ECOLOGICAL AND CULTURAL RESEARCH & MONITORING PLAN

FOR THE SAHTU BIOSPHERE RESERVE

Draft: August 21, 2014

TABLE OF CONTENTS

ECOLOGICAL AND CULTURAL RESEARCH & MONITORING PLAN

FOR THE SAHTU BIOSPHERE RESERVE

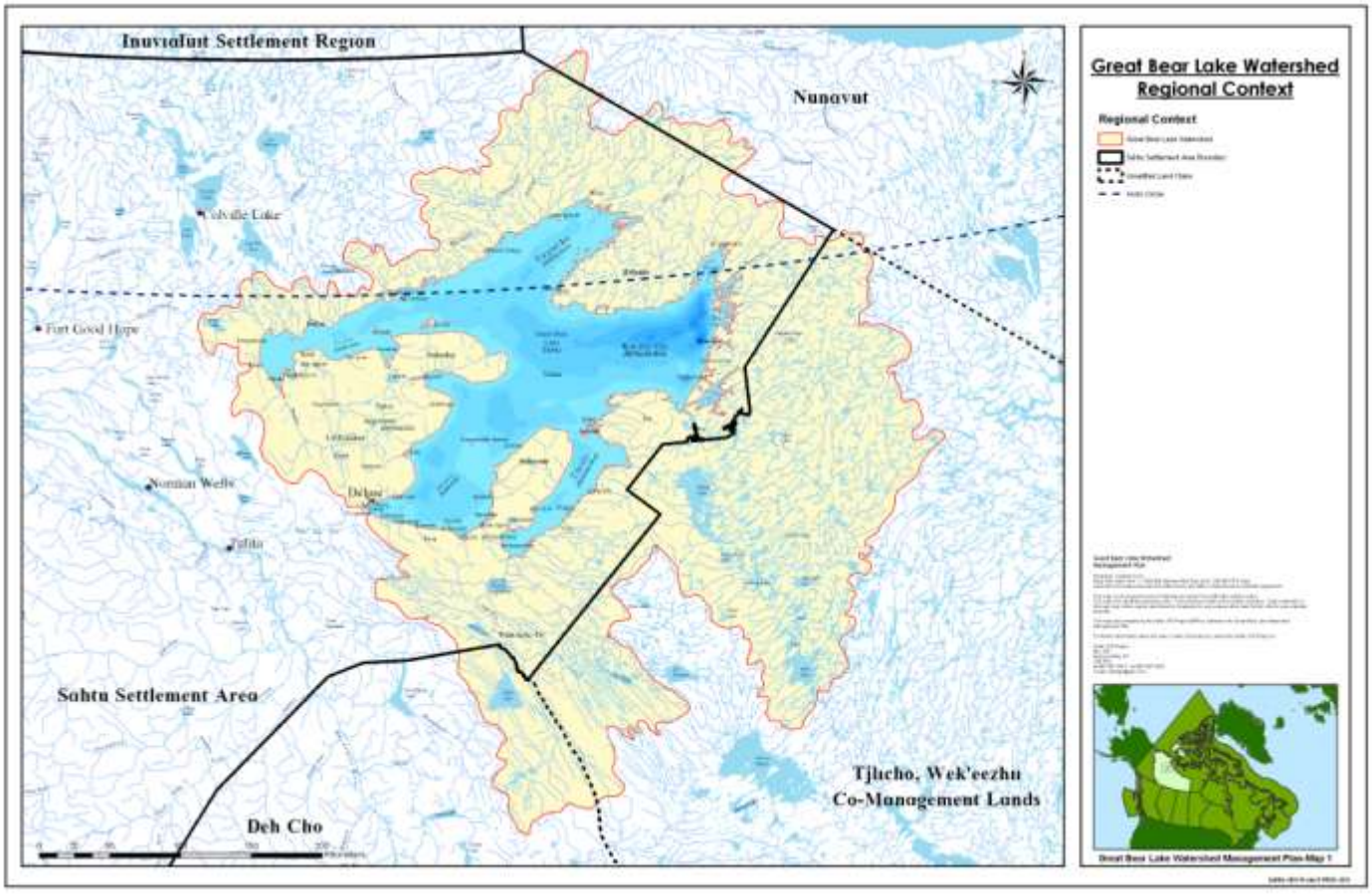

Figure 1: The Sahtu Biosphere Reserve would be comprised of Great Bear Lake and that portion of the Great Bear Lake watershed within the Délı̨nę District

1.0 Background

For many years the Sahtugot'ine of Délı̨nę have been advocating careful stewardship of Great Bear Lake and its watershed. Their efforts have resulted in the Sahtu Dene and Metis Comprehensive Land Claim Agreement (1993), the Great Bear Lake Watershed Management Plan (2005), the Sahtu Land Use Plan (2013) and the Délı̨nę Final Self-Government Agreement (2014). These agreements now provide a context for sound stewardship of the lake and its watershed, under the guidance and leadership of the Sahtugot'ine.

