresholds directly recognize the uncertainty around our understanding of complex environmental relationships. Finally, tiered thresholds provide the flexibility necessary for different land management zones and environmental settings, for a full range of development proposals, and for both project-specific and regional cumulative effects.

Indicators and candidate Thresholds/Limits of Acceptable Change for each Valued Component are described in Sections 4 through 8.

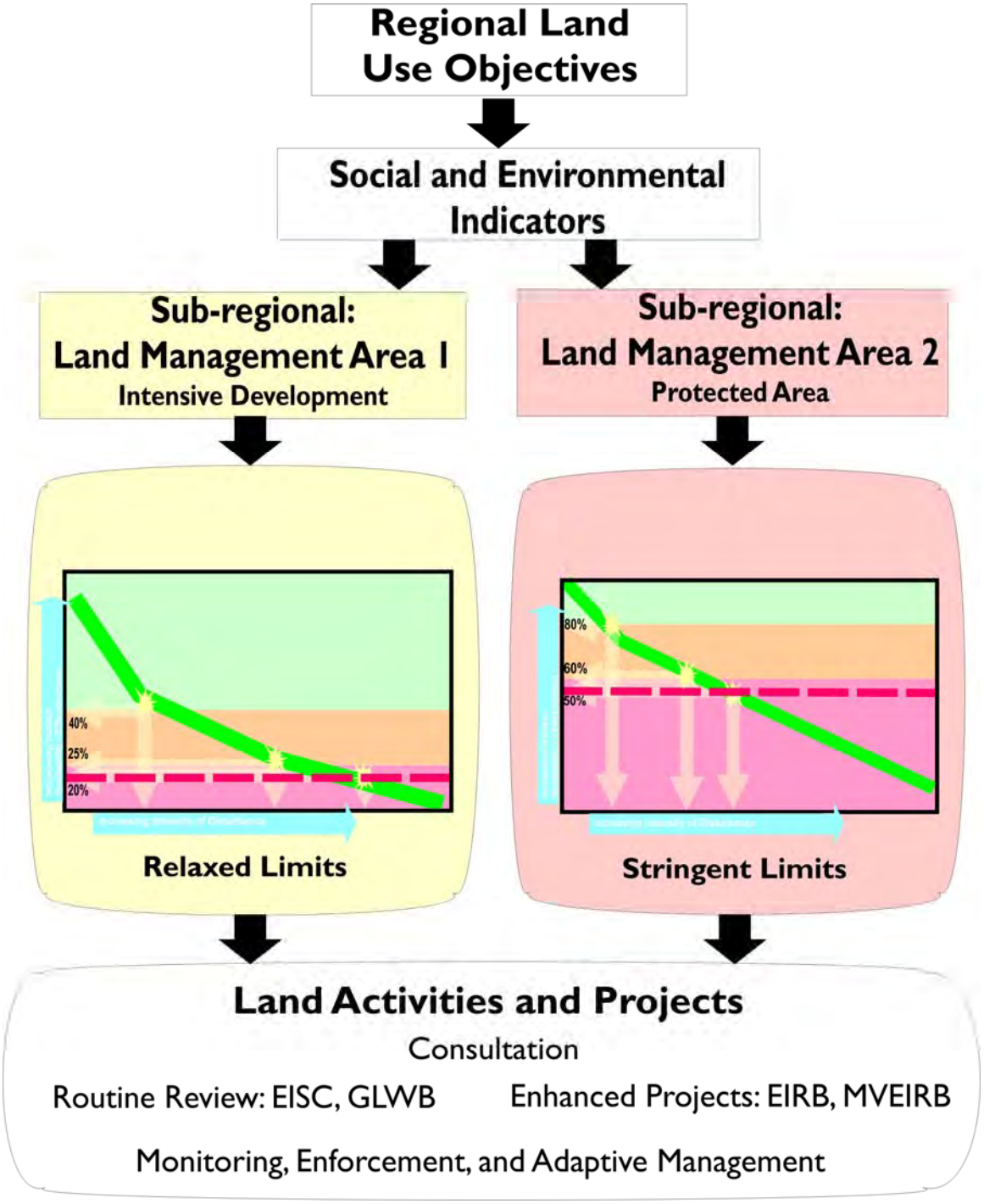

Figure 9 Linking tiered thresholds or Limits of Acceptable Change with land use categories in a Beaufort Delta cumulative effects framework.

4 AIR

Current air quality in the Beaufort Delta region is very good (Section 2.1). Cumulative effects on air quality and noise could occur where regional sources of emission and noise overlap in time and space or when they combine with pollutants transported from outside the region (AMAP 1998). Air quality of the Alaskan North Slope has been affected by industrial activities there and elsewhere, but there have been no documented negative effects on vegetation (NRC 2003).

4.1 Indicator

Air quality is used as a cumulative effects indicator in the NWT and is also recommended as an indicator for the Beaufort Delta study area (Table 5). The GNWT has adopted ambient air concentration limits to protect ambient air quality throughout the NWT (Table 6); these limits apply to selected pollutants established under the NWT *Environmental Protection Act* and are summarized in RWED (2003). NWT air quality standards are used to assess air quality monitoring results and to determine the acceptability of emissions from proposed and existing developments. Where NWT standards are not available for a particular pollutant, the Canadian National Ambient Air Quality Objectives or limits established by other jurisdictions are used (RWED 2003).

The rationale for selecting air quality as a cumulative effects indicator for the Beaufort Delta region is described in Table 5. Similar air quality indicators were also proposed by Salmo et al. (2004) for the Deh Cho region. IORVL (2004) also used many of same indicators, but supplemented their list by also using Federal Ambient Air Quality Objectives for NO_2 and CO as set out in the Clean Air Act (EC 1981), and benzene and total BTEX (i.e., benzene, toluene, ehtylbenzene and xylene, collectively) in the Alberta Ambient Air Quality Guidelines (AENV 2000).

Table 5 Proposed air indicator for the Beaufort Delta region.

Valued Component	Candidate Indicator	Rationale
Air	**Air quality** (ground level concentration of regulated emission parameters).	Reflects cumulative effects of air emissions. Air quality identified as valued resource in ICCPs and the GLUP. Established standards exist for Total Suspended Particulates (TSP), fine particulate matter (PM 2.5 and PM 10), sulphur dioxide (SO_2), ground-level ozone (O_3), and acid precipitation (RWED 2002a). These parameters are routinely considered in project applications and accepted predictive models exist. Provides a measure of local and sub-regional cumulative effects risk to air quality.

ICCP - Inuvialuit Community Conservation Plan; GLUP – Gwich'in Land Use Plan

Noise (i.e., ambient sound level) has been used as a key indicator to assess project-specific cumulative effects (e.g., IORVL 2004) and was suggested by co-management interviewees. It is not recommended here because noise-related effects can be considered indirectly using other candidate cumulative effects indicators. Noise from equipment and human transportation contributes to the indirect footprint around industrial sites, communities, and transportation corridors. This is considered in calculations used to define this indirect footprint (zone-of-influence) for nearshore marine, terrestrial, and freshwater cumulative effects indicators (see discussions in Section 5, 6, and 7 below).

4.1.1 Candidate Thresholds

The approved NWT ambient air quality standards (Table 6) represent appropriate Critical Thresholds for the Beaufort Delta region.

Project designs and regulatory approvals should be designed to maintain ambient air quality below these values. Adoption of a Cautionary Threshold is also recommended to ensure that monitoring occurs to document actual environmental conditions. The recommended Cautionary Threshold is for approved emission sources (i.e., an appropriate monitoring program should be required for all approved emission sources to document actual ambient air quality and confirm impact predictions over several years).

Consideration should also be given to the need for intermediate Target Thresholds in areas where pristine air quality is defined as a management objective. Target Thresholds could also be used where defined standards do not exist for a pollutant of interest.

Table 6 NWT air quality standards (RWED 2003).

Parameter	Standard (ug/m^3)*	Standard (ppb$_v$)**
Sulphur dioxide		
1 hour average	450	172
24 hour average	150	57
Annual arithmetic mean	30	11
Ground level ozone		
8 hour running average	127	65
Total suspended particulate		
24 hour average	120	
Annual geometric mean	60	
Fine particulate matter ($PM_{2.5}$)	30	

* - micrograms per cubic metre ** - parts per billon by volume

5 LAND

Sources of cumulative effects on land, vegetation, and wildlife include (Figure 10; Walker et al. 1987; Kavik-Axys and LGL 2001; Kavik-Axys et al. 2002; and NRC 2003):

- Direct Footprint:
  - disturbance of permafrost leading to thawing, slumping, slides and associated changes in surface and subsurface flow;
  - alteration and loss of vegetation communities due to clearing, direct surface disturbance, air emissions, and oil and contaminant spills;
  - presence of facilities (e.g., artificial islands and causeways) that change physical, chemical, and ice conditions;
  - direct mortality from collisions, flares, vessel movements, and disturbance of dens and nests.
- Indirect Footprint (including edge effects):
  - alteration and loss of vegetation communities due to air emissions and dust fall, permafrost disturbance, changes in surface and subsurface water flow, changes in snow cover, light and nutrients, and introduction of non-native and invasive species;
  - changes in seasonal animal habitat use resulting from noise, above-ground facilities, human activity, and harassment;
  - changes in timing and location of animal movements resulting from noise, above-ground facilities and human activity; and
  - contact with, or uptake of, contaminants.
- Harvest and Predation:
  - changes in predator-prey relationships and predation risk resulting from noise, above-ground facilities and human activity; and
  - changes in harvest locations and numbers resulting from changes in animal or human movements, distribution, or numbers; and
- Natural Disturbance:
  - alteration and loss of vegetation communities and wildlife populations from fire, insects, disease, floods, wind, ice, weather, climate change, and beaver activity.

5.1 Indicators

Selected indicators and thresholds must reflect national (e.g., *Species at Risk Act*), regional (e.g., regional vision provided in Section 3.4), and local (e.g., Inuvialuit Community Conservation Plan) goals for management of the wildlife and landscape conditions. Direct input from affected communities is important in selecting indicators and establishing appropriate thresholds or targets. Priority issues in the Beaufort Delta region are health of the land and the abundance, availability, and ‘quality’ of valued species such as caribou, waterfowl, and furbearers.

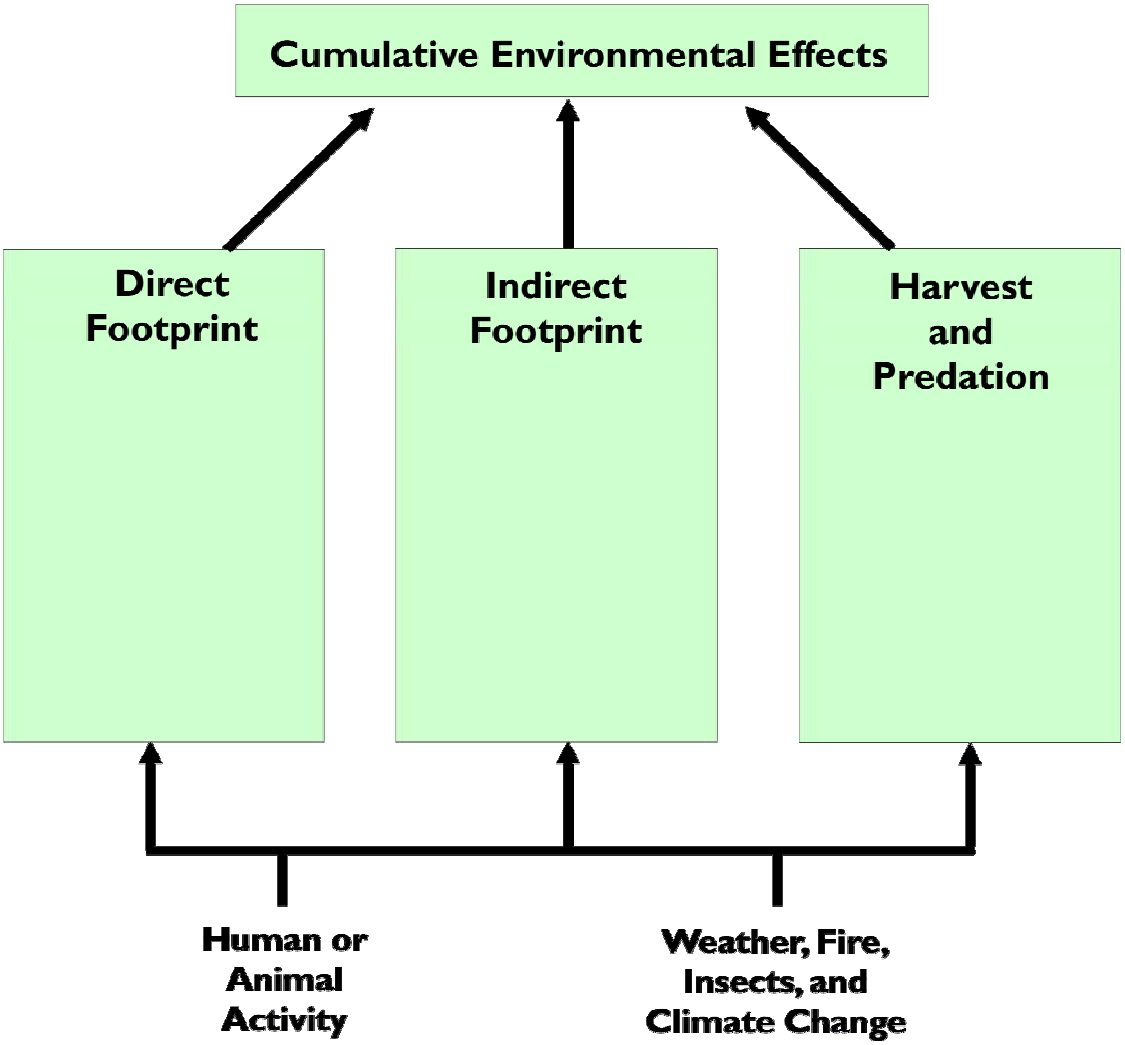

Figure 10 Sources of cumulative environmental effects on land, vegetation, and wildlife.

Several recent reviews of ecological indicators and thresholds are relevant to the Beaufort Delta study area, although most have been developed for forested landscapes. A review of ecological indicators and thresholds applicable to the NWT is provided in Macleod (2002). Axys (2000, 2001a, 2002) and Anderson et al. (2002) reviewed indicators and thresholds for selected wildlife species in the Yukon, and Olson and Olson et al. (2002) reviewed terrestrial and watershed indicators applicable to the oil sands area of Alberta. Salmo et al. (2003, 2004) reviewed ecological indicators and thresholds for management of wildlife resources in the boreal forest and foothills of northeast British Columbia and the Deh Cho Planning region. A literature review and meta-analysis of ecological indicators and thresholds applicable to land use planning is provided in ELI (2003).

Both species-specific and generalized habitat indicators and thresholds have been identified or proposed in the scientific literature for terrestrial resources and there is ongoing debate about the relative merits of each approach (e.g., Salmo et al. 2004). The major assumption underlying the single species-habitat approach is that the status of any given species is correlated with habitat availability for the focal as well as other species (Carignan and Villard 2002). Larger-scale landscape indicators are used based on the assumption that landscape composition and spatial patterns affect habitat quality, and ultimately animal population dynamics (Franklin and Forman 1987; Andrén 1994; Dooley and Bowers 1998; Mönkkönen and Reunanen 1999; Fahrig 2001, 2002; Schmiegelow and Mönkkönen 2002).

General conservation guidelines reflect ecological principles such as the size of habitat patches that species require to survive, or the amount of habitat necessary for long-term persistence of native species (ELI 2003). Habitat indicators and thresholds are a practical option for cumulative impact management, because they can be readily quantified and are assumed to be biologically meaningful (Hill et al. 1997; Axys 2000). Habitat indicators can refer to the availability of specific habitat units (e.g., disturbance of each habitat type or quality class; MSRM 2004), or to measures of larger scale habitat patterns (e.g., area in forest cover and area in wetlands; NRTEE 2003).

Both species-specific and generalized indicators are recommended for management of cumulative impacts on land, vegetation, and terrestrial wildlife in the Beaufort Delta region, and proposed indicators are described in Table 7. Many of the recommended thresholds are based on those suggested by Salmo et al. (2004). However, both indicators and thresholds have been modified to suit the unique landscape involved in Tundra ecosystems. In particular, natural processes in areas of permafrost are significantly different than those in unfrozen surficial deposits, and this creates constraints both on environmental protection and industrial design (NRC 2003). As well, snow machines and winter roads allow almost unlimited winter access on tundra with fewer disturbances than in forested areas. In the Arctic, recovery of the vegetation following disturbance is closely linked to changes in, and recovery of, permafrost and surface flow regimes (Walker and Walker 1991).

5.2 Direct and Indirect Footprint

Research on the Alaskan North Slope investigating long-term habitat loss and alteration is reviewed by NRC (2003). Documented effects include:

- Networks of seismic lines, ice roads, and trails cover extensive areas of the North Slope tundra. Most trails created for petroleum exploration recover within relatively short periods. After eight years only about 3% of seismic lines and 10% of camp-move trails in the Arctic National Wildlife Refuge were considered ‘disturbed’ and recovery reached a plateau after this point. Visual effects persist longer; about 15% of the trails created in the Arctic National Wildlife Refuge between 1984 and 1985 are still visible almost 20 years later. Significantly less disturbance occurred when snow depth exceeded 20 to 25 cm at the time of use. There is limited information available

on the long-term effects of current three-dimensional seismic methods, but the intensity and duration of effects appear to be reduced (Felix and Raynolds 1989a, b; Raynolds and Felix 1989; Felix et al. 1992; Emers et al. 1995; NRC 2003); and

- On the Alaskan North Slope, the area of indirect vegetation effect from roads equals or exceeds their direct footprint due to fugitive dust fall and changes in flow regimes. Most non-native species have not persisted or spread beyond the sites where they were introduced (Walker et al. 1987; NRC 2003). Dust fall did not cause marked short-term changes in tundra plant communities near the Lupine gold mine (Gunn et al. 1998).

Disturbances can cause both alteration/loss and fragmentation of wildlife habitat (Figure 11). While changes in predation and harvest risk are often the initial symptom of cumulative effects (e.g., Nagy and Branigan 1998; Dzus 2001; McLoughlin et al. 2003), habitat loss and fragmentation are normally assumed to be the most significant threats to the long-term persistence of species and communities (Forman and Godron 1986; Seagle 1986; Tilman et al. 1994; Flather and Sauer 1996; Collinge 1996; Jalkotzy et al. 1998; Fahrig 2001, 2002; Schmiegelow and Mönkkönen 2002; ELI 2003). Studies in temperate forested areas have shown a positive relationship between the number of species and the area of contiguous suitable habitat. Three general effects result from habitat disturbances:

- original habitat is lost;
- remaining habitat patches decrease in size; and
- patches become increasingly isolated from one another.

Figure 11 Representation of the habitat fragmentation process (adapted from Collinge 1996).

Habitat availability guidelines and thresholds are reviewed in Axys (2000), ELI (2003), and Appendix 1 of Salmo et al. (2003). Two general approaches have been applied to evaluating cumulative effects of direct and indirect habitat loss: species-specific habitat evaluations; and generalized regional or landscape indicators. Both are described below.

5.2.1 Species-specific Habitat Indicators

The most common approach in the NWT is to calculate changes in habitat for selected focal species. Species-specific evaluations usually consider both habitat availability and quality. Animal distribution and abundance is the result of both local habitat conditions and larger-scale environmental and human factors (Rich et al. 2003). Animal response to habitat and man-made features such as facilities and roads is often considered at two scales of analysis (e.g., Johnson 1980; McLoughlin et al. 1999; and Rettie and Messier 2000). At the regional scale individuals or groups select home ranges or territories that meet all of their life history needs (second order selection). Within this home range or territory, individuals and groups select or avoid areas based on site-specific features (third-order selection).

Where habitat requirements of a species are reasonably well understood, minimum levels of suitable habitat can be identified for regulatory or management purposes (Axys 2000). Habitat suitability is commonly used as an environmental impact assessment indicator, and has been applied in the NWT (e.g., Hegmann et al. 1999; Paramount 2003; IORVL 2004). Habitat suitability models provide a relative numerical quality value to a mapped habitat unit. These values consider specific life requisites, often by season or activity (such as denning or calving), and reflect the ability of habitat units to provide resources for identified wildlife species (reviewed in Salmo et al. 2001, 2003, but also see Van Horne 1983). The most extensively used predictive models of species-habitat relationships are derived through the Habitat Evaluation Procedure methodology developed by the United States Fish and Wildlife Service (USFWS 1980; Stalnaker et al. 1995). The methodology was developed for use in environmental assessments and provides a measure of available habitat (Habitat Units) that allows potential losses and gains to be quantified (Salmo et al. 2001).

More recently, resource selection functions have been used. This method employs statistical analyses of animal location data to predict the probability of occurrence as a function of the availability of mapped variables (Manly et al. 2002). Habitat effectiveness models predict the value and amount of habitat available to an animal, and can take into account man-made disturbances (Mace et al. 1996; Trombulak and Frissell 2000; Hamilton and Wilson 2001). This approach has been recommended for development of woodland caribou thresholds in the Yukon and Alberta (Anderson et al. 2002; BCC 2003) and is being used for grizzly bear research and management (Stenhouse et al. 2003).

Cumulative effects risk is associated with the amount of remaining habitat relative to baseline or historical conditions or relationships developed for the species. It assumes that we have a good understanding of habitat selection and that cumulative effects can be correlated with habitat availability. Although this approach is attractive conceptually, quantitative relationships between habitat availability

and population viability have not been determined for wildlife in the Tundra ecozone. Data from the Alaska North Slope suggests that barren-ground caribou and grizzly bear population trends in Alaska during petroleum development appear to have been related to factors other than habitat availability (Shideler and Hechtel 2000; NRC 2003). Demographic parameters of the Porcupine caribou herd have varied significantly from year to year in the absence of any significant development (Fancy et al. 1994).

One outcome of this approach is that predicted effects of development are more significant in regions with lower amounts of suitable habitats. Advantages of species-specific approaches are that underlying mechanisms are better understood and value of mitigation measures is easier to assess. However, these approaches have proven to be less likely to detect cumulative effects (Boutin and Bayne 2004), and they are costly and complex – particularly for small projects – where standardized datasets and models are not available. Thresholds are set separately for various focal species, and application of the method requires mapping and interpretation of habitats. Mapping and analysis boundaries are normally different for each focal species in order to reflect home range sizes and landscape features (Johnson et al. 2004).

5.2.1.1 Woodland Caribou

Woodland caribou have low ecological resilience and southern populations have declined precipitously over the last 40 years, concurrently with an increase in road access and industrial and recreational activities. These factors are believed to have resulted in a significant increase in mortality from wolves and hunters (Bergerud et al. 1984; Seip 1992; Thomas and Gray 2002). The challenge for woodland caribou conservation is to maintain sufficient quantities of suitable habitat through time in each range without inducing excessive predation and harvest pressure (Dzus 2001). Three indicators have been used, or proposed, for management of southern woodland caribou populations: corridor density; habitat effectiveness; and a regression equation developed for Alberta herds. An overview of these indicators is provided below; additional information is provided in Salmo et al. (2004).

Analyses conducted for the Alberta Boreal Caribou Committee (BCC 2003) using ten years of monitoring data from six herds found that two home range attributes (i.e.: industrial footprint - expressed as area within 250 m of clearings and corridors; and forest age - expressed as area burned within the last 50 years) were excellent predictors of population trends. Caribou population growth was inversely related to industrial footprint and young forest, and a regression equation was developed to define this relationship. Habitat effectiveness and habitat, as defined by the Boreal Caribou Committee working group, did not seem to affect population trends.

Total corridor density has also been found to be related to boreal-ecotype population decline and boreal and barren-ground caribou behavioural response. Increasing access density has also been found to be correlated with a shift from native to non-native mammal communities in north-central Alberta (Boutin and Bayne 2004).

5.2.2 Generalized Habitat Indicators

A variety of generalized landscape-level metrics have been proposed and used to monitor or assess effects of habitat loss and fragmentation (e.g., Flather et al. 1992; McGarigal and Marks 1995; Mladenoff et al. 1995; Edenius and Elmberg 1996; Reed et al. 1996a, b; Miller et al. 1997; Tewksbury et al. 1998; Villard et al. 1999; Vos et al. 2001; Cumming and Vernier 2002; Gu et al. 2002; McGarigal and Cushman 2002). Total area disturbed has been widely used for land and resource management and recommended as a cumulative effects indicator elsewhere in the NWT (Salmo et al. 2004) and western Canada (MSRM 2004).

The advantages of 'top-down' generalized indicators such as total area disturbed are that:

- they can be more easily related to cumulative effects risk by developing underlying relationships (dose-response curves) using data from different areas encompassing a gradient of landscape changes;
- they incorporate 'time lags' that are not apparent with short-term response studies; and
- they can be used to identify thresholds between acceptable and unacceptable conditions to be defined before the change actually occurs.

The weaknesses of generalized indicators are that underlying mechanisms may not be apparent, so the value of mitigation measures is difficult to measure (Bayne et al. 2004).

This approach has the advantages of being easy to apply by review bodies and land managers. It also focuses on overall cumulative effects risk to native plant and wildlife communities, and does not require species and season-specific evaluations of habitat quality. Use of integrated environmental indicators is believed to be more consistent with the regional vision for environmental protection provided in Section 3.4.

5.2.3 Core Area

Core areas (core security areas) are portions of the landscape that are relatively undisturbed by human disturbances such as noise, vegetation alteration, and human-caused mortality or harvest. These are defined on the basis of wildlife reactions to various types or intensities of disturbances. Effects can occur where wildlife use areas immediately adjacent to man-made features differently from nearby areas of similar habitat. These become cumulative when wildlife encounter activities from more than one project. Over time, this change in the direct and indirect footprint (habitat effectiveness) can lead to reduced productivity, biodiversity, and species abundance.

In general, impacts are inversely related to the level and predictability of human activity. Animals may habituate to repeated or predictable disturbance that is perceived to be non-threatening. Unpredictable high-intensity activities (e.g., motorized snow machines, powerboats, hunting, and aircraft fly-overs) cause greater response than low intensity continuous activities (e.g., stationary, constant motor noise).

However, specific responses vary, and are complicated by many factors (reviewed in Appendix 1, Salmo et al. 2003). Responses of hunted animal populations is normally greatest, and birthing periods and times of nutritional stress are considered to be the most sensitive period (Wolfe et al. 2000; Nagy et al. n.d.).

Core area is a simple measure that incorporates patch geometry by excluding large patches that because of their shape have little interior area (Temple 1984).

5.2.4 Sensitive Environmental Features

Sensitive features occur at both the local and landscape scales. Landscape features include large areas of particularly favourable or critical habitats, such as seasonal caribou ranges and migration routes, and Mackenzie River Delta Migratory Bird Habitat (Figure 3). These tend to be rare in terms of their extent but are important for maintenance of wildlife populations and biological diversity. Landscape-scale effects on habitat loss and fragmentation addressed with the indicators outlined above do not ensure that specialized local features will be adequately protected. Conservation of habitats that are rare and important to wildlife is more important than habitats with extensive distribution. Specialized environmental features are commonly used as a project-specific indicator to ensure that these important sites and areas are properly managed.

Protection of sensitive environmental features is a clearly defined goal in all Inuvialuit Community Conservation Plans and the Gwich'in Land Use Plan. These include: point features such as mineral licks, dens, wallows, nests, and rare plants; uncommon habitat features such as the Caribou Hills (Inuvik ICCP 2000) and Campbell Hills (GLUPB 2003); and designated areas such as the KIBS. Each of these is limited in extent on the landscape, but contributes to biodiversity and regional productivity.

5.2.5 Vehicle and Aircraft Activity

Seasonal aircraft and vehicle activity was considered as a cumulative effects indicator for the Beaufort Delta region. This would track the total land area in designated travel corridors and areas where low level flights and ground vehicle movements could occur as an indicator of cumulative disturbance risk, a key concern for waterfowl, whales, and caribou.

The EISC (2004) has identified minimum flight height guidelines of 610 m (2000 ft) above wildlife, except where there are concentrations of birds, in which case the minimum height is 1,100 m (3500 ft) to address this effect pathway. Sensitive seasons and areas identified in the Inuvialuit Community Conservation Plans include: seabird colonies; raptor nesting sites; caribou calving and post-calving sites (May 25 to July 15); and large aggregations of caribou.

No readily-available information on vehicle and aircraft activity in the Beaufort Delta region was located, so these disturbance sources were not included in calculations of indirect footprint for the core area indicator.

5.2.6 Candidate Indicators

Candidate indicators for evaluating cumulative effects on terrestrial resources and their rationale are provided in Table 7. Candidate thresholds for each indicator are discussed below and summarized in Table 9. These candidates should be discussed and refined with input from interested governments, communities, groups, and individuals in the Beaufort Delta region before being formally adopted.

5.2.6.1 Total Area Disturbed

Total area disturbed is recommended as a candidate indicator to track the direct footprint of industrial and human activities in the Beaufort Delta region. This includes all forms of surface disturbance that could affect permafrost, plants and vegetation communities, and wildlife habitat and be perceived as a negative visual effect.

Table 7 Proposed Land indicators for direct and indirect footprint in the Beaufort Delta region.

Potential Indicator	Rationale
Total area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	Reflects cumulative effects of habitat loss and alteration. Can be calculated for specific terrestrial values where sufficient information is available (e.g., plant communities, focal wildlife species). Important areas and wildlife (e.g., caribou, grizzly bear, and geese) identified in Community Conservation Plans. Provides measure of local, sub-regional and regional cumulative effects risk for permafrost, vegetation communities, and terrestrial wildlife habitat,
Core habitat available (ha and % of area available more than 1000 m from a disturbance feature)	Reflects cumulative effects of habitat loss and alteration. Can be calculated for specific terrestrial values where sufficient information is available (e.g., plant communities, focal wildlife species). Important areas and wildlife (e.g., caribou, grizzly bear, and geese) identified in Community Conservation Plans. Core habitat, relatively undisturbed areas, can be used as measure of sub-regional and regional cumulative effects risk for all terrestrial wildlife and plant communities.
Sensitive environmental features (ha and % of area disturbed in unique vegetation communities, rare plants, mineral licks, dens, nests, nesting colonies; Pingo Canadian Landmark)	Reflects cumulative effects of habitat loss and alteration; complements generalized habitat indicators. Can be calculated for specific terrestrial values where sufficient information is available (e.g., landforms; plant communities, focal plant and wildlife species). Routinely considered in project applications. Provides measure of local, sub-regional, and regional cumulative effects risk for landforms, permafrost, vegetation, and terrestrial wildlife.
Total corridor density (km of seismic lines, pipeline rights-of-way, and roads per square kilometer)	Reflects both direct and indirect effects of habitat loss and alteration.

GIS analysis of current conditions indicated that within the ISR portion of the Beaufort Delta study area, 0.1% of lands are currently considered disturbed in Category E (extremely sensitive), 2.8% in Category D (year-round sensitivity), 1.0% in Category C (seasonally sensitive), 2.4% in Category B (some sensitivity), and 0.1 % in Category A (no known sensitivity). Based on GIS analysis for the GSA portion of the study area, 0.2% of lands are currently considered disturbed in Conservation Zones (restricted use), 0.3% of lands are currently considered disturbed within Heritage Conservation zones (restricted use), 0.3% in Special Management Zones (valued resources identified), and 0.2% in General Use Zones.

Disturbance and habitat thresholds are generally outcome-based (i.e., undisturbed or available habitat). Because no single amount of available habitat represents a transition from an acceptable to unacceptable state, outcome-based targets may be established:

- at points where rapid changes in the size and isolation of habitat patches occur;
- based on calculated degree of population risk; or
- using social preferences.

Theoretical and field investigations have identified so called 'critical thresholds' in the process of habitat fragmentation where changes in the size and isolation of patches occur (Andrén 1994; With and Crist 1995; Mönkkönen and Reunanen 1999; Fahrig 2001, 2002). As habitat becomes increasingly fragmented the likelihood of local extinctions increases. In remnant patches, even moderate habitat loss increases the extinction risk of abundant species, although there is a 50 to 400 year lag before this is predicted to occur (Tilman et al. 1994).

Habitat effectiveness thresholds of <80% loss have been proposed for grizzly bear management in National Parks (Parks Canada 1997). Targets of <2% loss have been established in Muskwa-Kechika Special Management Areas (MSRM 2004).

Recent research suggests that some hypothesized habitat fragmentation effects such as patch isolation and edge effects have likely been overstated for boreal landscapes (Findlay and Houlahan 1997; Fahrig 2001, 2002; Schmiegelow and Mönkkönen 2002). For most species, habitat fragmentation effects do not occur when less than 10% of available regional habitat is lost. Cumulative effects risk increases at intermediate levels of habitat loss (30% to 40%), and increases dramatically when 70% to 90% of functional habitat in a region is lost (Andrén 1994; Rich et al. 1994; Fahrig 1997; Forman and Collinge 1997; Hannon 2000; Schmiegelow and Mönkkönen 2002). Habitat specialists associated with localized or uncommon habitats or features (e.g., riparian shrub lands), and species with large area requirements (Schmiegelow and Mönkkönen 2002) or low resilience (Weaver et al. 1996; BCC 2003) are more sensitive. The composite multi-species cumulative effects risk curve provided in Figure 12 was derived from these sources and other relevant references on ecological response to landscape change.

The risk curve provided in Figure 12 was reviewed with participants at the October 2004 workshop. Community representatives indicated that they considered only very low to low risk acceptable, except in Category E lands and Conservation Zones where no risk was acceptable (Dillon and Salmo 2004b). This is consistent with work in other subsistence-based mixed economies where social limits of change (e.g., visual impact) are lower than levels known to cause adverse biological effects (NRC 2003). These stated risk acceptance levels were used to derive the following candidate habitat availability thresholds.

Candidate Target and Critical Thresholds proposed for Inuvialuit Community Conservation Plan Category C and D lands and Gwich'in Land Use Plan Special Management Zones are to disturb no more than 5% and 10%, respectively, of the land base. Candidate Target and Critical Limits for Inuvialuit Community Conservation Plan Category A and B lands and Gwich'in Land Use Plan General Use Zones are to disturb no more than 10% and 15%, respectively, of the land base. The candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category E lands and Gwich'in Land Use Plan Conservation/Heritage Conservation Zones are to disturb no more than 0% and 0.5% of the land base, respectively.

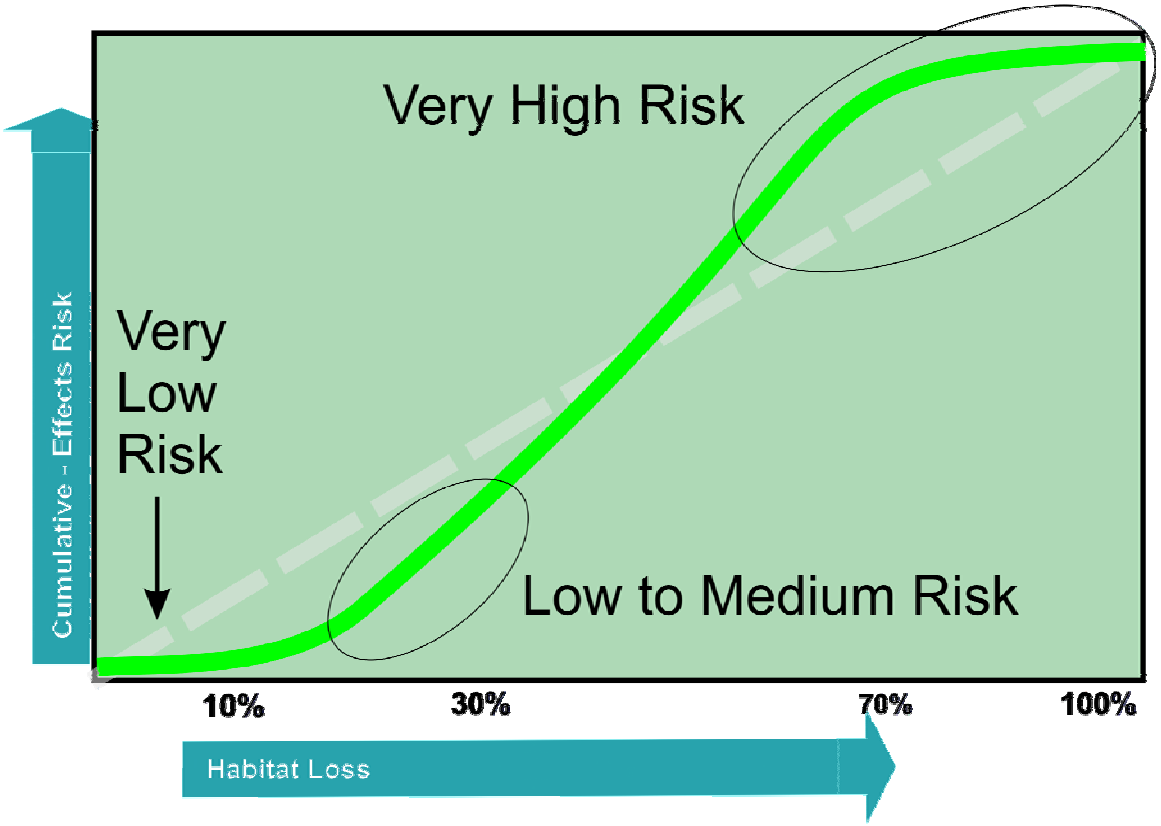

Figure 12 Relationship between cumulative effects risk and habitat loss.

One advantage of total area disturbed as an indicator is that, where sufficient information is available, it can be calculated for specific terrestrial values (e.g., plant communities, caribou, grizzly bear, waterfowl), or designated areas (e.g., Conservation Zones and Category E lands).

Relationships between landscape change and environmental response are based largely on research conducted in forested landscapes, so it is important that research into responses of land, vegetation and wildlife to habitat factors in the Beaufort Delta continues and that results are incorporated into refined thresholds. Use of Cautionary Thresholds (Section 3.7.2.3) will help ensure that effects monitoring is initiated in this region.

5.2.6.2 Core Area

Remaining core area is recommended as a candidate indicator to consider cumulative direct and indirect effects of industrial activities on land, vegetation communities, and wildlife in the Beaufort Delta region. Remaining core habitat can be used as a measure of sub-regional and regional cumulative effects risk for all terrestrial resources.

The zone-of-influence around industrial, recreational, and community sites and activities depends (among other factors) on: the resource being considered; the nature of the disturbance; and the season. The proposed method for calculating core area is based on the assumption that indirect effects are confined to an area within 1,000 m of sites that have intensive human use or are highly visible (i.e., roads, industrial facilities, roads, above ground pipelines, operating well sites, active camps and staging areas, airstrips, active seismic programs, cabins and communities). This zone of influence in considered conservative for most species and all seasons except nesting/birthing (Henson and Grant 1991; Monda et al. 1994). In forested landscapes of Canada, core security habitat for bears is normally assumed to be 500 m from roads or other high use features (e.g., Gibeau et al. 1996; ESGBP 1998; Axys 2001b; Kansas 2002). In open landscapes this distance will be increased because there are fewer visual barriers to provide security. In habitat models for Yellowstone Park grizzly bears, setbacks from roads and trails are two- to four-fold greater in open habitats (Weaver et al. 1996). The MVEIRB has indicated that maximum disturbance zones should be used in assessments provided to them in order to provide a conservative estimate of core habitat (MVEIRB 2004b).

The recommended 1,000 m zone of influence can be modified once information on actual physical, chemical, and wildlife use of areas near active sites in the Beaufort Delta region is obtained. One advantage of this indicator is that it can be calculated with different zones of influence for specific terrestrial values or seasons (e.g., plant communities, caribou, grizzly bear, nesting waterfowl and raptors), or designated areas (e.g., Conservation Zones and Category E lands) where sufficient information is available and these additional analyses will assist land and resource managers.

GIS analysis of current conditions indicated that within the ISR portion of the Beaufort Delta study area, 94% of lands are currently considered core habitat in Category E (extremely sensitive), 73% in Category D (year-round sensitivity), 85% in Category C (seasonally sensitive), 74% in Category B (some

sensitivity), and 97% in Category A (no known sensitivity). In the GSA portion of the study area, GIS analysis indicated that 69% of lands are currently considered core habitat in Conservation zones (restricted use), 20% of lands are currently considered core habitat in Heritage Conservation zones (restricted use), 85% in Special Management Zones (valued resources identified), and 91% in General Use Zones (no known sensitivity).

Core security area thresholds of >60% have been proposed for grizzly bear management in Banff National Park (Gibeau 2000) and Yukon territory (Horesji 1996). Thresholds in Montana and Idaho National Forests are >58% to >68% of total land area (NCGBRT 2001).

Candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category C and D lands and Gwich'in Land Use Plan Special Management Zones are to maintain more than 70% and 60%, respectively, in large core areas greater than 1,000 ha. Core areas of this size are capable of providing life requirements for several days and providing secure denning or calving areas. Candidate Target and Critical Limits for Inuvialuit Community Conservation Plan Category A and B lands and Gwich'in Land Use Plan General Use Zones are to maintain more than 60% and 50% respectively, in large core areas greater than 1,000 ha. The candidate Critical Limit proposed for Inuvialuit Community Conservation Plan Category E lands and Gwich'in Land Use Plan Conservation/Heritage Conservation Zones is to maintain more than 90% in large core areas greater than 1,000 ha.

Relationships between landscape change and environmental response are based largely on research conducted in forested landscapes, so it is important that research into responses of land, vegetation and wildlife to core area availability in the Beaufort Delta is undertaken so that results can be incorporated into refined thresholds. Use of Cautionary Thresholds (Section 3.7.2.3) will help ensure that effects monitoring is initiated in this region.

5.2.6.3 Total Corridor Density

Total corridor density is proposed as an indicator of cumulative effects risk to woodland caribou in forested areas of the Beaufort Delta region. Although the BCC (2003) regression equation appears to provide the most rigorous and defensible indicator for woodland caribou assessment and management, it requires information on vegetation age structure that is not currently available for the Beaufort Delta study area. Total corridor density can be used for land management until required vegetation data become available.