The Sahtu Land Use Plan establishes much of the Great Bear Lake watershed as a "special management zone". Development within special management zones is permitted, subject to stringent terms and conditions. Some areas within the watershed (e.g., Saoyú-ʔehdacho) are permanently off-limits to industrial development and others

(e.g., Edaįjla) are temporarily off-limits subject to measures set out in the Sahtu Land Use Plan. Pursuant to the land use plan, large-scale development is prohibited within Great Bear Lake itself. The zoning and conformity requirement approach set out in the Sahtu Land Use Plan allows for core protected areas, buffer areas where development can proceed if that development meets conformity requirements and does not impair the ecological and cultural integrity of the lake and its watershed. Areas of the watershed outside the Sahtu Settlement Area are subject to development in accordance with the respective land use plans and regulatory requirements.

Despite the Sahtu Dene and Metis Comprehensive Land Claim Agreement, the Sahtu Land Use Plan, the Great Bear Lake Watershed Management Plan and the Délįnę Final Self-Government Agreement, Sahtugot'ine feel that more needs to be done to ensure the long-term ecological and cultural integrity of Great Bear Lake and its watershed. In particular, Sahtugot'ine feel that their stewardship role must be enhanced and strengthened to ensure that the vision set out in the Great Bear Lake Watershed Management Plan is achieved. That vision is clear and succinct: "the waters of Great Bear Lake will remain clean and bountiful for all time". Sahtugot'ine are convinced that the only way to ensure the vision is achieved is through their stewardship.

After many discussions within the community, Délįnę elders and leaders have agreed to pursue International Biosphere Reserve designation for the lake and that portion of its watershed within the Délįnę District. The total area of the proposed Sahtu Biosphere Reserve is about 120,000 km².

While largely honorary and non-regulatory, the designation would enable Délįnę to take a more central and influential role in overseeing environmental stewardship for the biosphere reserve including a more direct role for Délįnę in enforcement on the lake, a matter of particular concern to the community. Délįnę has established the Sahtu Biosphere Reserve Steering Committee to lead the nomination process.

The Committee will finalize the biosphere reserve nomination form, build support for the nomination within the community and with partner organizations, and move the nomination forward to Sahtu Secretariat Inc., Government of the Northwest Territories, Government of Canada, and ultimately to UNESCO for approval.

The Great Bear Lake Watershed (GBLW) Management Plan emphasizes the importance of maintaining the ecological and cultural integrity of the watershed, as follows:

"*The ecological integrity of this unique watershed is maintained and, where necessary and feasible, restored. Great Bear Lake is kept clean and bountiful for all time. Activities in the watershed are designed, regulated and carried out with the particular characteristics of GBLW ecosystems in mind, including their generally very low biological productivity and slowness to recover from degradation. The generally pristine quality of Great Bear Lake water is maintained. All resource uses are consistent with conservation."*

and,

"*Activities in the GBLW protect and promote the existing and future social, cultural and economic well-being of residents of the watershed, while also having regard to the interests of all Canadians. Since a significant degree of self-determination is fundamental to social, cultural and economic wellbeing, any assessment of the*

acceptability of proposed activities in the GBLW gives very strong consideration to whether Déline supports the proposed activities. Déline residents and others are able to find work in the community and on the land."

2.0 A Sahtu Biosphere Reserve Research and Monitoring Plan

An integrated and comprehensive research and monitoring plan is needed to provide an information base adequate for the maintenance of the ecological and cultural integrity of the proposed Sahtu Biosphere Reserve (SBR).

The intent of such a plan is to enable research and monitoring programs which will characterize the current state of the environment; to provide a better understand of the functioning and structure of the SBR ecosystem; and to determine if conditions are changing due to climatic variability and/or anthropogenic activities. Programs will also characterize the current state of cultural integrity within the SBR, inventory culturally significant sites and help in understanding the state of cultural integrity and socio-economic health. Research findings will inform better decision-making and contribute to monitoring and reporting in the NWT (e.g., the NWT Cumulative Impact Monitoring Program and Audit).

This research and monitoring plan, which is derived from one developed in 2005 to support the Great Bear Lake Watershed Management Plan, is a starting point and is intended to be a living document that will be regularly updated. The plan and its programs will need to be adapted as experience is gained, information is collected and the collective understanding of the cultural and ecological environments changes.

Research and monitoring programs will also facilitate and strengthen the role played by Délı̨nę organizations in SBR co-management, respect for and connection with the land, and the interpretation and transmission of Sahtugot'ine values to younger generations. Connections to the land will be strengthened by the direct involvement of Délı̨nę elders, hunters and trappers, and youth in all aspects of research and monitoring programs, from inception through design, implementation and reporting.

Successful implementation of the plan will require the cooperative involvement of organizations such as the Délı̨nę Renewable Resources Council, Délı̨nę Lands Corporation, Délı̨nę First Nation and Délı̨nę Charter Community governments, Sahtu Renewable Resources Board, Sahtu Secretariat Inc, federal government departments including Fisheries and Oceans Canada and Environment Canada, the Government of the Northwest Territories, industry, and other non-government organizations. Training and capacity building opportunities should be incorporated in all programs.

The SBR research and monitoring plan has the following broad objectives:

- promoting community-based research and monitoring programs;
- using both scientific and traditional knowledge throughout;
- encouraging the broader research and monitoring community to conduct studies in the SBR;
- creating a research centre in Délı̨nę to coordinate research and monitoring programs, to facilitate community engagement in these programs and to facilitate the dissemination of program results;
- acquiring a better understanding of climate change and long-range transport of atmospheric pollutants impacts in the SBR;

- acquiring a better understanding of ecosystem functioning in the SBR;
- improving the management of the SBR through better information;
- establishing appropriate indicators of ecosystem and cultural health;
- improving communication and the sharing of information generated from research and monitoring projects, and
- ensuring that community training opportunities are incorporated in all programs.

In the short to medium term (1 to 10 years), research and monitoring programs promoting the ecological integrity of the SBR will focus on establishing a baseline understanding of the SBR ecosystem including the use of control sites in conservation zones. Specific objectives include:

- establishing current environmental conditions of the SBR;
- improved understanding of climate change and the effects of long-range transport of atmospheric pollutants on the SBR; and
- improved understanding of ecosystem functioning.

In the short to medium term, research will also focus on establishing a sound understanding of cultural integrity and socio-economic health in the SBR. Among the key objectives are:

- documenting culturally significant sites in the SBR (including places, trails, grave sites, archaeological sites, etc.);
- documenting elders' place names and stories and the oral histories associated with the sites identified above; and
- undertaking research and monitoring programs that will identify and track key socio-economic and cultural indicators in Délı̨nę.

A key purpose of the broad research and monitoring plan is to enable Délı̨nę organizations and individuals to play an increasing and ultimately central role in SBR research and monitoring. In the short and medium term, the key objective will be to determine and measurably increase the role that Délı̨nę plays in SBR research and monitoring. In the longer term Délı̨nę residents and organizations should be fully involved in SBR research and monitoring. Key objectives include:

- incorporating training opportunities for Délı̨nę residents in all SBR research and monitoring projects;
- involving Délı̨nę elders as research collaborators and trainers;
- linking Délı̨nę schools, school kids, teachers and elders with research and monitoring programs; and
- using the research and monitoring program to aid in the transmission of Sahtugot'ine culture from the elders to the younger generations — both in school and on the land.

The SBR Research and Monitoring Plan is divided into eight different themes:

- **Terrestrial Research & Monitoring;**
- **Water Quality Research & Monitoring;**
- **Water Quantity Research & Monitoring;**
- **Permafrost Research & Monitoring**;
- **Fisheries Research & Monitoring;**
- **Aquatic Ecology Research & Monitoring**;

- **Neh Karila K'ets'Edi Research & Monitoring;**
- **Cultural Research & Monitoring; and**
- **Economics Research & Monitoring**

The research and monitoring programs described in the following sections fall into the above categories.

3.0 Terrestrial Research and Monitoring

Although basic information is available for major species such as caribou, muskox, marten and waterfowl, there are dozens of mammal and fish species, more than a hundred bird species, and thousands of species of invertebrates, plants, mosses and lichens on the land surrounding Great Bear Lake for which there is little basic information on numbers and distribution. Also, information on the physical environment has been developed primarily from remote sensing and satellite imaging and needs to be verified on the ground. The basic objectives of the terrestrial research and monitoring program include:

- establishing a baseline to assess the diversity of wildlife throughout the watershed prior to any new developments, including tourism;
- studying the current health of the ecosystems and wildlife populations in the watershed;
- inventorying the landcover within the watershed, as the basis from which changes to wildlife habitat can be measured over time;
- documenting subsistence, resident, non-resident, and commercial harvest of wildlife, including fish, and,
- establishing a baseline of natural occurrences of known toxic elements, such as mercury, and significant mineral deposits of economic importance.

3.1 Baseline studies of wildlife diversity and distribution

Wildlife diversity is an important indicator of the ecological integrity of the watershed and of its overall health. A baseline inventory of wildlife species is needed to determine species distribution, composition, and relative abundance throughout the SBR. The main goal of monitoring is to document any changes in populations over time and to form the basis for adaptive management plans as required.

Boreal woodland caribou and grizzly bear have been extirpated in some parts of Canada. In the NWT, boreal woodland caribou are assessed as Threatened (COSEWIC; SARC) and therefore, grizzly bears and wolverines are assessed as Special Concern (COSEWIC) in Canada including the NWT. All species at risk warrant both research and long-term monitoring.

Barren-ground caribou have been extensively researched since 1996. However, recent population declines require ongoing research and monitoring to determine the health of the herds using the SBR and sustainable harvest levels.