In the GSA portion of the study area, total corridor density (all roads, trails, pipelines, seismic lines, utility corridors >3 m wide) is 0.00 km/km^2 in Conservation/Heritage Conservation zones (restricted use), 0.05 km/km^2 in Special Management Zones (valued resources identified), and 0.01 km/km^2 in General Use Zones (no known sensitivity). The majority of corridors identified in the digital database provided were roads and pipelines. Although an extensive system of seismic trails was evident in the ISR, the database did not reveal any seismic trails in the GSA within the study area.

Southern boreal-ecotype caribou populations declined when total corridor density exceeded 1.8 km/km^2 (Anderson et al. 2002). Density of calving barren-ground caribou was highest in unroaded areas, and declined by 86% at road densities greater than 0.6 km/km^2 (Nellemann and Cameron 1998). Weclaw and Hudson (2004) used simulation modeling to predict that boreal-ecotype caribou would likely decline at total corridor densities greater than 1.22 km/km^2 when wolves were present and 40 km/km^2 in the absence of wolves.

Candidate Target and Critical Thresholds proposed for Gwich'in Land Use Plan Special Management Zones are to maintain total corridor densities less than 0.6 km/km^2, and 1.0 km/km^2, respectively, to maintain very low risk of caribou declines. Candidate Target and Critical Limits for Gwich'in Land Use Plan General Use Zones are to maintain total corridor densities less than 1.0 km/km^2, and 1.2 km/km^2, respectively to maintain low risk of caribou declines. The candidate Target and Critical Limits proposed for Gwich'in Land Use Plan Conservation/Heritage Conservation Zones are to maintain total corridor densities less than 0.1 km/km^2, and 0.2 km/km^2, respectively, to respect the Gwich'in Land Use Plan and ensure there is no risk of caribou declines.

5.2.6.4 Sensitive Environmental Features

The importance of sensitive environmental sites to Beaufort Delta residents is acknowledged in existing land use plans and review processes. Adoption of explicit thresholds for these resources would help clarify management and mitigation expectations.

The candidate Target Threshold for these features is no disturbance or industrial activity within 250 m of the site, as specified by the Gwich'in Land Use Plan. However, recognizing that site avoidance may not always be possible, the Critical Threshold is no net loss, defined as no disturbance without mitigation or compensation (i.e., improving quality or amount of similar habitat in the same ecological unit). Cautionary Thresholds and more restrictive Critical Thresholds should be considered for Inuvialuit Community Conservation Plan Category E lands and Gwich'in Land Use Plan Conservation/Heritage Conservation Zones where environmental values are the primary management objective.

5.3 Harvest and Predation

Human-induced mortality is the proximate cause of population-level effects for most harvested species. Grizzly bear are particularly sensitive to combined mortality from harvest and management actions because they have low ecological resilience (Weaver et al. 1996; Branigan et al. 2003; McLoughlin et al. 2003). Localized sources of bear mortality may affect the demographics of grizzly bears in the entire region.

Industrial activity substantially increases bear-human interactions that can lead to increased harvest and management kills to protect life or property, although it is difficult to correlate actual mortality with project-specific activities. McLoughlin and Messier (2001) studied population dynamics of barren-ground grizzly bear in the Slave Geological Province east of the Beaufort Delta study area. They

concluded that population declines could occur with comparatively small changes in mortality. Incremental grizzly bear mortality has been identified as key concern for the petroleum development in the Beaufort Delta region, but there is no recent information relating mortality to industrial activity intensity (IORVL 2004).

5.3.1 Candidate Indicators

The current allowable harvest is ten bears/year in the Tuktoyaktuk Grizzly Bear Management Area, ten bears/year in the Inuvik Grizzly Bear Management Area, four bears/year in the Aklavik Grizzly Bear Management Area, two bears/year in the Fort McPherson Grizzly Bear Management Area, and two bears/year in the Tsiigehtchic Grizzly Bear Management Area (M. Branigan, pers. com., RWED). All bears killed to protect life or property must be reported and taken off established community quotas. Grizzly bear mortality is recommended as a candidate cumulative effects indicator (Table 8) that should be relatively easy to track and relate to the direct and indirect industrial footprint. This will allow mortality from industry-associated sources to be tracked and combined with legal and illegal harvest statistics to document cumulative annual mortality for regional population management purposes.

Table 8 Proposed Land Indicators for predation and harvest in the Beaufort Delta region.

Potential Indicator	Rationale
Grizzly bear mortality Grizzly bear mortality from management actions, illegal kills by industry workers, other industry-related mortality, and legal/illegal harvest	Reflects cumulative effects of human-induced mortalities on grizzly bear populations Can be combined with other sources of human-induced mortalities that are tracked and considered in established community quotas Critical harvest thresholds already exist for grizzly bears Provides measure of local, sub-regional and regional cumulative effects risk for grizzly bear populations

Bear harvest is currently near quota levels so any additional mortality from management actions is considered undesirable in the Inuvialuit Community Conservation Plans. The candidate Target Threshold for industry-associated grizzly bear mortality is, therefore, set at no incremental mortality and the candidate Critical Threshold is no more than one bear.

5.4 Candidate Land Indicators and Thresholds

To be most effective, resource managers, communities, and other regional groups should help define land indicators and thresholds within a consistent regional framework. The candidate indicators and thresholds provided here are intended to help inform such discussions by demonstrating how practical limits can be derived and by providing a reasonable starting point for consultation. The candidate

framework is based on relevant guidance documents, statements made by Gwich'in and Inuvialuit organizations and other participants at the October 2004 workshop in Inuvik, and the regional vision described in Section 3.1.5.

Figure 13 shows how the suite of candidate land indicators allows potential cumulative effects pathways to be tracked. These project-specific indicators can be directly related to proposed oil and gas activities, and supplemented with regional indicators monitored to help document and understand long-term cumulative effects. Candidate thresholds for each project-specific land indicator are summarized in Table 9.

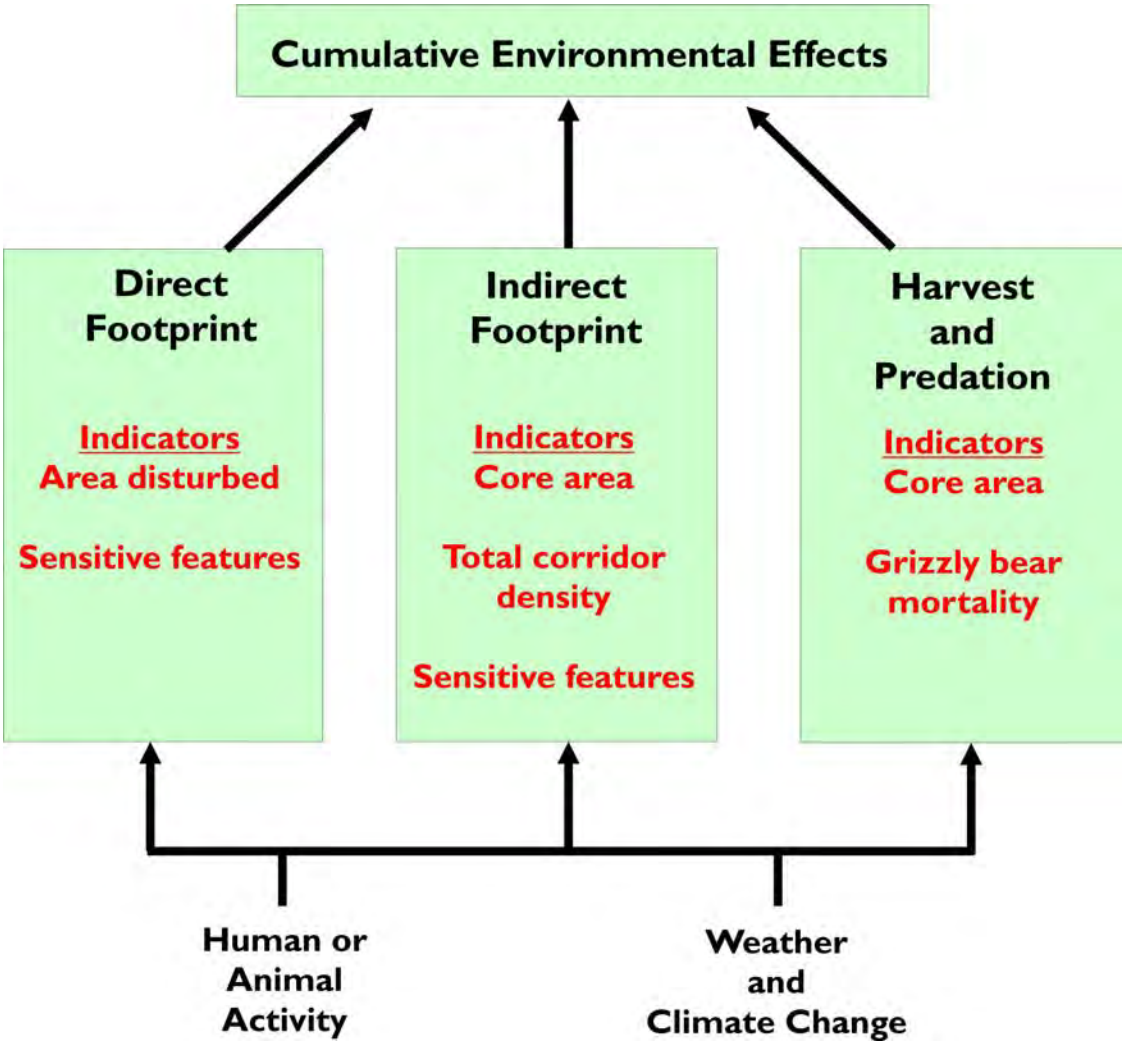

Figure 13 Candidate project-specific and regional Land indicators for the Beaufort Delta region.

Table 9 Candidate Land indicators and thresholds for the Beaufort Delta region.

Candidate Project-Specific Indicator	Candidate Thresholds
Total area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear, waterfowl) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.
Core habitat available (ha and % of area available more than 1000 m from sites with intensive human or industrial use, including: industrial facilities, above ground pipelines, producing well sites, active camps and staging areas, airstrips, active seismic programs, cabins, and communities)	**Target**: no more than 60% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 60% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 50% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: more than 70% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: more than 90% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.
Total corridor density (km/km^2**;** including all roads, trails, pipelines, seismic lines, power lines >3 m wide)	**Target**: no more than 1.0 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 0.6 km/km^2 on ICCP Category C and D lands and Special Management Zones. **Target**: no corridors on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 1.2 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 1.0 km/km^2 on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.2 km/km^2 on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.

Sensitive environmental features (ha and % of area disturbed in unique vegetation communities, rare plants, mineral licks, dens, nests, nesting colonies; Pingo Canadian Landmark)	**Target**: no disturbance or activity within 250 m. **Critical**: no net loss (taking into account mitigation or compensation). **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where environmental values are the primary management objective.
Grizzly bear mortality (from industry-associated causes and legal and illegal harvest)	**Target**: no industrial-associated mortality. **Critical**: one industrial-associated mortality.

ICCP - Inuvialuit Community Conservation Plans GLUP – Gwich'in Land Use Plan

6 FRESHWATER

Sources of cumulative effects on freshwater resources (e.g., surface water and groundwater quantity and quantity, aquatic and riparian habitats, and aquatic communities including fish, other aquatic organisms and vegetation) identified by Tera and Salmo (1999); MMS (2003) and IORVL (2004) can include:

- direct footprint (e.g.: physical disturbances or alterations of instream and riparian habitat; reduced habitat quality and quantity caused by water crossings, effluent discharge, and water withdrawal/diversion);
- indirect footprint (e.g.: migration blockages caused by impassible fish barriers; changes in permafrost and surface and subsurface flow caused by clearings and other land uses; altered habitat quality and quantity caused by changes in sediment yield, water column concentrations, and deposition, introduction of aquatic weeds or other pests; contact with, or uptake of contaminants from routine discharge and accidental spills);
- harvest and mortality (e.g., changes in predator-prey relationships and predation risk due to human activities such as increased harvest and changes in harvest patterns due to increased access and allowable harvest regulations; fish stocking; direct mortalities and injuries caused by blasting, water diversions, and pollution events; and direct and indirect mortalities caused by introduction of disease, parasites and other pests); and
- natural disturbance (e.g., alteration and/or loss of aquatic communities and habitats from floods, climate change, ice conditions, drought, ambient temperatures, fire and beaver activity).

6.1 Indicators

An overview of watershed assessment models and indicators was provided by Salmo et al. (2003 - Appendix 1, Section 5.5). They reported that research throughout western North America has shown that clearings and road/trail networks created for resource extraction can create direct and indirect effects on flow rates, patterns, sediment yield, stream habitat, invertebrates, and fisheries (e.g., see Furniss et al. 1991; McCurk and Fong 1995; Trombulak and Frissel 2000). Just as clearings and road trail networks can contribute to increased sediment yields, they can also contribute to changes in water quality such as increased suspended sediment loads (e.g., Anderson 1998; Beaudry 1998; Tera and Salmo 1999), and increased water temperatures (e.g., Buchanan and Gregory 1997; MacDonald et al. 1998) which in turn can affect fish assemblages (e.g., Haas 2001b; Sloat et al. 2003). Recent studies in northern Alberta (i.e., in the Kakwa and Simonette River basins) have also shown that cumulative percent disturbance from industrial activities and cumulative density of stream crossings can also have impacts on fish populations (Scrimgeour et al. 2003). Investigators in Alberta, British Columbia and the northwestern United States have utilized watershed indices to evaluate the potential for cumulative aquatic effects from combined land uses in a watershed. Salmo et al. (2003) reported that the majority of cumulative effects techniques consider disturbed area, potential for sediment yield, water quality, and/or probable changes in peak flow

and channel characteristics (e.g., Klock 1985; Reid 1993; Lowrence and Vellidis 1995; Lull et al. 1995; McGurk and Fong 1995; Collins and Pess 1997; Carver 2001; and Beaudry 1998). Other studies have also used similar approaches (e.g., Scrimgeour et al. 2003; Sawyer and Mayhood 1998). Scrimgeour et al. (2003), for example, found total cleared area was inversely related to bull trout presence in west-central Alberta, and that the effects occurred at low forest harvest levels. Some studies have also looked at allowable harvest levels of fish based on using the legal harvest (i.e., commercial and recreational harvest combined), hooking mortality and illegal harvest (e.g., Sullivan 2003).

6.2 Direct and Indirect Footprint

Natural and human-caused activities can alter flow rates and patterns, sediment yield, stream habitats, and aquatic communities (see review in Salmo et al. 2003). Habitat-based indicators and associated thresholds provide a practical approach for managing cumulative effects on freshwater resources (Salmo et al. 2004).

Although some indicators have been used in other parts of North America, for a variety of reasons, they are not suitable indicators for activities that occur in the Mackenzie Delta. For example, although changes in peak flow and stream temperature have been used by a variety of investigators (e.g., Klock 1985; Reid 1993; Lowrence and Vellidis 1995; Lull et al. 1995; McGurk and Fong 1995; Collins and Pess 1997; and Carver 2001), they are not suitable for the Mackenzie River within the study area because of the overall size of the Mackenzie River Basin and the relatively small proportion of the Basin that occurs in the study area. However, for smaller waterbodies such as headwater streams that provide important habitat for species like Arctic grayling and Dolly Varden char, changes to stream flow and stream temperature from human disturbance within the stream area could provide cumulative effect indicators within the study area.

The recent cumulative effects assessment for the Mackenzie Gas Project included the Mackenzie Delta in its study area (IORVL 2004). The indicators IORVL (2004) used were: groundwater (i.e., quantity and flow patterns, and quality); hydrology (i.e., runoff and drainage pattern, levels and flow velocity, sediment concentration and channel morphology); water quality (i.e., wastewater releases and suspended sediments); and fish and fish habitat (i.e., fish habitat, fish health and fish abundance and distribution).

6.2.1 Hydrology

Hydrology was used a cumulative effects indicator for freshwater resources by IORVL (2004). It has also been as an indicator for a variety of cumulative effects assessments (e.g., HydroConsult 1999; Rothwell et al. 2004; and numerous references reviewed by Salmo et al. 2003). However, as previously indicated, although hydrology may provide a good indicator of cumulative effects for industrial development in the upper watersheds of some streams and rivers in the study area (e.g., waterbodies providing critical habitats for species like Arctic grayling and Dolly Varden char), changes to flows caused by small- to medium-sized oil and gas projects would be undetectable when compared to the

extremely large volumes of Mackenzie River surface flow. As a result, hydrology is not recommended as an indicator for the study area for the Beaufort Delta Cumulative Effect Project.

6.2.2 Groundwater Flow Patterns

Although groundwater flow patterns were used for the Mackenzie Gas Project's entire study area (IORVL 2004), much of the study area for the Beaufort Delta Cumulative Effect Project is in the active floodplain of the Mackenzie River. The warming by the Mackenzie River causes permafrost to be absent throughout much of the Delta (Section 2.3.1). This, and the permeable soils in the inner Delta, cause subsurface flows in the inner Delta to be heavily influenced by surface flows from the Mackenzie River. Elsewhere, the permafrost limits groundwater flow. As a result, it is unlikely that changes to groundwater flow and flow patterns caused by diversions from small oil and gas projects would be detectable in a large part of the study area. Groundwater flow patterns, therefore, are not recommended as an indicator of cumulative effects for the Beaufort Delta study area.

6.2.3 Fish Health

IORVL (2004) also used fish health as a cumulative effects indicator for the Mackenzie Gas Project. Many of the fish found in the lower Mackenzie River and inner Delta are migratory species (e.g., anadromous species) that migrate between habitats that may be impacted by several, or many, industrial and human activities. Because individual proponents would be unable to determine what other project activities migratory fish were exposed to, or how long fish were exposed to the influences of an individual project, fish health is not recommended as an indicator of cumulative effects for proponents of small- to moderately-sized oil and gas proponents in the Beaufort Delta Cumulative Effect Project study area.

6.2.4 Fish Abundance

Sportfish abundance was a cumulative effects indicator used for the Mackenzie Gas Project (IORVL 2004) and has also been used as a cumulative effects indicator in other watersheds (e.g., McLeod River sub-basin in west central Alberta - Allan 1999). Caution must be applied when considering combined sportfish abundance without identifying which species are likely to increase or decrease as a result of changes in water flow, habitat quality, or improved access and increased angling pressure (Antoniuk 2000). To address such concerns, some investigators have used fish community assemblages (e.g.: native and non-native assemblages – Antoniuk 2000; fish community structure – Scrimgeour et al. 2003); species-specific indicators such as bull trout (e.g., Scrimgeour et al. 2003; Ripley et al. 2004; Popowich and Volpe 2004); or several focal species (e.g., Arc 2005.).

Although fish abundance, biomass and distribution can all be used as indicators for cumulative effects, these parameters are typically influenced by year-to-year (as well as seasonal) variation in fish populations, and long-term trend data is generally needed to distinguish differences between natural year-

to-year variation and variation caused by a specific project. There are also large number of migratory species, as well as predators (e.g., nearshore marine mammals, avian predators, and humans) in the Mackenzie Delta; some of these species (or predators) may respond differently to changes in habitat or other human-caused impacts (e.g., some species may increase due to changes in habitat or fishing pressure while others may decrease – Antoniuk 2000). Without adequate baseline datasets, fish abundance cannot be recommended as a project-specific cumulative effects indicator for the Beaufort Delta region.

6.2.5 Water Quality

Water quality is commonly used as a cumulative effects indicator (e.g., IORVL 2004; MRBB 2004). It is also given a high priority in the Inuvialuit Community Conservation Plans and the Gwich'in Land Use Plan.

In 1987, the Water Quality Task Group of the Canadian Council of Environment Ministers (CCME) published the *Canadian Water Quality Guidelines* (CCREM 1987). The document included recommended guidelines for five water uses: raw water for drinking water supply; recreational water quality and aesthetics; aquatic life (freshwater and marine); agricultural uses (irrigation and livestock watering); and industrial water supplies. These guidelines have been distributed widely by the United Nations Environment Program and the World Health Organization and are currently used in 45 different countries around the world. These Water Quality Guidelines are annually updated by the CCME and are summarized by CCME (2004).

Water chemistry and hydrology data are generally limited in the study area. Unlike air quality, widely accepted models and assumptions are not available because of the influence that local variability has on water quality. In recognition of these challenges, CCFM (2003) revised its water quality indicators from measured values to rate of compliance with construction and management standards.

6.2.6 Total Area Disturbed

As discussed in Section 6.1, investigators in Alberta, BC, and the northwestern U.S. have developed watershed indices to evaluate the potential for cumulative aquatic effects from combined land uses in a watershed. A review of the available literature did not reveal specific relationships that relate total area disturbed to abundance or health of northern fish species. However, some northern species like Dolly Varden share many of the same habitat preferences as similar species for which thresholds have been considered. Haas (2001a) conducted a risk assessment of Dolly Varden by comparing habitat and temperature preferences between bull trout and Dolly Varden using 15 habitat variables. He reported the only variable where statistical differences occurred was for the percentage boulder composition of substrate (i.e., Dolly Varden preferred streams with fewer boulders). He also reported that Dolly Varden had a preference for slightly colder water temperatures. Due to their sensitivity to habitat disturbances,

bull trout are often used as an indicator species for aquatic ecosystems (e.g., Salmo et al. 2003; Scrimegour 2003; Ripley et al. 2004; McLeary 2004).

This suggests that disturbance thresholds for bull trout may useful for Dolly Varden, and other northern aquatic species (e.g., Arctic char). Scrimgeour et al. (2003) used total cleared area and reported that at levels of disturbance of 18.7% and 10.2% in the Kakwa and Simonette River sub-basin examined (both major tributaries of the Peace River in west-Central Alberta), they reported watershed disturbance levels generally had minimal impact on bull trout presence. The disturbances they examined included forest harvest, oil and gas exploration and development, and road crossings. Ripley et al. (2004) also studied the effects of the industrial activity on bull trout in the Kakwa River sub-basin, and although no values were published, they reported that industrial type disturbance variables were not strongly associated with bull trout presence. McLeary (2004) also used land-use variables (i.e., percent of basin harvested, basin road density and presence of man-made barriers) and several ecological variables to determine using resource selection models if land use activities were associated with bull trout occurrence. He reported that the presence of downstream barriers, and percent of basin harvested, had a negative influence on the probability of bull trout presence.

Other investigators have also used landscape disturbances within watersheds to evaluate cumulative effects risk. Sawyer and Mayhood (1998) and Mayhood et al. (2004) used British Columbia's Level 1 Watershed Assessment Procedure to conduct cumulative effects assessments of watersheds in the Carbondale River sub-basin, and of 90 different watersheds in southwestern Alberta, respectively.

Scrimgeour et al. (2003) examined the effects of land disturbances (i.e., forest harvest, roads, seismic trails, wells and pipelines) in two moderately-sized sub-basins in west central Alberta. They reported a negative association between bull trout and percent disturbance in one sub-basin. Additional analyses showed that the negative association between bull trout presence and percent watershed disturbance was primarily from forest harvesting which, on average, accounted for about 84% of human-induced disturbance. However, additional analyses indicated that the presence of bull trout was unrelated to percent of the watershed disturbed by all other non-harvesting activities including percent disturbance by roads, pipelines and seismic lines.

Although Scrimgeour et al. (2003) reported land disturbance had a negative relationship with the occurrence of bull trout, they also reported that total watershed disturbance had a positive relationship with fish biomass (which suggests responses to disturbances may be species-specific), and that they found a detectable effect of watershed disturbance on fish community structure.

Scrimgeour et al. (2003) suggested the two primary contributors to the negative relations between bull trout presence and forest harvesting and density of stream crossing were that: i) negative effects of forest harvesting and stream crossings on bull trout were detectable at relatively low levels of watershed disturbance; and ii) the slope of the relationship between bull trout presence, and percent watershed

harvested and density of stream crossings are relatively linear. The latter result suggests that if a disturbance threshold exists, it likely occurs at very low levels of watershed disturbance (i.e., <15%).

Tonn et al. (2003) and Tonn et al. (2004) examined the effects fire and forest harvest, and fire, respectively, on fish assemblages in northern Alberta lakes, they reported that these disturbances had little if any assemblage-level effects. However, the length of their study was relatively short (within two years) and they suggested that population level differences may be more apparent over the long-term.

Salmo et al. (2004) proposed the use of total disturbed area as cumulative effects indicator for the Deh Cho Region, NWT. Part of their rationale was that total disturbed area can also provide a cumulative effects indicator for water quality and quantity.

6.2.7 Total Aquatic and Riparian Area Disturbed

Aquatic system integrity was found to be lower in coldwater streams with reduced riparian vegetation and increased road density and highest in comparatively undisturbed wilderness areas and national parks of the Pacific northwest (Hughes et al. 2004). A negative relationship between watershed disturbance and sensitive native species has been observed elsewhere (Frissell and Bayles 1996; Wang et al. 1997, 2003).

Roads are known to be an important contributor to cumulative effects on aquatic systems (Trombulak and Frissell 2000). Angermeier et al. (2004) developed a conceptual framework for assessing impact of roads that includes long-term large scale impacts that are typically overlooked. They note that roads within 1 km of waterbodies are 'ecologically present', while those that cross or are directly connected are of particular concern. Active stream crossings are often a chronic source of sediments and instream and riparian habitat changes as a direct result of disturbance caused by construction activities or post-construction erosion, or indirectly from the transport of sediments and contaminants (metals, oil, grease, salts, toxic spills) along the right-of-way (Reid and Dunne 1984; BCF and BCE 1995; Haskins and Mayhood 1997; Mayhood et al. 1998; Anderson et al. 1996; Brown 1999; Reid and Anderson 1999; Angermeier et al. 2004). Road crossing density has also been found to be positively correlated with fine substrate and embeddedness and/or negatively correlated with salmonid presence and abundance (Liknes and Graham 1988; Eaglin and Hubert 1993; Rieman et al. 1997; Clarke et al. 1998; Baxter et al. 1999; Scrimgeour et al. 2003; USFWS 1999; WNTC 2001). Stream crossings also provide increased access opportunities for subsistence users and anglers as well as potential barriers to upstream fish movements (Marshall 1996; Warren and Pardew 1998; Harper and Quigley 2000; Scrimgeour et al. 2003).

Bull trout strongholds were found in areas with road densities less than 0.25 km/km^2, but they were absent in areas where road densities exceeded 1.05 km/km^2 (Hitt and Frissel 1999 in WNTC 2001). Changes in bull trout redd numbers over time are also negatively correlated with catchment road density (Baxter et al. 1999). Reiman et al. (1997) found that bull trout are more likely to occur and have stronger populations in colder, high-elevation, low- to mid-order catchments with lower road densities. Sawyer and Mayhood (1998) reported road densities in the Carbondale River sub-basin ranged from 0.91 km/km^2

to 2.60 km/km^2 and an average of 2.21 km/km^2 for the entire watershed. Fitch (1997) discussed the long-term declines of bull trout in southern Alberta as a result of a variety of effects and indicated only a remnant fluvial bull trout still remained in the Carbondale River system.

Salmo et al. (2004) discussed the applicability of using road densities, stream crossing indices, and other measurements as cumulative effects indicators in the Deh Cho region of the NWT, and recommended stream crossing indices as the most practical aquatic cumulative effects indicator for the Deh Cho region. Their rationale were that the index: is readily calculated; and provides the most direct indicator of cumulative effects erosion and mortality risk, because it includes features that intersect watercourses directly. They also indicated watercourses that are repeatedly crossed are more likely to experience increased erosion and temperature, provide increased angling access, and have temporary or permanent barriers to upstream fish passage.

The number of waterbody crossings has been used as an indicator of land use activity for aquatic evaluations. This index is an easily calculated measure of sediment and mortality sources and stream habitat fragmentation in a watershed (BCF and BCE 1995), and can be expressed as the number of access corridor crossings (e.g., from roads, trails, utility corridors, railways and cut lines) per kilometre of stream or watershed area.

6.2.8 Sensitive Environmental Features

The importance of sensitive environmental sites to Beaufort Delta region communities is acknowledged in existing land use plans (i.e., Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan) and review processes. Adoption of explicit thresholds for these resources would help clarify management and mitigation expectations.

Sensitive freshwater features in the ISR that are to be managed for their sensitivity and require extra protection are Category E, and Category C and D, areas that are discussed in Section 2.4.4.1 and 2.4.4.2, respectively. Specialized freshwater features in the GSA that are to be managed for their sensitivity and require extra protection are Gwich'in Conservation Zones, and Gwich'in Special Management Areas, and are discussed in Section 2.4.4.3 and 2.4.4.4, respectively. Similarities between the criteria used to establish Category E areas and Gwich'in Conservation Zone, as well as Category C and D areas and Gwich'in Special Management Areas, allow similar thresholds to be recommended for these areas. During the October 2004 Thresholds Workshop in Inuvik, Category E lands were suggested as areas where no development should be permitted (Dillon and Salmo 2004b). Because of similarities in the criteria used to identify Gwich'in Conservation Zones, similar protection should be given to them.

Several documents (e.g., ICCPs; GLUP; Sekerak et al. 1992; Harwood 2001) discuss the sensitivity of the groundwater springfed areas that provide critical spawning and overwintering habitats for the Rat River Dolly Varden population.

6.2.9 Candidate Indicators

Proposed freshwater indicators for direct and indirect footprint in the Beaufort Delta region, and their rationale, are described in Table 10.

6.2.9.1 Water Quality

A water quality indicator is recommended for the Beaufort Delta region because of the social and economic importance of water quality in this area (e.g., Inuvialuit Community Conservation Plans). MRBB (2004) references the CCME water quality guidelines when discussing water quality issues in the Mackenzie Delta.

Table 10 Proposed Freshwater indicators for direct and indirect footprints in the Beaufort Delta region.

Potential Indicator	Rationale
Water quality (ambient concentration of regulated discharge parameters)	Reflects cumulative effects of industrial and municipal discharges; complements generalized indicators. Water quality identified as valued resource in ICCPs, NWT CIMP (DIAND 2003), federal reporting (NRTEE 2003), and Deh Cho (Salmo et al. 2004). Established guidelines exist for many domestic and industrial discharges. Water quality parameters are routinely considered in project applications and accepted predictive models exist. Provides a measure of local and sub-regional cumulative effects risk to water quality.
Total land area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	Reflects indirect cumulative effects of land disturbance. Can be calculated for specific aquatic values where sufficient information is available (e.g., water quality; waterbody, watershed, focal fish species and habitats). Important areas and fish (e.g., whitefish and lake trout) identified in ICCPs. Provides measure of sub-regional and regional cumulative effects risk for water quality and fish,
Total aquatic and riparian area disturbed (ha and % of area disturbed by stream crossings, bank and bed alterations, and riparian clearing/disturbance)	Reflects cumulative effects of habitat loss and alteration. Can be calculated for specific aquatic values where sufficient information is available (e.g., waterbody, watershed, and focal fish species). Important areas and fish (e.g., whitefish and lake trout) identified in ICCPs. Provides measure of local, sub-regional and regional cumulative effects risk for fish habitat.
Specialized environmental features (disturbance of spawning and overwintering areas)	Reflects cumulative effects of habitat loss and alteration; complements generalized habitat indicators. Can be calculated for specific aquatic values where sufficient information is available (e.g., key habitats, focal fish species). Routinely considered in project applications. Provides measure of local, sub-regional, and regional cumulative effects risk for aquatic habitat and fish.

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A direct water quality index is not recommended at this time for the Beaufort Delta region. This is because the level of existing and likely future development is unlikely to cause a detectable cumulative effects risk at the regional scale (i.e., Mackenzie River Basin drains approximately one fifth of Canada's total land area, and the Beaufort Delta region and the water uses in the region are relatively small when compared to the balance of the Basin and all water uses in the basin). However, water quality would be an appropriate indicator to manage water uses at sub-regional scales where concerns exist.

The recommended Canadian Water Quality Guidelines for the protection of aquatic life represent an appropriate Critical Threshold applicable to the entire Plan area. Project design and regulatory approvals should be designed to maintain water quality below these values. Adoption of a Cautionary Threshold is also recommended to ensure that monitoring is conducted at all approved discharges in order to document actual water quality and confirm impact predictions. Because some water quality parameters naturally exceed the recommended Canadian water quality standards, site-specific monitoring will also provide the data required to allow guidelines to be modified to reflect local conditions.

Consideration should also be given to the need for intermediate Target Thresholds in areas where pristine water quality is defined as a management objective. Target Thresholds could also be used where defined guidelines do not exist for a particular water quality parameter.

6.2.9.2 Total Disturbed Area

Total disturbed area is proposed as a cumulative effects indicator to track the direct footprint of industrial and human activities on freshwater resources in the Beaufort Delta region. This includes all forms of surface disturbance that could affect water quality and quantity, as well as aquatic habitats and organisms (Table 10).

GIS analysis of current conditions indicate that within the ISR portion of the Beaufort Delta study area, 0.1% of lands are currently considered disturbed in Category E (extremely sensitive), 2.8% in Category D (year-round sensitivity), 1.0% in Category C (seasonally sensitive), 2.4% in Category B (some sensitivity), and 0.1 % in Category A (no known sensitivity). In the GSA portion of the study area, currently disturbed areas were calculated by GIS analysis to include 0.2% of lands in Conservation Zones (restricted use), 0.3% of lands in Heritage Conservation zones (restricted use), 0.3% in Special Management Zones (valued resources identified), and 0.2% in General Use Zones (no known sensitivity).

Total disturbed area has also been recommended as a candidate indicator for cumulative effects on Land (see section 5.2.6.1). This indicator can be easily calculated and applied by proponents and resource managers and does not require evaluation of habitat quality. Another advantage of a total area disturbed indicator is that, where sufficient information is available, it can be calculated for specific values, or designated areas (e.g., Conservation Zones and Category E lands).

The environmental risk curve provided in Figure 12 (Section 5.2.6.1) should also apply to aquatic systems. This curve was discussed with participants at the October workshop; community

representatives indicated that they considered only very low to low risk acceptable, except in Category E lands and Conservation Zones where no risk was acceptable (Dillon and Salmo 2004b). These stated risk acceptance levels were used to derive the following candidate habitat availability thresholds.

Candidate Target and Critical Thresholds proposed for Inuvialuit Community Conservation Plan Category C and D lands and Gwich'in Land Use Plan Special Management Zones are to disturb no more than 5% and 10%, respectively, of the land base. Candidate Target and Critical Limits for Inuvialuit Community Conservation Plan Category A and B lands and Gwich'in Land Use Plan General Use Zones are to disturb no more than 10% and 15%, respectively, of the land base. The candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category E lands and Gwich'in Land Use Plan Conservation/Heritage Conservation Zones are to disturb no more than 0% and 0.5% of the land base, respectively.

6.2.9.3 Aquatic and Riparian Area Disturbed

The amount of aquatic and riparian area disturbed can be calculated from information submitted by proponents of various activities (e.g., linear developments intersecting waterbodies) when they apply for regulatory permits. These data can be used to calculate total and average road (or linear development) densities, or stream crossing indices for watersheds or the Beaufort Delta region. Arctic grayling are particularly sensitive to linear corridor creation that facilitates human access because they are readily overharvested (Falk and Gillman 1974; Berry 1998).

Unlike developed forested regions, comparatively few roads and permanent linear corridors occur, or are proposed for the Beaufort Delta region. A candidate Cautionary Thresholds of <0.25 crossings/km^2 is recommended for consideration for watersheds where fisheries values are a primary objective.

DFO has developed policy and regulatory tools to promote the protection of fish habitat, including the guiding 'No Net Loss' principle (DFO 1995). Under this principle, DFO strives to balance unavoidable losses of the 'productive capacity of fish habitat' with habitat replacement on a project-by-project basis. This approach is designed to avoid direct loss and alteration of habitats that experience commercial, recreational, or subsistence harvesting activities.

A Critical Threshold for aquatic and riparian losses for individual projects is that they should result in no net loss in fish habitat, defined as no disturbance without appropriate levels of mitigation and/or compensation (i.e., improving quality or amount of similar habitat in the same ecological unit).

6.2.9.4 Sensitive Environmental Features

The candidate Target and Critical Thresholds for known critical habitats for the Rat River Dolly Varden char population (e.g., areas where spawning and overwintering habitat use has been documented) is no disturbance or industrial activity within 250 m and 100 m, respectively, of identified reaches.

The candidate Target Threshold for the other waters in the ISR and GSA where critical habitat for fish have been documented (e.g., spawning and overwintering area) is no disturbance or industrial activity

within 100 m of these critical habitats. However, recognizing that site avoidance may not always be possible, the Critical Threshold is no net loss of fish habitat, defined as no disturbance without mitigation or compensation (i.e., improving quality or amount of similar habitat in the same ecological unit).

The candidate Target Limits proposed for Category E lands in the ISR and Conservation Zones in the GSA is to alienate no more than 1% of these areas that are to be managed to protect sensitive freshwater resources. The candidate Critical Limits proposed for Category C and D lands in the ISR and Special Management Zones in Conservation Zones in the GSA is to alienate no more than 5% of these areas that are to be managed to protect sensitive freshwater resources. Where disturbances do occur on these lands, there should be no net loss of fish habitat, defined as no disturbance without compensation

6.3 Harvest and Predation

Information exists for harvest level of freshwater fish by Inuvialuit (JS 2003) and Gwich'in (e.g., MacDonald 1998a. 1998b) communities; however, other human-induced mortalities of freshwater fish populations also occur in the region.

Although data on other human-induced mortalities (i.e., other than the subsistence harvest) of fish in the Beaufort Delta region is limited, the cumulative effects of subsistence harvest and other human-induced mortalities could negatively impact local and regional fish populations. A variety of other human activities may be contributing fish mortalities within the study area. These include such activities as: recreational fishing (i.e., recreational harvest as well as hooking mortalities); illegal harvest (i.e., poaching); mortalities caused during fishery inventories and/or research (e.g., accidental sampling mortalities, fish sacrificed for fish research purposes); industry, community, and utility activities (e.g., dewatering short-reaches of streams to conduct instream activities that result in stranding fish or developing embryos in the dewatered reaches; use of explosives underwater; use of machinery in streams that crush incubating embryos; and intakes for water diversions that result in impingement or entrainment of fish.

Proponents of these permitted activities are required to submit data on fish mortalities to the appropriate regulatory agencies. For example, in the NWT Fisheries and Oceans Canada requires proponents of fishery research and inventory activities to obtain a scientific license and to complete a summary report on scientific license activities that documents the number of each species of fish captured and the number of mortalities that occur. Proponents of fish inventory and research activities in the NWT are also required to obtain a fish research permit from the Aurora Institute. Enforcement officers with DFO may keep records or estimates of illegal harvest. The Federal Fisheries Act (i.e., Section 32) also requires proponents of activities that result in the destruction of fish to obtain a federal authorization, and these authorizations typically are accompanied by conditions that require proponents to document and report data related to the fish that are killed during their activities.

Efforts can also be undertaken to mitigate the numbers of losses from industrial-related activities to freshwater fish populations in the Beaufort Delta region. These include: requirements to salvage fish in waters that are dewatered as a result of instream activities; fish screening requirements for water intakes (Katopodis 1992); guidelines for the use of explosives in waters containing fish (Wright and Hopky 1998); guidelines for pipeline crossings (e.g., Tera and Salmo 1999; Cott and Moore 2003); guidelines for other activities in, and near, water (e.g., Cott and Moore 2003); and recreational fishing regulations that apply to all recreational anglers, including industrial workers (GNWT 2004).

6.3.1 Candidate indicators

Proposed freshwater indicators for harvest and predation in the Beaufort Delta region, and their rationale, are described in Table 11.

Table 11 Proposed Freshwater indicators for harvest and predation in the Beaufort Delta region.

Potential Indicator	Rationale
Char industrial mortality (number of lake trout and Dolly Varden mortalities caused by all industry-related causes in addition to legal/illegal harvest)	Reflects cumulative effects of human-induced mortalities on fish populations. Can be calculated based on numbers provided through existing sources of fish harvest data and information from fish research licenses and Section 32 authorizations. Critical harvest thresholds already exist for some fish species Provides measure of local, sub-regional and regional cumulative effects risk for fish populations

6.3.1.1 Char Mortality

For most species, the co-management boards do not restrict the total allowable harvest (e.g., inconnu – FJMC et al. 2000). However, for some species or stocks which are considered at risk, management plans have been developed for (e.g., Rat River Dolly Varden population). During the Inuvik workshop participants also indicated that similar concerns exist for lake trout. Sustainable harvest levels of slow-growing northern lake trout populations are <0.2 kg/ha/year (M. Sullivan, pers. comm.., Alberta Fish and Wildlife Division, Edmonton). A conservative suite of candidate thresholds for industry-associated mortalities of char species is proposed for the Beaufort Delta Region.

Estimates of industry-related char mortality should include mortality attributable to all activities (e.g., oil and gas, mining, forestry and transportation) as well as the commercial fishing industry (e.g., fishing lodges and guides and any other commercial fishing activity in the future). These industries would be required to report all char mortalities as well as captured and released char. This would allow mortality

from industrial-associated activities to be tracked and combined with legal and illegal harvest statistics to document cumulative annual mortality for regional population management purposes.

A Cautionary Threshold is recommended that would require all activities that result in industry-related char harvest and mortality in the Beaufort Delta region to be monitored and reported.

A Target Threshold is also recommended that would restrict cumulative industry-related mortalities of Dolly Varden char to 1% or less of the total annual allowable harvest (e.g., <15 of 1,500 per year in the Rat River) for that species (see Section 2.4.3.3). A Target Threshold is also recommended for lake trout that would restrict cumulative industry-related harvest and mortality of lake trout to 10% or less of the recorded subsistence harvest for the species during the previous year (i.e., when total annual allowable harvest levels for lake trout the threshold would be revised). If additional mitigation to reduce non-fishery losses of fish are not considered viable, or some activities result in unacceptable losses, then compensation may need to be considered (e.g., as part of federal *Fishery Act* authorizations issued under Section 32 of the *Act*).

6.3.2 Candidate Indicators and Thresholds

To be most effective, resource managers, communities, and other regional groups should help define freshwater indicators and thresholds within a consistent regional framework. The candidate indicators and thresholds provided here are intended to help inform such discussions by demonstrating how practical limits can be derived and by providing a reasonable starting point for consultation. The candidate framework is based on relevant guidance documents, statements made by Gwich'in and Inuvialuit organizations and individuals at the October 2004 workshop in Inuvik, and the regional vision described in Section 3.1.5.

Figure 14 shows how the suite of candidate freshwater indicators allows potential cumulative effects pathways to be tracked. These project-specific indicators can be directly related to proposed oil and gas activities, and supplemented with regional indicators monitored to help document and understand long-term cumulative effects. Candidate Thresholds for each project-specific Freshwater indicator are summarized in Table 12.

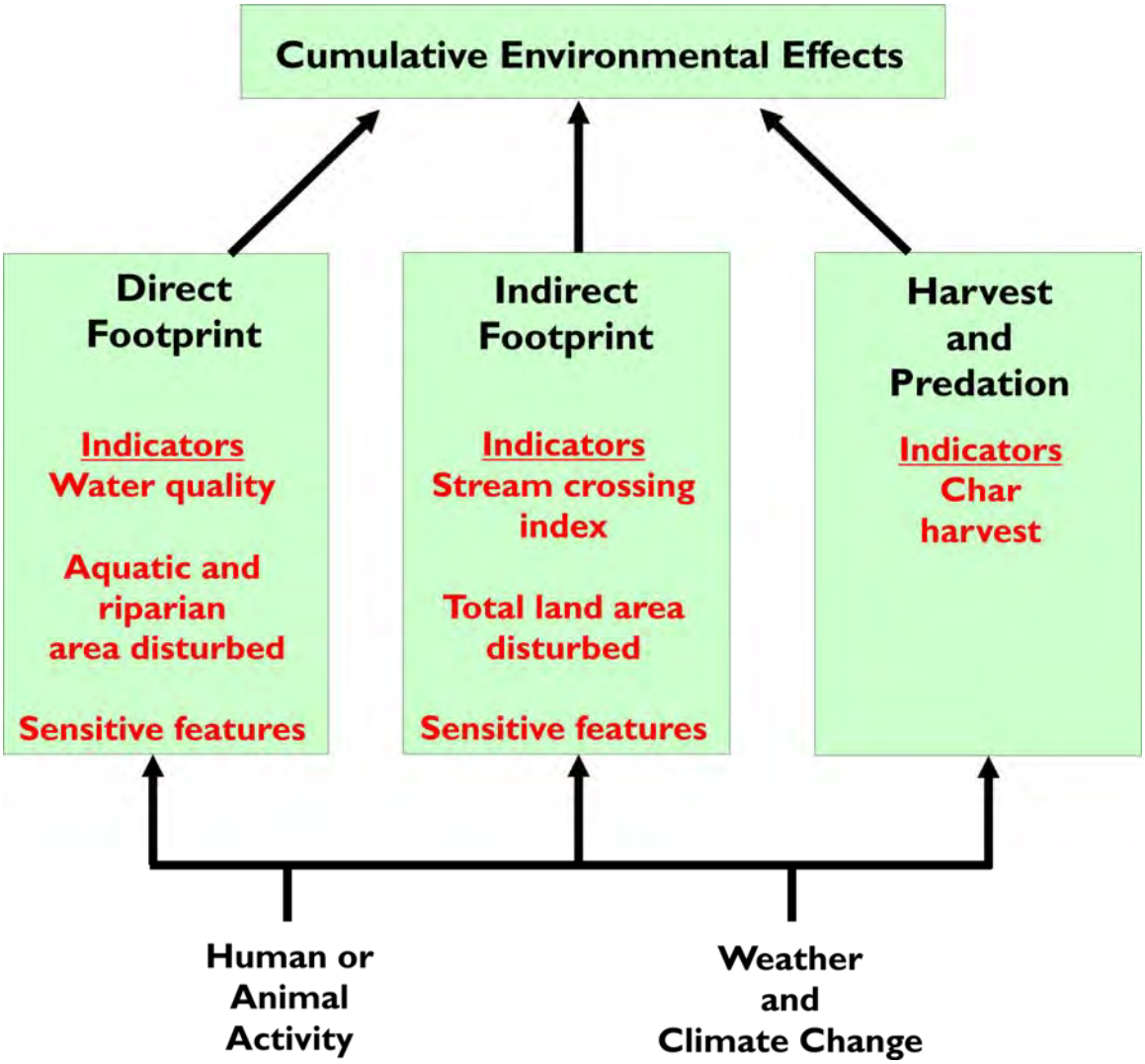

Figure 14 Candidate project-specific and regional Freshwater indicators for the Beaufort Delta region.

Table 12 Candidate Freshwater indicators and thresholds for the Beaufort Delta region.

Candidate Project-Specific Indicator	Candidate Thresholds
Water quality (concentration of regulated discharge parameters).	**Critical:** Canadian Water Quality Guidelines. **Cautionary/Restrictive:** Monitoring at all approved discharges. Consider intermediate Target Thresholds where pristine water quality is an management objective and where defined guidelines do not exist for a particular parameter.
Total land area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines).	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
Total aquatic and riparian area disturbed (ha and % of area disturbed by stream crossings, bank and bed alterations, and riparian clearing/disturbance).	**Critical:** no net loss (taking into account mitigation, enhancement or compensation). **Cautionary/Restrictive:** stream crossing density less than 0.25 crossings/km^2.
Specialized environmental features (ha and % of area disturbed in spawning and overwintering areas).	**Target**: no disturbance or activity within 250 m of overwintering and spawning areas of Rat River Dolly Varden char. **Target**: no disturbance or activity within 100 m of designated overwintering and spawning areas. **Critical**: no disturbance or activity within 100 m of overwintering and spawning areas of Rat River Dolly Varden char. **Critical**: no net loss of designated overwintering and spawning areas.
Char mortality (number of fish mortalities caused in addition to legal/illegal harvest)	**Target**: cumulative industrial-associated mortality of Dolly Varden char no more than 1% of the total annual allowable harvest **Target:** cumulative industrial-associated mortality of lake trout no more than 10% of recorded subsistence harvest during the previous year. Cautionary/Restrictive: all activities resulting in industry-related harvest and mortality should be monitored and reported.

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7 NEARSHORE MARINE

NRC (2003) and MMS (2003) reviewed information about petroleum activities in nearshore areas off the Alaskan North Slope to identify cumulative effects that have occurred since 1977. These studies also assessed likely future cumulative effects based on its judgment of probable future development scenarios. NRC (2003) and MMS (2003) concluded that full scale industrialization of nearshore areas would most likely result in minor cumulative effects over the next 25 years, not considering potential effects of climate change and substantial oil spills. Identified cumulative effect sources included:

- changes in whale movements resulting from vessel noise and seismic exploration;
- presence of facilities (artificial islands, causeways) that change physical, chemical, and ice conditions;
- at least partial displacement of ringed seals in nearshore areas;
- increase in polar bear harassment and mortality risk;
- possible reduction in suitability of some areas for use by denning polar bears; and
- increased contact with spilled oil or other contaminants.

Other potential effects from nearshore drilling programs in the Canadian Beaufort Sea identified by Devon (2002) include: potential contamination of the food chain; and altered movements or distribution of marine fish and birds due to vessel and aircraft movements. Nearshore marine resources can also be impacted by other activities. For example, JS (2003) report that many marine species (e.g., bearded and ringed seals, beluga whale, polar bear, waterfowl species, and fish species) are harvested by the Inuvialuit. USFWS (2003) also report that aircraft activity can affect the behaviour of some nearshore marine species (e.g., seals, beluga whales, and waterfowl). Research and monitoring needs for offshore activities were considered by Beaufort Environmental Monitoring Program (BEMP) (ESL et al. 1985).

7.1 Indicators

Suites of nearshore marine indicators have been identified for several initiatives. The Arctic Borderlands Ecological Knowledge Co-op (Section 3.2.3) identified the following eight ‘coast and sea’ indicators: seal productivity; beluga whale abundance; organochlorines in beluga whales; bowhead whale abundance; seal abundance; mercury in marine mammals; polar bear abundance; and coastal bird abundance and distribution. BEMP (Table 2, Appendix B) also identified several marine cumulative effect indicators which included: bowhead whale distribution and productivity; beluga whale harvest; landfast ice extent, distribution, and breakup; fish tissue quality; seal abundance; and offshore bird abundance and distribution.

Most of these indicators, however, cannot be directly related to petroleum activities in the Beaufort Delta region. For example, although the Arctic Borderlands Ecological Knowledge Co-op discusses how mercury in marine mammals (i.e., beluga whales and ringed seals) and seabird eggs has increased dramatically between the 1980s and 1990s (see www.taiga.net/coop/indics/contam_marinemammals_hg.html), they also note that mercury is transported to the North through the atmosphere in the same manner as organochlorine pesticides. As such, although contaminant body burden is a useful regional cumulative effects indicator, it is not practical for small project-specific reviews.

Similarly, many factors including weather conditions, harvest, and industrial activities affect the distribution and abundance of nearshore marine animals. Regional population monitoring is most frequently conducted for harvested or highly-valued species and is generally considered to be impractical for project-specific reviews (see Section 3.6).

Information on potential marine cumulative effect indicators is provided below as background to the discussion of candidate indicators and thresholds.

7.2 Direct and Indirect Footprint

Natural and human-caused activities can alter seabed, water column, and ice conditions that lead to alteration, loss and fragmentation of marine fish and wildlife habitat (LGL et al. 1984). Habitat-based indicators and associated thresholds are a practical approach for many marine species because habitat availability has been documented as an ultimate limiting factor (Dames and Moore 2000).

7.2.1 Total Area Disturbed

Total disturbed area is used as a numerical index of nearshore marine habitat availability and fragmentation. At regional scales, there is a positive relationship between number of species and area of contiguous suitable habitat. Conversely, habitat loss is assumed to be the ultimate cause of species extinction.

NMFS (2003) examined the cumulative effects on habitats used by beluga whales in Cook Inlet, Alaska which they considered one of the most industrialized and urbanized regions of Alaska. They reported that although a significant part of the habitat for this species in the upper Cook Inlet had been modified by municipal, industrial and recreational activities, beluga whale range had not been reduced. Moore et al. (2000) reviewed available information, including effects of petroleum development, and described habitat associations for beluga whales in Cook Inlet; they concluded that significant effects from anthropogenic factors, other than hunting, were not apparent. They also noted that the "… potential disturbance from petroleum activities is not considered a key determinant to distribution at this point".

Harvesters have expressed concerns that petroleum activities could effect ringed and bearded seal populations, but the existing information on the effects of disturbances on nearshore ice used by seals appears to be limited. To address this deficiency, ESRF, DFO, DIAND, the Fisheries Joint Management Committee, the Polar Continental Shelf Project, and the World Wildlife Fund are cooperating in a three year study that began in 2003 and is examining the potential effects of industry activity on seals (see www.beaufortseals.com/industry.htm). This study involves work amongst breeding seals in an offshore area in the Mackenzie Delta where the oil and gas industry has proposed exploratory drilling as early as 2005. The study will include both 'before' and 'after' studies of seal behaviour, movements and density.

Like marine mammals, fish in nearshore marine areas could be affected by dredging, petroleum exploration and production islands and structures, water intakes, and discharges from vessels and production facilities (LGL et al. 1984; Axys et al. 1992). Fish are important components of the marine food chain (e.g., primary prey item for seals is fish, and seals are primary prey items of polar bears) and effects on fish could also affect animals that feed on them.

Offshore seismic and exploration drilling in the Beaufort Sea Region began in the 1970s. Devon (2002) indicated that during the 1970s and 1980s, a total of 89 wells were drilled offshore in the Canadian Beaufort Sea, and that a variety of innovative drilling concepts were successfully deployed during this period including man-made islands, steel and concrete caisson systems, and floating drilling units. While some systems were designed to operate during the winter or summer season, several bottom-founded structures were capable of providing stable year-round platforms for drilling activities. No offshore structures are currently present outside harbours, and no information on the status of artificial islands used as exploration drilling platforms was located.

7.2.2 Core Area

Core area is an indicator of relatively undisturbed areas that remain outside the combined direct and indirect footprint of human facilities and activities. Although commonly used for terrestrial systems (see Section 5.2.3), this indicator does not appear to have been applied to marine areas. Conceptually, however, it should be applicable.

BEMP concluded that a zone of influence may exist around active offshore structures, but the size of this zone is unknown and would vary with a complex of factors (LGL et al. 1984). Alaskan studies showed there was probably some displacement of ringed seals from areas close to artificial islands, although no broad scale effects on distribution were noted (Frost and Lowry 1988 and Frost et al. 1988 *in* NRC 2003).

Frequency of polar bear contact with people and structures will increase as activity levels increase. As with grizzly bears (Section 5.3), the combined risk of management kills to protect life or property would be expected to rise as core security areas decrease.

There may also be some potential for habitat enhancement from petroleum activities. For example, offshore oil and gas structures have been found to increase available habitat in southern environments. Habitat suitability modeling reported by LGL and SAIC (1998) estimated that just under 0.5% of the total reef habitat available in the Gulf of Mexico was provided by petroleum platforms. Almost one quarter of sportfishing trips reportedly took place within 100 m of these structures (MMS 2002). Although different structures will likely be used in the Beaufort Sea, positive local effects on fish communities could occur. A core area indicator could be used to quickly quantify such effects.

7.2.3 Vessel and Aircraft Activity

Marine mammal, bird, and fish reactions to noise disturbances, particularly mobile sources such as marine vessels and aircraft, vary. Reactions depend on the prior exposure of individuals to the disturbance source and their need or desire to occupy particular habitats where the exposures occur (USFWS 2003).

Vessel-based seismic activity is known to affect marine fish and wildlife. Stone (2003) summarized the literature on the effects of seismic activity on marine mammals and reported that baleen whales (e.g., bowhead whales) are generally considered to be more sensitive to seismic activity than toothed whales (e.g., beluga whales), with small dolphins the most sensitive. Other potential effects of seismic activity remain largely unknown (e.g., long-term effects, effects on vocalizations, social behaviour and physiology, consequences of auditory masking and the potential for damage to hearing). Bowhead whales offshore Alaska divert around noise sources, including operating drill ships and seismic vessels by distances of 15-20 km (NRC 2003).

NMFS (2003) summarized the impacts of noise on beluga whales. They reported that behavioral responses are affected by habituation as well as sensitization. They reported, however, that beluga whales display weaker responses to slower moving vessels and vessels that are not moving towards them, and that they avoid vessel noises that are typically associated with hunting (e.g., skiffs powered by outboard motors, and small, fast and erratic moving boats).

NPS (2003) developed vessel quotas and speed restrictions to mitigate the impacts of whale-watching and cruise vessel activity in Glacier Bay, Alaska on humpback whales and other species using nearshore habitats. They concluded that most adverse effects would be proportional to vessels numbers, speed and distribution. The NPS's (2003) Biological Opinion included four conservation recommendations to protect marine resources in Glacier Bay which included: requiring the NPS to monitor the level of disturbance from vessels and vessel noise; implementing speed restrictions and exclusion zones in nearshore areas; and to monitor the effectiveness and compliance of the regulations.

Richardson et al. (1995 in NRC 2003) reported that aircraft flying at more than 500 m overhead did not cause a reaction in beluga whales, but at lower heights (i.e., 150-200 m) animals would dive for longer

periods and sometimes vacate an area. However, Moore et al. (2000) concluded that there is uncertainty regarding whether belugas respond to either noise or visual cues from aircraft.

USFWS (2003) also reviewed the available information on the impacts of aircraft activities on polar bears and concluded that aircraft flights would generally only result in short-term behavioural responses, but that extensive overflights may result in bears abandoning their dens. To mitigate for this possibility, they recommended minimum flight elevations and flight restrictions over areas where denning activity is known to occur. Amstrup (1993) examined the effects of polar bears exposed to greater than usual levels of aircraft (helicopter and fixed-wing) traffic and reported mixed results among bears that ranged from no response, to fleeing and returning to the den, to abandoning their den. He recommended that spatial and temporal restrictions be used to help mitigate potential disruptions. Blis and Lentfer (1992) studied noise levels from helicopters in artificial dens and concluded that because snow muffles both sound and vibrations extremely well, spatial setbacks from den sites would provide effective mitigation.

Born et al. (1999) studied escape responses of hauled out ringed seals to aircraft disturbances. They reported that helicopters generally caused more reaction than fixed-wing aircraft and that other factors also influenced response distances from aircraft (e.g., wind chill, ambient temperature and time of day). Although escape behaviours were observed as far away as 2.3 km from helicopters, behaviour intensity was reduced substantially beyond distances of 500 m, and 1500 m, for small fixed-wing, and small helicopters, respectively. Snow geese are sensitive to aircraft overflights and flush at distances of 2 to 3 km (Davis and Wisely 1974; Belanger and Bedard 1989).

Concerns about the effects of aircraft activity on wildlife, including nearshore marine species, have led the EISC (2004; Appendix I) to develop recommended Environmentally Acceptable Minimum Flight Altitudes for aircraft.

7.2.4 Sensitive Environmental Features

Sensitive features occur at both local and regional scales and protection of these features is a clearly defined goal in all Inuvialuit Community Conservation Plans and the Gwich'in Land Use Plan. Specialized features in the nearshore marine area include: the Beluga Management Zone 1 areas; polar bear denning habitat on small islands offshore the Mackenzie Delta and Tuktoyaktuk Peninsula; and the KIBS in the outer delta (Section 2.5.3).

Potential development activities in Beluga Management Zone 1 Areas were mentioned during the October 2004 workshop in Inuvik (Dillon and Salmo 2004b). On several occasions local communities used this zone as an example of an area where development activities should not be permitted. However, most community participants who attended a workshop held a year earlier to discuss allowable activities within Zone 1 areas thought that some industrial activities may be compatible with conservation objectives in these areas (Salmo and McManus 2003). This reinforces the need for further consultation with communities and regulators to better understand land and resource management preferences.

For most of the year, polar bears are not very sensitive to noise or other human disturbances (Amstrup 1993; Richardson and Williams 2000 *in* NRC 2003). Although polar bears have been known to den within close proximity of industrial activities, den abandonment has occurred in response to human disturbances (e.g., USFWS 2003; Amstrup 1993). Despite this, USFWS (2003) concluded that vessel traffic would most likely result in short-term behavioural responses only. Blis and Lentifer (1992) studied noise and vibration levels resulting from seismic testing, drilling and transport in artificial polar bear dens in Alaska. They concluded that the dry and wind-beaten Arctic snow muffles both sound and vibrations and that it is unlikely polar bears in dens would be disturbed by the type of petroleum-related activities they measured, provided the activities do not take place within 100 m of the den.

7.3 Candidate Indicators

Table 13 summarizes the rationale used to select the three candidate indicators are recommended for evaluating cumulative effects on marine habitat alteration and loss.

7.3.1 Total Area Disturbed

The digital GIS databases made available for this study did not provide specific information on the location or nature of the 89 offshore wells discussed by Devon (2002). Data provided by the NEB indicate 60 offshore wells occurred within the Beaufort Delta Cumulative Effects Project study area. Similarly, although qualitative descriptions of the types of habitat disturbances resulting from nearshore oil and gas activities were located (e.g., Devon 2002; NRC 2003), no quantitative information describing the extent of the actual direct footprint in the Beaufort Nearshore Marine area was found. However, based on the estimated average area for disturbance features (Appendix I, Table I-2), it was estimated approximately 0.27% of the total nearshore marine with the study area (and 0.06% of Category E areas) has been disturbed by existing wells and one winter road. A development scenario developed for Beaufort Environmental Monitoring Program estimated up to 0.7% of the seafloor in the groundfast ice zone could be disturbed by dredging for projected oil and gas development (LGL et al. 1984).

Although quantitative information about impacts in the Beaufort Delta appears limited, marine mammals that occupy nearshore marine habitats appear to be fairly resilient to habitat disturbances [e.g., beluga whales - NMFS (2003), Moore et al. (2000); polar bears - USFWS (2003)]. However, programs are being developed in both Canada and Alaska to monitor the effects of industrial activities on habitat and habitat use (e.g., beluga whales - NMFS 2003; polar bears - USFWS 2003; seals - www.beaufortseals.com/industry.htm).

DFO has developed policy and regulatory tools to promote the protection of fish habitat, including the guiding 'No Net Loss' principle (DFO 1995). Under this principle, DFO strives to balance unavoidable losses of the 'productive capacity of fish habitat' with habitat replacement on a project-by-project basis. This approach is designed to avoid direct loss and alteration of habitats that sustain commercial, recreational, or subsistence harvesting activities.

Table 13 Candidate Nearshore Marine habitat indicators for the Beaufort Delta region.

Candidate Indicator	Rationale
Total area disturbed (ha and % of area disturbed by dredging, artificial islands, bottom-founded vessels or structures)	Reflects cumulative effects of seabed, water column, and ice cover disturbance and associated habitat loss and alteration. Provides measure of cumulative multi-species direct habitat loss for marine mammals such as beluga whale and ringed seal identified as important subsistence resources in ICCPs. Provides a measure of sub-regional and regional cumulative effects risk for marine mammals.
Seasonal vessel and aircraft activity (ha and % of area by month in designated travel corridors and movement areas where low level flights and vessel activity could occur)	Reflects cumulative effects of direct and indirect disturbance from aircraft flights below altitude restrictions and vessel traffic for sensitive species such as bowhead whale, waterfowl, and seals. Aircraft corridors buffered by 2500 m each side to account for indirect footprint. Vessel corridors buffered by 15 km each side to account for indirect footprint. Can be related to specific marine values where sufficient information is available (e.g., beluga whale management zones). Provides measure of local, sub-regional, and regional cumulative disturbance risk for sensitive marine wildlife such as beluga whale and staging waterfowl.
Specialized environmental features (disturbance of polar bear dens; % of KIBS and beluga whale Zone 1 area disturbed)	Reflects cumulative effects of habitat loss and alteration; complements generalized habitat indicators. Important nearshore marine areas identified in ICCPs and beluga management plan. Routinely considered in project applications. Provides measure of local, sub-regional, and regional cumulative effects risk for specialized nearshore marine features.

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The relationship between habitat loss and cumulative effects risk was described earlier in Section 5.2.6.1. Although this was developed from terrestrial studies, the same concepts should apply to marine systems. The following candidate thresholds are based on those proposed for land systems. Most nearshore waters are included in Category C; some areas at the mouth of the Mackenzie Delta are included in Category D and E.

Candidate Target and Critical Thresholds proposed for Inuvialuit Community Conservation Plan Category C and D lands are to disturb no more than 5% and 10%, respectively, of the grounded ice zone. The candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category E lands are to disturb no more than 0% and 0.5% of the marine area, respectively. Areas used for commercial, recreational, or subsistence harvesting should sustain no net loss in habitat.

Advantages of this indicator are that it can be calculated for specific marine values (e.g., bowhead whale and waterfowl concentration areas) where sufficient information is available and it will assist resource managers.

Relationships between regional change and environmental response are based largely on research conducted in forested landscapes, so it is important that research into responses of marine animals to habitat factors in the Beaufort Delta be used to refine the candidate thresholds. Use of Cautionary Thresholds (Section 3.7.2.3) is one tool to ensure that effects monitoring is initiated in this region.

7.3.2 Vessel and Aircraft Activity

Area affected by vessel and aircraft activity is recommended as a candidate indicator to consider the cumulative direct and indirect effects of movements and noise on marine wildlife. Cumulative effect of aircraft activity is an assessment issue for environmental review in the ISR, although population-level effects on marine birds and mammals were concluded to be unlikely by BEMP (LGL et al. 1984) and MEMP (LGL et al. 1986) and have not been detected in Alaska (Truett and Johnson 2000; NRC 2003). No digital information on aircraft and vessel activity corridors or activity was located and it is assumed that this would change both seasonally and annually.

The zone of influence around vessels and aircraft depends, among other factors, on the: species being considered; the type of vessel or aircraft; season; and environmental conditions (LGL et al. 1986). The proposed method for calculating the direct and indirect transportation footprint is to apply a zone of influence of 15 km on each side of vessel tracks, and 2,500 m on each side of aircraft routes where minimum flight altitudes cannot be maintained. The former is derived from the minimum disturbance identified for bowhead whales, and the latter from the distance at which effects on seals and waterfowl is likely to diminish. The combined footprint should be calculated by month, to reflect the temporary nature of these activities.

The relationship between available core area and cumulative effects risk was described earlier in Section 7.2.6.2. Although this was developed from terrestrial studies, the same concepts should apply to marine wildlife. The following candidate thresholds are based on those proposed for the core area indicator in land systems. Most nearshore waters are included in Category C; some areas at the mouth of the Mackenzie Delta are included in Category D and E.

Candidate Target and Critical Thresholds proposed for Inuvialuit Community Conservation Plan Category C and D lands are to disturb no more than 20% and 30%, respectively, of the nearshore marine area. The candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category E lands and KIBS are to disturb no more than 0% and 5% of these areas, respectively, during the beluga harvest and bird nesting seasons.

Advantages of this indicator are that it can be calculated for specific marine values (e.g., beluga whale and waterfowl concentration areas) where sufficient information is available and it will assist resource managers.

The candidate thresholds are not based on research from the region, so research into responses of marine animals to vessel and aircraft in the Beaufort Delta should be incorporated into refined thresholds. Use of Cautionary Thresholds (Section 3.7.2.3) is one tool to ensure that effects monitoring is initiated in this region. Operating and monitoring and operating recommendations of Stone (2003) and JNCC (2004) should be considered.

7.3.3 Sensitive Environmental Features

The importance of sensitive environmental sites to Beaufort Delta residents is acknowledged in existing land use plans and review processes. Adoption of explicit thresholds for these resources would help clarify management and mitigation expectations.

EC has implemented a 1% disturbance threshold for the KIBS. This threshold includes all long-term disturbances, defined as altered, disrupted, removed, covered, or degraded habitat which cannot be restored to its natural state within three years (Section 2.3.1.3). This threshold is adopted as the candidate Critical Threshold for this area.

The candidate Target and Critical Thresholds for polar bear dens is no disturbance or industrial activity within 250 m, and 100 m, respectively, of identified den sites.

The candidate Target and Critical Limits proposed for Beluga Zone 1 areas are to disturb no more than 0%, and 0.5%, of the marine area, respectively.

7.4 Harvest and Predation

Information exists for harvest level of fish and wildlife species along the nearshore marine area by the Inuvialuit (JS 2003) and Gwich'in (e.g., MacDonald 1998a. 1998b) communities; however, other human-induced mortalities of nearshore marine fish and wildlife species also occur in the region. Examples of these may include: polar bear-human encounters resulting in direct bear mortalities; boat collisions with whales and seals; mortalities of fish and wildlife following oil spills; and direct mortalities (sampling and accidental mortalities) of fish and wildlife used for inventorying and research purposes.

There are special management considerations for several nearshore marine species. For example, polar bears and bowhead whales are listed by COSEWIC (COSEWIC 2002). Management plans and sustainable harvest levels have been identified for beluga whale (FJMC 2001) and polar bears.

No information about direct industry mortality of beluga whales in the Beaufort Delta was located, although this could occur if vessel traffic increases dramatically or an oil spill occurs (NPS 2003). Beluga whale harvest levels are currently well below the sustainable harvest rate, so this is not considered to be a limiting factor for this species (Harwood and Smith 2002; Harwood et al. 2000).

USFWS (2003) indicate that the majority of impacts from the oil and gas industry on polar bears have resulted from direct human-bear encounters, but that potential effects can be mitigated. They also report that the actual impacts on polar bears related to oil and gas activities during the past 30 years have been minimal. During this time only two polar bear deaths related to industry have occurred in Alaska. In contrast, 33 polar bears deaths occurred in the NWT due to encounters with industry; no explanation for the differences between jurisdictions was provided (USFWS 2003).

7.4.1 Candidate Indicators

Polar bear mortality is recommended as a cumulative effects indicator that should be relatively easy to track (Table 14).

The current allowable harvest for the southern Beaufort Sea population (80) is shared by the Inuvialuit and the Inupiat of Alaska according to a bilateral agreement and is allocated by community. All bears killed to protect life or property must be reported and taken off established community quotas. Polar bear harvest in the Beaufort Delta region is generally near quota levels, so any additional mortality from management action is considered undesirable in the Inuvialuit Community Conservation Plans; it may also affect the bilateral agreement The candidate Target Threshold for industry-associated polar bear mortality is, therefore, set at no incremental mortality, and the candidate Critical Threshold is no more than one bear.

7.5 Candidate Land Indicators and Thresholds

To be most effective, resource managers, communities, and other regional groups should help define land indicators and thresholds within a consistent regional framework. The candidate indicators and thresholds provided here are intended to help inform such discussions by demonstrating how practical limits can be derived and by providing a reasonable starting point for consultation. The candidate framework is based on relevant guidance documents, statements made by Gwich'in and Inuvialuit organizations and participants at the October 2004 workshop in Inuvik, and the regional vision described in Section 3.1.5.

Figure 15 shows how the suite of candidate nearshore marine indicators allows potential cumulative effects pathways to be tracked. These project-specific can be directly related to proposed oil and gas activities, and supplemented with regional indicators monitored to help document and understand long-term cumulative effects. Candidate Thresholds for each project-specific nearshore marine indicator are summarized in Table 15.

Table 14 Candidate Nearshore Marine harvest and predation indicator for the Beaufort Delta study area.

Candidate Indicator	Rationale
Polar bear mortality (number of polar bear mortalities from all industrial causes – management action, research, illegal kills by industry worker, and legal/illegal harvest)	Reflects cumulative effects of human-induced mortalities on marine mammal populations. Can be calculated based on numbers provided through existing sources of harvest data and information from wildlife research licenses and known accidental mortalities Provides measure of local, sub-regional and regional cumulative effects risk for marine animals

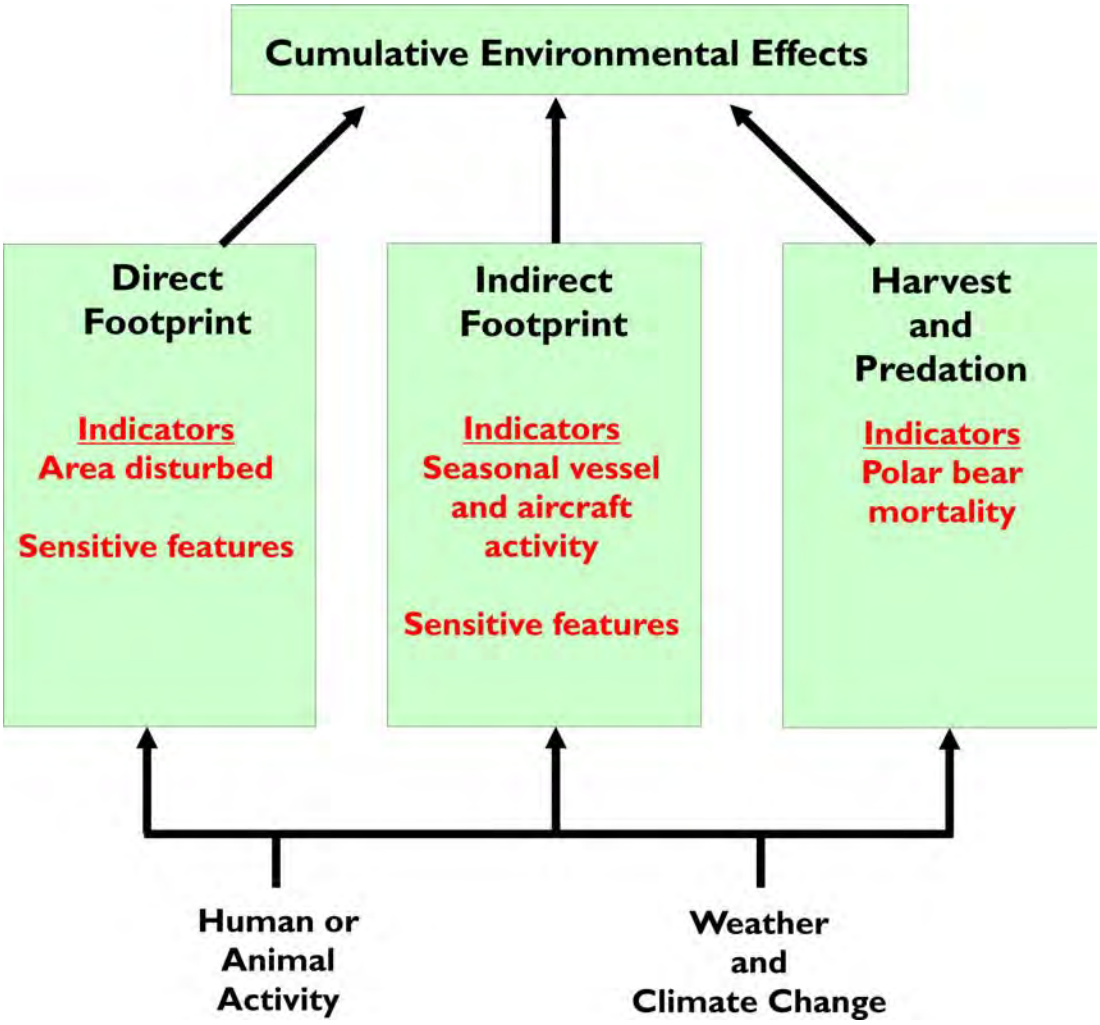

Figure 15 Candidate project-specific and regional Nearshore Marine indicators for the Beaufort Delta region.

Table 15 Candidate Nearshore Marine indicators and thresholds for the Beaufort Delta region.

Candidate Project-Specific Indicator	Candidate Thresholds
Total area disturbed (ha and % of area disturbed by dredging, artificial islands, bottom-founded vessels or structures)	**Target**: no more than 5% on ICCP Category C and D lands. **Critical**: no more than 10% on ICCP Category C and D lands. **Critical**: no more than 0.5% on ICCP Category E lands.
Seasonal vessel and aircraft activity (ha and % of area by month in designated travel corridors and movement areas where low level flights and vessel activity could occur)	**Target**: no more than 20% combined footprint on ICCP Category C and D lands. **Target**: 0% on Beluga Management Zone 1 during beluga harvest. **Target**: 0% on KIBS during the nesting season. **Critical**: more than 30% combined footprint on ICCP Category C and D lands. **Critical**: no more than 5% on Beluga Management Zone 1 during beluga harvest. **Critical**: no more than 5% on KIBS during the nesting season.
Specialized environmental features (disturbance of polar bear dens; % of KIBS and beluga whale Zone 1 area disturbed)	**Target**: no disturbance or activity within 250 m of polar bear dens. **Critical**: no disturbance or activity within 100 m of polar bear dens. **Critical:** no more than 1% long-term disturbance within KIBS.
Polar bear mortality (number of polar bear mortalities from all industrial causes – management action, research, illegal kills by industry workers, and legal/illegal harvest)	**Target**: no industrial-associated mortality. **Critical**: one industrial-associated mortality..

ICCP – Inuvialuit Community Conservation Plan

8 SOCIO-CULTURAL

Modern western culture, including resource exploration and development, has resulted in significant, and probably irreversible changes to the way of life in northern communities (Usher 2002; NRC 2003). Some social effects are related to changes in water, air, land, plants, or animals. Others that affect people's views or behaviour can occur without any physical disturbance. Both types of effects accumulate because they interact and cause yet more changes as people and communities adapt (Figure 16). A significant social assessment and management challenge, particularly for this study, is that it is usually very difficult to differentiate development effects from those attributable to western culture more generally. Cumulative effects that change people's views or behaviour must, therefore, be considered and managed with different tools (e.g., direct community involvement) than those previously discussed for environmental effects (NRC 2003).

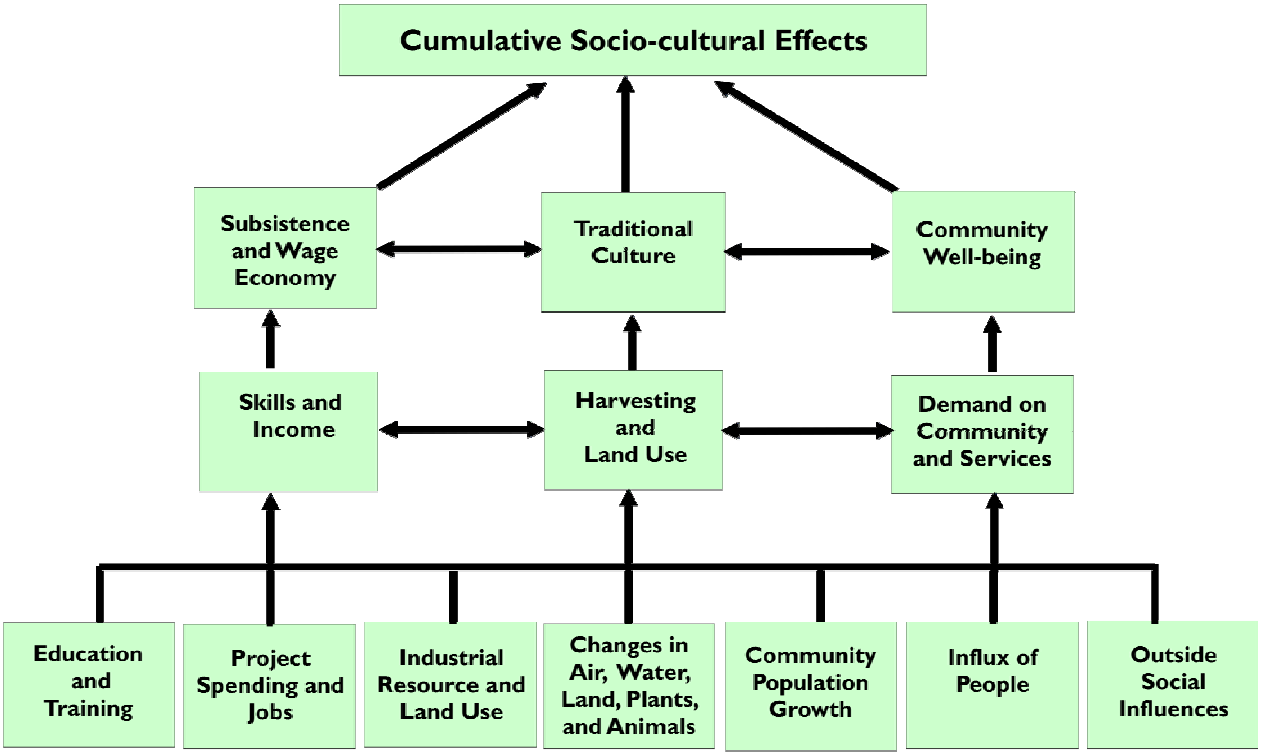

Figure 16. Sources of cumulative socio-cultural effects.

NRC (2003) reviewed information about petroleum activities on the Alaskan North Slope to identify cumulative social effects that have occurred since 1977. They also assessed likely future cumulative effects based on their judgment of probable future development scenarios. Although the North Slope situation is not directly applicable to the Beaufort Delta region, NRC's (2003) evaluation provides insight into the long-term effects of petroleum exploration and development on northern aboriginal communities

with mixed, subsistence-based economies. NRC (2003) found that there is a dynamic balance between perceived economic benefits and social costs. The primary pathway of social change has been the revenue that flowed into local communities. Many residents view the changes positively; however, the magnitude of social and cultural change has also created social and individual problems. The authors concluded that aboriginal residents have generally supported onshore development subject to adequate environmental controls. However, offshore exploration and development, and proposed future development in caribou calving areas, are perceived as cultural risks due to concerns about effects on bowhead whales and caribou. NRC (2003) noted that cumulative petroleum development activities have also changed the landscape in ways that have aesthetic, cultural, and spiritual consequences (i.e., loss of wilderness values).

Over 60 socio-cultural indicators have been used in the NWT and elsewhere to monitor community well-being and economic conditions; these reflect a wide range of interests and objectives. It is impractical to use all available indicators for cumulative effects assessment and management. NWT CIMP has concluded that social indicators should be integrated into fewer, useful metrics (DIAND 2002). However, no simple, generally accepted suite of socio-cultural indicators exists, because of the inherent complexity of social systems and the influence of local values and interests. In addition, causes and effects cannot be easily linked for much of the current data (DIAND 2002). A summary of representative indicators is provided in Table 16. A more inclusive list of social indicators used in northern initiatives is included in Appendix I.

Many aboriginal people perceive all aspects of life as interrelated and do not differentiate environmental and socio-cultural considerations. Preservation of languages, beliefs, histories, cultural and traditional knowledge, and protection of the spiritual relationship to the land were desired outcomes identified in both land claims settlements in the Beaufort Delta region. Indicators that help integrate socio-cultural and environmental approaches are, therefore, desirable (Section 3.1.5).

All levels of governments and industry are involved in collecting measurable information related to socio-cultural and economic indicators. The most comprehensive northern monitoring programs have been initiated by the GNWT (2004a), GNWT and BHP (GNWT 2000), and Diavik Diamond Mines Inc. (Diavik 2003). As noted earlier in Section 2.5, socio-cultural issues associated with petroleum development in the Beaufort Delta are formally considered during the environmental screening and review process.

Table 16 Valued Components and associated indicator types.

Valued Component	Examples of Indicator Types
Traditional Culture and Land Use	Cultural sites Archaeological sites Aboriginal languages Resource use Stewardship responsibilities
Community Well-being	Demographics Income and Cash Flow Education and Training Mental and Physical Health Population Addictions Crime Housing
Economy and Business	Average household income Net present value Community and regional business Household micro-economies

The NWT Bureau of Statistics tracks indicators of demography (population), social well-being, education, health, labour force activity, and economy. This information is summarized in reports such as the Socio-Economic Scan (NWT Statistics 2004a). However, from the perspective of cumulative effects assessment and management, there are several known problems with these data which include:

- There is a lack of socio-economic baseline information prior to the boom and bust cycles of the 1970's and again in the mid 1980's. These gaps limit efforts to document existing and future cumulative impacts;
- Existing statistical data were considered inadequate to evaluate the effectiveness of economic provisions of the Inuvialuit Final Agreement (DIAND et al. 2000; Usher et al. 2001);
- The manner in which the NWT Bureau of Statistics distinguishes ethnicity and languages does not show actual languages used within communities. Populations are differentiated as Inuit, Dene, Métis, and non-native, and languages are documented as aboriginal, English, and French. It is commonly understood that the Inuvialuit distinguish themselves from the Inuit, and the language family that both are a part of (i.e., Eskimo-Aleut family) is different than Na-Dene family (Boeree 2003) that includes the Gwich'in language, as well as the other five Dene languages (not dialects) in the NWT. Community web-pages provide more specific information, however, do not state when the information was last updated;

- Movement between regions and communities is not accurately tracked as part of population change; and
- In addition to external or measurable changes, socio-economic and political processes also influence communities. How people consider and respond to 'development' can vary significantly between cultures (Schmidt-Thomé and Jarva 2003).