Muskox studies are recommended since muskox hunts have the potential to be one of the key elements of Délı̨nę's growing tourism business and muskox populations appear to be expanding in both numbers and range within the SBR.

Among other things, caribou and muskox studies should include aerial population surveys (to determine relative abundance and distribution); fall composition surveys (to determine number of bulls, cows, yearlings and calves); spring recruitment surveys (to determine the number of calves that survive the first year); productivity surveys (to determine birth rates); and range use/movement surveys.

Small mammals and furbearers include the following key species: marten, wolves, wolverine, beaver, snowshoe and arctic hare, voles and lemmings. Small mammal studies should include: winter track counts, fecal counts (e.g., hares), live trapping/mark/release (e.g., voles), and aerial lodge counts (e.g., beaver). Many of these small mammal/furbearer studies would be good community-based monitoring projects, especially for school involvement.

Nine bird species have been assessed by COSEWIC: Eskimo curlew (Endangered in Canada), common nighthawk, bank swallow, barn swallow, olive-sided flycatcher, (Threatened in Canada), rusty blackbird, horned grebe, peregrine falcon and short-eared owl (Special Concern in Canada) and therefore, warrant both research and long-term monitoring. To date, there is very little documentation on bird species distribution, composition and relative abundance in the SBR. Studies for songbirds, shorebirds, and raptors should include: recording bird observations, avian population monitoring, migration monitoring, breeding bird inventories and banding stations. Specific waterfowl studies would include: systematic aerial reconnaissance, breeding pair, brood production and staging surveys of dabblers and divers, and banding stations.

More information is required for the following:

- scaup
- songbirds
- shorebirds
- raptors and owls

As amphibians have both an aquatic and terrestrial life stage, they are widely considered to be sensitive environmental indicator species. Some scientists have referred to amphibians as the ‘canaries in a coal mine’, a reference to their potential value as indicator species of environmental decline. To date, little research has been done on amphibians in the Sahtu. Basic occurrence, abundance and distribution studies are required for frogs (boreal chorus and wood frogs).

To date, little to no research has been done on invertebrates in the NWT, which gives them a designation of “Undetermined status”. Basic occurrence, abundance and distribution studies are required for:

- moths and butterflies
- dragonflies
- spruce budworm and other forest pest species
- overall insect abundance and timing of emergence

Baseline studies should focus on establishing conditions in key representative areas in the SBR against which future changes can be tracked.

The basic project would inventory and monitor barren-ground caribou, muskox, marten, scaup, one representative songbird, one representative shorebird, and frogs. Caribou

and waterfowl are very important subsistence species to the community of Déline, as determined by the Sahtu Settlement Harvest Study. Economically, muskox (licensed outfitting) and marten (trapping) are very important to Dél̨nę or have the potential to be. Frogs, shorebirds, and songbirds are sensitive indicator species of environmental change. This project is considered to be the minimum required to begin the process of determining the status of key terrestrial species. An enhanced program would inventory and monitor all the species listed above in each of the categories: large mammals, small mammals/furbearers, birds, amphibians, and invertebrates.

One-time sampling every five years is considered to be the minimum level of effort required to generate the needed data, while annual sampling for 5 years with long-term sampling every five years after the completion of initial baseline collection would provide significantly better results, and annual sampling indefinitely would provide the most detailed and precise data. Protocols of low-cost and effort annual sampling exist for some groups (e.g., small mammals and invertebrates) and could be implemented as part of community-based monitoring.

Caribou and muskox would be surveyed over the short-term (1-2 years), while marten, scaup and frogs would be surveyed over the medium term (5-6 years). Both the songbird species and shorebird species would be monitored over the long-term.

3.2 Studies to determine the current health of wildlife populations

The main goal of this initiative is to determine a current 'snapshot' of species physical condition (health), including documenting diseases and parasites, throughout the SBR. Currently, little is known about how pathogens affect wildlife populations and how these pathogens are affected by changes in the ecosystem, particularly in the SBR.

The GNWT's Wildlife Health Monitor program provides for collection of a standard suite of biological samples from harvested barren-ground caribou. The samples enable monitoring of body condition, pregnancy, contaminant levels, parasites, and disease occurrence, all of which are key indices components for long-term monitoring of the overall population health of barren-ground caribou herds. Training in sampling procedure has been provided for community members who then report any diseases, parasites, and abnormalities that they find in the wildlife species harvested throughout the year.

The sampling project would include annual sampling of opportunistic and planned collections for 5 years with long-term sampling every five years after the completion of initial baseline collection (minimum), or annual sampling of targeted populations indefinitely (a better approach), or annual sampling of all species (the best approach).

3.3 Landcover studies

Many factors can contribute to the decline of wildlife species, with the most important often being habitat loss or fragmentation. The main goal of this initiative is to determine a current 'snapshot' of the landscape/vegetation, including berries, medicinal plants and invasive plant species, throughout the SBR allowing for detection of changes over time. The landcover inventory can also be used as an important predictive tool when determining possible key areas for wildlife species.