Governments, industry, and communities now recognize the importance of information collected through open-ended interviews that allow for a more realistic contextual assessment to supplement statistical information (Staples 1997; DIAND et al. 2000; Freese 2000; Usher et al. 2001; Vodden 2001; Ward et al. 2002; Marlowe et al. 2002; Usher et al. 2003; IGC et al. 2004). For these reasons, community-based attitudinal surveys were added in 2000 to the suite of 14 socio-cultural indicators that the GNWT has monitored since 1996. This monitoring was initiated in eight Slave Geological Province communities as part of the BHP-GNWT Socio-economic Agreement (GNWT 2000). In 2002, Diavik Diamonds Mines Inc. (Diavik) initiated regional committees consisting of Diavik community liaison representatives and community members to oversee socio-economic monitoring (Diavik 2003). The Inuvialuit Final Agreement Economic Measure Working Group charged with evaluating the success of Inuvialuit Final Agreement economic measures also recognized the need for qualitative indicators collected from documents, and literature as well as interviews to enhance quantitative data (Usher et al. 2001).

Available information, interviews, and workshop feedback suggests that while Beaufort Delta residents seek to enhance sustainable economic development opportunities, local Limits of Acceptable Change have already been exceeded in the Beaufort Delta region for many socio-cultural indicators. This was consistently stated by Gwich'in and Inuvialuit community representatives at the Inuvik October 2004 workshop in terms of the trade-off between cultural risk and economic benefits (Dillon and Salmo 2004). They specifically requested the wording of the regional management '*Vision'* should be to improve quality of life, rather than maintaining the status quo in terms of social conditions. As one individual said, "It is not enough to say that our lives should not become worse".

The IRC's preliminary assessment of potential social impacts from the Mackenzie Gas Project (IRC 2004:15) states that "project effects will exacerbate current negative social trends and compound health and social problems at the individual, household, and community levels".. The Gwich'in Land Use Plan (GLUPB 2003) discusses these trade-offs and concludes that: "… with proper planning … the negative environmental and cultural impacts [of a pipeline corridor] within the conservation zones can be relatively minor while potentially having significant, positive economic impacts in the region."

The Inuvialuit Final Agreement Economic Measures Evaluation found that "the economic performance of the ISR had not improved since the signing of the Inuvialuit Final Agreement …[and] … In almost all measures the Inuvialuit are losing ground when compared to their neighbors in the North" (DIAND et al. 2000:41). An independent study prepared for DIAND, the Inuvialuit Regional Corporation, and the

GNWT that used both qualitative and quantitative indicators also concluded that the economy of the ISR had not improved since the signing of the Inuvialuit Final Agreement (Vodden 2001). For the purposes of this project, discussion is restricted to those indicators that: can relate petroleum activities to social effects; are believed to reflect the concerns of Beaufort Delta residents; and can be practically monitored and evaluated. This includes indicators that will help understand how people and communities could be impacted by land and resource development decisions. The following sources were considered to select recommended socio-cultural indicators for the Beaufort Delta region:

- the regional '*Vision'* described in Section 3.1;
- articles and reports that aboriginal organizations have contracted experts to produce;
- statistical information generated by the territorial government and others;
- northern socio-cultural monitoring programs and evaluations;
- data collection models designed by northern ethnographic researchers (Freeman 2001; Usher et al. 2003); and
- relative merits of qualitative and quantitative indicators in overcoming any unintentional ethnocentric bias of researchers (described earlier in Section 3.3.2).

8.1 Traditional Culture and Land Use

Aboriginal communities in the NWT consistently express the traditional relationship to the land as a major cultural, nutritional, and economic value that is intricately linked to community well-being. This value is reflected in the Gwich'in and Inuvialuit land claim agreements and land use plans (Sect 3.1). As stated in Section 2 of this document, the peoples' relationship with the land is affirmed when they get together in their homes, at community events, and on the land to tell stories, thereby drawing spiritual strength. It is also affirmed when they hunt, fish, trap, and collect medicine plants and berries. Each of these activities includes a connection to the land and a reciprocal responsibility, currently interpreted to mean safe-guarding the natural environment from development activities that may pollute or disrupt natural cycles. This cultural relationship to land includes traditional knowledge of both past and current conditions, both of which are important for establishing baselines in the Beaufort Delta region (Legat et al. 2001; Legat 2002).

Community-based monitoring programs such as the Arctic Borderlands Ecological Knowledge Co-op (see Section 3.1.3.3) track local knowledge of the land, plants, animals, and community in an integrated way. This inherently recognizes complexities in the inter-relationships within the natural environment and the many variables that contribute to cumulative effects (Barnaby and Emery 2002).

Many indicators have been used or proposed to monitor traditional land use and culture (Table 16; Appendix I).

8.1.1 Significant Cultural Features

Protection of significant cultural features is a clearly defined goal in all Inuvialuit Community Conservation Plans and the Gwich'in Land Use Plan. Specific features of spiritual, historical, cultural, religious, and educational significance include: sacred sites; burial sites; archaeological and historic sites; named places; traditional camps; trails; meeting places; berry picking areas; medicine, wildlife, and fish harvesting areas; caribou corrals; and other areas identified as cultural landmarks or of spiritual significance by community representatives (GLUPB 2003). Traditional knowledge holders usually work with traditional land use researchers, archaeologists, land use planners, and others to document the location and significance of these sites. The use of sites is often seasonal and some sites may remain culturally important although they are not used for several years.

The location of significant cultural features in the Beaufort Delta region is identified in existing land use plans and files maintained by the land management agencies (Inuvialuit Land Administration, Gwich'in Land and Water Board, and DIAND). Surveys by qualified specialists (accompanied by community representatives) are required to obtain land use approvals.

8.1.2 Aboriginal Languages

Gwich'in and Inuvialuktun are official languages in the NWT. The NWT Bureau of Statistics monitors the level of language use by surveying number of speakers and users. Because language is an integral part of culture, this quantitative indicator provides a measure of traditional land use and cultural integrity (RCAP 1996). Loss of aboriginal languages was suggested as a possible indicator at the October 2004 workshop (Dillon and Salmo 2004b).

The Inuvialuit Cultural Resource Centre's mandate is to preserve and modernize the Inuvialuktun language and develop a language plan for the region. The centre notes that this language is endangered because it is spoken by less than half the population, many of whom are elders (ICRC n.d.). The Gwich'in Social and Cultural Institute has a similar mandate to document, preserve, and promote the Gwich'in language. The Institute states that Dinjii Zhu' Ginjik (the Gwich'in language) is one of the most endangered aboriginal languages in Canada and the most endangered Athapaskan (Dene) language in the NWT. The Inuvialuit Cultural Resource Centre and Gwich'in Social and Cultural Institute are developing a second language program for schools in partnership with the Beaufort Delta Educational Council (GSCI n.d.). Aboriginal language use is considered a useful indicator for long-term cumulative effects monitoring in the Beaufort Delta region. However, it is not practical as project-specific indicator because changes in language use cannot be directly related to oil and gas development proposals.

8.1.3 Resource Use

Resource use indicators can be used to measure the extent and intensity of both renewable and non-renewable uses and to reflect the relationship between culture and land. Three classes of resource use

indicators can be identified. These are:

1) Supply or activity-based;
2) Benefits-based; and
3) Experience-based.

All can be applied to subsistence, recreational and industrial resource use.

One easily understood measure of resource availability is the total area where a specified use can occur. The inverse measure – area not available for use – has also been used (CCFM 2003; FMF 2003). Important harvesting areas in the Beaufort Delta region are identified in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan. Although site-specific harvesting patterns have changed over the last 40 years, the total area used by Inuvialuit for harvesting has not (Usher 2002). No known studies demonstrate quantitatively whether changes in animal movement patterns on the Alaskan North Slope have altered sustainable harvest or changed the time it takes to harvest caribou or bowhead whales (NRC 2003).

Other activity- and benefits-based subsistence use indicators include: time engaged in activity; number of individuals harvesting a selected plant or animal; total harvest; harvest success (catch-per-unit-effort); and equivalent cash value of harvest. Gwich'in harvest monitoring was initiated in 1995 and continues to the present; analysis of these data has not been initiated, but total harvest statistics are available online (http://www.grrb.nt.ca/activefr.html). Comprehensive surveys of Inuvialuit harvesters were conducted in the 1960's, 1970's, and 1990's (Usher 2002; JS 2003). Usher (2002) concluded that industrial development between 1960 and 2000 had not affected the ability of Inuvialuit harvesters to meet the needs of a growing population. He attributed this at least partly to the presence of a mixed economy that reduces incentives to overharvest.

Qualitative indicators of subsistence resource use relate to traditional knowledge and stewardship responsibilities. Traditional knowledge is grounded in oral narratives that have been passed down and are associated with territories used by extended families. This includes general knowledge of plants, animals and land as well as knowledge also specific to travel routes, sites, and areas that are traditionally used (Staples 1997; Freese 2000). This information can be collected through open-ended interviews and participant observations, as can the social, cultural, and economic significance of harvesting food. MVEIRB (2004c) guidelines applicable to the GSA describe how traditional knowledge should be incorporated into the impact assessment process. Sharing of resources is another indicator that reflects the integrity and viability of traditional culture and land use (Freese 2000; Freeman 2001). This is discussed further in Section 8.1.4.2.

First Nations across Canada talk about stewardship responsibilities in relationship to land based activities. Individuals may feel responsible for development impacts even when not directly involved (Barnaby

2003). The degree to which communities and households actively participate in stewardship or management initiatives is thus an indicator of the strength of the relationship between land and culture (Staples 1997; Freeman 2001).

8.1.4 Candidate Indicators

Two candidate indicators are recommended for evaluating cumulative effects on cultural relationship to the land:

- Significant cultural features; and
- Area unavailable for traditional land use.

Candidate Limits are provided below for each indicator. Candidate indicators and limits should be discussed and refined with input from interested governments, communities, groups, and individuals in the Beaufort Delta region before being formally adopted.

8.1.4.1 Significant Cultural Features

The importance of cultural, archaeology, and heritage sites to Beaufort Delta residents is acknowledged in existing land use plans and review processes. Adoption of explicit Limits of Acceptable Change for these resources would help clarify management and mitigation expectations.

The candidate Target Limit for these features is no disturbance or industrial activity within 100 m of the site. However, recognizing that site avoidance may not always be possible, the Critical Limit is no net loss, defined as no disturbance without mitigation or compensation (e.g., site excavation and interpretation or feature relocation).

Cautionary Limits and more restrictive Critical Limits should be considered for Inuvialuit Community Conservation Plans Category E lands and Gwich'in Land Use Plan Conservation/Heritage Conservation Zones where cultural values are the primary management objective.

8.1.4.2 Area Unavailable for Traditional Use

Area unavailable for traditional use is recommended as a candidate indicator to consider cumulative effects on the opportunity to pursue traditional land use activities important to Beaufort Delta communities. Access to industrial developments can be reduced because hunting is prohibited, physical barriers exist, or harvesters are reluctant to enter for personal or aesthetic reasons. This can reduce

harvest and be perceived as a negative effect on the spirit of the land (NRC 2003). Tracking areas of direct and indirect permanent and seasonal loss could also provide useful input for any compensation claims relating to lost opportunity or reduced harvest.

The proposed method for calculating area available for traditional use is based on the assumption that harvesting would not occur within 1000 m of sites that have intensive industrial use or are highly visible (i.e., production facilities, active well sites, camps, above ground pipelines). This zone of influence can be modified once information on actual use of areas near active sites is obtained. GIS analysis indicated that within the ISR portion of the Beaufort Delta study area, 6% of lands are currently considered unavailable in Category E (extremely sensitive), 27% in Category D (year-round sensitivity), 15% in Category C (seasonally sensitive), 26% in Category B (some sensitivity), and 3% in Category A (no known sensitivity). It also indicated that within the GSA portion of the study area, 21% of lands are currently considered unavailable in Conservation Zone zones (restricted use), 80% of lands are currently considered unavailable in the Heritage Conservation zones (restricted use), 15% in Special Management Zones (valued resources identified), and 9% in General Use Zones (no known sensitivity).

Candidate Target and Critical Limits proposed for Inuvialuit Community Conservation Plan Category C and D lands and Gwich'in Land Use Plan Special Management Zones are to alienate no more than 5% and 10%, respectively, of traditional use areas. Candidate Target and Critical Limits for Inuvialuit Community Conservation Plan Category A and B lands and Gwich'in Land Use Plan General Use Zones are to alienate no more than 10% and 20% respectively, of traditional use areas. The candidate Critical Limit proposed for Inuvialuit Community Conservation Plan Category E lands and GLUP Conservation/Heritage Conservation Zones is to alienate no more than 0.5% of traditional use areas.

8.2 Community Well-Being

Resource development activities have both beneficial and adverse effects on community health and well-being. Beneficial effects result from jobs and economic benefits that contribute to a better standard of living. Adverse effects occur when family and community support systems breakdown, social disruption and violence increases, or individuals lose cultural identity or face increasing stress, anxiety, and feelings of alienation (GNWT 2000). A key challenge from cumulative effects assessment and management is that it is usually very difficult to differentiate adverse development-related effects from those attributable to western culture more generally.

NWT CIMP (DIAND 2002) recommended that human health and community well-being be considered separately for monitoring purposes to permit the relevant parties to more effectively identify key indicators. This discussion focuses on community well-being indicators, which describe the social characteristics of a community. These include:

- quality of life measures such as wealth and poverty, income and cash flow, education, training and employment, mental and physical health, population, addiction and substance abuse, violent and property crime, family size and structure, and housing availability and cost;
- infrastructure measures such as health services (including counseling), local government services, and transportation; and
- civic responsibility measures such as volunteerism, and civic participation.

Because all aspects of life are integrated, indicators describing community well-being also encompass those that describe individual and family well-being. This was aptly stated by an individual at the October 2004 thresholds workshop who said "individual behaviour impacts the whole community and often the families throughout the region; therefore, when we talk about the community, we are talking about the individuals and the family". Generally, if family and community relationships are supportive, individual well-being is highest (IORVL 2004).

As noted previously, regional representatives at the October 2004 workshop indicated that socially acceptable limits have already been passed for many indicators of community well-being (Dillon and Salmo 2004b). One cited example was that individuals in the helping fields (often volunteers), become burned out because communities lack the funding, staff, and infrastructure to deal with social issues. 'Burn-out rate' was, therefore, suggested as a qualitative indicator of community well-being and quality of life. While this indicator might be appropriate for regional monitoring purposes, it is not practical as a project-specific cumulative effects indicator, because it cannot be directly related to oil and gas development proposals.

8.2.1 Demographics

Demographics is the study of human population characteristics such as size, location, movement, and capacity for change from births and deaths. Stability and change within a population are reliable indicators of community health and well-being. Highly transient populations, and the rapid growth and rapid decline that goes with the boom-bust economic situations, can lead to stress on long-term community residents and infrastructure. Most community developers agree that well-being is highest where communities are stable (Beckley 2000).

The NWT Bureau of Statistics provides data on the social and demographic profiles of communities in the Beaufort Delta region. This information is important for understanding in- and out-migration in communities of the region, as well as between communities and other regions. However, factors that contribute to migration patterns need to be considered to understand the cause(s) behind these movements. Ideally, age and gender, as well as births and deaths, and factors leading to or causing deaths, should also be considered when looking at demographics. As discussed in Section 2.5, individuals move between Beaufort Delta communities to visit relatives and move to the larger centres if

employment is available, but continue to return to their communities to acquire country food. IRC (2004:1) stated to understand social effects of petroleum development, "… given the complexity and interrelationships of social and economic factors and existing local and regional conditions, it is important to know who is moving where and who is being impacted in both positive and negative terms by development."

Petroleum exploration and development affects demographics by increasing both transient workers and permanent residents. On the Alaskan North Slope, most workers are transients and the number of permanent residents is comparatively low (NRC 2003). This situation is expected to be similar in the Beaufort Delta region (IORVL 2004).

Project-related increase in transient and community populations is a key pathway for cumulative effects on community well-being.

8.2.2 Income and Cash Flow

Annual income and poverty rates are related indicators used as indirect measures of quality of life and direct measures of economic performance. There is also a clear world-wide relationship between income and health (GNWT 2000). The NWT Bureau of Statistics monitors average household and individual income with the information being reported in terms of community population (i.e., per capita). The proportion of the population relying on social assistance has also been used as a community well-being indicator elsewhere in the NWT (GWNT 2000).

Effects of increased income can be both positive and negative. Income distribution throughout a population is also important (GNWT 2000; see Section 8.3.2). Wages can be used to purchase more efficient harvesting equipment or amenities that increase family and community quality of life (Usher 2002). In contrast, they are also sometimes used for gambling, to purchase of drugs and alcohol, or to purchase of goods and services that do not contribute to family or community well-being (IORVL 2004).

For comparative purposes, the NWT Bureau of Statistics generates a Living Cost Differential in which northern communities are compared with Edmonton. The value of this statistic is somewhat questionable; however, because households in the Beaufort Delta may not spend their cash on the same items as those in Edmonton, and there is no specific information on how country food consumption contributes to increasing or lessening the Living Cost Differential (Freese 2000). There appears to be a relationship between successful harvesting activities and income (Usher et al. 2003). As one workshop participant stated: "Just count the year (age) of the skidoos that children are driving. That will tell you how rich or poor the family/community is".

Net regional assets may be a better indicator of long-term cumulative effects than personal income. Net assets are a measure of private and public wealth that can accumulate over time, whereas income represents value earned over a short period such as a year (NRC 2003).

Petroleum exploration activities have helped support the mixed economy of the Beaufort Delta region over the last 40 years (Usher 2002). Future oil and gas exploration and development activities will continue to make direct contributions to the wage economy and reasonable estimates of per capita income can be generated for all types of petroleum projects.

8.2.3 Education, Training, and Employment

There is a positive correlation between education, employment and health status in Canada and other parts of the world (GNWT 2000). Education, training, and employment statistics are monitored by the NWT Bureau of Statistics. Measures of education levels were used as a human capital indicator in the West Kitikmeot-Slave Study (Macleod 2002), BHP-GNWT socio-economic monitoring (GNWT 2000), national sustainable development monitoring (Kennett 2000; NRTEE 2003), and sustainable forest management (Parkins and Beckley 2001; CCFM 2003). Education and other training data for the Beaufort Delta region were summarized earlier in Section 2.5.

Care must be taken when evaluating education and training statistics because they do not factor in on-the-job training, outdoor skills for subsistence life styles, or entrepreneurial skills (Usher et al. 2001). Nor do they consider the 'social-passing' approach taken in northern schools, whereby students are passed to the next grade to stay with their peers rather than based on demonstrated skills or knowledge. This was identified as a major concern by community and social service representatives at the Inuvik workshop in October 2004 (Dillon and Salmo 2004b). According to the participants, youth become depressed and suffer from low self-esteem later in life when they realize they are not qualified for available jobs even though they have met the educational requirements. Ideally, statistics should be supplemented with qualitative local information so that education and training data can be correlated with 'real' levels of skill and knowledge.

As discussed above, all smaller communities in the Beaufort Delta region are subsistence-based mixed economies at both community and household levels. Wage employment is, therefore, a key component of community economies influenced by: the available labour force; job availability; level of social assistance; the age, gender and ethnicity of those employed; duration of employment (part-time, seasonal, or full time); type of employment (entrepreneur or employee); and the employment sector (industry or occupation, such as government worker or trapper).

Participants at the October 2004 workshop noted that young people may drop out of school or choose not to pursue higher level education when high paying industry jobs are available during 'boom' periods.

Conversely, wage employment can provide experience, skills, and training that would otherwise be unavailable.

Changes in employment and training levels are obvious outcomes of petroleum exploration and development activities that can be both monitored and predicted.

8.2.4 Mental and Physical Health and Well-being

Detailed information on mental and physical health in small communities is difficult to obtain due to confidentiality and privacy laws. Quantitative indicators that have been used in the NWT include: death rate; number of injuries; number of communicable diseases; number of suicides; number of potential years of life lost; incidence of cigarette smoking; frequency of alcohol consumption; physical activity index; life expectancy; and self-assessed health status (GNWT 2000, 2004).

Suicide rate is one of the few available numerical indicators that reflects the state of mental health in a community, but these figures do not include attempted suicides. Suicide rates are higher in the Beaufort Delta region than in the rest of the GNWT or Canada. Although this information does not explain why individuals attempt or commit suicide, it does indicate that something is very wrong as community members feel that any suicide is too many.

The NWT Bureau of Statistics collects information on alcohol and tobacco use (NWT Statistics 2004). Realistic figures on gambling have not been collected, and local monitoring would be necessary to determine the number of individuals involved in both licensed and unlicensed gambling activities.

Many qualitative indicators of mental and physical health are available. For northern aboriginal communities these include: participation in religious and spiritual practices; attendance at family or community functions and the type of functions taking place (e.g., bingo, dances, traditional games); and frequency of elder visitations and by whom. This type of information can be gathered through open-ended questions and ethnography and may be appropriate for long-term regional monitoring.

Suicide rate, supplemented with qualitative information on causative factors, is considered to be a useful mental health indicator for long-term cumulative effects monitoring in the Beaufort Delta region. However, it and other quantitative and quality mental and physical health indicators are not practical for project-specific cumulative effects assessment and management, because they cannot be directly related to small and medium oil and gas development projects.

8.2.5 Infrastructure

The sustainability and well-being of communities is integrally related to their infrastructure (physical, human, and governance capacity) and its ability to accommodate outside change. In addition to emotional and cultural accommodation and adjustment, well-being is dependent on the ability of the community infrastructure (including both structures and staffing) to accommodate rapid increases or decreases in population and income. For example, addiction programs in Fort McPherson and Inuvik faced major cutbacks and closure during the last 'bust cycle'.

Infrastructure includes the following categories: health; emergency response (e.g., fire); law enforcement; social services (e.g., child and elder care); municipal services (e.g., heating, lighting, water, waste disposal); transportation (e.g., roads, aircraft); housing; communications (e.g., telephone and internet); educational; recreational; spiritual/cultural (e.g., churches, cultural training); and governance.

Housing is an important and widely used indicator of how local infrastructure is coping with population change (GNWT 2000, 2004). Over-crowding can lead to increased health problems and accidents. When housing is scarce, households tend to be multi-generational. In such households, older members of the family allocate labour and resource use, but when housing becomes available to each generation, the roles and responsibilities change (J. Ryan, pers. obs.). Participants at the October 2004 workshop noted that care must be taken when interpreting housing statistics, because they are confounded by social assistance disincentives (Dillon and Salmo 2004b).

8.2.6 Crime and Violence

One of the most obvious indicators of community well-being is the level of violence against persons and crime against property. Injuries from family and community violence are more common in the NWT than in other areas of Canada. As noted in Section 3.3.2, crime statistics are inconsistent because of the way that crime is perceived and reported. Usher et al. (2001) decided not to use crime as an indicator of the success of Inuvialuit Final Agreement economic measures due to these inconsistencies.

Petroleum exploration and development can lead to indirect increases in crime and violence rates due to increased population, greater numbers of transient workers and job seekers, and higher income and stress levels (NRC 2003; IORVL 2004). Crime and violence rates are considered to be useful indicators for long-term cumulative effects monitoring in the Beaufort Delta region. However, they are not practical as project-specific indicators because changes in crime and violence cannot be directly related to small and medium scale development proposals.

8.2.7 Candidate Indicators

Three candidate indicators are recommended for evaluating cumulative effects on community well-being:

- employment;
- training; and
- community population.

Candidate Limits of Acceptable Change are provided below for each indicator. Candidate indicators and limits should be discussed and refined with input from interested governments, communities, groups, and individuals in the Beaufort Delta region before being formally adopted.

8.2.7.1 Employment

Project employment can have both positive and negative effects on community well-being. Full- and part-time direct and indirect employment projections are typically included in project applications and actual employment is monitored for benefits reporting. Employment (including projections of project-specific employment) is recommended as a direct indicator of wage income and an indirect measure of the portion of each Beaufort Delta community participating in the development-related wage economy. Employment can be predicted by project proponents, compared to desired conditions, and monitored to track success relative to desired conditions. It is hoped that this quantitative indicator can ultimately be related to qualitative community-based indicators of well-being.

Employment includes direct and indirect full- and part-time employment (including self-employment) attributable to a particular exploration or development project/activity. The standard open-model oil and gas multiplier (1.22 total jobs per direct job) developed for the NWT Input Output model (NWT Statistics 2004d) should be used until such time as standard Beaufort Delta region multipliers are developed for project employment calculations.

The most recently reported labour force participation rates were 42% to 63% in smaller communities and almost 81% in Inuvik (Table 2). Participation rates in smaller communities are somewhat lower than those reported ten years ago (NWT Statistics 1994).

The candidate Target Limit for each community is for labour force participation to be higher than the ten year average value. The candidate Critical Limit for each community is for labour force participation to be no lower than the ten-year average. A ten-year averaging period is proposed to smooth major boom-bust cycles and year-to-year variation and encourage stable wage employment growth in each community, consistent with the regional vision. Part-time employment is included because residents may prefer this option so that they can continue to pursue harvesting activities.

8.2.7.2 Training

Skills training can enhance benefits and reduce adverse social effects of resource development by increasing regional human capital, or 'real' levels of skill and knowledge. Training is a cumulative effects indicator that can be readily tracked and ultimately related to frequency of positive and negative social metrics. This also provides an opportunity to track the overall petroleum sector (and individual company) contribution to education and training.

The candidate Target Limit is for all resident full- and part-time employees and contractors in the Beaufort Delta region to complete at least two new skill training programs each year and for all non-resident full- and part-time employees and contractors to complete a cross-cultural training program every five years. The candidate Critical Limit is for all resident full- and part-time employees and contractors to complete at least one new skill training programs each year and for all non-resident full- and part-time employees and contractors to complete a cross-cultural training program every five years. This is intended to encourage on-going skill development and cross-cultural awareness in the Beaufort Delta region.

The merits of Target and Critical limits for community-based skills training should also be considered.

8.2.7.3 Community Population

Rapid or dramatic changes in community permanent and transient populations increase the risk of adverse cumulative effects on community well-being. The communities of Inuvik, Tsiigehtchic and Tuktoyaktuk have grown at less than 2% over the last ten years, while Aklavik and Fort McPherson populations have declined by 1 to 2% annually over this period. Candidate limits are intended to encourage stable community populations and reduce impacts from large numbers of transient workers.

The candidate Target Limit for the Beaufort Delta region is no more than 10% change from the ten year average population growth/decline rate in each community, assuming that this will minimize adverse effects on community infrastructure and capacity. The candidate Critical Limits is no more than 25% change in ten year average community population growth/decline rate.

8.3 Economy and Business

Economic indicators measure community, regional, territorial, and federal variables including: prices; expenditures; revenue-generation; supply and demand; employment opportunities; and business opportunities. The Consumer Price Index is an indicator used to track the rate at which prices change for all goods and services bought by Canadian consumers (Macleod 2002). Economic indicators such as GDP and total capital expenditures are commonly used to measure or predict the societal benefits of

resource development. However, most of these focus on short-term production, rather than 'wealth', a concept that reflects both human and social capital. Although GDP was not designed to be used as a summary indicator of overall society progress, it is often used that way (NRTEE 2003).

Indicators that have been used by CCFM (2003) to describe regional economies include: contribution of financial benefits by sector; distribution of financial benefits; and sustainability of benefits (return on capital employed, direct, indirect and induced employment, average income, and economic diversity index).

8.3.1 Community and Regional Revenue

On Alaska's North Slope, the primary pathway of social change has been the revenue that has flowed into local communities over the last 25 years (NRC 2003). Sources that can be petroleum exploration and development related include: purchase of goods and services; employment income; and fees and taxes. These expenditures can be both forecast and monitored directly at regional and community levels.

Documenting regional petroleum-related regional expenditures provides an opportunity to relate this revenue input to both positive and negative cumulative social effects.

8.3.2 Household Micro-economy

As has been discussed in Section 2, Beaufort Delta communities within the study area are subsistence-based, mixed economies that are best understood at the household level. Household success is dependent on a balancing of cash income and the production of country food and other commodities for domestic use (Staples 1997; Freeman 2001; Usher et al. 2003).

Usher et al. (2003) developed a model for the collection of both qualitative and quantitative information on the household micro-economy. They suggested three factors of production:

1) availability of land and resources;
2) labour; and
3) capital.

Land and resources are the basis of all activity within a subsistence economy. Labour is organized to both produce items for sale and for family consumption, and when possible, to earn wages working for others. Labour also includes the skills, knowledge and 'human capital' of the household. Finally, capital from wages, sale of commodities (such as fish, furs, or crafts), and transfer payments (old age or disability pensions, and unemployment/social assistance) are used to produce commodities and buy

equipment required for harvesting (snowmobiles, all-terrain vehicles, trucks, boats, motors, firearms, fish nets, etc.), as well as on-going maintenance.

As noted below, this model provides a framework to link socio-cultural indicators for long-term cumulative effects monitoring in the Beaufort Delta region.

8.3.3 Candidate Indicators

The Usher et al. (2003) model considers all aspects of a mixed economy in a contemporary society and provides a framework to understand cumulative social effects. Both social and economic indicators of land and resource availability have been identified as candidates in this report (see Sections 8.1.4.2, 8.1.7.1, 8.3.3.1 and 8.3.3.2). Project employment and training were identified as candidate community well-being indicators (see Section 8.2.7). This provides information on the labour component of this model as a direct indicator of time spent pursuing wage employment and an indirect indicator of time and skills available for subsistence activities. Finally, an income indicator is recommended here to provide information on the capital component of this micro-economy model.

Candidate Limits are provided below for each indicator. These candidate indicators and limits should be discussed and refined with input from interested governments, communities, groups, and individuals in the Beaufort Delta region before being formally adopted.

8.3.3.1 Employment

Employment was identified as a candidate Community Well-being indicator, but this indicator can also be used to understand regional economic effects. The candidate Target and Critical provided in Section 8.2.7.1 would also apply here.

8.3.3.2 Income

Projections of project employment, business, and service expenditures are typically included in project applications and actual expenditures are monitored for benefits reporting. Project income is recommended as a direct indicator of capital input to households, communities, and the Beaufort Delta region. Expenditures can be predicted by project proponents, compared to desired conditions, and monitored to track success relative to desired conditions. It is hoped that this quantitative indicator can ultimately be related to qualitative community-based indicators of well-being.

The candidate Target Limit is for project community per-capita income to be higher than the ten year average value for that community. The candidate Critical Limit for each community is for labour force participation to be no lower than the ten year average. A ten year averaging period is proposed to smooth

major boom-bust cycles and year-to-year variation and encourage stable capital growth in each community, consistent with the regional vision.

8.4 Candidate Socio-Cultural Indicators and Limits of Acceptable Change

To be most effective, communities and regional groups should help define socio-cultural indicators and Limits of Acceptable Change within a consistent regional framework. The candidate indicators and Limits of Acceptable Change provided here are intended to help inform such discussions by demonstrating how practical limits can be derived and by providing a reasonable starting point for consultation. The candidate framework is based on relevant guidance documents, statements made by Gwich'in and Inuvialuit organizations and participants at the October 2004 workshop in Inuvik, and the regional vision described in Section 3.1.5.

Figure 17 shows how the suite of candidate socio-cultural indicators allows social effects pathways to be tracked. This graphic reinforces the need for both project-specific indicators that can be directly related to proposed oil and gas activities, and regional indicators that can be monitored to help document and understand long-term cumulative effects.

Candidate Limits of Acceptable Change are provided in Table 17 for each project-specific socio-cultural indicator.

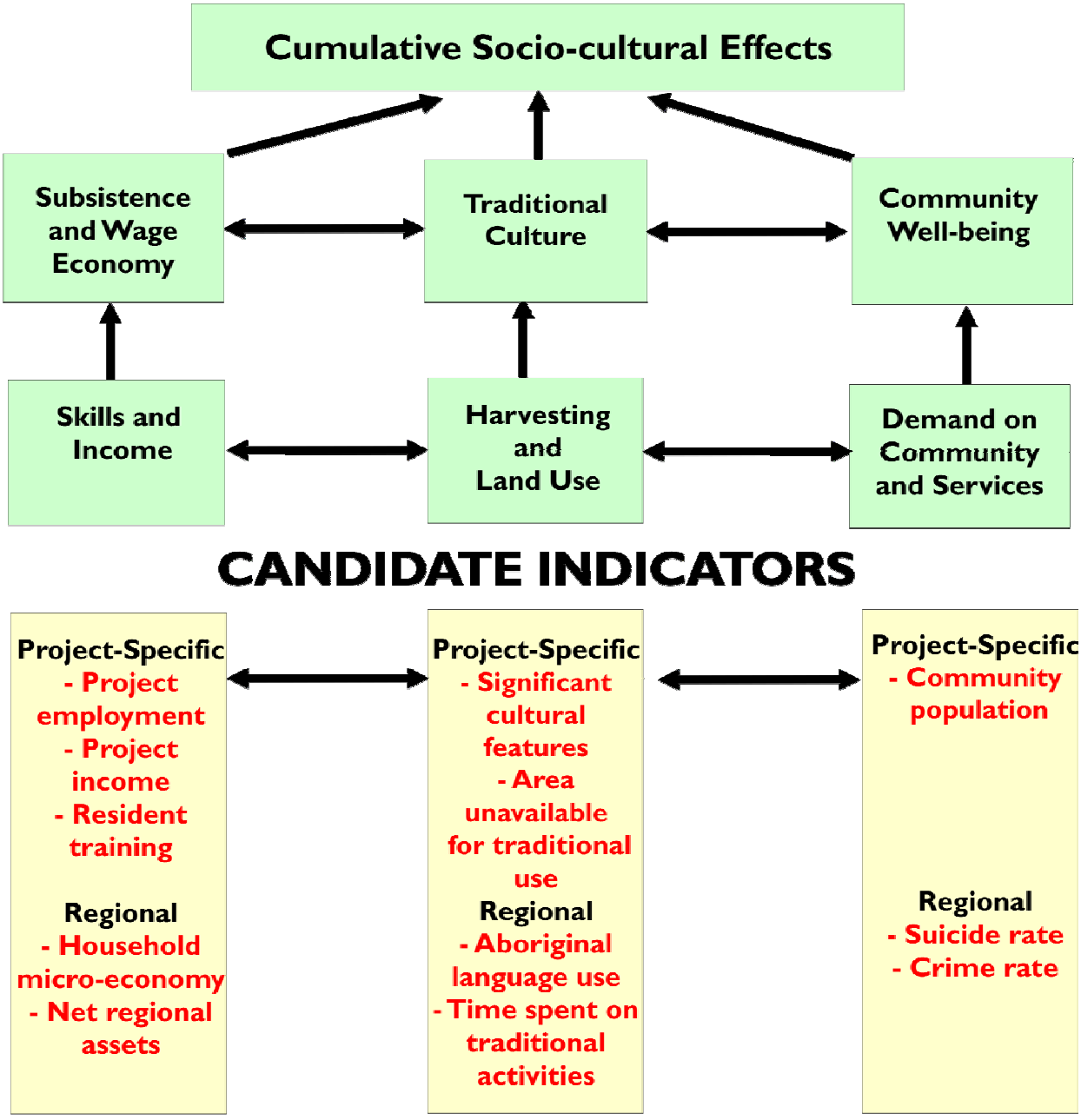

Figure 17 Candidate project-specific and regional socio-cultural indicators for the Beaufort Delta region.

Table 17 Candidate socio-cultural indicators and Limits of Acceptable Change for the Beaufort Delta region.

VC	Candidate Project-Specific Indicator	Candidate Limits of Acceptable Change
Land and Culture	**Significant Cultural Features** (including archaeology and heritage sites as well as cultural sites still in use: trapping, fishing, hunting and gathering locations; cabins; burial sites, historic trails; spiritual sites)	**Target**: no disturbance or activity within 100 m. **Critical**: no net loss (taking into account mitigation or compensation). **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where cultural values are the primary management objective.
	Area unavailable for traditional use (assumed to include land area within 1000 m of highly visible sites and those with intensive industrial use, including: production facilities, active well sites, camps, above ground pipelines)	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 20% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
Community Well-being	**Employment** (full- and part-time employment by community, including project-specific employment)	**Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Training (resident employee/contractor skill training and non-resident employee/contractor cross-cultural training)	**Target**: all residents to complete at least two skill training programs and all non-residents to complete a cross-cultural training program every five years. **Critical**: all resident employees/contractors to complete at least one skill training program and all non-residents to complete a cross-cultural training program every five years. Consider merits of limits for community-based skills training.
	Community population (transient and permanent population increase by community, including project-specific projections)	**Target**: no more than 10% change from ten year average population growth/decline rate (final target limit to be defined by community) **Critical**: no more than 25% change from ten year average population growth/decline rate (final critical limit to be defined by community)
Economy and Business	**Employment** (projected full- and part-time employment by community)	**Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Project Income (business and employment income (expenditures) by community, including project-specific projections)	**Target**: average household income higher than ten year average rate (final target limit to be defined by community) **Critical**: average household income no lower than ten year average rate (final critical limit to be defined by community)

VC – Valued Component ICCP – Inuvialuit Community Conservation Plan GLUP - Gwich'in Land Use Plan

9 Conclusions and Recommendations

Jurisdictions across North America have been challenged to find a satisfactory approach for assessing and managing cumulative environmental and social effects. In fact, it could be argued that a successful approach has yet to be found. This is largely due to the typical 'silo' organization structure that divides roles and responsibilities among a large number of institutions, departments, agencies, communities, groups, and industries (Kavik-Axys 2002b).

The overall objective of the ESRF Beaufort Delta Cumulative Effects Project is to identify a suite of candidate environmental and social Valued Components, indicators, and thresholds or Limits of Acceptable Change that are of practical assistance in assessing and minimizing adverse cumulative effects in the region. One advantage of this approach is that they can be applied within a typical 'silo' organization.

9.1 Beaufort Delta Region Framework

The overall objectives of the Environmental Studies Research Funds (ESRF) Beaufort Delta Cumulative Effects Project is to identify a suite of candidate environmental and social Valued Components, indications, and management thresholds that are of practical assistance in assessing and minimizing adverse cumulative effects in the region. These have been developed as components of an integrated cumulative effects framework incorporating socially-derived Tiered Thresholds and Limits of Acceptable Change (Figure 5). This framework is recommended to supplement the existing Beaufort Delta regulatory and resource management institutions and initiatives described in Section 2.6, and to reflect known regional values and concerns.

Preliminary Valued Components, indicators, and management thresholds were presented to community, government, co-management, and industry representatives at a workshop held in Inuvik in October 2004. Workshop attendees were generally supportive of the approach, and the framework provided here incorporates their comments and suggestions. A workshop summary is included in Appendix II.

Although cumulative effects must ultimately be managed cooperatively at the regional scale, the emphasis of this study is consistent with the mandate of the ESRF, namely on local or operational level tools that would improve petroleum development decision making. As a result, the approach adopted here was to explicitly encourage linkages between project-specific and regional activities by adopting a suite of complementary indicators as a 'common language'.

Further work will be required to refine the framework and define project-specific, joint project, and cooperative regional impact management measures, including roles, responsibilities, and their relationship to current consultation, decision-making, and management processes. The candidate indicators and management thresholds presented here are intended to provide a clear basis for such discussions. Additional information on recommended next steps is provided in Section 9.2.

9.1.1 Regional Vision

Existing Inuvialuit Community Conservation Plans, the Gwich'in Land Use Plan (GLUPB 2003), and other sector- and resource-specific planning documents discussed in Sections 2 and 3 provide direction for land and resource management in the Beaufort Delta region. As stated in Kavik-Axys (2002b): "Many people in the [ISR] want to see future landscapes that include the opportunity to choose between participating in the wage economy, the subsistence economy, or a blend of both." The Gwich'in Land Use Plan (GLUPB 2003) states that "Communities have strongly expressed their need for more employment and training… [and] … would like to see … local commercial activities building on skills they possess and are related to traditional activities. … Traditional land uses should also be encouraged because they provide an economic option other than the wage economy."

Management objectives identified in existing guidance documents demonstrate the priority placed on environmental protection, sustainable economic development, and integrated management in the Beaufort Delta region. Management goals were interpreted to provide the following regional *Vision* for cumulative effects assessment and management in this region (Section 3.2):

1. Valued Components and indicators should reflect the strong linkage between environmental conditions and community well-being;
2. Indicators should be selected to help integrate environmental and socio-economic assessment, resource management, economic development, social service provision, and cultural programs;
3. Environmental thresholds should be conservative (i.e., precautionary) in areas with sensitive or valued resources to reflect the priority placed on renewable resource conservation and sustainable use; and
4. Social Limits of Acceptable Change should accommodate increased community and regional economic development while improving existing social conditions.

Participants at the October 2004 workshop generally agreed that this vision was a reasonable basis for cumulative effects assessment and management in the Beaufort Delta region (Dillon and Salmo 2004b). Participants also indicated that this vision (and the associated framework) will need to be more widely discussed, and refined, if appropriate, prior to implementation.

9.1.2 Value Components

Limited time and resources make it impractical for managers, reviewers, communities, and proponents to consider all environmental and social factors in equal detail. A suite of representative environmental and social components is commonly used to summarize information and help focus assessment and management activities. However, definitions vary, and no standard widely accepted suite of Valued Components exists.

The NWT CIMP (DIAND 2003) defines a Valued Component as: "… an aspect of the environment that is considered important, on the basis of economic, social, cultural, community, ecological, legal or political concern. A Valued Component is not an indicator in itself, although impacts on, or trends in, some characteristic of a Valued Component may be used as an indicator." Valued Components selected for most other northern initiatives have emphasized species or species groups that are of management interest because they are harvested, at risk, or sensitive to disturbance (Table 2 in Section 3.5).

The emphasis of the ESRF Beaufort Delta Cumulative Effects project is on local or project-specific tools that are compatible, or can be linked, with these research and monitoring initiatives. Based on direction provided by the ESRF Technical Advisory Group, and feedback from participants at the Inuvik workshop in October 2004, a suite of eight general Valued Components was identified for the Beaufort Delta region (Table 18).

Table 18 Summary of Valued Components identified for the Beaufort Delta region.

VC	Description
Air	air quality, noise and climate
Land	soil, permafrost, vegetation, and terrestrial wildlife
Freshwater	lakes, streams, water quality, fish and aquatic organisms
Nearshore Marine	grounded (landfast) ice area and associated marine wildlife and organisms
Sensitive and Protected Areas	ICCP Category E lands, Gwich'in Conservation Zones, and areas protected by territorial and federal legislation
Traditional Culture and Land Use	social, cultural, heritage, and archaeological resources, traditional resource use and culture, and stewardship responsibilities
Community Well-being	demographics, income and cash flow, education and training, mental and physical health, crime, and infrastructure
Economy and Business	wage employment and business opportunities

ICCP - Inuvialuit Community Conservation Plans

These Valued Components (Table 18) are known to be important to regional residents, and when taken together, reflect overall environmental and social conditions in the Beaufort Delta region. Their condition can be easily measured and described at multiple scales (e.g., community, sub-regional, regional). In addition, they are compatible with Valued Components and indicators proposed or adopted for other northern cumulative effects initiatives such as the NWT CIMP; Ecological Monitoring and

Assessment Network; Arctic Borderlands Ecological Knowledge Co-op; and Slave Geological Province Socio-economic Monitoring.

9.1.3 Indicators

An indicator is defined here as "a characteristic of the social or ecological setting that is used to describe, measure, manage, and report on Valued Components". Indicators help land and resource users and managers speak a common language when they assess and manage cumulative effect risk.

There is considerable scientific debate around the comparative merits of different types of indicators for cumulative effect assessment and management. As with Valued Components, no standard, widely accepted suite of indicators exists. Because of the project's emphasis on local or project-specific tools, a primary selection criterion for the Beaufort Delta region is that indicators can be quickly and easily measured, or calculated with readily-available data. Another important condition is that they allow project-specific effects to be differentiated from other sources of social, industrial, or natural change.

These conditions are particularly relevant to indicators of cumulative socio-cultural effects. Numerical indicators are commonly used to describe and monitor economic and social conditions. However, these numbers never completely describe or allow understanding of the household and community influences on current social conditions. Such scientific or statistical findings may not explain a community's quality of life, as viewed by residents. In many cases, social and cultural impacts are viewed differently by those who are from the region, and those who reside elsewhere, or have lived in the region for a limited period. This may arise because non-residents and recent immigrants make false assumptions based on their own world view or experience, and may not be aware of how their assumptions influence their conclusions.

To address these biases, community representatives should ideally help collect local information to help put numerical data in an appropriate perspective. Because this is not practical for project-specific reviews and management, the ideal framework would build links between project-specific, community, regional, and territorial indicators and management activities. This approach has been adopted for cooperative socio-economic monitoring in the Slave Geological Province (GNWT 2000).

Potential indicators and the recommended candidate indicators for each Valued Component are discussed in Sections 4 through 8. When combined (Table 19), a suite of 13 candidate cumulative effect indicators is identified for the Beaufort Delta region. As noted below, several of these apply to more than one Valued Component to encourage the integration identified in the regional vision.

Table 19 Summary of 13 cumulative effects indicators selected for the Beaufort Delta region.

Cumulative Effects Indicators	Description
Air Quality	Ground level concentration of regulated emissions.
Water Quality	Ambient concentration of regulated freshwater and marine discharges.
Total Area Disturbed	Direct footprint of industrial and human activity on land, on lake, stream, and riparian habitat, and in nearshore marine areas.
Core Habitat Available	Relatively undisturbed areas outside the direct and indirect footprint of industrial and human activity on land and in nearshore marine areas.
Total Corridor Density and Crossing Index	Kilometres of linear corridors per square kilometre on land and number of stream crossings per square kilometre.
Seasonal Aircraft and Vessel Activity	Area by month in designated travel corridors and movement areas where low level flights and vessel activity could occur.
Char and Bear Mortality	Mortality of sensitive focal species (grizzly bear, polar bear, Dolly Varden char, and lake trout) from all industry sources (including harvest, management action, research, and illegal kill), and legal/illegal harvest.
Sensitive Environmental and Cultural Features	Disturbance of designated features such as pingos, dens, nesting colonies, spawning and overwintering areas, harvesting sites, cultural sites, heritage sites.
Area Unavailable for Traditional Use	Area within the direct and indirect footprint of highly visible sites and those with intensive industrial use (inverse of core area available).
Employment	Full and part-time employment by community, including projected project-specific change.
Training	Resident employee and contractor skill training and non-resident cross-cultural training.
Income	Projected business and employment income (expenditures) by community, including projected project-specific change.
Community Population	Projected permanent and transient population increase by community, including projected project-specific change.

9.1.4 Thresholds, Limits and Targets

Indicators provide information about the likelihood of negative cumulative effects, but provide no direct measure of the acceptability of those impacts. Setting a numerical value on indicators is one of the most challenging aspects of cumulative effect assessment and management.

The best examples of science-based thresholds are air and water quality guidelines and standards developed by the federal government. In most cases, the risk of adverse cumulative effects increases with the amount of human activity or disturbance, and there is no clear break-point that distinguishes acceptable and unacceptable conditions. Similarly, there are no clear social thresholds because there are many different views on what an unacceptable adverse impact is. To be politically acceptable and socially responsible, thresholds and limits must balance community, regional, territorial, and national values, interests, and expectations. Tiered thresholds, and Limits of Acceptable Change, are two tools that have been developed to achieve this. Participants at the October 2004 workshop noted that the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan provide a reasonable starting point to develop technically and socially-based '*Made for the Beaufort Delta*' limits and thresholds (Dillon and Salmo 2004b).

Candidate Tiered Thresholds and Limits of Acceptable Change are developed for each indicator to manage cumulative effect risk in the Beaufort Delta region (see Section 3.7). These tools (defined in Table 20) recognize that precise environmental and social thresholds may not exist, and set boundaries based on the amount of change that will be permitted.

A series of two to three thresholds or limits was considered for each indicator. The primary strength of a tiered framework is the formal link between the limits and impact management. This provides a method to gather data on actual responses and modify management actions as appropriate. A secondary benefit is that tiered limits directly recognize the uncertainty around our understanding of complex social and environmental relationships. Finally, tiered thresholds provide the flexibility for different land management zones and settings, for a full range of development proposals, and for both project-specific and cumulative effect management.

Candidate thresholds and limits identified for each Valued Component and indicator are summarized in Table 21. These were derived from available information in a transparent manner so that their rationale is clear. Limits and thresholds were linked to existing land use zoning schemes provided in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan wherever possible. Feedback from participants at the October 2004 workshop was also used to help establish acceptable risk levels of Beaufort Delta residents.

Table 20 Definitions for thresholds, Limits of Acceptable Change, and tiered thresholds.

Term	Definition
Threshold	A technically or socially-based management standard that identifies the point at which an indicator changes to an unacceptable condition.
Limits of Acceptable Change	A socially-defined endpoint or management standard that reflects the desired balance between human activities and environmental or socio-cultural sustainability.
Tiered Thresholds	A series of progressive thresholds or limits of acceptable change that reflect increasing degrees of concern or risk *Critical Threshold*: continuous maximum amount of stress that an environmental or social system can support without long-term harm. When this threshold is reached or approached, restrictive management practices are formally adopted to reduce risk. *Target Threshold*: politically or socially-defined goal for the amount of stress on a system. When this threshold is reached, enhanced management practices are formally adopted to reduce risk or increase understanding of the system. *Cautionary Threshold*: established to indicate the point at which additional or more intensive monitoring is required to document conditions or environmental and social response.

Table 21 Suite of candidate Valued Components, Indicators, Thresholds, and Limits of Acceptable Change proposed for the Beaufort Delta study area.

Candidate VC	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Air	**Air quality** (ground level concentration of regulated emission parameters)	**Critical**: no exceedance of regulated emission guideline or standard. Consider need for intermediate Target Thresholds in area(s) where pristine air quality is identified as a management objective or where regulatory guidelines/standards do not exist for an emission of interest.
Land	**Total area disturbed** (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear, and waterfowl) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.
	Core habitat available (ha and % of area available more than 1000 m from sites with intensive human or industrial use, including: industrial facilities, above ground pipelines, producing well sites, active camps and staging areas, airstrips, active seismic programs, cabins, and communities)	**Target**: more than 40% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: more than 60% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: more than 50% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: more than 70% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: more than 90% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. Consider species-specific thresholds (e.g., caribou, grizzly bear) and Cautionary Thresholds to initiate effects monitoring in areas where environmental values are the primary management objective.

Candidate VC	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Land	**Total corridor density** (km/km^2; including all roads, trails, pipelines, seismic lines, power lines >3 m wide)	**Target**: no more than 1.0 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 0.6 km/km^2 on ICCP Category C and D lands and Special Management Zones. **Target**: no corridors on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 1.2 km/km^2 on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 1.0 km/km^2 on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.2 km/km^2 on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
	Sensitive environmental features (ha and % of area disturbed in unique vegetation communities, rare plants, mineral licks, dens, nests, nesting colonies; Pingo Canadian Landmark)	**Target**: no disturbance or activity within 250 m. **Critical**: no net loss (taking into account mitigation or compensation). **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where environmental values are the primary management objective.
	Grizzly bear mortality (number of grizzly bear mortalities from all industrial causes (management action, research, and illegal kill by industry worker) and legal/illegal harvest)	**Target**: no industrial-associated mortality. **Critical**: one industrial-associated mortality.
Freshwater	**Water quality** (ambient concentration of regulated discharge parameters).	**Critical:** Canadian Water Quality Guidelines. **Cautionary/Restrictive:** Monitoring at all approved discharges. Consider intermediate Target Thresholds where pristine water quality is a management objective and where defined guidelines do not exist for a particular parameter.
	Total land area disturbed (ha and % of area disturbed by communities, camps, borrow pits, sewage lagoons, airstrips, military and industrial facilities, roads, pipelines, seismic lines)	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Target**: no disturbance on ICCP Category E and GLUP Conservation/Heritage Conservation Zones. **Critical**: no more than 15% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.

Candidate VC	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Freshwater	**Total aquatic and riparian area disturbed** (ha and % of area disturbed by stream crossings, bank and bed alterations, and riparian clearing/disturbance)	**Critical:** no net loss (taking into account mitigation or compensation). **Cautionary/Restrictive:** stream crossing density less than 0.25 crossings/km^2.
	Specialized environmental features (disturbance of spawning and overwintering areas)	**Target**: no disturbance or activity within 250 m of overwintering and spawning areas of Rat River Dolly Varden char. **Target**: no disturbance or activity within 100 m of designated overwintering and spawning areas. **Critical**: no disturbance or activity within 100 m of overwintering and spawning areas of Rat River Dolly Varden char. **Critical**: no net loss of designated overwintering and spawning areas.
	Char mortality (number of fish mortalities caused by all industry-related causes in addition to legal/illegal harvest)	**Target**: cumulative industrial-aossociated mortality of Dolly Varden char no more than 1% of total annual allowable harvest. **Target**: cumulative industrial-associated mortality of lake trout no more than 10% of recorded subsistence harvest during the previous year.
Nearshore Marine	**Total area disturbed** (ha and % of area disturbed by dredging, artificial islands, bottom-founded vessels or structures)	**Target**: no more than 5% on ICCP Category C and D lands. **Critical**: no more than 10% on ICCP Category C and D lands. **Critical**: no more than 0.5% on ICCP Category E lands.
	Seasonal vessel and aircraft activity (ha and % of area by month in designated travel corridors and movement areas where low level flights and vessel activity could occur)	**Target**: no more than 20% combined footprint on ICCP Category C and D lands. **Target**: 0% on Beluga Management Zone 1 during beluga harvest. **Target**: 0% on KIBS during the nesting season. **Critical**: more than 30% combined footprint on ICCP Category C and D lands. **Critical**: no more than 5% on Beluga Management Zone 1 during beluga harvest. **Critical**: no more than 5% on KIBS during the nesting season.
	Specialized environmental features (disturbance of polar bear dens; % of KIBS and beluga whale Zone 1 area disturbed)	**Target**: no disturbance or activity within 250 m of polar bear dens. **Critical**: no disturbance or activity within 100 m of polar bear dens. **Critical:** no more than 1% long-term disturbance within Kendall Island Bird Sanctuary.
	Polar bear mortality (number of polar bear mortalities from all industrial causes [management action, research, and illegal kills by industry workers] and legal/illegal harvest)	**Target**: no industrial-associated mortality. **Critical**: one industrial-associated mortality.

Candidate VC	Candidate Project-Specific Indicator	Candidate Thresholds / Limits of Acceptable Change
Traditional Culture and Land Use	**Significant cultural features** (including archaeology and heritage sites as well as cultural sites still in use: trapping, fishing, hunting and gathering locations; cabins; burial sites, historic trails; spiritual sites)	**Target**: no disturbance or activity within 100 m. **Critical**: no net loss (taking into account mitigation or compensation). **Cautionary/Restrictive Critical**: Consider for management units (e.g., ICCP Category E lands or GLUP Heritage Conservation Zones) where cultural values are the primary management objective.
	Area unavailable for traditional use (assumed to include land area within 1000 m of highly visible sites and those with intensive industrial use, including: production facilities, active well sites, camps, above ground pipelines)	**Target**: no more than 10% on ICCP Category A and B lands and GLUP General Use Zones. **Target**: no more than 5% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 20% on ICCP Category A and B lands and GLUP General Use Zones. **Critical**: no more than 10% on ICCP Category C and D lands and GLUP Special Management Zones. **Critical**: no more than 0.5% on ICCP Category E lands and GLUP Conservation/Heritage Conservation Zones.
Community Well-being	**Employment** (full- and part-time employment by community including project-specific projections)	**Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Training (resident employee/contractor skill training and non-resident employee/contractor cross-cultural training)	**Target**: all residents to complete at least two skill training programs and all non-residents to complete a cross-cultural training program every five years. **Critical**: all resident employees/contractors to complete at least one skill training program and all non-residents to complete a cross-cultural training program every five years. Consider merits of limits for community-based skills training.
	Community population (transient and permanent population increase by community including project-specific projections)	**Target**: no more than 10% change from ten year average population growth/decline rate (final target limit to be defined by community) **Critical**: no more than 25% change from ten year average population growth/decline rate (final critical limit to be defined by community)
Economy and Business	**Employment** (full- and part-time employment by community including project-specific projections)	**Target**: labour force participation higher than ten year average rate (final target limit to be defined by community) **Critical**: labour force participation no lower than ten year average rate (final critical limit to be defined by community)
	Income (business and employment income (expenditures) by community including project-specific projections)	**Target**: average household income higher than ten year average rate (final target limit to be defined by community) **Critical**: average household income no lower than ten year average rate (final critical limit to be defined by community)

ICCP - Inuvialuit Community Conservation Plans GLUP - Gwich'in Land Use Plan

9.2 Refining Limits and Indicators

Candidate '*Made for the Beaufort Delta*' indicators, tiered thresholds, and Limits of Acceptable Change provide a starting point for threshold application in this region. The next step, as experience in other jurisdictions clearly demonstrates, is to give all affected groups and individuals the opportunity to participate in threshold testing and refinement. This is because implementation is a shared responsibility that will be most effective when are accepted as both reasonable and based upon accepted science, traditional knowledge, and social values. The adaptive management approach also suggests that proposed management actions should be rigorously tested before they are widely applied (Salmo et al. 2003).

The candidate indicators and thresholds provide a measure for reviewers and regulators such as the Environmental Impact Review Board, Gwich'in Land and Water Board, Inuvialuit Land Administration, and Indian and Northern Affairs Canada to consider the acceptability of proposed activities (defined based on the associated environmental and socio-cultural risk). If thresholds or limits are exceeded, pre-defined project-specific, joint project, and cooperative regional impact management measures can then be mandated to reduce unacceptable risk (see Section 9.2.5).

A number of steps are recommended before candidate thresholds and limits are implemented in the Beaufort Delta region. This refinement will require:

- Consultation to reach general agreement on the indicators to be used and definitions of acceptable change and threshold values;
- Modeling to help understand the economic, social, and ecological implications of proposed limits and thresholds;
- Development of a standard public database;
- Definition of standard methods to calculate indicator values using this database; and
- Identification of project-specific and cooperative actions including mitigation, monitoring, and research to be implemented when specific thresholds and limits are approached or exceeded.

9.2.1 Consultation

All affected groups, individuals, and management agencies will understandably be concerned about the impacts of threshold and limit implementation and will need to be convinced that they provide an appropriate balance between desired economic development, social conditions, and environmental protection.

As a first step, the regional vision and suite of candidate Valued Components and cumulative effect indicators will need to be reviewed with a wider group of residents, managers, land users, and specialists to ensure that they properly reflect regional interests and values.

9.2.1.1 Modeling to Test and Refine Limits and Thresholds

Political and social acceptability of thresholds depends on how well they are perceived to balance community and regional values, interests and expectations. Formal evaluations are recommended to allow managers, regulators, communities, and land users to understand the implications of cumulative effect assessment management within the recommended framework. These evaluations would translate the proposed thresholds and limits into quantifiable terms to show what they would mean in terms of land use activity and community change. For example, how much activity could occur in an individual land management unit with the candidate threshold, and what would this mean for economic, social and environmental values and resources?

Integrated landscape management models provide the most effective tool to facilitate this consultation and refinement process. Integrated landscape models use information on natural disturbance, current landscape conditions, and existing and likely land use patterns to simulate future conditions. This allows affected groups and individuals to visualize the effect of various development scenarios and management options. These simulations also allow trade-offs between social and ecological indicators to be clearly evaluated so that the preferred (as defined by residents and managers) land and resource management actions can be identified and implemented.

Integrated landscape modeling is best conducted as an iterative process where the modeling team interacts with a wider set of groups and individuals. In early stages, agreed-upon scenarios of likely future development activities in the Beaufort Delta region are developed or adopted. Government agencies and industry members will have particular interest in ensuring that development scenarios accurately reflect their perceptions of likely activity levels and that such development is economically viable, as well as socially and politically acceptable and appropriate.

Sufficient time will need to be spent to incorporate traditional and local knowledge and expertise, ensure that affected groups and individuals understand modeling assumptions and findings, and revise simulations to reflect local input. This has been a critical gap elsewhere, but is essential to ensure that aboriginal cultures, values and knowledge play an appropriate role in both social and environmental evaluations. Traditional knowledge is likely to cover a substantial time period and can add important historical perspective on the response of people, plants, and animals to changes in the environment. Local knowledge held by some long-time non-aboriginal residents may be similar to traditional knowledge in some ways, and should also be collected and incorporated in a consistent fashion.

The ultimate goal of these evaluations is to use integrated landscape modeling tools to allow the ecological, social and economic benefits and trade-offs of applying candidate thresholds and limits to be directly visualized for the Beaufort Delta region. Thresholds and limits can then be refined to reflect preferred future conditions.

A less comprehensive approach would be to test the candidate thresholds and implementation process in a pilot study restricted to a defined area or type of activity. With this approach, actual implementation

costs and benefits could be tracked in parallel to the existing application review and permitting process. Affected stakeholders should be involved in selecting, designing, and evaluating the pilot study.

9.2.2 Standard Digital Database

Readily-available GIS datasets were obtained and evaluated to determine their suitability for calculating current status of potential and recommended candidate indicators. Although data were incomplete for all features, analyses confirm that the Beaufort Delta region is relatively undeveloped compared to most other areas of Canada.

A standard, publicly available digital regional database of land use, environmental, and social information will be required to allow cumulative effect indicators to be calculated and tracked in a consistent way. The existing public database will need to be enhanced and made more readily available. The requirements and uses of such a database in the Inuvialuit Settlement Region are discussed in Kavik-Axys (2002b). Although beyond the scope of their current mandates, the Inuvialuit Joint Secretariat and Gwich'in Land Use Planning Board appear to be the most suitable agencies to develop, maintain, and distribute such information.

The Gwich'in Integrated Geographic Information System has been set up as a GIS services partnership between the Gwich'in Tribal Council, Gwich'in Renewable Resources Board, and the Gwich'in Land Use Planning Board. This provides a central database for GIS information and shared GIS services (GLUPB 2004). The Inuvialuit Joint Secretariat also provides GIS support to environmental review and co-management agencies within the Inuvialuit Settlement Region. Interviewees indicated that additional resources would be needed to allow both GIS groups to collate and maintain standard regional databases. There are also licensing and liability issues that need to be addressed to allow regional data sets to be made publicly available.

9.2.3 Standard Methods

Many of the indicator calculations and associated candidate thresholds incorporate assumptions about the size of the indirect footprint (zone of influence) associated with different industrial and land use features. These were based on review of available literature and professional judgment of the authors. The appropriate analysis area is another critical factor that must be considered. Where not specified, indicator calculations should be completed for the land use zone they fall within.

Indicator calculation assumptions and methods will need to be tested as part of the threshold refinement process to develop transparent, efficient, and standardized analysis, reporting, and review methods.

9.2.4 Project-specific and Cooperative Management Actions

A tiered cumulative effects framework provides a formal link between pre-defined standards and impact management actions. Impact management includes any measures needed to minimize or eliminate impacts, whether implemented by individual projects, jointly by several projects, or regionally by both projects and governments. Frameworks developed elsewhere to link cumulative effects indicators and thresholds with specific impact management actions (Axys and Salmo 2003; Axys et al. 2003; Salmo et al. 2003; MSRM 2004) would be a useful starting point for the Beaufort Delta region. The need for specific impact management actions should be considered for each indicator and threshold so that expectations are clear to applicants, reviewers, and regulators.

Existing management procedures and actions must be incorporated in the thresholds framework. For example, the Inuvialuit Community Conservation Plans direct that when disturbances occur, areas of remaining habitat in that land use category (Category A, B, C, D) can be re-designated to a more protective category (Category B, C, D, E) in proportion to the amount of effective habitat lost as a result of disturbances. The land use category can be restored once the effects of disturbance have stopped and the land is restored to its original ecological productivity. This process acknowledges that remaining habitat becomes more valuable as disturbance increases, and should require greater public support to alter.

The regulatory and administrative setting (Section 2.6) must also be directly evaluated and addressed if threshold implementation is to be practical and efficient. Factors to be considered include: existing legal requirements; administrative processes and procedures; decision rules; and monitoring, enforcement, and reporting requirements.

Important components of cooperative management include monitoring and applied research to update land use information, confirm compliance with approval conditions, determine the effectiveness of impact management actions, and test and refine the relationships used to establish thresholds and limits. These will need to be further defined as part of the threshold implementation process.

Finally, the use of thresholds and limits also encourages use of innovative technology and provides an opportunity to adopt regulatory and fiscal incentives such as tradable land rights. These rights are linked to land use and provide economic incentives for reducing habitat loss (Adamowicz et al. 2003; Farr et al. 2004; McManus and Salmo 2004). These innovative approaches should be evaluated.

10 REFERENCES

Adamczewski, J.Z., R.F. Florkiewicz, and V. Loewen. 2003. Habitat Management in the Yukon Winter Range of the Little Rancheria Caribou Herd. Whitehorse, Yukon. TR-03-02. 32 p.

Adamowicz, W., S. Heckbert, J. Jabs, R. Naidoo, M. Weber, and Y. Zhang. 2003. Modeling spatial and temporal economic activity in forested landscapes. Edmonton, Alberta. Prepared for Sustainable Forest Management Network. 12 p.

AENV (Alberta Environment). 1999. Regional Sustainable Development Strategy for the Athabasca Oil Sands Area. Alberta Environment. Publication No. I/754. 78 p.

AENV (Alberta Environment). 2000. Alberta Ambient Air Quality Guidelines. Prepared by Alberta Environment, Edmonton, AB.

AENV (Alberta Environment). 2001. Regional Sustainable Development Strategy for the Athabasca Oil Sands Area, Progress Reprot July 2001.

AENV and CASA (Alberta Environment and the Clean Air Strategic Alliance). 1999. Application of critical, target, and monitoring loads for the evaluation and management of acid deposition. Prepared by Clean Air Strategic Alliance, Target Loading Subgroup. Publication No.: T/472. 67 p. Available online at: www.gov.ab.ca/env/protenf/standards.

AEUB (Alberta Energy and Utilities Board). 1999.Noise Control Directive – User Guide. Prepared by the Alberta Energy and Utilities Board, Edmonton, AB, Directive 038. Available online at: www.eub.ca/docs/documents/directives/Directive038.pdf.

Aklavik Inuvialuit Community Conservation Plan (Akaqvikmiut Nunamikini Nunutailivikautinich). 2000. Prepared by the Community of Aklavik, Wildlife Management Advisory Council (NWT), and the Joint Secretariat. 155 p.

Aklavik, RRC, Fort MacPherson RRC and Aklavik HRC. 2000. Rat River Char Fishing Plan. Fisheries and Oceans Canada, Inuvik, NT.

Alberta Boreal Caribou Committee (BCC). 2003. Quicknote: Developing a habitat planning target for range planning, August 22, 2003.

Allan, J.H. 1999b. Past and present status of fish populations in streams at the Luscar Mine and the Upper Coal Branch Area. Prepared for Cardinal River Coals Ltd., Hinton by Pisces Environmental Consulting Services Ltd., Red Deer. 10 p.

AMAP (Arctic Monitoring and Assessment Programme). 1998. AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme, Oslo, Norway.

Amstrup, S.C. 1993. Human disturbances of denning polar bears in Alaska. Arctic 46(3): 246-250.

Andelman, Sandy J. and William F. Fagan. 2000. Umbrellas and flagships: Efficient conservation surrogates or expensive mistakes? Proceedings of the National Academy of Sciences, USA. 97:5954-5959.

Anderson, L.E. 1995. Economic potential of the Mackenzie Delta broad whitefish exploratory fishery. Can. Manuscr. Rep. Fish. Aquat. Sci. 2319: iv + 17 p. Available online at: www.dfo-mpo.gc.ca/Library/192803.pdf>.

Anderson, P.G. 1998. Sediment generation from forestry operations and associated effects on aquatic ecosystems. Pages 491-508 in Brewin, M.K., and D.M.A. Monita editors, Forest-Fish Conference Proceedings: land management practices affecting aquatic ecosystems. Natural Resources Canada, Canadian Forest Service. Northern Forestry Centre, Edmonton, AB, Inf. Rep. NOR-X-356.

Anderson, P.G., B.R. Taylor, and G.C. Balch. 1996. Quantifying the effects of sediment release on fish and their habitats. Vancouver, British Columbia and Winnipeg, Manitoba. Fisheries and Oceans Canada, Eastern B.C. Habitat Unit and Alberta Area Habitat Management Division. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2346. 110 p. + app.

Anderson, R.B., S.J. Dyer, S.R. Francis, and E.M. Anderson. 2002. Development of a threshold approach for assessing industrial impacts on woodland caribou in Yukon. Draft ver. 2.1 ed. Whitehorse, YK. Prepared for Environment Directorate, Northern Affairs Program. 60 p.

Andrén, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos. 71:355-366.

Angermeier, P.L., A.P. Wheeler, and A.E. Rosenberger. 2004. A conceptual framework for assessing impacts of roads on aquatic biota. Fisheries 29(12):19-29.

Antoniuk, T. 2000. Review of the Cardinal River Coals Ltd. Cheviot Mine Cumulative Effects Assessment Aquatic VEC Analysis. Prepared by Salmo Consulting Inc., Calgary, Alberta, for Trout Unlimited Canada, Calgary, AB.

Arc Wildlife Services Ltd. In Prep. Selected Ecological Resources of Alberta's Castle Carbondale: A Synopsis of Current Knowledge. Compiled by Arc Wildlife Services Ltd., Calgary, AB. Prepared for CPAWS Calgary and Shell Canada, Calgary, AB.

Aurora Research Institute. 2002. Field Guide to the Birds of the Mackenzie Delta. Aurora Research Institute, Inuvik NT.

Auster, P.J. 2001. Defining thresholds for precautionary habitat management actions in a fisheries context. North American Journal of Fisheries Management. 21:1-9.

Axys Environmental Consulting. 1994. Beaufort Region Environmental Assessment and Monitoring Program, draft report for 1993/1994 : annotated guide to the final reports of BEMP, MEMP and BREAM. Prepared for Indian and Northern Affairs Canada and Fisheries and Oceans Canada.

Axys Environmental Consulting Ltd. 2000. Regional Approaches to Managing Cumulative Effects in Canada's North. Calgary, Alberta. Department of the Environment, Government of Canada. 72 p. + app.

Axys Environmental Consulting Ltd. 2001a. Thresholds for addressing cumulative effects on terrestrial and avian wildlife in the Yukon. Calgary, AB. Department of Indian and Northern Affairs, Environmental Directorate and Environment Canada, Whitehorse, Yukon. 92 p. + app.

Axys Environmental Consulting Ltd. 2001b. Wildlife CEA Thresholds: Phase II Workshop Summary. Calgary, AB. DIAND, Environmental Directorate, Whitehorse, Yukon. 14 p. + app.

Axys Environmental Consulting Ltd. 2002. Options for implementation of a Yukon wildlife thresholds pilot program: a scoping level review. Prepared for Environment Directorate, Northern Affairs Program, DIAND. 22 p. + app.

Axys Environmental Consulting , LGL Limited, Environmental and Social Systems Analysts Ltd., North/South Consultants Inc., Coastal and Ocean Resources Ltd., Delta Environmental Management Group Ltd., and S.L. Ross Environmental Research Ltd. 1993. Beaufort Region Environmental Assessment and Monitoring Program (BREAM) : final report for 1992/1993. Prepared for Dept. of Indian Affairs and Northern Development .

Axys Environmental Consulting Ltd., Salmo Consulting Inc., Diversified Environmental Services, Paragon Environmental Consultants, Limnotek Research and Development, RWDI West Inc., and There's More to Forests Policy Advisory and Ecological Services. 2003. A cumulative effects assessment and management framework (CEAMF) for Northeast British Columbia. Prepared for the BC Oil and Gas Commission and the Muskwa-Kechika Advisory Board. Vol. 1.

Axys Environmental Consulting Ltd. and Salmo Consulting Inc. 2003. Approaching cumulative impact management in northeast British Columbia: Summary Report. Prepared for the BC Oil and Gas Commission and the Muskwa-Kechika Advisory Board. 23 p.

Axys Environmental Consulting Ltd., LGL Limited, Environmental Research Associates, Delta Environmental Management Group Ltd., North/South Consultants Inc., Environmental and Social Systems Analysts Ltd., S.L. Ross Environmental Research Ltd., and Lutra Associates Ltd. 1992.

Beaufort Region Environmental Assessment and Monitoring Program (BREAM): final report for 1991/1992. Prepared for Indian and Northern Affairs Canada. Ottawa, ON. 359 p.

Barnaby, J. and A. Emery. 2002. Discussion paper: Issues and challenges to meet in acquiring and using aboriginal traditional knowledge in CEAM. Cumulative Effects Assessment and Management, Indian and Northern Affairs, Yelowknife.

Barnaby, J. 2003. Drawing on Aboriginal Wisdom. Prepared for the Nuclear Waste Management Organization. Available online at: http://www.nwmo.ca/adx/asp/adxGetMedia.asp?DocID=222,206,199,20,1,Documents&MediaID=790&Filename=17_NWMO_background_paper.pdf

Baxter, C.V., C.A. Frissell, and F.R. Hauer. 1999. Geomorphology, logging roads, and the distribution of bull trout spawning in a forested river basin: Implications for conservation and management. Transactions of the American Fisheries Society 128:854-867.

Bayne, E.M., S. Boutin, and R. Moses. 2004. Are boreal forest mammals good indicators of cumulative effects? Edmonton, AB. Sustainable Forest Management Network. 43 pages. ((Project Reports 2003/2004)).

BCC (Boreal Caribou Committee). Developing a habitat planning target for range planning. 2003.

BCF (British Columbia Forest Service) and BCE (British Columbia Environment). 1995a. Riparian Management Area Guidebook. British Columbia. BC Environment. (BC Forest Practices Code of British Columbia).

BCF (British Columbia Ministry of Forests) and MELP (British Columbia Ministry of Environment, Lands and Parks). 1999a. Landscape Unit Planning Guide. Victoria, B.C. British Columbia Ministry of Environment, Lands and Parks. 101 pages. (Forest Practices Code of British Columbia).

Beanlands, G.E. and P.N. Duinker. 1983. An ecological framework for environmental impact assessment in Canada. Halifax, NS. Institute for Resource and Environmental Studies, Dalhousie University and Federal Environmental Assessment Review Office. 132 pages.

Beaudry, P.G. 1998. Suspended sediment regimes of three experimental watersheds in the Takla area of north-central British Columbia. Pages 231-240 in Brewin, M.K., and D.M.A. Monita editors, Forest-Fish Conference Proceedings: land management practices affecting aquatic ecosystems. Natural Resources Canada, Canadian Forest Service. Northern Forestry Centre, Edmonton, AB, Inf. Rep. NOR-X-356.

Beaufort-Delta Self-Government. N.d. Strength through partnership: Gwich'in. Available online at: www.beaudelselfgov.org

Beckley, T.M. 2000. Sustainability for Whom? Social Indicators for Forest-dependant Communities in Canada. Edmonton, AB. University of Alberta. 2000-34. 34 p.

Beckley, T.M. and T. Burkosky. 1999. Social Indicator Approaches to Assessing and Monitoring Forest Community Sustainability. Edmonton, AB 29 p.

Bélanger, L. and J. Bédard. 1989. Responses of staging greater snow geese to human disturbance. Journal of Wildlife Management. 53(3):713-719.

Bergerud, A.T., R.D. Jakimchuk, and D.R. Carruthers. 1984. The buffalo of the North: caribou (Rangifer tarandus) and human developments. Arctic. 37(1):7-22.

Berry, D.K. 1998. Alberta's Acrtic grayling management and recovery plan. Prepared by Fisheries Management Division, Natural Resources Service, Alberta Environmental Protection, Edmonton, AB. Publication T/140.

Blis, A.S., and J.W. Lentifer. 1992. Noise and vibration levels in artificial polar bear dens as related to selected petroleum exploration and developmental activities. Arctic. 45(1): 20-24.

BMMDA. No date. Beaufort-Mackenzie Mineral Development Area website. Available online at: www.bmmda.nt.ca/mackenzie_delta.htm.

Boeree, C.G. 2003. The language families of the world. Shippensburg, PA. Available online at: http://www.ship.edu/%7Ecgboeree/languagefamilies.html

Boreal Ecology Service Ltd. 1986. Normal Wells Research and Monitoring Program – Third annual summary report. Prepared for Environmental Protection Service, Conservation and Protection, Prepared for the Department of the Environment, Yellowknife, NWT, by Boreal Ecology Service Ltd.

Born, E. W., F. F. Riget, R. Dietz, and D. Andriashek. 1999. Escape responses of hauled out ringed seals *Phoca hispida* to aircraft disturbance. Polar Biology 21:171-178.

Boutin, S. and E. M. Bayne. 2004. Development of dose-response curves for wildlife in Alberta: Cumulative effects at different scales. Presentation at The Wildlife Society 11th Annual Conference, September 18-22, 2004, Calgary, Alberta.

Branigan, M., J.L. Nagy, W. Wright, and T. Devine. 2003. Summary of harvest data for species under quota in the Inuvialuit Settlement Region, June 1998 to June 2003. Government of the Northwest Territories, Department of Resources, Wildlife and Econominc Development, Inuvik Region.

Brown, C.M. 1999. Evaluating the effects of pipeline watercourse crossings on fish habitat in streams and recommendations to prevent or mitigate effects. Calgary, AB: University of Calgary.; c1999. 127 p.

Buchanan, D.V., and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull and other coldwater species in Oregon. Pages 119-126 in MacKay, W.C., M.K. Brewin and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force (AB), c/o Trout Unlimited Canada, Calgary, AB.

Bull, K.R. 1991. The critical loads/levels approach to gaseous pollutant emission control. Environmental Pollution. 69:105-123.

Bull, K.R. 1992. An introduction to critical loads. Environmental Pollution. 77:173-176.

Cairns, Jr., John, P.V. McCormick, and B.R. Niederlehner. 1993. A proposed framework for developing indicators of ecosystem health. Hydrobiologia. 263:1-44.

Carignan, R., P. D'Arcy, and S. Lamontagne. 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield lakes. Edmonton, AB. Sustainable Forest Management Network. Final Project Report 2000-32. 24 p.

Carignan, V. and M.A. Villard. 2002. Selecting indicator species to monitor ecological integrity: A review. Environmental Monitoring and Assessment 78(1): 45-61.

Caro, T.M. and G. O'Doherty. 1999. On the use of surrogate species in conservation biology. Conservation Biology. 13(4):805-814.

Carver, M. 2001. Using indicators to assess hydrologic risk. In: Toews, D.A.A. and S. Chatwin, eds. Watershed Assessment in the Southern Interior of British Columbia: Workshop Proceedings; Penticton, B.C. Victoria, B.C.: British Columbia Ministry of Forests 26-43.

Canadian Council of Forest Ministers. 1995. Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators .available at http://www.ccfm.org/ci/defining1997_e.html.

CCFM (Canadian Council of Forest Ministers). 1997. Criteria and indicators of sustainable forest management in Canada, Tech. Report. Available online at: www.ccfm.org/ci/pdf/tech/ci_e.pdf

CCFM (Canadian Council of Forest Ministers). 2003. Defining sustainable forest management in Canada, Criteria and indicators 2003. Available online at: www.ccfm.org/2000pdf/CI_Booklet_e.pdf.

CCME (Canadian Council of Environment Ministers). 2004. Canadian Environmental Quality Guidelines. Available online at: www.ccme.ca/publications/can_guidelines.html

CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines.

CEQ (Council on Environmental Quality). 1993. Incorporating Biodiversity Considerations into Environmental Impact Analysis under the National Environmental Policy Act. Washington, DC 29 p.

Clark, R.N. and G.H. Stankey. 1979. The Recreation Opportunity Spectrum: A Framework for Planning, Management, and Research. U.S. Department of Agriculture. 32 p.

Clarke, K.D., D.A. Scruton and J.H. McCarthy. 1998. The effect of logging and road construction on fine sediment accumulation in streams in the Copper Lake watereshed, NFLD. Pages 353-360 in Brewin, M.K., and D.M.A. Monita editors, Forest-Fish Conference Proceedings: land management practices affecting aquatic ecosystems. Natural Resources Canada, Canadian Forest Service. Northern Forestry Centre, Edmonton, AB, Inf. Rep. NOR-X-356.

Cocklin, C., S. Parker, and J. Hay. 1992a. Notes on cumulative environmental change I: concepts and issues. Journal of Environmental Management. 35:31-49.

Cocklin, C., S. Parker, and J. Hay. 1992b. Notes on cumulative environmental change II: a contribution to methodology. Journal of Environmental Management. 35:51-67.

Cole, D.N. and G.H. Stankey. 1998. Historical development of Limits of Acceptable Change: conceptual clarifications and possible extensions. In: McCool, S.F. and D.N. Cole, comps. Limits of Acceptable Change and related planning processes: progress and future directions; Missoula MT. Ogden, UT: Department of Agriculture, Forest Service, Rocky Mountain Research Station 5-9.

Collinge, S.K. 1996. Ecological consequences of habitat fragmentation: implications for landscape architecture and planning. Landscape and Urban Planning. 36:59-77.

Collins, B.D. and G.R. Pess. 1997. Critique of Washington's watershed analysis program. Journal of the American Water Resources Association. 33(5):9997-1010.

Connon, D. and K. Hanna. 2002. Kendall Island Bird Sanctuary (KIBS) oil and gas development concepts and land use estimates. Prepared by Chevron Canada Resources.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. Canadian Species at Risk. Ottawa, ON. 44 pages. Available on-line at: http://www.cosewic.gc.ca

Cott, P.A. and J.P. Moore. 2003. Working Near Water, Considerations for Fish and Fish Habitat. Reference and Workshop Manual. Northwest Territories, Department of Fisheries and Oceans - Western Arctic Area. Inuvik, Northwest Territories. 92 p. + app.

CSA (Canadian Standards Association). 1996. A sustainable forest management system: guidance document. Etobicoke, ONCAN/CSA-Z808-96. 49 p.

Cumming, S. and P.R. Vernier. 2002. Statistical models of landscape pattern metrics, with applications to regional scale dynamic forest simulations. Landscape Ecology. 17:433-444.

Dames and Moore. 2000. Parameters for Florida Keys ecosystems/habitats and species of concern. Prepared for the US Army Corps of Engineers and Florida Department of Community Affairs. Available online at: www.saj.usace.army.mil/projects/paramspecies.htm.

Davis, R.A. and A.N. Wiseley. Chapter II Normal behaviour of snow geese on the Yukon-Alaska north slope and the effects of aircraft-induced disturbance on this behaviour, September 1973. In: Gunn, W.W.H., W.J. Richardson, R.E. Schweinsburg, and T.D. Wright, eds. 1974. Studies on snow geese and waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1973. Canadian Arctic Gas Study Limited and Alaskan Arctic Gas Study Company. (Arctic Gas Biological Report Series; Volume 27).

Day, C. 1998. Mackenzie River inconnu. DFO Science Stock Status Report D5-04. 9 p. Available online at: www.dfo-mpo.gc.ca/csas/CSAS/status/1998/d5-04e.pdf

Devon. 2002. Beaufort Sea Exploration Drilling Program: Project Description. Devon Canada Corporation, Calgary. Available online at:

DFO. 1995. Fish Habitat Conservation and Protection: Guidelines for attaining 'No Net Loss'., Fisheries and Oceans Canada, Ottawa.

DIAND (Department of Indian Affairs and Northern Development). 2002. A preliminary state of knowledge of valued components for the NWT Cumulative Impact Monitoring Program (NWT CIMP) and Audit - Final Draft. Prepared for NWT CIMP and Audit Working Group. 94 p. Available online at: ww.nwtcimp.ca/documents/cimp%20vc%20report%20sept23.pdf.

DIAND (Department of Indian and Northern Affairs and Northern Development). 2003. A preliminary state of knowledge of valued components for the NWT Cumulative Impact Monitoring Program (NWT CIMP) and audit. Edited September 24, 2003. Prepared for the NWT CIMP and Audit Working Group. Available online at: www.nwtcimp.ca/documents/cimp%20vc%20report%20sept23.pdf.

DIAND/ IRC/ GNWT (Department of Indian Affairs and Northern Development, Inuvialuit Regional Corporation and Government of the Northwest Territories). 2000. Inuvialuit Final Agreement Economic Measures: Evaluation. Technical report #1, Existing Statistical Data. 42 p.