Studies would build on existing data already collected by ENR and Ducks Unlimited Canada by using Landsat Thematic Mapper satellite scenes. Up to six bands of

information are combined to produce spectrally unique signatures, which can then be classified using helicopter field verification (ground-truthing).

Continued mapping of seismic lines, including age, width and re-growth, can also provide important information about land use practices and their respective effects.

Permanent monitoring plots need to be established to understand the growth and succession patterns of different forest types, to monitor changes on the landscape over time that may be linked to climate change and patterns of wildlife movements, to verify land and ecological classification systems, and for habitat analysis. Permanent monitoring plots and timber cruising would include:

- regular measurements of height, age, health and other characteristics of the same trees; and,
- regular measurements of regeneration and mortality of trees, and other stand characteristics, such as ground vegetation, soil type and coarse woody debris.

The basic study would complete satellite classification every ten years with annual mapping of forest fires and seismic lines, including permanent monitoring plots to document changes that may be linked to climate change and to provide an inventory of berries, medicinal plants and invasive species. A more comprehensive study would include satellite classification (with intensive ground-truthing), random permanent monitoring plots (10), and timber cruising every ten years with annual mapping of forest fires and seismic lines. An optimum study would be to complete satellite classification (with even more intensive ground-truthing), random permanent monitoring plots (20), and timber cruising every ten years with annual mapping of forest fires and seismic lines.

3.4 Subsistence, resident, non-resident & commercial harvest of fish & wildlife

This program would continue the documentation of wildlife harvests, including fish, in the SBR by beneficiaries, other residents, and non-residents. The data collected would provide important information to enable effective management of wildlife and fish.

The study would document and summarize harvest data reported by beneficiaries in the Sahtu Settlement Harvest Study, as well as residents, non-residents and commercial hunters through ENR surveys. Community members would continue to provide harvest data to trained community interviewers. Lodges and outfitters could use guide-conducted surveys or have guest questionnaires to document sport-fishing harvest; non-resident hunter harvest reporting is mandatory in the NWT.

The minimum effort required to address this gap is quarterly reporting of subsistence, non-resident and commercial harvest. An enhanced level of the project would be monthly reporting of subsistence, resident, non-resident and commercial harvest, and mandatory monthly reporting of subsistence, resident, non-resident and commercial harvest.

3.5 Significant mineral deposits

The project would compile the location of natural occurrences of economically important elements and mineral deposits in the SBR. Mapping these geologic and geomorphologic occurrences could help scientists and others determine where efforts to study key wildlife habitat should be focused.

The study would build on existing mineral deposit and geologic (era and rock type) mapping conducted government and non-government agencies. Compilation of existing information would be complemented by additional field studies as resources and time permit.

4.0 Water Quality Research and Monitoring

Great Bear Lake is one of the world's largest freshwater bodies and the largest lake entirely within the borders of Canada. The lake is unique because of its size, northerly location and natural environment. Great Bear Lake and the watershed lakes and streams remain largely unaltered by human activity and at present, is almost certainly the largest arctic lake in the world remaining in a relatively pristine condition. Monitoring water quality in the SBR will help ensure that the quality of the Great Bear Lake aquatic environment is maintained indefinitely.

The key objectives of this program include:

- establishment of a water quality baseline on Great Bear Lake's major tributaries and the lake;
- determination of seasonal patterns in water quality in Great Bear Lake as they relate to the normal, healthy functioning of the lake;
- establishment of a long-term water quality monitoring station in the vicinity of Délı̨nę to assess trends which could be associated with long-range inputs, localized inputs, and/or climate change;
- collection of water quality measurements for the lake as a whole (in summer) and integration of those values with satellite and other monitoring approaches;
- collection of water quality data from SBR streams important to the community for water and food;
- collection of water quality data to support and augment any fisheries and/or ecological research within watershed; and,
- assessment of water quality downstream from the abandoned mine sites in the Camsell River watershed.

4.1 Baseline water quality of major inflows to Great Bear Lake

Great Bear Lake has distinctive features such as the world's largest mass of cold fresh water, very clear waters, low nutrient levels, and a relatively simple food web. Water quality should be considered an indicator of ecosystem health to ensure the ecological integrity of the lake. Without protecting water quality, the overall features and ecological integrity of Great Bear Lake cannot be protected.

The two main inflows to the lake are the Camsell River and the Johnny Hoe River, which together occupy approximately 30% of the total drainage area. The Sloan and Whitefish Rivers are also important tributaries of the lake. The Whitefish and Johnny Hoe sub-basins are very important subsistence fishery areas for Délı̨nę. Smaller tributaries to the lake include the Dease and Haldane rivers, both of which drain into Dease Arm. Presently, there is no water quality monitoring being conducted on inflows to Great Bear Lake.