DIAND and EC (Department of Indian Affairs and Northern Development and Environment Canada). 2001. NWT Cumulative Effects Assessment and Management Framework: Current context, 'Lessons

learned', Gaps and Challenges; Discussion Paper: Tasks 2 and 3, October 2001. Available online at: http://www.ceamf.ca/ceam_documents/NWT_CEAM_Context_Oct_2001_Rpt_incl_App_ABC.pdf

Diavik (Diavik Diamond Mines Inc.). 2003. Socio-economic monitoring report to December 31, 2003. Available online at: www.diavik.ca/PDF/2003%20SEMA%20Report.pdf

Dickins, D., L. Martin, I. Bjerkelund, S. Potter, D. Erickson, J. Harper, P. Norton, and P. Vonk, 1987. Environmental Atlas for Beaufort Sea Oil Spill Response. Prepared for Environment Canada, by Dickins (D.F.) Associates Ltd.

Dillon and Salmo. 2004a. Beaufort Delta Cumulative Effects Assessment Project: Information Package for Workshop Participants. Prepared for the Environmental Studies Research Funds, Calgary, AB. Prepared by Dillon Consulting Limited, Calgary, AB and Salmo Consulting Inc., Calgary, AB. 17 p. + cover letter and agenda.

Dillon and Salmo. 2004b. Beaufort Delta Cumulative Effects Threshold Workshop: Post-Workshop Distribution Package: Workshop Results and Meeting Minutes. Prepared for the Environmental Studies Research Funds, Calgary, AB. Prepared by Dillon Consulting Limited, Calgary, AB and Salmo Consulting Inc., Calgary, AB.

Dome Petroleum Limited, Esso Resources Canada Limted, and Gulf Canada Resources Inc. 1982. Beaufort Sea-Mackenzie Delta Environmental Impact Statement. Calgary, AB. Prepared on behalf of all land-holders in the Beaufort Sea-Mackenzie Delta region. Volume 3A - Beaufort-Delta Setting.

Dooley, J.L. and M.A. Bowers. 1998. Demographic responses to habitat fragmentation: experimental tests at the landscape and patch scale. Ecology. 79(3):969-980.

Dunham, J.B. and B.E. Rieman. 1999. Metapopulation structure of bull trout: influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications, 9(2), 1999. pp 642-655.

Dzus, E. 2001. Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta. Edmonton, AB. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association. Wildlife Status Report No. 30. 47 p.

Eaglin, G.S. and W.A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. 199313, (4): 844-846.

Eastern Slopes Grizzly Bear Project (ESGBP). 1998. Grizzly bear population and habitat status in Kananaskis Country, Alberta: A report to the Department of Environmental Protection, Natural Resource Service, Alberta. Eastern Slopes Grizzly Bear Project, University of Calgary. Calgary, Alberta.

Ecological Stratification Working Group. 1996. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada and Environment Canada, Ottawa/Hull. 125p.

EC (Environment Canada). 2004. The Canadian Council of Ministers of the Environment (CCME). Available online at: www.ec.gc.ca/ceqg-rcqe/English/ccme/default.cfm

Edenius, L. and J. Elmberg. 1996. Landscape level effects of modern forestry on bird communities in North Swedish boreal forests. Landscape Ecology. 11(6):325-338.

EISC (Environmental Impact Screening Committee). 2004 Environmental Impact Screening Committee Operating Guidelines and Procedures. Inuvik, NWT.

ELI (Environmental Law Institute). 2003. Conservation thresholds for land use planners. Environmental Law Institute, Washington, D.D. Available online at: www.elistore.org/reports_detail.asp?ID=10839&topic=Land_Use.

Emers, M., J.C. Jorgenson, and M.K. Raynolds. 1995. Response of arctic tundra plant communities to winter vehicle disturbance. Canadian Journal of Botany. 73:905-917.

Environment Canada. 1981. Air Pollutions Regulations and Protocols Report EPS-1 AP-81-1. Air Pollution Control Division. Ottawa..

Environment Canada. 2004. Canadian Climate Normals 1971-2000. Available online at : www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html.

ESL Environmental Sciences Limited. 1992. Beaufort Region Environmental Assessment and Monitoring Program (BREAM): final report for 1990/1991. Prepared for Indian and Northern Affairs Canada. Ottawa, ON. 416 p.

ESL Environmental Sciences Limited, LGL Limited, Environmental Research Associates, Environmental and Social Systems Analysts Ltd., Arctic Laboratories Limited, and Arctic Sciences Limited. 1985. Beaufort Environmental Monitoring Project 1984-1985 final report . Prepared for the Dept. of Indian Affairs and Northern Development, Ottawa, Canada. 162 p.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management. 61(3):603-610.

Fahrig, L. 2001. How much habitat is enough? Biological Conservation 100: 65-74.

Fahrig, L. 2002. Effect of habitat fragmentation on the extinction threshold: a synthesis. Ecological Applications 12: 346-353.

Falk, M.R. and D.V. Gillman. 1974. Impact of a sport fishery on Arctic grayling in the Brabant Island area, Northwest Territories. Department of the Environment Fisheries and Marine Service. Technical Report Series No. CEN/T-74-7. 21 p.

Fancy, S. G., K. R. Whitten, and D. E. Russell. 1994. Demography of the Porcupine caribou herd, 1983-1992. Canadian Journal of Zoology 72:840-846.

Farr, D., S. Kennett, M. Ross, B. Stelfox, and M.Weber. 2004. Al-Pac Case Study Report - Part 3: Fiscal Barriers and Options. Prepared for the National Round Table on the Environment and the Economy by Biota Research, Canadian Institute of Resources Law, Forem Technologies, and Alberta Research Council. Available online at: http://www.nrtee-trnee.ca/eng/programs/Current_Programs/Nature/Case-Studies/200407-AlPac-Case-Study/200407-AlPac-CS_Complete_E.pdf

Federal Environmental Assessment Review Office, T. 1994. A reference guide for the *Canadian Environmental Assessment Act* Addressing Cumulative Environmental Effects. Canadian Environmental Assessment Agency. 133-156 p.

Felix, N.A. and M.K. Raynolds. 1989a. The effects of winter seismic trails on tundra vegetation in northeastern Alaska, U.S.A. Arctic and Alpine Research. 21(2):188-202.

Felix, N.A. and M.K. Raynolds. 1989b. The role of snow cover in limiting surface disturbance caused by winter seismic exploration. Arctic. 42(1):62-68.

Felix, N.A., M.K. Raynolds, J.C. Jorgenson, and K.E. DuBois. 1992. Resistance and resilience of tundra plant communities to disturbance by winter seismic vehicles. Arctic and Alpine Research. 24(1):69-77.

Findlay, C.S. and J. Houlahan. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. Conservation Biology 11(4):1000-1009.

Fitch, L. 1997. Bull trout in southwestern Alberta: Notes on historical and current distribution. Page 147-160 in MacKay, W.C., M.K. Brewin and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force (AB), c/o Trout Unlimited Canada, Calgary, AB.

FJMC (Fisheries Joint Management Committee). 2001. Beaufort Sea Beluga Management Plan. Prepared by the Fisheries Joint Management Committee. Inuvik, NWT. Available online at: www.fjmc.ca/publications/Beluga%20Management%20Plan%20(%202001)as%20printed%20with%20covers.pdf

FJMC (Fisheries Joint Management Committee), Gwich'in Renewable Resource Board, Sahtu Renewable Resource Board, and Department of Fisheries and Ocean. 2000. Integrated Fisheries Management

Plan for Coney (Stenodus leuchicthys) in the Gwich'in Settlement Area, Inuvialuit Settlement Region, and the Sahtu Settlement Area, Northwest Territories, 2000-2005 (with Work Plans for 2000-2005). Prepared by the Fisheries Joint Management Committee. Available online at: www.fjmc.ca/publications/Inconnu-final.PDF

Flather, C.H. and J.R. Sauer. 1996. Using landscape ecology to test hypotheses about large-scale abundance patterns in migratory birds. Ecology 77(1):28-35.

Flather, C.H., S.J. Brady, and D.B. Inkley. 1992. Regional habitat appraisals of wildlife communities: a landscape-level evaluation of a resource planning model using avian distribution data. Landscape Ecology. 7(2):137-147.

FMF (Foothills Model Forest). 2003. Local level indicators of sustainable forest management for the Foothills Model Forest - initial status report. 54 p.

Forman, R.T.T. and S.K. Collinge. 1997. Nature conserved in changing landscapes with and without spatial planning. Landscape and Urban Planning. 37:129-135.

Forman, R. T. T. and M. Godron. 1986. Landscape Ecology. John Wiley, New York. 619 p.

Francis, R.I.C.C. and R. Shotton. 1997. 'Risk' in fisheries management: a review. Canadian Journal of Fisheries and Aquatic Sciences. 54(8):1699-1715.

Franklin, J.F. and R.T.T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology. 1(1):5-18.

Freeman, M.M.R. 2001. Small-scale whaling in North America. Understanding the cultures of fishing communities: a key to fisheries management and food security. J.R. McGoodwin Rome: Food and Agriculture Organization of the United Nations.

Freese, C. 2000. The consumptive use of wild species in the Arctic: challenges and opportunities for ecological sustainability. World Wildlife Fund Canada and World Wildlife Fund International Arctic Program, Canada.

Frissell, C.A. and D. Bayles. 1996. Ecosystem management and the conservation of aquatic biodiversity and ecological integrity. Water Resources Bulletin. 32(2):229-240.

Frost, K.J., and L.E. Lowry. 1988. Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. *In* National Research Council of the National Academies. 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington, D.C. The National Academies Press. 288 p.

Frost, K.J., L.F. Lowry, J.R. Gilbert, and J.J. Burns. 1988. Ringed Seal Monitoring: Relationships of Distribution and Abundance to Habitat Attributes and Industrial Activities. *In* National Research Council of the National Academies. 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington, D.C. The National Academies Press. 288 p.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. Pages 297-323 in Meehan, W.R., ed. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. Bethesda, Maryland: American Fisheries Society.

Gartner Lee Limited, Highwood Environmental Ltd., Burn, Dr. C., Barnaby, J., AEM Ltd., BGC Engineering, and RWDI. 2003. Identification of the Biophysical Information and Research Gaps Associated with Hydrocarbon Exploration, Development and Transmission in the Mackenzie Valley: Background Paper Report. Prepared for DIAND, GNWT, and ESRF.

Geomatics International Inc. 1999. Selecting core variables for tracking ecosystem change at EMAN sites. Burlington, ON. Prepared for Environment Canada Ecological Monitoring and Assessment Network. 28 p. + app.

Geo-North Ltd. and Axys Environmental Consulting Ltd. 1997. Identifying research priorities to refine the West Kitikmeot Slave Study Research Framework: Final Report. 40 p. + app.

GeoNorth Limited. 2002. Draft Final Report: Updating the Mackenzie Valley Cumulative Impact Monitoring Inventory and Tariuq Oceans Monitoring Inventory. Submitted to Environment and Conservation Division, Indian & Northern Affairs Canada NWT Region. 9 p.

Gibeau, M.L. 2000. A conservation biology approach to management of grizzly bears in Banff National Park. [Web Page]. Accessed 2000. Available at: http://www.canadianrockies.net/Grizzly/pubs_and-papers.htm.

Gibeau, M.L., S. Herrero, J.L. Kansas, and B. Benn. 1996. Grizzly bear population and habitat status in Banff National Park. Calgary, AB. A report tot he Banff Bow Valley Task Force. 62 pages.

GLUPB (Gwich'in Land Use Planning Board). 2003. Nanh' Geenjit Gwitr'it T'igwaa'in Working for the Land: Gwich'in Land Use Plan. Prepared by the Gwich'in Land Use Planning Board, Inuvik.

GLUPB (Gwich'in Land Use Planning Board). 2004. Implementing the Gwich'in Land Use Plan: A five year work plan (2003-2008), October 2004 revision. Prepared by the Gwich'in Land Use Planning Board, Inuvik.

GNWT (Government of the Northwest Territories). 2000. 1999 Annual report on community health and well being, BHP NWT Point of Hire Communities: Lutsel K'e, Rae-Edzo, Rae Lakes, Wha Ti, Wekweti,

Detah, N'dilo, Yellowknife. Prepared by the GNWT Departments of Health and Social Services, Resources, Wildlife and Economic Development, and NWT Bureau of Statistics.

GNWT (Government of the Northwest Territories). 2004. Progress Report May 2004. Doing Our Part: the GNWT's Response to the Social Agenda. GNWT, Yellowknife.

GNWT Bureau of Statistics. 1994. 1994 Labour force survey, Overall results and community detail. Report No. 1. Available online at: www.stats.gov.nt.ca/Statinfo/Labour/labourforce/lfs94.pdf

GNWT Bureau of Statistics. 2004. NWT Socio-Economic Scan. Available online at: www.stats.gov.nt.ca/Statinfo/Generalstats/Scan/2004%20SCAN.pdf.

GNWT Bureau of Statistics. 2004a. NWT Economic multipliers, Overview and Results. Available online at: www.stats.gov.nt.ca/Statinfo/Economic/Multiplier/Multiplier%20Report_2004.pdf

GNWT HSS (Government of the Northwest Territories Health and Social Services) Accessed 2002a. Deh Cho Region Community Programs and Services. 23 p. Available online at: http://www.hlthss.gov.nt.ca/Features/Initiatives/reports_pdf/social_agenda/dehcho.pdf

GNWT HSS (Government of the Northwest Territories Health and Social Services) Accessed 2002b. South Slave Region Community Programs and Services. 27 p. Available online at: http://www.hlthss.gov.nt.ca/Features/Initiatives/reports_pdf/social_agenda/southslave.pdf

Graburn, N.H.H. 1969. Eskimos without igloos: social and economic development in Sugluk. Little, Brown and Co. Boston, Mass.

Greenland, B.J. and J. Walker-Larsen. 2001. Community Concerns and Knowledge about Broad Whitefish (Coregonus nasus) in the GSA. Gwich'in Renewable Resource Board Report 01-08, Gwich'in Renewable Resource Board, Inuvik, NT.

GRI (Global Reporting Initiative). 2002. Sustainability Reporting Guidelines. 94 p. Available online at http://www.globalreporting.org/guidelines/2002/GRI_guidelines_print.pdf.

Griffith, J.A. 1998. Connecting ecological monitoring and ecological indicators: a review of the literature. Journal of Environmental Systems. 26(4):325-363.

GSCI (Gwich'in Social and Cultural Institute). nd. Language web page. Available online at: www.gwichin.ca/Language/language.html

Gu, W., R. Heikkilä, and I. Hanski. 2002. Estimating the consequences of habitat fragmentation on extinction risk in dynamic landscapes. Landscape Ecology. 17:699-710.

Gunn, A., M. Svoboda, and J. Dragon. 1998. Effect of gravel road- and tailing pond dust on tundra plant communities near Lupin Mine, NWT. Submitted to West Kitikmeot Slave Study Society. 59 p.

Gunn, A., J. Antoine, J. Boulanger, J. Bartlett, B. Croft, and A. D'Hont. 2002. Boreal caribou habitat and land use planning in the Deh Cho, Northwest Territories. Yelllowknife, NWT 47 pages.

Haas, G. 2001. An at risk assessment of Dolly Varden through a field study comparison of habitat and maximum temperature preferences with bull trout. Pages 23-25 in Brewin, M.K., A.J. Paul and M. Monita. 2001. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB.

Haas, G. 2001. The mediated associations and preferences of native bull trout and rainbow trout with respect to maximum water temperature, its measurement standards and habitat. Pages 53-56 in Brewin, M.K., A.J. Paul and M. Monita. 2001. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB.

Hamilton, D. and S. Wilson. 2001. Access management in British Columbia: a provincial overview. Victoria, B.C. Prepared for Ministry of Environment, Lands and Parks, Habitat Protection Branch. 29 p.

Hannon, S.J. 2000. Avian response to stand and landscape structure in the boreal mixedwood forest in Alberta. Edmonton, AB. Sustainable Forest Management Network. Project Report 1999-37. 26 p.

Hanski, I., A. Moilanen, and M. Gyllenberg. 1996. Minimum viable metapopulation size. The American Naturalist. 147(4):527-541.

Hanski, I. and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society. 42:3-16.

Harper, D.J. and J.T. Quigley. 2000. No net loss of fish habitat: An audit of forest road crossings of fish-bearing streams in British Columbia, 1996-1999. Vancouver, BC. Fisheries and Oceans Canada. Canadian Technical Report of Fisheries and Aquatic Sciences #2319.

Hart, E. 2001. Reindeer days remembered. Inuvik: Inuvialuit Cultural Resource Centre, Inuvik, NWT.

Hart, E and Amos, B. 2004. Learning about Marine Resources and their use through Inuvialuit Oral History. Inuvialuit Cultural Resource Centre , Inuvik, NWT.

Harwood, L. 1999 Hornaday River Arctic charr. Stock Status Report D5-68. Departmetn of Fisheries and Oceans, Central and Arctic Region. Available online: http://www.fjmc.ca/publications/Hornaday%20Arctic%20Char%20SSR%20(1999).pdf

Harwood, L.A., S. Innes, P. Norton and M.C.s. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie Estuary, south-east Beaufort Sea and west Amundsen Gulf during late July 1992. Canadain Journal of fisheries and Aquatic Sciences. 53:2262-2273.

Harwood, L.A., P. Norton., B. Day and P.Hall. 2000. The harvest of Beluga whales in Canada's western Arctic: Hunter-based monitoring of the size and composition of the catch. Fisheries and Oceans Canada Research Document 2000/141. Available online at: www.fjmc.ca/publications/Harvest%20of%20Beluga%20in%20Western%20Arctic%20(Harwood%202000).pdf

Harwood, L. 2001. Rat River Dolly Varden. DFO Science Stock Status Report D5-61, Central and Arctic Region, Fisheries and Oceans Canada. 15 p.

Harwood, L.A. and T.G. Smith. 2002. Whales of the Inuvialuit Settlement Region in Canada's western Arctic: an overview and outlook. Arctic. 55(Supp. 1):77-93.

Haskins, W. and D. Mayhood. 1997. Stream crossing density as a predictor of watershed impacts. Proceedings of the 17th Annual ESRI User Conference. San Diego, CA. Paper 457, 4 p. + erratum.

Hegmann, G.L., C. Cocklin, R. Creasey, S. Dupuis, A.J. Kennedy, L. Kingsley, W.A. Ross, H. Spaling, and D. Stalker. 1999. Cumulative Effects Assessment Practitioners Guide. Hull, Quebec. Prepared by AXYS Environmental Consulting Ltd. and the CEA Working Group for the Canadian Environmental Assessment Agency.

Henson, P. and T.A. Grant. 1991. The effects of human disturbance on trumpeter swan breeding behavior. Wildlife Society Bulletin. 19(3):248-257.

Hill, D., D. Hockin, D. Price, G. Tucker, R. Morris, and J.R. Treweek. 1997. Bird disturbance: Improving the quality and utility of disturbance research. Journal of Applied Ecology 34(2):275-288.

Hitt, N.P. and C.A. Frissel. 1999. Wilderness in a landscape context: an evaluation of wilderness and aquatic biological integrity in western Montana. Presented at the Wilderness Sciences Conference May 1999, Missoula, Montana.

Howland, K.L. 1997. Migration patterns of freshwater and anadromous inconnu, *Stenodus leucichthys*, within the Mackenzie River system. Unpubl. M.Sc. thesis. Univer. Alberta. 96 p.

Horejsi, B.L. 1996. Guidelines enabling land use managers to eliminate or reduce the impact of their decisions on bears and bear habitat in the Yukon Territory. 24 p.

Hughes, R.M., S. Howlin, and P.R. Kaufmann. 2004. A biointegrity index (IBI) for coldwater streams of western Oregon and Washington. Transactions of the American Fisheries Society. 133:1497-1515.

Hydroconsult EN3 Services Ltd. 1999. Cheviot Coal Mine Project Cumulative Effect Assessment Surface Water Quality and Sediment. Prepared for Cardinal River Coals Ltd., Hinton by Hydroconsult EN3 Services Ltd., Calgary. Part D in Cardinal River

Coals Ltd. 1999d. Cheviot Mine Cumulative Effects Assessment, November 1999.

ICRC (Inuvialuit Cultural Resource Centre). nd. Language web page: www.irc.inuvialuit.com/inuvialuit/irc-website.nsf/AllDoc/5D64543373C822E387256DEE00796D0F?OpenDocument

IEMA (Independent Environmental Monitoring Agency). 2001. Annual Report 2000-2001. Available online at www.monitoringagency.net/Website/Agency%20Publications/Annual%20Report/Annual%20Report%202000-2001/IEMA_AR_00.pdf

IER Planning, Research and Management Services and Terriplan Consultants Ltd. 2002. NWT Cumulative Effects Assessment and Management Strategy and Framework: A Discussion Paper. Working Draft, January 15, 2002. Prepared for the Workshop to Review the Working Draft NWT CEAM Strategy and Framework. 26 p.

IGC (Inuvialuit Game Council), Mackenzie Valley Environmental Impact Review Board (MVEIRB), and C. Minister of Environment. 2004. Environmental impact statement: terms of reference. 65 p.

Inuvik Inuvialuit Community Conservation Plan. 2000. Prepared by the Community of Inuvik, Wildlife Management Advisory Council (NWT), and the Joint Secretariat. 150 p.

IORVL (Imperial Oil Resources Ventures Limited). 2004. Environmental Impact Statement, Volume 6: Socio-economic impact assessment. Submitted to the National Energy Board and Joint Review Panel. Available online at: www.ngps.nt.ca/Upload/Environmental%20Impact%20Statement/EIS.html

IRC (Inuvialuit Regional Corporation). 2004. Mackenzie gas project: preliminary assessment of potential social impacts on the Inuvialuit Settlement Region. (Inuvialuit Regional Corporation, Inuvik, NWT.

Jalkotzy, M.G., P.I. Ross, and M.D. Nasserden. 1998. The Effects of Linear Development on Wildlife: A Review of Selected Scientific Literature. Calgary, Alberta. Prepared for the Canadian Association of Petroleum Producers by Arc Wildlife Services Ltd. Publication #1998-0002. 117 p.

JNCC. 2004. Guidelines For Minimising Acoustic Disturbance To Marine Mammals From

Seismic Surveys. Joint Nature Conservation Committee. Available online at: www.jncc.gov.uk/pdf/Seismic_survey_guidelines_200404.pdf

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology. 61(1):65-71.

Johnson, C.J., M.S. Boyce, R. Mulders, A. Gunn, R.J. Gau, H.D. Cluff, and R.L. Case. 2004. Quantifying patch distribution at multiple spatial scales: applications to wildlife-habitat models. Landscape Ecology. 869-882.

JS (Joint Secretariat). 2003. Inuvialuit Harvest Study, Data and Methods Report 1988–1997, The Joint Secretariat, Inuvik, NT. Available online at: www.fjmc.ca/publications/IHS10yrData&MethodsReport.pdf

Kansas, J.L. 2002. Critical review of methods to evaluate grizzly bear cumulative effects. In: Kennedy, A.J., ed. Cumulative Environmental Effects Management: tools and approaches; Calgary, Alberta. Edmonton, AB: Alberta Society of Professional Biologists 247-265. 487 p.

Katopodis, C. 1992. Fish Screening Guide for Water Intakes. Freshwater Institute, Central and Arctic Region, Fisheries and Oceans Canada.

Kavik-Axys Inc. and LGL, 2001. Overview of key issues and data gaps related to development and transportation of gas from the western Canada Arctic and Alaska. Prepared for the Department of Indian and Northern Affairs, Yellowknife, NT, by Kavak-Axys Inc., in association with LGL Limited Environmental Research Associates. 131 p.

Kavik-Axys Inc. 2002a. Cumulative effects assessments in the Inuvialuit Settlement Region: a guide for reviewers. Inuvik, NWT. Prepared for the Environmental Impact Screening Committee and the Environmental Impact Review Board. KA019. 27 p + app.

Kavik-Axys Inc. 2002b. Cumulative effects assessments in the Inuvialuit Settlement Region: current and potential capability. Inuvik, NWT. Prepared for the Environmental Impact Screening Committee and the Environmental Impact Review Board. KA019. 41 p + app.

Kavik-Axys Inc. 2002c. Cumulative effects assessments in the Inuvialuit Settlement Region: a guide for proponents. Inuvik, NWT. Prepared for the Environmental Impact Screening Committee and the Environmental Impact Review Board. KA063. 39 p + app.

Kavik-Axys Inc., LGL Limited Environmental Research Associates, North/South Consultants Inc., Salmo Consulting Inc., McGill University, and The National Hydrology Research Institute. 2002. Knowledge gaps associated with exploration and development of natural gas in the Mackenzie Delta region. Calgary, AB, Prepared for the Environmental Studies Research Fund.

Kelly, J.R. and M.A. Harwell. 1990. Indicators of ecosystem recovery. Environmental Management. 14(5):527-545.

Kennett, S. 2000. Aboriginal Communities and Non-Renewable Resource Development. Prepared for the National Round Table on the Environment and the Economy. Available online at: http://www.nrtee-trnee.ca/Publications/HTML/SOD_Aboriginal_E.htm

Klock, G.O. 1985. Modeling the cumulative effects of forest practices on downstream aquatic ecosystems. Journal of Soil and Water Conservation. March-April:237-241.

Kritsch, I.D., and A.M. Andre. 1998. Gwich'in traditional knowledge and heritage studies in Gwich'in settlement area. At a crossroads: archaeology and First Peoples in Canada. G.P. Nicholas, and T.D. Andrews Burnaby: Archaeology Press, Simon Fraser University.

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology. 11(4):849-856.

Lamberson, R.H., R. McKelvey, B.R. Noon, and C. Voss. 1992. A dynamic analysis of northern spotted owl viability in a fragmented forest landscape. Conservation Biology. 6(4):505-512.

Lande, R. 1987. Extinction thresholds in demographic models of terrestrial populations. The American Naturalist. 130(4):624-635.

Legat, A. 2002. Experiencing Stories: Information, Knowledge and Skill. Presentation at the Ninth International Conference On Hunting And Gathering Societies, Edinburgh Conference Centre, Heriot-Watt University, Edinburgh, Scotland, September 9-13, 2002, Available online at: www.abdn.ac.uk/chags9/final.htm.

Legat, A., G. Chocolate, B. Gon, S. A. Zoe, and M. Chocolate. 2001. Caribou migration and the state of their habitat. Final report to West Kitikmeot Slave Study Society, Yellowknife

LGL Limited, ESL Environmental Sciences Limited, and ESSA Limited. 1984. Beaufort Environmental Monitoring Project: 1983-1984 Final Report. Prepared for Dept. of Indian Affairs and Northern Affairs.

LGL Limited, Environmental Research Associates, ESL Environmental Sciences Limited, and Environmental and Social Systems Analysts Ltd. 1985. Beaufort Environmental Monitoring Project, 1983-1984. Prepared for the Arctic Land Use Research Program. Ottawa, Ontario.

LGL (Limited Environmental Research Associates), ESL Environmental Sciences Limited, Environmental and Social Systems Analysts Ltd., and P.J. Usher Consulting Services. 1986. Mackenzie Environmental Monitoring Project 1985-1986 Final Report. Prepared for Dept. of Indian Affairs and Northern Development, Environment Canada, Dept. of Fisheries and Oceans, Northwest Territories, and Yukon Territory.

LGL Limited, Environmental and Social Systems Analysts Ltd., Lutra Associates Ltd., ESL Environmental Sciences Limited, Seakem Oceanography Ltd., P.J. Usher Consulting Services, Renewable Resources Consulting Services, M. Miles and Associates Limited, and A. Gell. 1988. Mackenzie Environmental Monitoring Project - Phase II, 1987 activities. Prepared for Dept. of Indian Affairs and Northern Development.

LGL and SAIC. 1998. Cumulative ecological significance of oil and gas structures in the Gulf of Mexico: Information search, synthesis and ecological modeling: l Phase I: Final report. U.S. Dept of Interior, U.S. Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region. OSC Study MMS 97-0036. Available online at: www.gomr.mms.gov/homepg/regulate/environ/studies/1997/97-0036.pdf

Liknes, G.A. and P.J. Graham. 1988. Westslope cutthroat trout in Montana: life history, status and management. American Fisheries Society Symposium 4: 53-60.

Lowrence, R. and G. Vellidis. 1995. A conceptual model for assessing ecological risk to water quality function of bottomland hardwood forests. Environmental Management. 19(2):239-258.

Lull, K.J., J.A. Tindall, and D.F. Potts. 1995. Assessing nonpoint-source pollution risk. Journal of Forestry. 35-40.

MacDonald, I. 1998a. Gwich'in Harvest Study Data Report. August 1995 – December 1996. Prepared by the Gwich'in Renewable Resources Board, Inuvik, NWT.

MacDonald, I. 1998b. Gwich'in Harvest Study Data Report. 1997. Prepared by the Gwich'in Renewable Resources Board, Inuvik, NWT.

Macdonald, J.S., J.C. Scrivenor, D.A. Patterson, and A. Dixon-Warren. 1998. Temperatures in aquatic habitats: the impacts of forest harvesting and the biological consequences to sockeye salmon incubation habitats in the interior of BC. Pages 313-324 in Brewin, M.K., and D.M.A. Monita editors, Forest-Fish Conference Proceedings: land management practices affecting aquatic ecosystems. Natural Resources Canada, Canadian Forest Service. Northern Forestry Centre, Edmonton, AB, Inf. Rep. NOR-X-356.

Mace, R.D., J.S. Waller, T.L. Manley, L.J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. Journal of Applied Ecology. 33:1395-1404.

Mackay, J.R. 1963. The Mackenzie Delta area, NWT. Geological Survey of Canada, Ottawa. Misc. Report #23.

Mackay, Ross J. 1990. Pingos of the Western Arctic Coast. The Science Institute of the Northwest Territories, Inuvik, NT.

Macleod (Macleod Institute). 2002. Carrying capacity and thresholds: Theory and practice in environmental management. Prepared for Canadian Arctic Resources Committee, Ottawa and Yellowknife, by Macleod Institute, Calgary. Available online at: www.macleodinstitute.com/publications/pdf/report_final.pdf

Manly, B.F.J., L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 2002. Resource Selection by Animals. 2nd ed. The Netherlands: Kluwer Academic Publishers. 221 p.

Marlowe, E., D. Enzoe, B. Parlee, and S. Ellis. 2002. Final report to the West Kitikmeot Slave Study Society: Community-Based Monitoring . Available online at: www.wkss.nt.ca.

Marsh, Philip. 1998. Lakes and Water in the Mackenzie Delta. Aurora Research Institute Scientific Report No.6, Inuvik NT.

Marshall, T. 1996. Stream crossings on the Weldwood FMA, 1995 stream crossing inventory report. Prepared for Weldwood of Canada, Hinton Division.

Martell, A.M., Dickinson, D.M. and Casselman, L.M. 1984. Wildlife of the Mackenzie Delta Region. Boreal Institute for Northern Studies, University of Alberta, Occasional Publication No.15. Edmonton, AB.

Mayhood, D. W., M. D. Sawyer and W. Haskins. 1998. British Columbia's level 1 watershed assessment procedure as a tool for monitoring potential impacts of development on aquatic ecosystems in Canada's Rocky Mountains**.** Pages 677-686. *in* Munro, N. W. P., and J. H. M. Willison, editors. Linking protected areas with working landscapes conserving biodiversity. Science and Management of Protected Areas Association, Wolfville, NS. xvii + 1018 p. Available online at: www.hayduke.ca/science/iwap.html

Mayhood, D.W., M. D. Sawyer and W. Haskins. 2004. Historical risk analysis of watershed disturbance in the southern east slopes region of Alberta, Canada, 1910-1996. Pages 23-29 *in* G.J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins and M. Monita, editors. Proceedings of the Forest Land-Fish Conference – Ecosystem Stewardship through Collaboration. 26-28 April 2004, Edmonton, Alberta. x+212 p.

McCool, S.F. and D.N. Cole, *eds.* 1997. Proceedings - Limits of Acceptable Change and Related Planning Processes: Progress and Future Directions. Ogden, UT: United States Department of Agriculture Forest Service. INT-GTR-371.86 pages.

McGarigal, K. and B.J. Marks. 1995. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. PNW-GTR-351. 122 p.

McGarigal, K. and S. Cushman. 2002. Comparative evaluation of experimental approaches to the study of habitat fragmentation effects. Ecological Applications. 12:335-345.

McGurk, B.J. and D.R. Fong. 1995. Equivalent roaded area as a measure of cumulative effect of logging. Environmental Management. 19(4):609-621.

McJannet, C.L., Argus, G.W., and Cody, W.J. 1995. Rare Vascular Plants of the Northwest Territories. Canadian Museum of Nature, Ottawa, ON.

McLeary, R.J. 2004. Influences of Basin, Stream Reach and Land-Use Characteristics on the Distribution of Rainbow Trout, Bull Trout, Brook Trout and All Fish Species in Selected Foothills Model Forest Watersheds**,** Pages 41-42 in Scrimegour, G.J., G. Eisler, B. McCulloch, U. Silins and M. Monita, editors. Forest-Fish conference II Proceedings – Ecosystem stewardship through collaboration. April 26-28, 2004, Edmonton, AB.

McLellan, B.N. 1990. Relationships between human industrial activity and grizzly bears. In. 8th International Conference on Bear Research and Management; Victoria. 57-64.

McLoughlin, P.D. and Messier, F.. 2001. The Demography of Barren-Ground Grizzly Bears *(Ursus arctos)* in Nunavut and the Northwest Territories. Available online at: www.nwtwildlife.rwed.gov.nt.ca/NWTwildlife/bears/grizzlybear/DemographyReport.pdf.

McLoughlin, P.D., F. Messier, R.L. Case, R.J. Gau, R. Mulders, and H.D. Cluff. 1999. The spatial organization and habitat selection patterns of barren-ground grizzly bears (*Ursus arctos*) in the Northwest Territories and Nunavut: final report to the West Kitikmeot / Slave Study Society.

McLoughlin, P.D., E. Dzus, B. Wynes, and S. Boutin. 2003. Declines in populations of woodland caribou. Journal of Wildlife Management 67(4):755-761.

McManus and Salmo. 2004. Conserving Canada's Natural Capital: The Boreal Forest Muskwa-Kechika Case Study (Northeastern British Columbia and adjacent areas of Yukon and the Northwest Territories). Prepared for: The National Round Table on the Environment and the Economy, Ottawa, ON, by R. McManus Consulting Ltd. and Salmo Consulting Inc., Calgary, AB, Available online at: http://www.nrtee-trnee.ca/eng/programs/Current_Programs/Nature/Case-Studies/200407-Muskwa-Kechika-Case-Study/200407-Muskwa-Kechika-Case-Study_E.pdf

Merigliano, L.,D.N. Cole, and D.J. Parsons. 1997. Application of LAC-type processes and concepts to nonrecreation management issues in protected areas. *In*: McCool, S.F. and D.N. Cole, comps. 1997. Proceedings - Limits of acceptable change and related planning processes: progress and

future directions; 1997 May 20-22. Ogden, UT. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Gen. Tech. Rep. INT-GTE-371.

Miller, J.N., R.P. Brooks, and M.J. Croonquist. 1997. Effects of landscape patterns on biotic communities. Landscape Ecology. 12:137-153.

Minshall, G.W., C.T. Robinson, and D.E. Lawrence. 1997. Postfire responses of lotic ecosystems in Yellowstone National Park, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 54(11):2509-2525.

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. Conservation Biology. 9(2):279-294.

MMS. 2002**.** Economic Impact of Recreational Fishing and Diving Associated with Offshore Oil and Gas Structures in the Gulf of Mexico - OCS Study MMS 2002-010. MMS Technical Announcement. Mineral Management Service, U.S. Department of the Interior, Gulf of Mexico OCS Region. Available online at: www.gomr.mms.gov/homepg/whatsnew/techann/2002-010.html

MMS. 2003. Beaufort Sea Planning Area Oil And Gas Lease Sales 186, 195, and 202. Final Environmental Impact Statement (Volumes 1-4). U.S. Dept Of Interior, U.S. Geological Survey, Biological Resources Division, and Minerals Management Service, Alaska OCS Region. OCS EIS/EA, MMS 2003-001. Available online at: www.mms.gov/alaska/cproject/beafort sea.

Moore, S.E., K.E.W. Shelden, L.K. Litzky, B.A. Mahoney, and D.J Rugh. 2000. Beluga, Delphinapterus leucas, Habitat Associations in Cook Inlet, Alaska. Marine Fisheries Review 60-80. Available online at: http://spo.nwr.noaa.gov/mfr623/fr6237.pdf.

Monda, M.J., J.T. Ratti, and T.R. McCabe. 1994. Reproductive ecology of tundra swans on the Arctic National Wildlife Refuge, Alaska. Journal of Wildlife Management. 58(4):757-773.

Mönkkönen, M. and P. Reunanen. 1999. On critical thresholds in landscape connectivity: a management perspective. Oikos. 84(2):302-305.

MRBB (MacKenzie River Basin Board). 2004. The Mackenzie Great Bear sub-basin. Chapter 7. Pages 169-194 in State of the Aquatic Ecosystem Report 2003, MRBB Secretariat, Fort Smith, NWT.

MSRM (British Columbia Ministry of Sustainable Resource Management). 2004. Pre-tenure plans for oil and gas development in the Muskwa-Kechika Management Area. Consultation Draft.

Murphy, R.F. and J.H. Steward. 1956. Tappers and trappers: Parallel process in acculturation. Economic development and cultural change 4: 335-355.

Murdie, R.A., D. Rhyne, and J. Bates. 1992. Modelling Quality of Life Indicators in Canada: A Feasibility Analysis. Toronto, ON. Institute for Social Research York University. 68 pages.

Murphy, D.D. and B.A. Wilcox. 1984. Butterfly diversity in natural habitat fragments: a test o the validity of vertebrate-based management. *In:* Verner, J., M.L. Morrison, and C.J. Ralph, *eds*. Wildlife 2000. Modeling habitat relationships of terrestrial vertebrates; Stanford Sierra Camp, Fallen Leaf Lake, California. The University of Wisconsin Press 287-292.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2004. Draft 2: Traditional knowledge guidelines, November 2004. Prepared by the Mackenzie Valley Environmental Impact Review Board, Yellowknife. Available online at: www.mveirb.nt.ca/HTML/MVGuides/MVEIRB_TK_Guidelines_0411.pdf

MVEIRB (Mackenzie Valley Environmental Impact Review Board. 2004a. Report of Environmental Assessment and Reasons for Decision on the Paramount Resources Limited Cameron Hills Extension Project. Yellowknife, NWT. EA03-005. 84 p.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2004b. Environmental Impact Assessment Guidelines. Available online at www.mveirb.nt.ca/documents/guidelines/MVE_EIA%20Guidelines.pdf.

Nagy, J.A., M. Branigan, E. McLean, N. Larter, A. Veitch, and R. Popko. n.d. Co-management plan for the Cape Bathurst, Bluenose-West, and Bluenose-East caribou herds. Draft ed. Government of the Northwest Territories Department of Resources, Wildlife, and Economic Development. 41 p.

Nagy, John A. and Branigan, Marsha. 1998. Co-Management Plan for Grizzly Bears in the Inuvialuit Settlement Region, Yukon Territory and Northwest Territories. Department of Resources, Wildlife and Economic Development, Inuvik Region, Inuvik NT.

Nagy, J.A., D. Auriat, I. Ellsworth, W. Wright, and T. Slack. 2003. Ecology of boreal woodland caribou in the Lower Mackenzie Valley: work completed in the Inuvik region 1 April 2002 to 31 March 2003. Inuvik, NT. Co-funded by Northwest Territories Western Biophysical Project, Government of Canada Habitat Stewardship Program for Species at Risk, Gwich'in Renewable Resource Board, and Department of Resources, Wildlife, and Economic Development Inuvik region. 63 p.

NCGBRT (North Cascades Grizzly Bear Recovery Team). 2001. Recovery Plan for Grizzly Bears in the North Cascades of British Columbia. Consensus Recommendation Draft for Consultation.

Nellemann, C. and Cameron, R. D. 1998. Cumulative impacts of an evolving oilfield complex on the distribution of calving caribou. Canadian Journal of Zoology 76: 1425-1430.

Newcombe, C.P. and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management. 11:72-82.

Nichols, T, F. Berkes, D. Jolly, N.B. Snow and the Community of Sachs Harbour. 2004. Climate change and sea ice: Local observations from the Canadian Western Arctic. Arctic 57(1): 68-79.

NMFS. 2003. Subsistence harvest management of Cook Inlet beluga whales: final Environmental Impact Statement. Prepared by the Alaska Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, Alaska. Available online at: www.fakr.noaa.gov/protectedresources/whales/beluga/eis2003/final.pdf.

NMFS. 2002a. Bearded Seal (*Erignathus Barbatus*): Alaska Stock – Stock assessment report. 4 p. Prepared by the Alaska Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, Alaska. Available online at: www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/Pinnipeds/Bearded_Seal/AK02beardedseal_Alaska.PDF

NMFS. 2002b. Ringed Seal (*Phoca Hispida*): Alaska Stock. 4 p. Prepared by the Alaska Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, Alaska. Available online at: www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/Pinnipeds/Ringed_Seal/AK02ringedseal_Alaska.PDF.

North/South Consultants Inc. 2002. Ecological assessment of the Beaufort Sea beluga management plan zone 1(A) as a marine protected area of interest. Prepared by North/South Consultants Inc, Winnipeg, MN. Prepared for Department of Fisheries and Oceans. 71 p.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology. 4(4):355-364.

Noss, R.F., H.B. Quigley, M.G. Hornocker, T. Merrill, and P.C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology. 10(4):949-963.

NPS. 2003. Glacier Bay National Park and Preserve, Alaska: Vessel Quotas and Operating Requirements - Final Environmental Impact Statement. Prepared by the National Park Service, Alaska Region, United States Department of the Interior. Available online at: www.glba.ene.com/feis_2003.htm

NRC (National Research Council of the National Academies). 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington, D.C. The National Academies Press. 288 p.

NRTEE (National Round Table on the Environment and the Economy). 2003. Environment and Sustainable Development Indicators for Canada. Ottawa, ON. Renouf Publishing Co. Ltd. 92 p.

NWT Bureau of Statistics: 2004. 2004 NWT Socio-Economic Scan. Available online at: www.stats.gov.nt.ca.