It is recommended that all major inflows to Great Bear Lake be monitored to establish or build upon water quality baseline records. Monitoring the Haldane, Sloan, Whitefish,

Johnny Hoe, Dease and Camsell rivers will provide useful information on the nutrients, metal concentrations and other inputs from their respective sub-basins. Baseline conditions can be established and site-specific objectives can be developed prior to any development activity to ensure the highest level of protection for the aquatic environment.

Flow data exist for the Haldane, Sloan, Whitefish, Johnny Hoe, Camsell and Bear rivers. The relationship between water quality and quantity data on these rivers can also be investigated.

Water samples will be collected and analyzed for physical parameters (pH, turbidity, conductivity, total and dissolved suspended solids, temperature and dissolved oxygen), major ions, nutrients and metals.

Physical parameters, and major ions are important to provide basic background information on water quality and are useful for the interpretation of other results. Measurements of nutrients are a measure of the overall productivity in a water body which is particularly important for Great Bear Lake considering the relatively low nutrients which limit the growth of fish and other aquatic organisms. Metal analyses will describe the levels of trace metals in water as well as provide information about the underlying geology of an area that could hold potentially economic mineral deposits.

At least one sample from three major inflows representing each ecozone of the watershed (Camsell River, Haldane River and either Whitefish River or Johnny Hoe River) should be collected for each portion of the water-year (spring freshet, summer recession and winter baseflow) or season (spring, summer, winter and fall) to determine seasonal variability. This monitoring frequency will not provide complete representation but should allow representative sampling at each stage of the hydrologic cycle. The monitoring program should be carried out for at least five complete years, at about the same time each year, to establish a baseline against which future changes could be compared. The regular sampling will also help to address annual variability.

A more advanced water sampling project would be to collect samples every two months from all the major inflows for a total of five years. This would provide an excellent baseline on the long-term seasonal variability in water quality parameters. An ideal program would collect the full suite of analyses monthly in the six major river inflows for a total of five years. All water quality monitoring results, no matter the extent of the program, should be linked with fisheries and other types of research in the SBR.

4.2 Great Bear River seasonal variability

The only active water quality monitoring site in the watershed is located on Great Bear River at the outlet of Great Bear Lake, active since 1969. Two to six samples have been collected by Environment Canada each year and are analyzed for routine parameters including pH, conductivity, turbidity, total dissolved and suspended solids, major ions, nutrients and metals.

The basic plan for monitoring water at the outflow of Great Bear Lake is to augment the current monitoring to ensure that sampling takes place in all four seasons. An enhanced plan would be to augment the current monitoring plan to sampling every two months while the best plan would be to conduct monthly sampling. The program can largely be conducted by Délı̨nę residents at relatively low cost.

4.3 Monitoring of baseline water quality in Great Bear Lake offshore Déline

While Great Bear Lake is a healthy lake with naturally low concentrations of plant nutrients, dissolved salts, and a near-neutral pH (acidity) this could change through a variety of mechanisms. One mechanism is long-range atmospheric transport of phosphorus, nitrogen, sulfur, and other compounds. A second mechanism is through localized inputs into the lake from various human activities including sewage and industrial releases. While both of these activities currently are minimal on Great Bear Lake, it is important to establish baseline conditions as development in the north is expected to grow markedly over the decades. For example, if nutrient levels began to increase, microscopic algae could become more abundant (chlorophyll levels become higher) and the water less clear (Secchi disc readings become lower). Oxygen levels in deeper waters could also decrease as productivity increases in the surface waters.

Many aspects of water quality vary seasonally. Oxygen concentrations vary with temperature, lake mixing, and lake cover. Plant nutrients also cycle as they are reduced in concentration with plant growth and then increase as dead material decomposes. Therefore, it is desirable to measure water quality on a seasonal basis.

The vicinity of Délı̨nę is selected as a “Master station” for the long-term monitoring of lake water quality because travel distances to the Master station will be short, allowing for frequent and relatively inexpensive sampling in comparison to more remote sites. Second, while Délı̨nę is small, the community size will change over the decades and this increase could potentially affect Great Bear Lake waters through the release of various effluents and discharges into the lake.

The Master station would be the focus of water quality monitoring and the results linked to aquatic biology studies and to tributary sampling. Water quality measurements would include Secchi disc depth, a Hydrolab cast, and water quality sampling with depth. The number of depths would depend upon water column depth. A minimum of two depths would be sampled for water quality as in “baseline water quality inflows” with the exception of major ions and metals, which would be sampled only once.

A minimum sampling effort would involve taking samples from three depths, four times a year for a total of five years. An enhanced sampling program would provide sampling quarterly, with an increase in sampling frequency to bi-weekly during the open water season. The optimum sampling regimen would be to collect samples at several depths monthly, with an increase in the frequency to biweekly during the ice-free season.

4.4 Spatial variations in water quality in Great Bear Lake

Great Bear Lake is a large lake with five major arms and a central area. Numerous tributary inflows bring essential plant nutrients and salts into the lake. The shallow waters are probably the most important areas in the lake for plant and animal growth, including fish. The microscopic plants, which form the base of the food web, are believed to grow slower in deeper, offshore waters.

There are two aspects to measuring spatial variation of water quality in Great Bear Lake: a general survey of the physical and chemical features of Great Bear Lake to determine inshore-offshore differences in these features; and the effects of tributary inputs on the

water quality of the major arms of the lake. Such a study would be linked with tributary studies, aquatic biology studies and studies of the heat budget of the lake.

A second way to obtain information on water temperature, chlorophyll concentrations, movement of river plumes, etc. is through satellite images. The images only provide a picture of the upper few meters of the water but do provide a detailed picture of the entire lake. Satellite images could be used to investigate how these features of the lake change through the ice-free season. Such images also could be used to investigate how freezing and thawing occurs and when.

The basic project required to collect the necessary information on physical and chemical characteristics would include the collection of three to four samples in each arm of Great Bear Lake during open water season in one year. The studies could be combined with other projects examining fish or other aquatic resources. An enhanced version of the project would include a survey of two to three arms and the offshore areas of Great Bear Lake in one year, followed by surveys of the rest of the lake in the following year. These surveys would be conducted in conjunction with some analysis of satellite images taken during the same time period. The most advanced version of the project is a comprehensive survey of the entire lake in midsummer in a single year with the use of satellite images to provide information on temperature, chlorophyll, river inflows, etc. in other times of year. The satellite images would be verified or ground truthed, with real data. In later years, this could be expanded to sampling in three time periods.

4.5 Baseline water quality of lakes and rivers

In addition to Great Bear Lake and the tributaries flowing into it, there are numerous smaller lakes and streams in the watershed. For example, there are a series of lakes within the Johnny Hoe River system, including Lac Ste. Therese where the fish have high mercury levels. This river system is one of the traditional fishing areas for the people of Délįne, however fishing in this area has now declined because of the mercury problem. Mercury levels are lower in Kelly and Mahony lakes, and also in the Great Bear Lake drainage basin.

Baseline water quality studies are desirable on the lakes and tributaries within the Great Bear Lake drainage basin to establish baseline conditions. Such studies would be integrated with aquatic biology and fisheries studies on these lakes. Data collected during these studies could be used to help explain why mercury levels are high in fish in some lakes and not others.

The basic level of effort required to obtain the necessary information from these lakes would be to sample three to five lakes or streams that have been identified by the community as traditionally important. Three sets of measurements would be collected from each site per year. A better project would be to collect water quality measurements at least once in the summer in major lakes or streams. Samples would be collected at two depths, with bathymetric mapping of the larger lakes. The optimal project would include water quality measurements at two depths at least once for the major water bodies in the watershed, with bathymetric mapping of the water bodies.

4.6 Water quality at abandoned mine sites in the Camsell River basin

Residents of Délįnę have raised concerns regarding past mining practices in the Camsell River basin. These concerns stem from the silver and other base metal mining activity in the area that took place intermittently from the 1960s until closure of the last

mine site in 1985. The Silver Bear mine sites include Terra, Northrim and Norex mines on the Camsell River, approximately 12km upstream from Great Bear Lake. The mine sites were abandoned without proper decommissioning, remediation or long-term monitoring plans to ensure that the sites were not negatively affecting the receiving environment.

Mine site runoff can result in significant adverse impacts to aquatic ecosystems. Downstream water quality such as pH, major ions and concentrations of certain metals can be affected by how the land is used. Monitoring water quality at abandoned mine sites is important to determine potential impacts from the abandoned mines on the local area and downstream receiving aquatic environment.

Since 2002 a study has ben underway to determine metal concentrations at various locations at each mine site including tailings containment areas, seepages from waste rock piles and drainage from mine adits and to determine whether contaminants are migrating into and potentially impacting the local area and nearby water bodies. Current water quality conditions of the Camsell River will be established. This program has been coordinated with monitoring at other abandoned contaminated and waste sites in the Sahtu Biosphere Reserve, where economically and logistically feasible. ***(Current status? Recommendations?)***

5.0 Water Quantity Research and Monitoring

The hydrologic regime of a watershed is a product of topography, geology, elevation, climate, permafrost conditions, drainage area, the presence of lakes and vegetation cover. Given the size and diversity of the Sahtu Biosphere Reserve, the physiography varies from one area to another. There are three terrestrial ecozones surrounding Great Bear Lake: Taiga Plains, Taiga Shield and Southern Arctic. It is important to establish baseline conditions in each ecozone in order to characterize the hydrology and to attempt to understand the potential impacts of change, whether natural or human-induced. Key objectives of this program include:

- establishment of a baseline of the existing flow regimes in order to characterize the hydrology of the watershed;
- establishment of a research and monitoring plan that will use both existing and new sites to improve hydrologic and climatic records; and,
- promotion of efficient and effective research and monitoring within the SBR focusing on components water balance aspects including precipitation, evaporation and runoff.