NWT Bureau of Statistics: 2004. Statistics Quarterly. Available on line at: www.stats.gov.nt.ca

NWT Bureau of Statistics: 2004. Northwest Territories 2004, by the numbers. Available online at: www.stats.gov.nt.ca

NWT CIMP. 2004a. Final Summary Report: Community Consultation - Paulatuk. NWT Cumulative Impact Monitoring Program (CIMP) and Audit: An Environmental Monitoring Program for the NWT. Government of Canada,

NWT CIMP. 2004b. Final Summary Report: Community Consultation - Sachs Harbour. NWT Cumulative Impact Monitoring Program (CIMP) and Audit: An Environmental Monitoring Program for the NWT. Government of Canada,

Olsen, Jeffrey B.; William J. Spearman; George K. Sage; Steve J. Miller; Blair G. Flannery, and John K. Wenburg. 2004. Variation in the population structure of Yukon River chum and coho salmon: evaluating the potential impact of localized habitat degradation. Transactions of the American Fisheries Society. 133:476-483.

Olson+Olson Planning and Design Consultants, Watertight Solutions Ltd., Bandaloop Landscape-Ecosystem Services, K. Freemark, and D. Kirk. 2002. Landscape, Biodiversity and Watershed Indicator Review and Assessment. Prepared for CEMA Landscape & Biodiversity Subgroup. 246 p.

Paramount (Paramount Resources Ltd., Golder Associates, and AllNorth Consultants Limited). 2003. Developers Assessment Report for the Paramount Cameron Hills Extension. Submitted to the Mackenzie Valley Environmental Impact Review Board. Available online at: ftp://www.mveirb.nt.ca/Registry/EAParamountoil/DAR_Paramount_Oil/

Parkins, J. and T. Beckley. 2001. Monitoring Community Sustainability in the Foothills Model Forest: a Social Indicators Approach. Fredericton, NB. Canadian Forest Service. M-X-211E. 146 p.

Parks Canada. 1997. Banff National Park Management Plan. Minister of Public Works and Government Services Canada.

Parlee B and Lutsel K'e Dene First Nation. 1996. "Community-Based Monitoring Pilot Project" Yellowknife NT: West Kitikmeot Slave Study Society. http://www.wkss.nt.ca

Porcupine Caribou Management Board. n.d. Porcupine Caribou Herd Management Plan 2000/2001 to 2002/2003. Porcupine Caribou Management Board, Whitehorse, Yukon,

Petts, J., G. McGregor, S. Niemeyer, and K. Hobson. 2003. Predicting thresholds of social behavioural responses to rapid climate change. Available online at: www.psi.org.uk.

Popowich, R.P. and Volpe, J.P. 2004. Troubled waters: cumulative anthropogenic activity and a declining bull trout population in the Elbow River watershed. Pages 15-16 in G.J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins and M. Monita. Editors. Forest-Land–Fish Conference II – Ecosystem Stewardship through Collaboration. Proc. Forest-Land-Fish Conf. II, April 26-28, 2004, Edmonton, AB.

R. McManus Consultants Ltd. and Salmo Consulting Inc. 2004. Conserving Canada's Natural Capital: the Boreal Forest - Muskwa-Kechika Case Study. Calgary, AB. Prepared for National Round Table on the Environment and the Economy. 74 pages.

Raynolds, M.K. and N.A. Felix. 1989. Airphoto analysis of winter seismic disturbance in northeastern Alaska. Arctic. 42(4):362-367.

RCAP (Royal Commission on Aboriginal Peoples). 1996. Available online at: www.ainc-inac.gc.ca/ch/rcap/sg/sgmm_e.html.

Reed, R.A., J. Johnson-Barnard, and W.L. Baker. 1996a. Contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology. 10(4):1098-1106.

Reed, R.A., J. Johnson-Barnard, and W.L. Baker. 1996b. Fragmentation of a forested Rocky Mountain landscape, 1950-1993. Biological Conservation. 75:267-277.

Reid, L.M. 1993. Research and cumulative watershed effects. Albany, CA. Pacific Southwest Research Station. General Technical Report PSW-GTR-141. vii+118 p.

Reid, L.M. and T. Dunne. 1984. Sediment production from forest road surfaces. Water Resources Research. 20(11):1753-1761.

Reid, S.M. and P.G. Anderson. 1999. Effects of sediment released during open-cut pipeline water crossings. Canadian Water Resources Journal. 24(3):235-251.

Reiman, R.E., D.E. Lee and R.F. Thurow. 1997. Distribution, status and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17: 111-1125.

Rettie, W.J. and F. Messier. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23:466-478.

Rich, C.F., Jr., T.E. McMahon, B.E. Rieman, and W.L. Thompson. 2003. Local-habitat, watershed, and biotic features associated with bull trout occurrence in Montana streams. Transactions of the American Fisheries Society. 132:1053-1064.

Rich, A.C., D.S. Dobkin, and L.J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8(4):1109-1121.

Richardson, W.J., Green Jr., C.R., Malme, C.I., and D.H. Thomson. 1995. Marine Mammals and Noise. New York, Academic Press.

Richardson, W.J., and M.T. Williams *eds.* 2000. Monitoring of Ringed Seals During Construction of Ice Roads for BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999. Prepared by LGL Ltd. and LGL Alaska Research Associates, Inc. for BP Exploration (Alaska) Inc. and National Marine Service.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17(4):1111-1125.

Ripley, T.D., M. Boyce, and G.J. Scrimegour. 2004. Effects of industrial activity on bull trout populations in Alberta's boreal forest: an evaluation of current and future impacts. Pages 39-40 in Scrimegour, G.J., G. Eisler, B. McCulloch, U. Silins and M. Monita, editors. Forest-Fish conference II Proceedings – Ecosystem stewardship through collaboration. April 26-28, 2004, Edmonton, AB.

Roberge, J.M. and P. Angelstam. 2004. Usefulness of the umbrella species concept as a conservation tool. Conservation Biology 18(1):76-85.

Ross, R. 1992. Dancing with a ghost: exploring Indian reality. Octopus Publishing Group. Markham, ON.

Rothwell, R.L., Swanson, R.H. and Spillios, L.C. 2004. WrnsAB2k for hydrologic simulation of the long term effects of forest harvesting. Pages 19-20 in G.J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins and M. Monita. Editors. Forest Land–Fish Conference II – Ecosystem Stewardship through Collaboration. Proc. Forest-Land-Fish Conf. II, April 26-28, 2004, Edmonton, AB.

Russell, D.E., A.M. Martell, and W.A.C. Nixon. 1993. Range ecology of the Porcupine caribou herd in Canada. Rangifer. 13(Special Issue No. 8):167.

RWED. 2000a. NWT Species 2000 - General Status Ranks of Wild Species in the Northwest Territories. Government of the Northwest Territories, Department of Resources, Wildlife and Economic Development. Available on line at: www.nwtwildlife.rwed.gov.nt.ca/monitor.

RWED (Resources, Wildlife & Economic Development). 2000b. 1999/2000 Northwest Territories Air Quality Report. 9 p. Available online at: www.gov.nt.ca/RWED/eps/environ.htm.

RWED (Resources, Wildlife & Economic Development). 2001a. 2000/2001 Northwest Territories Air Quality Report. 9 p.. Available online at: www.gov.nt.ca/RWED/eps/environ.htm.

RWED (Resources, Wildlife & Economic Development). 2001b. Northwest Territories Greenhouse Gas Strategy. 11 p. + app. Available on-line at: www.gov.nt.ca/RWED/eps/pdfs/nwt_greenhouse_gas_strategy.pdf.

RWED (Resources, Wildlife & Economic Development). 2002a. Air Quality Code of Practice Upstream Oil and Gas Industry Consultation Draft. 98 p.. Available on-line at: www.gov.nt.ca/RWED/eps/pdfs/airquality_codeofpractice.pdf

RWED (Resources, Wildlife & Economic Development). 2002b. 2001/2002 Northwest Territories Air Quality Report. 12 p.. Available online at: www.gov.nt.ca/RWED/eps/environ.htm.

RWED (Resources, Wildlife & Economic Development). 2003. 2002/2003 Northwest Territories Air Quality Report. 25 p. Available online at: www.gov.nt.ca/RWED/eps/environ.htm.

Ryan, J. 1995. Doing things the right way. University of Calgary Press, Calgary, AB

Salmo Consulting Inc. 2003. Cumulative effects: Sources, indicators, and thresholds – Appendix I. In Salmo Consulting Inc., Diversified Environmental Services, GAIA Consultants Inc., Forem Technologies Ltd., and Axys Environmental Consulting Ltd. 2003. Volume 2: Cumulative Effects Indicators, Thresholds, and Case Studies. Calgary, AB. Prepared for British Columbia Oil and Gas Commission and Muskwa-Kechika Advisory Board. 83 p.

Salmo Consulting Inc. and R. McManus Consultants Ltd. 2003. Beaufort Sea Integrated Management Planning Initiative - 17-19 September 2003 Oil and Gas Technical Workshop Summary Report. Calgary, AB. Prepared for BSIMPI Working Group. 24 p. + appendices.

Salmo Consulting Inc., Axys Environmental Consulting Ltd., Forem Technologies, and Wildlife & Company. 2004. Deh Cho Cumulative Effects Study Phase I: Management Indicators and Thresholds. Prepared for Deh Cho Land Use Planning Committee. 150 p.

Salmo Consulting Inc., Diversified Environmental Services, GAIA Consultants Inc., Forem Technologies Ltd., and Axys Environmental Consulting Ltd. 2003. Volume 2: Cumulative Effects Indicators, Thresholds, and Case Studies. Calgary, AB. Prepared for British Columbia Oil and Gas Commission and Muskwa-Kechika Advisory Board. 83 p.

Salmo Consulting Inc., URSUS Ecosystem Management Ltd., and GAIA Consultants Inc. 2001. Review of predictive modelling tools for wildlife and fish key indicators in the Wood Buffalo Region. Ft. McMurray, AB. Prepared for: Cumulative Environmental Management Association - Wood Buffalo Region Wildlife and Fish Working Group. 55 p. + Attachment.

Sawyer, M.D., and D.W. Mayhood. 1998. Cumulative effects analysis of land-use in the Carbondale River catchment: implications for fish management. Pages 429-444 in M.K. Brewin and D.M.A. Monita (editors). Proceedings of the Forest-Fish Conference: land management practices affecting aquatic ecosystems. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-356.

Schiller, A., C.T. Hunsaker, M.A. Kane, A.K. Wolfe, V.H. Dale, G.W. Suter, C.S. Russell, G. Pion, M.H. Jensen, and V.C. Konar. 2001. Communicating ecological indicators to decision makers and the public. Conservation Ecology [Online]. 5(1): 19 [online] http://www.consecol.org/vol5/iss1/art19/index.html.

Schmidt-Thomé, P. and J. Jarva. 2003. 1st Interim Report. The spatial effects and management of natural and technological hazards in general and in relation to climate change. European Spatial Planning Observation Network, Europe.

Schmiegelow, F.K.A. and M. Mönkkönen. 2002. Habitat loss and fragmentation in dynamic landscapes: avian perspectives from the boreal forest. Ecological Society of America 12(2):375-389.

Scrimgeour, G., P. Hvenegaard, J. Tchir, S. Kendall and A. Wildeman. 2003. Stream fish management: cumulative effects of watershed disturbances on stream fish communities iin the Kakwa and Simonette River basins. Prepared by the Alberta Conservation Association and the Alberta Research Council for the Northern Watershed Project Stakeholder Commtitte. Northern Watershed Project Final Report No. 3. 126 pp. Available online at: www.ab-conservation.com/about_us/reports_publications/NWP.

Seagle, S.W. 1986. Generation of species-area curves by a model of animal-habitat dynamics. P. 281-285 *in*: J.E. Verner, M.L. Morrison, and C.J. Ralph (*eds*.). Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison.

Seip, D.R. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology. 70:1494-1503.

Sekerak, A.D., N. Stallard, and W.B. Griffiths. 1992. Distribution of fish and fish harvests in the nearshore Beaufort Sea and Mackenzie Delta during ice-covered periods, October-June. Calgary, AB. Environmental Studies Research Funds. Environmental Studies Research Funds Report No. 117. xix + 157 + App pages.

Shideler, R. and John Hechtel. 2000. Grizzly Bear. Pages 105-132 *In:* Truett, J. C. and Stephen R. Johnson, *eds*. The Natural History of an Arctic Oil Field: Development and the Biota. Academic Press, San Diego, California.

Shoemaker, D.J. 1994. Cumulative Environmental Assessment. Waterloo, ON. University of Waterloo, Department of Geography. 129 pages. (Department of Geography Publication Series No. 42).

Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? Biological Conservation. 83(3):247-257.

Sloat, M.R., R.G. White, B.B. Shepard and S. Carson. 2001. Factors limiting the contemporary distribution of westslope cutthroat trout in the Madison River basin, Montana. Page 66 in Shepard, B. (editor). Practical approaches for conserving native inland fishes of the west. Montana Chapter, American Fisheries Society, MT.

Smit, B. and H. Spaling. 1995. Methods for cumulative effects assessment. Environ Impact Assess Rev. 15:81-106.

Solomon, S.M.. 2003. Plain language summary of the coastal and nearshore characteristics of the proposed Beaufort Sea marine protected areas. Inuvik, NWT. Prepared for the Beaufort Sea Integrated Management Planning Initiative Oil and Gas Technical Workshop.

Stalnaker, C., B.L. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. The Instream Flow Incremental Methodology - a primer for IFIM. Washington, DC. United States Department of the Interior National Biological Service. Biological Report 29. 45 p.

Stankey, G. H., McCool, S. F., and Stokes, G. L. 1984. Limits of Acceptable Change: a new framework for managing the Bob Marshall wilderness complex. Western Wildlands 10: 33-37.

Stankey, G.H., D.N. Cole, R.C. Lucas, M.E. Petersen, and S.S. Frissell. 1985. The limits of acceptable change (LAC) system for wilderness planning. Ogden, UT. U.S. Department of Agriculture, Forest Service. General Technical Report INT-176. 37 p.

Staples, L. 1997. Determining the impact of the Tulsequah Chief Mine Project on the traditional land use of the Taku River Tlingit First Nation: addendum on impacts. Prepared for British Columbia: Environmental Assessment Office, Province of British Columbia.

Stenhouse, G.B., J. Dugas, J. Boulanger, D.P. Hobson, and H.D. Purves. 2003. Grizzly bear cumulative effects assessment model review for the Regional Carnivore Management Group. Hinton, AB. Foothills Model Forest. 33 p.

Stirling, I. and M.K. Taylor. 1999. Update COSEWIC status report on the polar bear *Ursus maritimus* in Canada. Ottawa, ON. Prepared for Committee on the Status of Endangered Wildlife in Canada. 29 p.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters, 1998-2000. Prepared for the Joint Nature Conservation Committee. JNCC Report No. 323. Available online at: www.jncc.gov.uk/pdf/jncc323.pdf

Sullivan, M.G. 2003. Active Management of Walleye Fisheries in Alberta: Dilemmas of Managing Recovering Fisheries. North American Journal of Fisheries Management: Vol. 23, No. 4, pp. 1343–1358

Temple, S.A. 1984. Predicting impacts of habitat fragmentation on forest birds: a comparison of two models. *In*: Verner, J., M.L. Morrison, and C.J. Ralph, *eds.* Wildlife 2000. Modeling habitat relationships of terrestrial vertebrates; Stanford Sierra Camp, Fallen Leaf Lake, California. The University of Wisconsin Press 301-304.

Tera and Salmo (Tera Environmental Consultants (Alta.) Ltd. and Salmo Consulting Inc.). 1999. Watercourse Crossings – Second Edition. Prepared by Tera Environmental Consultants (Alta) Ltd., Calgary, AB, and Salmo Consulting Inc., Calgary, AB, for the Canadian Pipeline Water Crossing Committee, c/o the National Energy Board, Calgary, AB.

Tewksbury, J.J., S.J. Heil, and T.E. Martin. 1998. Breeding productivity does not decline with increasing fragmentation in a western landscape. Ecology. 79(8):2890-2903.

Thomas, D.C. and D.R. Gray. 2002. Update COSEWIC status report on the woodland caribou *Rangifer tarandus caribou* in Canada, *in* COSEWIC assessment and update status report on the Woodland Caribou *Rangifer tarandus caribou* in Canada. Ottawa, ON. Committee on the Status of Endangered Wildlife in Canada. 98 pages.

Tilman, D., R.M. May, C.L. Lehman, and M.A. Nowak. 1994. Habitat destruction and the extinction debt. Nature 371: 65-66.

Tonn, W.M., C.A. Paszkowski, G.J. Scrimgeour, P.K.M. Aku, M. Lange, E.E. Prepas and K. Westcott. 2003. Effects of Forest Harvesting and Fire on Fish Assemblages in Boreal Plains Lakes: A Reference Condition Approach. Transactions of the American Fisheries Society 132 (3): 514–523.

Tonn, W.M, S.M. Boss, P.K.M. Aku, G.J. Scrimgeour and C.A. Paszkowski. 2004. Fish Assemblages in Subarctic Lakes: Does Fire Affect Fish–Environment Relations in Northern Alberta?. Transactions of the American Fisheries Society 133(1): 132–143.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology. 14(1):18-30.

Truett, J.C. and S.R. Johnson. 2000. The Natural History of an Arctic Oil Field Development and the Biota. Academic Press; 422 p.

Tuktoyaktuk Inuvialuit Community Conservation Plan. 2000. Prepared by the Community of Tuktoyaktuk, Wildlife Management Advisory Council (NWT), and the Joint Secretariat. 168 p.

United States Fish and Wildlife Service. 1980. Ecological Services Manual Habitat Evaluation Procedures. U.S. Department of the Interior. ESM 100.

USFWS. 1999. Status review for westslope cutthroat trout in the United States. U.S. Fish and Wildlife Service, Department of the Interior, Portland, OR. 182 p.

USFWS. 2003. Marine Mammals: Incidental Take During Specified Activities – Final Rule. Federal Register. November 28, 2003. 68(229): 66744-66761. Available online at: www.r7.fws.gov/pdf/itr_regs.pdf.

Usher, P., F. Weihs and S. Ward. 2001. Quantitative data: Literature and document review and key informant interviews. Inuvialuit Final Agreement Economic Measures: Evaluation. : Inuvialuit Regional Corporation, Inuvik, NWT, Technical Report #3.

Usher, P.J. 2002. Inuvialuit use of the Beaufort Sea and its resources, 1960-2000. Arctic. 55(Supp. 1):18-28.

Usher, P.J., G. Duhaime, and E. Searles. 2003. The household as an economic unit in Arctic aboriginal communities, and its measurement by means of a comprehensive survey. Social Indicators Research 61:175-202.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47(4):893-901.

Villard, M.-A., M.K. Trzcinski, and G. Merrian. 1999. Fragmentation effects on forest birds: relative influence of woodland cover and configuration on landscape occupancy. Conservation Biology. 13(4):774-783.

Vodden, K. 2001. Inuvialuit Final Agreement, Economic Measures: Evaluation Report. Prepared for Evaluation Working Group: Department of Indian Affairs and Northern Development, Inuvialuit Regional Corporation, Government of the Northwest Territories, in fulfillment of Project #99/10.

Vos, C.C., J. Verboom, P. Opdam, and C.J.F. Ter Braak. 2001. Toward ecologically scaled landscape indices. The American Naturalist. 183(1):24-41.

Walker, D.A. and M.D. Walker. 1991. History and pattern of disturbance in Alaskan Arctic terrestrial ecosystems: a hierarchical approach to analysing landscape change. Journal of Applied Ecology. 28:244-276.

Walker, D.A., P.J. Webber, E.F. Binnian, K.R. Everett, N.D. Lederer, E.A. Nordstrand, and M.D. Walker. 1987. Cumulative impacts of oil fields on northern Alaskan landscapes. Science. 238:757-761.

Wallis de Vries, M.F. 1995. Large herbivores and the design of large-scale nature reserves in Western Europe. Conservation Biology. 9(1):25-33.

Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. Fisheries. 22(6):6-12.

Wang, L., J. Lyons, and P. Kanehl. 2003. Impacts of urban land cover on trout streams in Wisconsin and Minnesota. Transactions of the American Fisheries Society. 132:825-839.

Ward, S., H. Klein, E. Weick, J. Freeman, P. Usher, P. Hogg, and G. Fratton. 2002. Delivering on the Mackenzie Valley Environmental Impact Review Board's Mandate to Assess the Socio-Economic Impacts of Proposed Developments. Issues and recommendations for social and economic impact assessment in the Mackenzie Valley. Consilium Gartner Lee Ltd. MVEIRB . MVEIRB, Yellowknife.

Warren, M.L., Jr. and M.G. Pardew. 1998. Road crossings as barriers to small-stream fish movement. Transactions of the American Fisheries Society. 127:637-644.

Waters, T.F. 1995. Sediment in Streams: Sources, Biological Effects and Control. Bethesda, Maryland: American Fisheries Society; 251 p.

Weclaw, P. and R.J. Hudson. 2004. Simulation of conservation and management of woodland caribou. Ecological Modelling. 177(1-2):75-94.

Weaver, J.L., P.C. Paquet, and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology. 10(4):964-976.

Whitfield, P.H, A.W. Hall, and A.J. Cannon. 2004. Changes in the seasonal cycle in the circumpolar Arctic, 1976-95 : temperature and precipitation Arctic 57(1): 80-93.

With, K.A. and T.O. Crist. 1995. Critical thresholds in species' responses to landscape structure. Ecology 76(8): 2446-2459.

WMAC (Wildlife Management Advisory Committee (NWT)) and FJMC (Fisheries Joint Management Committee). 1988. Inuvialuit Renewable Resources Conservation and Management Plan. Available online: http://www.jointsecretariat.ca/WMACNWT/pdf/Inuvialuit%20Renewable%20Resource%20Conservation%20and%20Management%20Plan%201988.pdf

WNTC. 2001. Imperiled western trout and the importance of roadless areas. Prepared by the Centre for Biological Diversity, Tucson, AZ, Pacific River Council, Eugene, OR, and Biodiversity Associates, Laramie, WY. 20 p.

Wolfe, S.A., B. Griffith, and C.A.G. Wolfe. 2000. Response of reindeer and caribou to human activities. Polar Research. 19(1):63-73.

Wright, D.G. and G.E. Hopky. 1998. Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters. Canadian Technical Report of Fisheries and Aquatic Sciences #2107

Ziemer, R.R. 1994. Cumulative effects assessment impact thresholds: myths and realities. In: Kennedy, A.J., ed. Cumulative Effects Assessment in Canada: From Concept to Practice; Calgary, Alberta. Edmonton, Alberta: Alberta Association of Professional Biologists 319-326.

Appendix I

Table I-1. List of Common and Scientific Names of species found in the Beaufort Delta region. Primary source for uses from Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan.

Table I-2 Assumptions used for estimating areas of disturbance features, and habitat and activity buffers (i.e., edge effects)

Table I-1. List of Common and Scientific Names of species found in the Beaufort Delta region. Primary source for uses from Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan.

Type	Common	*Scientific*	Use / Habitat
Plants	Dwarf birch	*Betula glandulosa*	
	Dwarf Arctic birch	*Betula nana subsp. exilis*	Food
	Black spruce	*Picea mariana*	Medicine
	White spruce	*Picea glauca*	Medicine
	Tamarack	*Larix laricina*	Medicine
	Alaska willow	*Salix alaxensis*	Food, chewing tobacco additive
	Black bearberry	*Arctostaphylos alpina*	Food
	Blueberry	*Vaccinium uligonosum subsp. alpinum*	Food, fuel
	Blueberry	*Vaccinium uligonosum subsp. microphyllum*	Food, fuel
	Crowberry	*Empetrum nigrum subsp. Hermaphroditum*	Food, fuel
	Laborador tea	*Ledum palustre subsp. groenlandicum*	Medicine
	Lingonberry, cranberry	*Vaccinium vitis-idaea subsp. minus*	Food
	Tea-leaf willow	*Salix pulchra*	Food, medicine, additive to chewing tobacco and snuff
	Willow	*Salix spp*	
	Arctic dock	*Rubus arcticus*	Food
	Bistort	*Polygonum bistorta subsp. plumosum*	Food
	Bistort	*Polygonum viviparum*	Food
	Mountain sorrel	*Oxyria digyna*	Food, medicine
	Seabeach sandwort	*Honckenya peploides*	Food
	Bulblet saxifrage	*Saxifraga cernua*	Food
	Bog saxifrage	*Saxifraga hirculus*	Food
	Cordate-leaved saxifragi	*Saxifraga punctata subsp. Nelsoniana*	Food
	Marsh marigold	*Caltha palustris subsp. arctica*	Food
	Pallas' buttercup	*Ranunculus pallasii*	Food
	Cloudberry	*Rubus chamaemorus*	Food
	Fireweed	*Epilobium angustifolium*	Food, medicine
	River beauty, willowherb	*Eoilobium latifolium*	Food
	Lousewort	*Pedicularis langsdorffii subsp. arctica*	Food
	Lousewort	*Pedicularis sudetica subsp. interior*	Food
	Wooly lousewort	*Pedicularis kanei subsp. kanei*	Food
	Dandelion	*Taraxacum lacerum*	Food
	Pasture sage	*Artemesia frigida*	
	Sweet coltsfoot	*Petasites frigidus*	Food
	Sweet coltsfoot	*Petasites hyperboreus*	Food
	Wormwood	*Artemisia tilesii subsp. tilesii*	Medicine
	Mare's tail	*Hippuris vulgaris*	Food

Type	Common	*Scientific*	Use / Habitat
Plants	Cottongrass	*Eriophorum spp*	Medicine
	Sedges	*Carex spp*	Forage for cattle
	Lettergrass	*Eriophorum angustifolium subsp. Subarcticum*	Food, weaving
	Horsetail	*Equisetum arvense*	Food, medicine
	Horsetail	*Equisetum silvaticum*	Medicine
	Sphagnum mosses		
	Licoriceroot, Eskimo potato	*Hedysarum alpinum subsp.americanum*	Food
	Eskimo rhubarb	*Polygonum alaskanum*	Food
	Valerian	*Valeriana capitata*	Medicine
	Tundra fescue	*Festuca lenensis Drobov*	
	Mackenzie's sedge	*Carex mackenziei*	
	Huron tansy	*Tanacetum bipinnatu*	
	Arctic raspberry	*Rubus arcticus* subsp. *stellatus*	Food
Fish	Arctic char	*Salvelinus alpinus*	Mackenzie River, delta, east along coast
	Arctic cisco	*Coregonus autumnalis*	Mackenzie River, delta & coast
	Arctic grayling	*Thymallus arcticus*	Small streams and river with cold clean waters
	Broad whitefish	*Coregonus nasus*	Mackenzie River and delta
	Chum salmon	*Oncorhynchus keta*	Rivers-Mackenzie westward
	Dolly varden	*Salvelinus malma*	Mackenzie River and tributaries
	Northern pike	*Esox lucius*	Mackenzie River watersheds
	Inconnu	*Stenodus leucichthys*	Mackenzie River, delta, Beaufort Sea coast
	Lake trout	*Salvelinis namaycush*	Large deep lakes and some large rivers
	Lake (humpback) whitefish	*Coregonus clupeaformis*	Winter in coastal rivers and deltas
	Least cisco	*Coregonus sardinella*	Mackenzie River and mouth
	Pink salmon	*Oncorhynchus gorbusha*	Rivers from Mackenzie westward
	Blue herring	*Clupea sp.*	Mackenzie estuary and tribs.
	Pacific herring	*Clupea harengus pallasi*	Winter in deeper offshore waters
	Rainbow smelt	*Osmerus mordax*	Winter in deeper offshore waters
	Arctic cod	*Boreogadus saida*	Winter in deeper offshore waters
	Burbot	*Lota lota*	Lake and tributary rivers, some brackish waters
	Saffron cod	*Eleginus navaga*	Winter in deeper offshore waters

Type	Common	*Scientific*	Use / Habitat
Birds	Common Eider	*Somateria mollissima*	Small islands near the sea, tundra ponds
	King Eider	*Somateria spectabilis*	Open areas with low vegetation; Tuktoyaktuk Peninsula
	Lesser Snow Geese	*Chen caerulescens*	
	Tundra swan	*Cygnus columbianus*	
	Sandhill crane	*Grus canadensis*	
	Northern Pintail	*Anas acuta*	Tundra areas
	Oldsquaw	*Clangula hyemalis*	Small islands; near tundra ponds
	Scoters	*Melanitta spp*	Forested areas, dense cover
	Rock Ptarmigan	*Lagopus mutus*	Coastal hills, rocky tundra
	Eskimo curlew	*Numenius borealis*	Outer Mackenzie Delta
	Ivory gull	*Pagophila eburnea*	Outer Mackenzie Delta
	Ross' gull	*Rhodostethia rosea*	Outer Mackenzie Delta
	Anatum Peregrine Falcon	*Falco peregrinus anatum*	Coastal areas with cliffs for nesting
	Golden Eagle	*Aquila chrysaetos*	Cliff and tree nests
Mammals	Arctic hare	*Lepus arcticus*	
	Snowshoe Hare	*Lepus americanus*	Mackenzie Delta
	Beaver	*Castor canadensis*	Streams, lakes and ponds
	Muskrat	*Ondatra zibethicus*	Mackenzie Delta
	Hoary marmot	*Marmota caligata*	
	Northern flying squirrel	*Glaucomys sabrinus*	
	Porcupine	*Erethizon dorsatum*	
	Muskrat	*Ondatra zibethicus*	Mackenzie Delta
	Alaska vole	*Microtus abbreviatus*	
	Brown lemming	*Lemmus sibiricus*	
	Greenland collared lemming	*Dicrostonyx torquatus*	
	Meadow vole	*Microtus pennsylvanicus*	
	Tundra redback vole	*Clethrionomys rutilus*	
	Tundra vole	*Microtus oeconomous*	
	Yellow-cheeked vole	*Microtus xanthognathus*	
	Bearded seals	*Erignathus barbatus*	Beaufort Sea
	Ringed seals	*Phoca hispida*	Beaufort Sea
	Pacific walrus	*Odobenus rosmarus*	
	Beluga whales	*Delphinapterus leucas*	
	Coyote	*Canis latrans*	
	Wolf	*Canis lupus*	Transition between treeline and tundra; Bluenose caribou wintering areas
	Arctic Fox	*Alopex lagopus*	Above treeline, generally

Type	Common	*Scientific*	Use / Habitat
Mammals	Red Fox	*Vulpes vulpes*	Generally below treeline
	Black Bear	*Ursus americanus*	Creeks and Mackenzie River valley, forested areas in the Delta
	Grizzly Bear	*Ursus arctos horribilis*	Mountainous terrain along the Mackenzie Delta
	Polar bear	*Ursus maritimus*	Beaufort Delta
	Marten	*Martes americana*	Older or regenerated conifer forests
	Least weasel	*Mustela nivalis*	
	Long-tailed weasel	*Mustela frenata*	
	Mink	*Mustela vison*	Delta, small creeks, dense vegetation
	Wolverine	*Gulo gulo*	
	River otter	*Lontra canadensis*	
	Lynx	*Lynx lynx*	River valleys, Mackenzie Delta
	Moose	*Alces alces*	Delta; winter in valleys and creeks with dense willows
	Barren-ground Caribou	*Rangifer tarandus groenlandicus*	Cape Bathurst and Bluenose-West herds use wintering areas north and east of Inuvik Porcupine herd uses wintering areas west of Fort McPherson
	Grant Caribou	*Rangifer tarandus-granti*	
	Woodland Caribou	*Rangifer tarandus*	
	Muskox	*Ovibos moschatus*	
	Dall's sheep	*Ovis dalli*	
Amphi-bians	Wood frog	*Rana sylvatica*	Mackenzie Delta Region

Table I-2 Assumptions used for estimating areas of disturbance features, and habitat and activity buffers (i.e., edge effects).

Feature	Width (m)	Area (ha)	Habitat Buffer (m)	Activity Buffer (m)	Source
Onshore wells		3	1000		MEMP 1986 Development scenario; ZOI based on typical grizzly bear response in Harding and Nagy (1980) and barren ground caribou response during calving (Cronin et al. 1994)
Historical offshore exploration well		25	500		500 m X 500 m area assumed for artificial island at sea floor; Buffer applied to centre point based on review for beluga whale response in Mackenzie Gas Project Environmental Impact Statement (IORVL 2004),Vol. 5, Section 3
Seismic line - tundra	8		50		MEMP 1986 Development scenario; general industry cat-cut average; ZOI based on typical effect distance noted by Paton 1994 review (cited in Salmo et al. 2003, App. 1)
Seismic line - forest	8		400		Woodland caribou avoidance documented by Nagy et al. 2003
Pipeline	30		50		Average for MEMP 1986 development scenario
All weather road	30		1000		Assumed width for Dempster Highway; Mackenzie Gas Project Environmental Impact Statement estimate (IORVL 2004; Vol. 2) of 20 m
Borrow sites, municipal waste dump		30	50		Average for MEMP 1986 development scenario; Mackenzie Gas Project Environmental Impact Statement (IORVL 2004) assumed 10 ha average
Airstrip	80 X 1600	12.8	1000	8000	80 m wide by 1600 m long oriented NW-SE; from Mackenzie Gas Project Environmental Impact Statement (IORVL 2004; Vol 2)
Offshore vessel				2500	Distance at which belugas moved away from vessels; review in Mackenzie Gas Project EIS Vol 5, Sect 3
Aircraft				8000	Typical max. flushing distance for snow geese; reviewed in MPG Environmental Impact Statement (IORVL 2004; Vol. 5, Section 3
Vehicle/ Snow-mobile				1000	ZOI based on typical grizzly bear response in Harding and Nagy (1980) and barrenground caribou response during calving (Cronin et al. 1994)
Community			1000		Obtained from community
Winter road	20		1000		Assumed width
Gas facility		5	1000		Area max. for MEMP 1986 Development scenario; ZOI based on typical grizzly bear response in Harding and Nagy (1980) and barren-ground caribou response during calving

					(Cronin et al. 1994)
Camps, misc (commun-ication towers)		0.7	1000		Mackenzie Gas Project Environmental Impact Statement (IORVL 2004; Vol 2)
Staging sites, ferry launch		5	1000		e.g., Lucas Point, Cape Farewell, Bar C; from Mackenzie Gas Project Environmental Impact Statement (IORVL 2004; Vol 2.
Swimming Point		20	1000		Mackenzie Gas Project Environmental Impact Statement (IORVL 2004; Vol 2)

[1] - Reduced habitat quality from physical changes, noise, or disturbance.

[2] - Disturbance zone-of-influence from moving equipment.

Appendix II

Dillon and Salmo (2004b). Beaufort Delta Cumulative Effects Workshop – Post-Workshop Distribution Package: Workshop results and meeting minutes.

Beaufort Delta Cumulative Effects Threshold Workshop

Post-Workshop Distribution Package: Workshop Results and Meeting Minutes

December 15, 2004

Prepared for the:
Environmental Studies Research Funds (ESRF)
Calgary, AB

04-3429-2000

Kerry Brewin- Project Manager

Submitted by

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(In reply, please refer to)
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December 2, 2004

Attention: Participants of the October 5th and 6th, 2004 Beaufort Cumulative Effects Workshop Distribution via individual e-mail addresses and mail

RE: FOLLOW-UP PACKAGE FOR OCTOBER BEAUFORT CUMULATIVE EFFECTS WORKSHOP

Dear Workshop Participant:

On behalf of the other members of the consulting team, and the Technical Advisory Group (TAG) for the Environmental Studies Research Fund (ESRF), I would like to thank everyone who participated in the Beaufort Delta Cumulative Effects Workshop that was held in Inuvik, NT on October 5 and 6, 2004. We were very pleased with the turnout and greatly appreciated all of the valuable feedback we received. Thank you for making the workshop a success!

As promised, we are forwarding a copy of the workshop summary to all the organizations that were invited to the workshop. Since several of the participants were representing multiple organizations, and we were not given mailing addresses for all participants, we are sending the workshop summaries to the individuals on the original pre-workshop distribution list and ask that you forward the summary package to the people who attended on your behalf.

At the workshop several commitments were made. One commitment was that information about ESRF would be included in the workshop summary. We have included information about ESRF in Appendix C of the attached report.

A commitment made by Dr. Laura Johnston, Chairperson of the ESRF TAG, was that a decision would be made on whether the draft report prepared for this project would be distributed to all workshop participants for comment. We understand that ESRF has decided the ESRF TAG will review the draft report, and that it will not be distributed to all participants who attended the workshop. However, because the project is an independent research project being conducted for the ESRF, additional opportunities for input are expected to be provided before any of the recommendations included in the report are implemented.

One of the concerns raised at the workshop was that the ESRF TAG did not include a Gwich'in representative. To address this concern, a decision was made to add Ms. Kim Hawkins, Gwich'in Tribal Council, to the ESRF TAG.

Once again, thank you for helping to make the workshop a success. If you have any questions or comments on the information in the attached package, please forward them to me.

Yours Sincerely,

DILLON CONSULTING LIMITED

per

Mr. Kerry Brewin, M.Sc., P.Biol.
Project Manager

Dillon Consulting Limited

Attachment

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APPENDICES

1 INTRODUCTION – Background and Summary for the Beaufort Delta Cumulative Effects Threshold Workshop

1.1 Background

A two-day workshop was held in Inuvik, Northwest Territories (NWT) on October 5 and 6, 2004 to discuss tools to monitor and manage cumulative effects in the Beaufort Delta region. The workshop was part of an independent research project on cumulative effects in the Beaufort Delta Region that is being conducted for Environmental Studies Research Funds (ESRF). The objectives of the study are to:

1. Identify **Valued Components** that are of importance to the people of the area;
2. Identify environmental and social **Indicators** for each Valued Component that are of practical assistance in assessing and minimizing adverse cumulative effects in the Beaufort Delta region; and
3. Develop candidate **Thresholds** and/or **Limits of Acceptable Change** for these indicators.

A consulting team including Kerry Brewin and Nalini Naidoo from Dillon Consulting Limited, Terry Antoniuk from Salmo Consulting Inc., and Joan Ryan and Allice Legat from Keano Social Analysts is conducting this study. This team is directed by ESRF's Technical Advisory Group (TAG) with representatives from government, regulatory and co-management groups, industry, non-government organizations, and universities.

The workshop was held to present initial findings from this study and to obtain feedback on the proposed indicators and approach. This feedback will be incorporated into a final report being prepared by the consulting team.

Fifty-seven people from 41 organizations were invited to the workshop. These included representatives from local communities, industry, federal and territorial agencies, co-management boards, academia, and local stakeholders groups. Two weeks before the workshop all invitees were sent an information package that contained a proposed agenda (Appendix A), and materials to be presented and discussed at the workshop (Dillon and Salmo 2004). This package provided participants an opportunity in advance of the workshop to review and become familiar with the materials that would be discussed.

1.2 Definitions

Technical terms used in this summary are defined as follows:

- *Valued Component:* an aspect of the environment that is considered important on the basis of economic, social, cultural, community, ecological, legal or political concern

- *Indicator:* a characteristic of the social, cultural, or environmental setting that is used to describe, measure, manage, and report on Valued Components.

- *Limits of Acceptable Change:* socially-defined endpoints or thresholds that reflect the desired balance between human activities and ecological and social sustainability.

- *Thresholds:* a point at which an indicator changes to an unacceptable condition, with acceptability defined either from an ecological or social perspective.

- *Tiered Thresholds:* a series of progressive targets that reflect increasing degrees of concern or risk.

1.3 Workshop Summary

The workshop followed the schedule outlined in the Agenda (Appendix A) and was held at the Midnight Sun Community Recreation Centre in Inuvik, NWT on October 5 and 6, 2004.

A meeting was held with community representatives on October 5 to review the workshop objectives, provide a summary of material provided in the pre-workshop distribution package (Dillon and Salmo 2004), and to begin collecting feedback from local community representatives. The workshop was attended by 16 community representatives and the chair of the ESRF TAG. The comments collected during this community session are included in Section 2.0 of this report.

Forty-four people attended the stakeholder workshop held on October 6; a list of attendees is provided in Appendix B. Attendees were divided into two breakout groups (Socio-cultural and Environment) and participated in roundtable discussions following presentations on: 1) management objectives and Valued Components; and 2) Indicators and Thresholds. The comments and feedback provided by workshop participants are summarized in Sections 3, 4, 5 and 6 of this report. Any participants interested in providing additional feedback were invited to submit written comments and were provided with a handout that included the questions discussed during the small break-out groups. Other than comments from the ESRF TAG, no written comments were forwarded to the consulting team before this summary report was completed.

1.3.1 General Comments

Local community representatives were very concerned about the potential effects of industrial activities on the environment and their communities. The participants also made it very clear that it is important for input from local communities to be incorporated into the resource management and socio-cultural decisions that are made, but their participation in the workshop does not necessarily mean they endorse the conclusions and recommendations from this project.

Participants indicated that there was general support for the regional Management Objectives, Valued Components, Indicators and the management approach (the Thresholds and Limits of Acceptable Change linked to land use plans) that were proposed by the consulting team. They also indicated the regional vision should be changed to 'improving existing social problems' instead of 'not worsening social problems'. It was also noted that Thresholds and Indicators should consider both positive and negative effects, and opportunities for improvement, rather than focusing solely on negative effects. However, it

was noted that the time allocated for workshop discussion was too limited, and that comments should not be considered formal community endorsement of this approach.
Many participants at the workshop were unclear about the structure and role of ESRF, and a commitment was made by the Project Team to include information about ESRF in the follow-up materials. This information is included in Appendix C.

There was a substantial amount of discussion about the impact to environment and communities as a result of industrial development, and the acceptability of the various risks involved. There was also discussion about the tradeoffs for accepting risk versus the economic rewards that are generated from development. Because of the complexity of these issues, and need for extensive public consultation before decisions about thresholds can be made, it was explained that the present study is an independent research project that represents a first step towards thresholds. Recommendations made by the consulting team in the final report should be discussed with all regional stakeholders before being implemented. These discussions should allow the likely tradeoffs between anticipated benefits and risks to be clearly understood and debated.

1.3.2 Socio-Cultural Breakout Group

1.3.2.1 Management Objectives and Valued Components

The socio-cultural breakout group agreed that 'Family' and 'Community' are Valued Components. There was also discussion about whether 'Individual' is a Valued Component because an individual's action affects the community. Furthermore, it was stated that individuals make up the family and individual families make up the community. The group thought the term 'land' as a Valued Component was too narrow and that 'culture' or 'land and culture' would be more encompassing.

1.3.2.2 Indicators and Thresholds

Many attendees felt that communities in the Beaufort-Delta region are already exceeding many social-cultural thresholds. The discussion then turned to what needs to be done to bring the community and family well-being back below the Limits of Acceptable Change. Many participants thought that if communities were provided funding to develop and run programs themselves, which they think of as part of self-government, then the need for band-aid programs and policies for social, health, education and cultural problems would be reduced.

Participants strongly expressed that programs/policies should be directed towards the real issues, such as:

- Providing parenting skills before and after children are born. The group thought if funding was put into parenting, then it would increase the probability of children having better nutrition and being more rested which would result in better learning while at school (and at home) and would likely result in less vandalism and fewer young people being apprehended.

- Programs to increase fur prices. It was thought that people should have knowledge of both oil and gas and traditional way of life so individuals can make choices about career paths and lifestyles.

In conjunction with discussions on indicators, the group struggled with the information some indicators would provide. The bullets for suicide, housing and education levels below are examples of these discussions:

- It was thought that it is easy to document the number of suicides, but it is more difficult to know why an individual attempts suicide. Although it was mentioned that knowing the demographics of suicide will help understand who may attempt suicide, the group insisted that without answering 'why', intervention will be unlikely.
- Some members of the group thought housing figures provided realistic and useable information, while others disagreed. For example, it was stated that everyone needs housing in a northern climate, but since it is so costly, individuals are often compelled to lie or end their employment in order to get affordable housing. It was also mentioned that there are no statistics on the number of individuals living in a particular size of house, and that often more than one family shares a two-bedroom house due to the high cost of housing.
- Education statistics look favourable, however, the group discussed the negative aspects of 'social passing', including the sudden realization of not knowing enough to get into some classes in high school. They discussed how young people may think they have an education until they try to get work or until they are in high school when social passing does not occur. It was stated that these students often fail, quit and/or feel badly about themselves.

Additional suggestions for potential indicators included:

- Weight gain (although at least one person suggested that weight gain could indicate both evidence of enough food and evidence of over-eating inappropriate food);
- Rate of violent crime and vandalism;
- Loss of language which can suggest better employment opportunities and loss of knowledge of identity and ancestry;
- Elderly care and abuse; and
- Burnout of individuals in responsible positions (e.g., volunteers).

1.3.3 Environmental Breakout Group

1.3.3.1 Management Objectives and Valued Components

The environmental break-out group agreed with most of the proposed Valued Components, but some representatives felt that 'nearshore' should be expanded to include 'offshore'. Protected Areas was proposed and generally accepted as a Valued Component because of the importance of these areas. This small group also indicated that access to land could be included as a Valued Component and that while

the land-use zone/categories provided in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan need to be respected, other legislation and regulations (e.g., federal Species At Risk Act) are also important.

1.3.3.2 Indicators and Thresholds

The small group discussion on environmental indicators also revealed that while there was general agreement with the approach, it is important to track harvest along with land use activities. Barriers to movements and seasonality are other factors that need to be addressed by environmental indicators.

The small group discussion on environmental thresholds indicated there was general support for the proposed approach. This discussion also revealed that there were several elements that would likely be required to achieve buy-in. These included:

- A scientific basis (e.g., changes need to be both monitored and measurable);
- Trusted and credible sources of information;
- Identifying acceptable thresholds and closing some of the data gaps for terrestrial communities (i.e., air and freshwater have relatively good standards in place, but terrestrial ecosystems do not);
- Integrating scientific knowledge with Traditional Knowledge.

There was also general agreement that the land use categories in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan provide good starting places, but that these may be subjected to revisions on an on-going basis. It was also agreed that there are some uses (e.g., harvest of caribou and beluga whale) that are extremely important to the local communities and that there should be very low tolerance for risk from impacts to these uses (e.g., saying 'no' to development activities in some areas, means 'NO').

2 MINUTES FROM COMMUNITY SESSION HELD OCTOBER 5, 2004

The following section represents the notes recorded from the Community Groups Session held on October 5, 2004. A total of 21 people attended the afternoon session on October 5, of which four were members of the Project Team and one was Dr. Laura Johnston, the Scientific Authority and Chairperson for the ESRF's Technical Advisory Group.

The workshop opened with individual introductions followed by a summary of the purpose of the project. One of the attendees emphasized the importance of the need to address the issue of offshore rights between First Nations and the Federal government.

T. Antoniuk and Allice Legat gave a Powerpoint presentation that focused on the objectives of the project and a summary of the information that was distributed in advance of the workshop.

Comments received following the presentation included:

- more clarification on the objectives of the study and who it is for was requested – Response: client is the ESRF and objectives of the project in the material distributed before the workshop were repeated and clarified;
- clarification was also requested on how the report will be used - Dr. Johnston indicated that the intent of the study is to look at the regional cumulative effects (i.e., study areas of all proponents in the areas) as opposed to specific study area boundaries of individual projects;
- how does this study relate to existing document such as the Inuvialuit Community Conservation Plans (ICCPs) – Response: we hope to receive feedback regarding whether workshop participants agree that the ICCPs should be used as the basis for the 'rules of the land';
- where will the numbers for the 'thresholds' come from? - Response: the project team will identify candidate numbers based on the available science, and then the next step is to finish our report and allow a period for public feedback on the numbers we propose in the report;
- concern was expressed by several participants that involvement in the workshop should not be construed to imply endorsement of results/outcome - Response: it was confirmed that the recommendations provided in the final report won't be from the workshop participants, but rather the consulting team's recommendations based on the input received during the workshop, our review of the available literature, the Terms of Reference for the project, and our experience. After the report is finalized, conclusions will need to be discussed with stakeholders before any of the recommendations are implemented. It was emphasized that the report is only a first step and that followup steps would be needed, particularly steps to secure community/stakeholder/regulatory support;
- several participants also indicated that they have been involved in similar initiatives in the past and questioned the relationship between this study and previous studies;
- it was suggested that we should look at what was already done in the area and that we use this existing information where ever possible;
- the question "who is TAG" was asked – Response: TAG is the Technical Advisory Group for ESRF that is overseeing and directing the project. Dr. Johnston is the Chairperson for TAG and

there were approximately 11 people on TAG that included representatives from federal and territorial agencies and co-management boards in the area, the oil and gas industry, and academia. There is also an Inuvialuit representative on TAG, but no Gwich'in rep;

- clarification regarding the definition of 'cumulative effect' was asked for and provided (i.e., cumulative effects refers to the effects of all human activities occurring in the area, including activities in the future that are likely to occur);
- one participant commented that in his opinion monitoring of everything that happens is very critical. He added that the second most important thing was that remediation and mitigation needs to occur to minimize impacts;
- the entire ISR should be represented at the workshop, including Sachs Harbour and Holman. (Similar comment was made later about the need to also involve Tuktoyaktuk and Aklavik communities) - Response – It would have been preferable to invite people from beyond the region, but available funding and other resources were limited to who received invitations.
- the time provided at the workshop was not sufficient. – Response: a blended workshop-literature review approach was used in an attempt to balance costs with opportunity for consultation. It would have been preferred to be more inclusive, and provide more time for consultation, but the budget was limited and more opportunities for additional input will be required after the report is completed;
- if stakeholders are giving their time and knowledge to the project then they don't want to hear that the report could be shelved. Dr. Johnston explained that the report will be reviewed by ESRF TAG and then eventually released to regulatory agencies and stakeholders. Whether the recommendations are picked up will be beyond TAG's control, but the decision to fund this project was made because TAG felt there was an excellent chance that the recommendations will be picked up;
- clarification about what is meant by a cumulative effect 'stop sign' and an example that is already in place were requested – Response: Category E Lands (e.g., the Beluga Management Area) is an example of an existing stop sign intended to restrict development in the designated area.
- one message that needs to go back to industry and regulators is that proponents need to 'stop shooting at the stop signs'. Too often a decision is made collectively to restrict development in a specific area (e.g., Beluga Management Area), but as soon as the stop sign is in place, industry will meet with individual stakeholder groups to try to get them to take the stop sign down;
- it is important that something consistent be developed so that the same message and information can be distributed between communities;
- several participants indicated that another stop sign that they have frequently requested is 'no more sumps', but that sumps keep getting approved by Indian and Northern Affairs Canada.
- you can have the best rules in the world, but without legislation to back it up, the rules won't work;
- 'Money has no value', and the only real thing with any value is the 'land', and that it is important the 'land' be adequately protected from impacts;
- to make this work, the first two points in T. Antoniuk's slide presentation (regarding the Beaufort Delta vision) are critical (i.e.: Valued Components and Indicators should reflect the strong linkage between environmental conditions and regional social well-being; and Indicators should be selected to help integrate environmental and socio-economic management and programs);
- the environmental impacts of the Mackenzie Valley pipeline will likely be minimal and that in the end, all it really is is a large cutline. However, the real impact from the pipeline will be the social impact that the communities experience. It was added by another participant that the impact of the gathering system for the pipeline is also where the impacts will be felt;

- Indian and Northern Affairs Canada has to improve on how it uses the public input it receives;
- most of the materials (re: Valued Components and Indicators) have already been reviewed several times with industry – Response: perhaps the most important difference is that numbers (e.g., for thresholds) are being requested this time;
- a few years ago a study identified social indicators and it should be included in the review;
- oil companies need to 'work on wellness' before they 'work on development';
- this study should look at all of the existing oil and gas, and mining activity in the area, and it will likely find that the thresholds that we should be using have already been passed;
- it was stressed that government agencies need to be represented better tomorrow.

3 MORNING PLENARY SESSION

The Workshop began the morning of October 6, 2004 with some welcoming comments and a prayer led by Evelyn Storr. A total of 44 people participated in the morning plenary session. After brief presentations by the Project Team and Dr. Johnston to provide some background about the project and discuss the workshop format, T. Antoniuk gave a brief presentation on 'Cumulative Effects Indicators'.

Before the plenary session disbanded and the participants broke into two break-out groups, several comments were made which included:

- The communities in the area have participated in workshops with similar objectives and clarification was requested about how this one is different and how the results will be used.
- Some regulators indicated tools for monitoring cumulative effects are needed for the area.
- Existing land claims need to be respected in anything that is developed from these projects.
- There was a search going on for people missing from the Tuktoyaktuk community. People attending the workshop were concerned about the missing people and the search crews, and the search affected participation from some communities in the workshop.

4 MORNING SMALL GROUP DISCUSSIONS – PROPOSED REGIONAL VISION AND VALUED COMPONENTS

Following the morning plenary session, participants broke into two smaller breakout groups to discuss the proposed regional vision and Valued Components. Participants were asked to break into two groups (one for environmental and the other social-cultural). The 'Environmental Group Discussion was facilitated by T. Antoniuk and notes were recorded by K. Brewin. The 'Socio-cultural Group Discussion' was facilitated by Allice Legat and notes were recorded by N. Naidoo.

It was agreed at the start of the breakout sessions that each recorder would type their notes directly into tables that would be projected on to a screen during the discussion. This would allow participants to view how their comments were being recorded and to request changes to the comments that were recorded. The notes from these breakout groups are provided in Table 1 (Socio-cultural small group discussion) and Table 2 (Environmental small group discussion).

Table 2 summarizes the Environmental Small Group Discussion. Although notes from this small group discussion were typed into a table and projected on the screen, the document file could not be retrieved after the session. Efforts were made to rebuild as much of this table as possible from flipchart notes and the recollections of the consulting team. Any help participants can provide to supplement the information in the table below for this small group discussion would be appreciated, and should be forwarded to Dillon. The questions in Table 2 are the same as those asked during the small group discussion.

Comments from participants after the summary presentation for the small groups included the following:

- Environmental issues are often over-emphasized and more emphasis needs to be given to the social side;
- Important to recognize that the approach appears to be putting priority on not worsening the existing situation, and attention should also be given to identifying existing problems and taking corrective actions to improve those situations;
- There was general agreement with what was said during the wrapup presentation, but there was concern expressed that once the report is written, it may vary substantially from what the community's views on particular topics may be;
- Communities want to be involved from beginning to end;
- One regulator indicated that it is important to keep expectations in check and that all he expects out of this process is a place to start; and
- There were numerous questions about the role of ESRF and TAG, and concerns were also expressed that there was no Gwich'in representative on TAG.

Each small break-out group then presented a summary of its discussions for comments and questions:

Question – Will workshop participants be able to review and provide comments on the draft report? Response - It was originally intended that TAG would review and provide comment on

the draft report and Dr. Johnston was unable to confirm whether the draft document could be shared among all of the participants. She did, however, indicate that she would raise this question with the ESRF and determine if this was possible. [Note: Subsequent to the workshop the ESRF TAG concluded that the draft report would not be distributed for public comment.]

- Some participants felt there was not enough time to adequately discuss the information and provide meaningful input on all of the materials that were being covered at the workshop.

There were also a number of questions related to the ESRF (e.g., what is ESRF, what is the ESRF's mandate, who funds them, who is TAG, and why are they funding this project), how the information discussed at the workshop would be used and implemented, how will existing ICCP's and past studies be used, and whether local communities had an opportunity to provide input into the design of the project. These questions were fielded and answered by T. Antoniuk, Dr. Johnston and Mieke Vander Valk (National Energy Board). A commitment was also made to include additional information about ESRF in the package of followup information that would be sent to workshop participants (see Appendix C).

Table 1: Notes collected during the Socio-cultural Small Group Discussion on Regional Vision and Valued Components.

Discussion topic	Comments by participants
Individual Well-being	• Individual rights area also valued in society vs. the values of the family • How does this work with the extended family? • We listen to individuals, but we represent our community • Communities are made up of individuals and individual families • If it affects one person, it may not be affecting all people. • In smaller communities if one person is affected, it will end up affecting the whole community.
Land/Culture (Culture & how it relates to land)	• Cost of living - people need money to go out on to the land. • The cost of gas, food, is too much for some people to go out on to the land. • Some families will save up money just to go out on to the land • Not all people will do this • There is a bigger category than land
Family	• Social well-being of families • Right now the social system is over- taxed • Everybody knows that money is not the best thing • When they make lots of money there is more drunkenness. We need to look at how families spend money. • We can't make a living off trapping anymore (off the land). The social well-being of families is the most important. • Life skills/training • People can't go to the bush anymore; kids don't want to do this. They want to play hockey (this needs money). • Healthy families are number one • Proper foods • Access to education • Spiritually • Emotional • Having access to resources - helping families overcoming obstacles
Community	• Basics that people need for survival are: clean water, water/sewer infrastructure, water treatment systems that are not overloaded, dumps that are not filled up, fire departments that are working well (municipal community infrastructure), plowing roads, etc. These are the issues MACA sees as valued components. Dumps are only designed for certain populations, for example. • Each community is different - we don't have enough time here today to discuss all of it • Social Impact Assessment was done • Social concerns, additions, births, FAS issues, we need to educate younger people - to build up capacity. • There are issues that will arise to deal with the income in the area. • You have to know who you are, where you come from and who your people are - Community Well-being • We are already doing a lot of these things • The Gwich'in are in the final stages of assessing these issues - we are doing our own work. • Communities that were invited and not here - means we are missing a part. Largest Gwich'in community not here. • We may end up missing something today that will get missed in the final report • We used to have life skills taught in the schools; kids now don't have this, it has to be part of the education system; for example, being a single parents, passing on these skills is harder. • Look at the people in the region, the well-being of the people in the communities - it is an on-going process. A lot of people are affected by what is going on. • The old ways are disappearing slowly, our cultural way of life is losing - slowly, because of development. • We need to take care of everyone in the region. • Cultural way of life is slowly declining, i.e. trapping. • No people are getting jobs and living on work alone. • Oil companies are going to be here for a while (people are getting jobs) • If the time comes and the oil companies are gone - what are we going to do? There is no more trapping. • The government needs to think about this. • These things are affecting us. • The pipeline is here now, and diamonds, it is going to be an on-going thing. • What is the best way we can all work together and manage • It costs so much to get out, we are losing. With the younger children - they need jobs up ahead, we have to create jobs for them; they have to take over. • How are we going to manage everything? The social issues, the impacts, the best way we can.

Table 2: Summary of the Environmental Small Group Discussion on Regional Vision and Valued Components.

Questions asked of participants	**Feedback from participants**
Are the Valued Components OK?	• Some confusion regarding difference between Valued Components (VCs) and Indicators. • A VC is also needed for offshore - shouldn't separate offshore from nearshore because animals and people use both. • Questioned definition of 'nearshore' and how landfast ice is defined as a set distance from the shoreline. Suggested that Grounded ice zone is better description. • Also important to recognize that just as some marine species are migratory, what happens on the nearshore also impacts people who reside outside of the study area (e.g., Sachs Harbour, Holman, and Paulatuk), but rely on these resources. • Links to population goals are tied to sustainable harvest – and important to also link land use to harvest. • Emphasis is currently given to habitat impacts/loss, but harvest levels can be equally as important
Does the framework provide enough linkage and balance between environment and social issues?	• Links to population goals are tied to sustainable harvest – and important to also link traditional land use to harvest. • Important that the rules be made to be clear and consistent for all communities. • Don't overlook the role of existing land management bodies such as the Inuvialuit Land Administration. The land management process has being modified to allow more direct community input into decisions. • The VC's are broad – this is a concern because 'the devil's often the detail' when it comes to evaluating trade-offs.
Are land use zones/categories a good foundation for thresholds?	• Land use zones aren't always sufficient and should also include other regulations and legislation (e.g., Species At Risk Act and species management plans). • Protected areas are important, but they don't provide enough protection for environmental resources, so thresholds are needed elsewhere. • Need to consider effects of vessels and harvesters that aren't confined to a particular land use zone.
How can Limits of Acceptable Change allow opportunities for increased economic development without worsening current problems?	• Tool must be manageable: ➢ Can't slice and dice the land into a large number of pieces. • The limits and tools need to be dynamic, and can't be set in stone • Need a clear, common regional vision of what's desired so that everyone is working together. All communities must participate in developing this: ➢ Wildlife safe – healthy, good number. ➢ Clean air and water. ➢ Maintain access to land (opportunity) – in time, space, number. ▪ "Sustainable" for our children and grandchildren.
Will use of conservative thresholds in sensitive areas be enough?	• It is critical that proponents recognize that "No really means no", and after cumulative effects 'stop signs' are developed that efforts shouldn't start that keep chipping away at the stop signs.

5 AFTERNOON PLENARY SESSION

After lunch the workshop resumed with 34 participants. To respond to concerns about the limited time provided for the small group discussions, the workshop agenda/format was revised and the two remaining presentations on Indicators and Thresholds were grouped together, thereby providing the breakout groups with more time to discuss Indicators and Thresholds.

6 AFTERNOON SMALL GROUP DISCUSSIONS – INDICATORS AND THRESHOLDS

Table 3 provides the notes that were collected during the small group discussions for the social-cultural Indicators and Thresholds.
Table 4 and 5 provides the notes that were collected during the environmental small group discussion on Indicators and Thresholds, respectively.

Table 3: Notes collected during the Socio-Cultural Small Group Discussion on Indicators and Thresholds for the Beaufort Delta Region.

Questions asked of participants	**Feedback from participants**
General comments	• Will a draft of the report be sent to the communities for review and comment (not just the attendees)? (Note: Subsequent to the workshop it was confirmed by ESRF that the draft report would only be reviewed by TAG). • The inter-agency committee (Inuvik) should have been invited to this workshop. These agencies are also present in the communities. • Gwich'in Social and Cultural Institute - should have been invited • Deborah Tynes - Director Social Services - should have been invited • We need to get access to the reports that have already been done.
Are there better indicators available?	• Discussing the item of suicide, alcohol abuse, vandalism - escalates at a certain time of year. No infrastructure to provide things for kids to do. If we had the $ to hire someone to have something to do for kids…we need space to hold events. Trying to find something for a community to do each night is a concern. • Young adults have nothing to do after 10pm - what will they do at night? • Over the past year all these problems were escalating (no one to talk to, uncomfortable). • Housing issue: there are rules now with getting housing (extended family). • A lot of our children are now experiencing 'social passing'. Just because they are of a certain age they get passed on to the next grade. • A lot of the teachers are here for a very short period of time. In the past they would stay for an extended period. Now they do not get involved in events like before. They don't interact with the community. The respect has to work both ways. It is not in their job descriptions so they don't have to get involved. • When it comes to housing the numbers work. This is an exception to other social issues. • When you look at the number of graduates it does not work as well. It does not tell you anything. • Education is an exception. We may see the levels getting higher, but they are not getting the actual education that we think they are. • People are tired of talking about issues; we already know what the problems are. • In this region - suicide, addictions, incarcerations, FAS, housing - we're bursting at the seams (way past the threshold). We need solutions. • What more do you need to tell you we have a problem with education, vandalism, additions, teenage pregnancies….we don't need anymore indicators. • Suicide: it is easy to get numbers. The trouble is the WHY. Without answering why how do you put in an intervention? • We need the numbers in combination with the whys and the hows? • Right now we are saying we are at the maximum for these indicators. • Once infrastructure is added - how would you know that it has helped? • Where does the question 'why' fit in? • Suicide, an indicator may be depression • What is the common ground around suicide (demographic - young men, education level, other common attributes) • If things are getting better: fewer child apprehensions, less vandalism, more children attending school regularly that are well fed. • What took place in the classroom is a good indication of what is happening in the community. • State of student (tired, no sleep, what did they eat that day). There are a lot of other issues, what is happening in their homes?

	• Parents working in camps - what happens to those kids? There is instability and a lot of switching around. Opportunities to work in camps affect the kids. • What happens to the family and the extended family? • Population trends? Demands on social workers are increasing (they are taxed to the limit) - it is hard to keep social workers. • How do we maintain a thriving community? We can't do it. We can't afford it. • 16-26 year olds - they have nothing to do. Bring up the fur prices - then they would have something to do. Then you have two ways to go (oil and gas) or traditional way (hunting and trapping). Economy will grow. • People can't afford a 2 bedroom house by themselves (they are sharing b/c they can't afford) • Industry, when it comes into the north, should be encouraged to look at job sharing. This may help to get people out on the land. 2.5 days wage income and 2.5 days subsistence activities. • You can't do this if you job is M-F all day. Oil companies are 2 and 2 though. • Cost of housing had jumped because of the demand of housing from industry. • When government got out of housing, the prices increased. There needs to be an intervention. They should do something about housing. • The housing corporation has empty houses. • Quit working and live on welfare (they can get housing). • The housing corporation develops these policies. They rent public housing. Rent is calculated on paystubs (25% or 30%). If you don't work you pay $32.00. If you don't bring your stub in you get charge economic rent. Lower income earners not in public housing pay more rent (can be paying $2000.00 a month). The initiatives are total backwards. We need to turn the policies around • Important not to generalize and compare one region to the next. • The cultural change here has been so rapid. This may be a lot of reasons for the dysfunction. • More accessibility to resources in other parts of Canada. • Everyone has different experiences, eg. Residential school - positive for some and negative for others. • In two generations there has been so much cultural change. • Where are people coming from? • Life skills is an important theme • The vision should be improvement, instead of using the words "not worsening social problems." It is not enough to say that we should not worsen. • The underlying economy of a region impacts the economy of the family. Small groups have all the wealth; rest of the population is marginalized. • There is a concentration of economic power - in the hands of a few. • This is considered to be good business. • Only a certain % of the economy or business should be owned by an individual or a company.
Are these indicators sufficient?	• Rate of weight gain - this may be a good indicator of enough food - a warning sign. • Money - how much money do you really need to run a household in different communities in this region? These numbers are community specific. What is the warning point that families don't have enough money? • What are the things we are concerned about? What worries us? How do we measure it to know it is getting out of hand? • Example - crowding in a house, how do you measure when crowding is too much? • What standard can be set? What is the threshold? This would give us a system to work with to determine crowding. • For housing - these indicators can be useful - housing crunch, crowding. These reports are provided to the inter-agency committee. Crime is also an indicator, and vandalism. • The community has a better handle on the indicators eg. State of equipment that children are using (more money in family), an outsider wouldn't know that. • Lifeskills, policing your own kids - this is important. • Tracking energy consumption may be a way of tracking vehicle usage on land. • We are talking about everyday community concerns. What about the other issues (off-shore, etc)? Can we talk about the effect of the pipeline? It might concern the people. What can we address to make it better? • Money for infrastructure and resources in the community; people in the community need to decide how this money should be used. • Change in policies, especially in the area of housing • Ask the right kinds of questions • Cutting out language and culture and living out on the land in order to go to school. Had to go to school in order to get a job. These are choices. • Life goes so fast, social change, • Crisis centre, justice committee - the only thing is - the men. After there is counseling the woman goes back and the problem starts again.

	• Young people running around the community with no place to go - we are looking at starting a men's shelter - need funding for this. • Life skills would a good workshop in our community; no shop, no home economic, no buses. • No counselor in our school • Suicides • This creates a problem in our community. • We have to get together as a group to address these problems. • Need direction - which way to go (life skills for men and women) • Family counseling • Social promotion - there are quite a few children passing through school this way. • What happens when they want to go to college? • It is better years back • The senior citizens home did help our elderly people - but no one to help out to give them medicine (funding for staff), some elders have to leave the community to get care. • Elderly care is an indicator that should be added. • No bussing - no kids going to school • Transportation infrastructure • Need more capacity within aboriginal organizations. We don't have enough skilled people in the communities - to work with the elderly, we need more people that are formally educated to take on these roles. For the people that are there, there is the potential for burn out. • We have to solve our own problems - we don't want it to be dependency. • Burnout rate may be a good indicator • We've trained people to take care of elders and then there is no funding for those jobs. • Government took the responsibility away from the people. Discipline used to be the parent's responsibility, government took that away and now kids are not disciplined… • The initiative is backwards - • Where do we start? • There would be counselors • Children would be going to school • Adequate nutrition • Gain weight at the appropriate time • Money given with appropriate rules • Appropriate housing • Appropriate care for the elders • Training in life skills • How to spend money properly • There would be appropriate food in the community so people would have the choice. • Funding needed to give food to children in school • The practical side of education • Because of the laws against disciplining children there is a lot more elder abuse. More conflicts in the house. • Elder abuse should be flagged as an indicator • Taking kids on the land is something that does happen in communities (school or no school). • Health curriculum covers diabetes, aids, STDs, etc. • Health board has a diabetes educator and nutritionist (not currently staffed) • These are STD clinics - one on one - not a class or course. • There are community health representatives • Sometimes people are too embarrassed to go to nurse, they will go to other people in the community for condoms, etc. • Communication is a big thing with these issues.

Table 4: Notes collected during the Environmental Small Group Discussion on environmental indicators for the Beaufort Delta Region.

Questions asked of participants	Feedback from participants
General Comments: • Concept of core area not intuitive (better word would be 'undisturbed areas') –seems to be opposite of what some people expected • In this region we have boundary lines and concern that proposed approach won't work here • Cautionary thresholds – should be when increased monitoring occurs • There is confusion between cautionary thresholds and precautionary approach – report will have to define the terminology that is used • Comments that local people should have been involved from the get-go –don't want to see mistakes from the past repeated	
Do candidate indicators provide enough linkage & balance between environmental & social issues?	• Beluga management areas were established to protect species, but just as important to protect harvest – therefore, on some levels they may be sufficient, but on other levels they aren't sufficient • Indicators need to balance habitat loss and harvest. Latter is managed with harvest regulation, former with activity or land management.
Are there better indicators available?	• Why are special management areas 'indicators' instead of 'VC's'? Suggestion that they are sometimes used to define the range (or habitat used by) of a species
Are these indicators sufficient?	• Doesn't appear to be an indicator that captures barriers to movement • Should include reference to seasonality with indicators (e.g., some species are only present at certain times of year; or some areas are only used at certain times of year) • Some indicators may have bigger environmental impacts than others (e.g. road density) • Need some measure of useable habitat (habitat effectiveness) • The direct and indirect effects of roads speak to available/usable habitat; some activities will displace animals; total km of roads is one indicator that has been widely used to track these indirect effects. • Need to track other human activities besides development (e.g., harvest) and look at the combined effect of habitat loss, disturbance, and harvest or hunting pressure - also have to look at natural factors • Didn't see a differentiation between permanent and temporary habitat loss and need to look at temporal scale somehow • Need a classification of disturbances that also looks at recovery rates; report will also include decision rules for discussion purposes • KIBS – uses 1% habitat loss over a 3-year period and this is still up for discussion • With some species will have to look at seasonally important habitats and how much of that habitat is available – one method won't fit all species and some flexibility is required • Caribou from Richardson Island have disappeared due to human activities. How much habitat loss should be tolerated? TA – need to apply caribou response from other areas to this area • Questions how balancing of issues (e.g., changes to caribou range) will be determined • Since caribou harvest is so important to area, there should be a low tolerance for risk. Many other communities have low tolerance for other risks (e.g., impact to beluga harvest) • How is it contemplated to quantify and assess resources that are temporal and that move? • Question raised whether or not ice roads located many kilometers offshore can be maintained • Sometimes indicators and thresholds to protect habitat fail to address harvest
Is there enough information to use and monitor these indicators?	• For some species there probably is – for other species such as fish and marine mammals there isn't. For some species there are data gaps regarding why some animals use some areas (e.g., belugas in the delta) • May not always have all the data needed to understand why some things are happening (e.g., caribou leaving the area before activity in seismic activity increased) • We seldom understand why some species use a specific area • Monitoring of 'undisturbed areas' should begin immediately.
Can the candidate indicators be linked to existing management processes?	• Need to look at the bigger picture

Table 5: Notes collected during the Environmental Small Group Discussion on environmental thresholds for the Beaufort Delta Region.

Questions asked of participants	Feedback from participants
What information should be used to develop candidate thresholds/limits?	• Sustainability of resources over the long-term is critical • Is current level of disturbance on the landscape acceptable or how much more can it handle? - suggestion that current level of disturbance may be acceptable because of existing technology - in certain areas some species may not be able to absorb 30% and may be able to in other areas - how do you quantify/balance the 'rewards' for absorbing the risk? Models are sometimes used to predict the future • Social thresholds are low for harvested species because there is a low risk tolerance for anything that could affect harvest or the opportunity to harvest; compensation is required, but this doesn't address the issue of lost opportunity • For buy-in: - need to know right now where we sit in terms of habitat and population numbers - traditional knowledge would also need to be integrated with technical info • What will it take to get buy-in? - some scientific info would be needed (e.g., changes need to be measurable) - need source of info that can be trusted and provides info information that helps people make a decision - air and freshwater already have pretty good standards, but the 'gap' is in the terrestrial and identifying what is acceptable • Does 'trustworthy' information need to be developed locally? It depends on the parameter being looked at (e.g., seismic data could be from other area, but for local species in different types of habitat local expertise would be more important) • Trust – sometimes can talk to developers until blue in the face, but they only understand after they have gone out on the land for themselves. This would also help get to acceptable levels of disturbance • Is there enough information in the region to make decisions and what are the next steps? - still need to go through the critical step of identifying candidates before we can set limits - identifying candidates isn't that difficult and we should be able to just ask people what they care about, e.g., whales, caribou, geese, fish/trout/whitefish/herring, berries, access to land to furbearers and traditional activities • Beluga Management Zone has to be a zero development area • Don't understand all cause-effect relationships, so this will need to be factored in. • Air/water standards are useful starting point.
Will the Limits of Acceptable Change /Tiered Threshold system work in the Beaufort Delta region?	• Most people, by show of hands, see some applicability in their jobs. Comments – buy-in and data is critical • Seems to be agreement that there would be some benefit to the process.
How should trade-offs of candidate thresholds/limits be evaluated?	• Defining cumulative effects and potentially acceptable effect/trade-off has to involve some sort of rational and transparent decisions • One difficulty in accepting approach is that if 10% development is acceptable, then development will likely be concentrated more in some areas than others. It is important to put numbers in proper context, and by running models it will help people to more fully understand the tradeoffs. But it is important that the data used is trustworthy and accurate. • Is there a benefit at looking at what the trade-off benefits would be to have 0.5% habitat loss in some protected areas? • One approach would be to work through examples for multiple species. • Don't just focus on negative effects, also need to consider positive effects and opportunities for improvement.
How should thresholds be implemented?	• Can ecoregions be used such as the big building blocks, e.g., vegetation? Or a charismatic mega-fauna – blended approach may be needed, e.g., don't put all of your eggs in one basket. • Management boundaries can be based on both habitat and harvest for key species. • There are land-use plans that have been developed and these need to be incorporated. Don't re-invent wheel -

	use what has already been developed. ICCPs, Gwich'in Land Use Plan and other existing documents seem to be a reasonable place to start. • Build on existing ILA process.

7 REFERENCES

Dillon and Salmo. 2004. Beaufort Delta Cumulative Effects Assessment Project: Information Package for Workshop Participants. Prepared by Dillon Consulting Limited, Calgary, AB, and Salmo Consulting Inc., Calgary AB, for the Technical Advisory Committee, Environmental Studies Research Fund, Calgary, AB. 17 p.

APPENDIX A

WORKSHOP AGENDA

AGENDA

Environmental Studies Research Funds - Cumulative Effects Project Workshop
October 5 and 6, 2004, Inuvik, NT, Midnight Sun Recreation Centre

Tuesday, October 5, 2004

3:00 – 5 PM: Meeting with Community Representatives

- Review of study objectives and process for ESRF workshop
- Using cumulative effects Valued Components, Indicators, and Thresholds to help manage cumulative effects
- Question and Answer Period
- *Option exists to extend discussion past 5:00 PM*

Wednesday, October 6, 2004

8:30 – 8:55 Continental Breakfast/Coffee

8:55 – 9:00 Opening Comments/Introductions – Kerry Brewin

9:00 - 9:05 Welcome – Laura Johnston, Technical Advisory Group

- Background to ESRF Cumulative Effects Project
- Workshop Objectives

9:05 – 9:15 Workshop Agenda– Terry Antoniuk / Nalini Naidoo

- Introduction of consulting team
- Overview of Agenda, Ground Rules, etc.
- Overview of October 5 Session with Community reps
- Facilitator's role.
  - How information from this workshop will be used

9:15 – 9:30 Cumulative Effects Management – Terry Antoniuk

- Managing cumulative effects in the Beaufort Delta Region
  - Management objectives
  - Valued Components
  - Indicators
  - Thresholds and Limits of Acceptable Change as 'Speed Limits'
- Proposal for Beaufort Delta region
  - Regional vision
  - Valued Components

9:30 – 10:15 Small Group Discussions

Break into **two groups** (Environmental; and Social/Cultural). Each group will discuss the proposed regional vision and Valued Components.

- Are the Valued Components appropriate?
- How conservative should Thresholds be in areas defined to have sensitive or valued resources?
- Will use of conservative Thresholds in sensitive areas be enough to protect the environment?
- Should Thresholds and Limits of Acceptable Change be different for the various land use zones and categories identified in the Inuvialuit Community Conservation Plans and Gwich'in Land Use Plan?
- What other information sources should be used to set environmental Thresholds or Limits of Acceptable Change?
- How could Limits of Acceptable Social Change allow opportunities for increased community and regional economic development but not worsen existing social problems?
- What other information sources should be used to set social Thresholds or Limits of Acceptable Change?
- Does this framework provide enough linkage and balance between environment and social areas?

10:15 – 10:30 BREAK

10:30 – 11:20 Small Group Presentations

- Summarize conclusions of small group discussions (10 minutes each)
- Questions, Answers, and Large Group Discussion – 20 minutes

11:20 – 11:45 Cumulative Effects Indicators – Terry Antoniuk / Allice Legat

- Selecting and using Indicators
  - Generalized vs. issue- or species-specific
  - Reflect sources of cumulative effects
  - Information readily available
  - Linked to other regional, territorial and national initiatives
- Candidates for Beaufort Delta region
  - Environmental
  - Social

11:45 – 12:45 LUNCH BREAK

12:45 – 1:45 Small Group Discussions

Break into **two** groups (Environmental; Social and Cultural). Suggested topics for each group to discuss for the proposed Indicators.

- Is there enough information to use candidate Indicators for oil and gas projects?
- Do the Indicators provide enough information to allow cumulative social and environmental effects to be evaluated?
- Can the candidate Indicators be linked to existing regulatory processes, management plans and initiatives?
- Do the candidate Indicators provide enough linkage and balance between environmental and social areas?
- Are there better Indicators available?

1:45 – 2:20 Small Group Presentations

- Summarize conclusions of small group discussions (10 minutes each)
- Questions, Answers, and Large Group Discussion – 15 minutes

2:20 – 2:45 Thresholds – Terry Antoniuk / Allice Legat

- Developing and Using Thresholds
  - Limits of Acceptable Change
  - Tiered Thresholds
  - Evaluating Trade-offs
- Candidates for Beaufort Delta region
  - Environmental
  - Social

2:45 – 3:00 Break

3:00 – 4:00 Small Group Discussions

Break into **two** groups (Environmental; Social and Cultural). Suggested topics for each group to discuss on Candidate Thresholds.

- Is the Limits of Acceptable Change system applicable to the Beaufort Delta region?
- Is the Tiered Threshold system applicable to the Beaufort Delta region?
- What information should be used to develop candidate Thresholds or Limits of Acceptable Change for small projects?
- How should trade-offs of candidate Thresholds and Limits of Acceptable Change be evaluated?
- How can Thresholds be implemented?

4:00 – 4:45 Small Group Presentations

- Summarize conclusions of small group discussions (10 minutes each)?
- Questions, Answers, and Large Group Discussion – 25 minutes

4:45 – 5:00 Concluding Remarks, Acknowledgements and Thank you

- *Invite participants to submit additional written input post-workshop and distribution of a post-workshop questionnaire*

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APPENDIX B

LIST OF ESRF CUMULATIVE EFFECTS PROJECT WORKSHOP ATTENDEES

LIST OF ESRF CUMULATIVE EFFECT PROJECT WORKSHOP ATTENDEES

NAME	ORGANIZATION	Attended on Oct 5/04	Attended on Oct. 6/04
Kerry Brewin	Dillon Consulting Limited	*	*
Nalini Naidoo	Dillon Consulting Limited	*	*
Terry Antoniuk	Salmo Consulting Inc.	*	*
Allice Leget	Keano Social Analysts	*	*
Max Kotokak	Fisheries Joint Management Committee	*	*
Kevin Bill	Fisheries Joint Management Committee	*	*
Ron Gruben	Inuvialuit Joint Secretariat	*	*
John Norbert	Resource Renewable Council	*	*
Laura Johnson	Environment Canada	*	*
Richard Binder	Inuvialuit Game Council	*	*
Leonard Harry	Hunters and Trappers Committee	*	*
Tom Wright	Nihtat Gwichin	*	*
Danny C Gordon	Aklavik Hunters and Trappers Committee	*	
Jean Gruben	Tuktoyaktuk Community Corporation	*	
Evelyn Storr	Wildlife Management Advisory Committee	*	
Duane Smith	Inuvik Community Council/Inuvialuit Regional Corp.	*	
JoJo Arey	Inuvik Hunters and Trappers Committee	*	
Carol Arey	Aklavik Community Corporation	*	*
Katherin Thiesenhausen	Wildlife Management Advisory Committee (NWT)	*	*
Pippa Seccombe-Hett	Joint Secretariat	*	*
Steve Baryluk	Joint Secretariat	*	*
Bill Crossman	Aurora Research Institute		*
Chuck Brumwell	Environment Canada		*
Linda Graf	ConocoPhillips Canada		*
Tim Shopik	Mackenzie Gas Project		*
Laura Van Ham	National Energy Board		*
Mike Fournier	Environment Canada		*
Mieke VanderValk	National Energy Board		*
Jari Heikkila	Gwichin Renewable Resource Board		*
Fred Wolki	Tuktoyaktuk Community Corportation?		*
Mike Harlow	Inuvilauit Land Administration		*
Kirsti Muller	Education Culture and Employment		*
Mike Muller	RWED - Wildlife		*
Laurie McEachern	DIAND		*
Chris Lough	Chevron		*
Kevin Williams	Chevron		*
John Nagy	RWED		*
Chris Beveridge	IRHSSA		*
Michelle Crossfield	Aurora Research Institute		*
Allen Firth	Nihtat Renewable Resource Council		*
Kim Hawkins	Gwichin Tribal Council		*
Denise Kurszewski	Gwichin Tribal Council		*
Kathleen Simms	Department of Fisheries and Oceans		*
Rob Walker	DIAND		*
Joe Thrasher	Inuvialuit Game Council		*

APPENDIX C

ENVIRONMENTAL STUDIES RESEARCH FUNDS PROFILE

Environmental Studies Research Funds Profile

The Environmental Studies Research Funds (ESRF) sponsor environmental and social studies designed to assist government decision-making related to oil and gas exploration and development on Canada's frontier lands. These studies pertain to the manner in which, and the terms and conditions under which, petroleum exploration, development and production activities on frontier lands should be conducted. The ESRF program, initiated in 1983 receives its legislated mandate through the *Canada Petroleum Resources Act* (CPRA). Funding is provided by industry through levies on exploration and production properties on frontier lands.

The Environmental Studies Research Funds (ESRF) are directed by a twelve-member Management Board which has representation from the federal government, the regional petroleum boards, the oil and gas industry, and the general public. Bonnie J. Gray, Professional Leader, Environment of the National Energy Board, is the current chairperson of the ESRF Management Board.

The ESRF Management Board directs the business of the ESRF, sets priorities for study topics, determines the program budget, and facilitates the development of study proposals on behalf of the Minister of Natural Resources Canada and the Minister of Indian Affairs and Northern Development.

The program operates on a calendar year basis. The Board generally meets quarterly; however, the frequency of meetings is adjusted as circumstances dictate. The Board assesses the information requirements of government and industry to determine priorities for the study program for the coming year. The budget to support the study program and its administration forms the basis for the calculation of the levy rate schedule. The budget and levy rates are submitted to the Ministers for approval by November 1 of each year. The projects under the study program are initiated following the collection of the levies that generally occurs in the first quarter of the calendar year.

Since its inception in 1983, the ESRF has published 144 reports which are distributed free of charge. A list of these publications is available at <www.esrfunds.org/publications.htm>.

More information about the ESRF, including the ESRF newsletter, the names of the members of its management board, and its annual reports can be obtained from its website <www.esrfunds.org>.