5.1 Hydrometric record

Since the early 1960s, hydrometric data have been collected from select locations in the Sahtu Biosphere Reserve. A few tributary streams were monitored between the mid-1970s until 1992. In all, nine stations have operated within the basin with records ranging from six to 43 years. At present, however, only three stations are operating: the Camsell River at Clut Lake, Great Bear Lake at Hornby Bay and Bear River at the outlet of Great Bear Lake. Given the diversity of the landscape around Great Bear Lake and the paucity of hydrometric gauges, differences in hydrologic characteristics of inflows to the lake are not currently being monitored. Although the historical records available for certain sites are helpful in characterizing hydrologic regime, the data records are relatively short and therefore have limited statistical value. They also fail to provide

information regarding current conditions. In order to obtain data representative of inflows to Great Bear Lake, more hydrometric stations should be installed at a variety of locations around the lake.

To quantify the larger inflows to Great Bear Lake, sites with historic data and with reliable locations should be re-established. These include the following: Haldane River, Sloan River, Johnny Hoe River and Whitefish River. These data would add to those currently available for the Camsell River and Bear River outflow. This would require several site visits per year, including following break-up and freeze-up to check stations and equipment.

5.2 Small basin hydrology

Establishment of small basin hydrology allows for a better understanding of the potential impacts of change within these basins. In order to characterize the hydrology of tributaries to Great Bear Lake, the water balance of three small basins representative of the three ecozones surrounding Great Bear Lake should be established. The collection of precipitation, evaporation, runoff and meteorological data is required.

The project requires the establishment of water level and climate stations at sites within three small basins representing the three ecozones in the Sahtu Biosphere Reserve. It would be beneficial to co-locate these sites with those identified in project 8.1 for potential logistical and information overlap. Site visits would be required at least three times per year. This project should be conducted over a medium duration (5-10 years).

5.3 Historic climatic and hydrologic conditions

In the NWT, instrumental hydrometric and meteorological records are relatively short (often less than 50 years), particularly in the more remote regions, like the SBR. Records of this length are a poor basis for the detection of environmental change and are unlikely to capture the annual and seasonal extremes that characterize hydrology and climate of a region. Results from tree ring studies and other proxies such as lake sediment can help place current hydrologic and climatic fluctuations into a long-term context and can assist in environmental management and impact assessment decision-making.

The project to establish a hydrometric and/or climatic history within the watershed includes conducting tree ring analysis on the east half of the SBR where geological and topographical conditions are favourable for the study of tree rings. One visit in mid to late summer per year for two or three years would be adequate. (Note: A tree ring analysis project was initiated in the SBR in 2004 as part of larger collaborative project initiated in 1999 by Environment Canada, University of Regina and Indian and Northern Affairs Canada focused on providing a longer perspective on hydrology and climate within the NWT but little came of this work).

5.4 Snow and ice conditions in Keith Arm

Snow depth and density records are important hydrologic data in that they provide an indicator of likely spring melt runoff. Long-term changes in the amount of snow received annually and in ice thickness could be indicators of climate change. Changes in snow volumes and ice thickness can have significant impacts on a variety of components of the ecosystem, including fauna and vegetation. In addition, if there is a trend to earlier break-up and later freeze-up, this means that there is a longer open-water season. This

could affect water temperature which has potential ecological implications. There is also community concern regarding changing snow and ice conditions.

The project involves conducting snow surveys and taking ice measurements at three sites on the Keith Arm with up to three visits per winter. Observations of ice conditions can be made from Délı̨nę and coordinated with satellite imagery and air photos. More in depth studies could include more measurements in the Keith Arm to improve precision, with a greater number of visits per winter.

5.5 Snow and ice conditions in the Sahtu Biosphere Reserve

This project is an extension of that described in 8.4. Further information on snow and ice conditions in the Sahtu Biosphere Reserve will improve our understanding of hydrologic and climatic conditions in the region and would be a necessary component of water balance calculations discussed in project 8.2.

The project involves conducting snow survey and ice thickness measurements at sites in the watershed. These sites could include the gauged Camsell River site, Haldane River, Johnny Hoe River, Whitefish River and Sloan River. One set of measurements would be conducted per site per winter.

5.6 Evaporation rates

A major component of the water balance in any watershed is the loss of moisture through evaporation. Good baseline information regarding evaporation rates facilitates improved understanding of the potential effects of development and of climate change (e.g., changes in duration of open water, water temperature and water levels can affect evaporation rates). Various estimates of the rate of evaporation from the watershed exist but these are general estimates based on modeled values.

The project entails establishing a climate tower on an island in Keith Arm to measure evaporation. In addition, cables will be floated in the water to measure surface water temperatures. This project was started in 2004 by Environment Canada and the University of Saskatchewan but is no longer active. ***(Recommendations?)***

6.0 Permafrost Research and Monitoring

Permafrost is a major feature of the northern terrestrial environment and is susceptible to disturbance, whether natural or human-induced. Permafrost is considered to be discontinuous over much of the SBR and continuous in the northern region. Changes in the state of permafrost could have an impact on the flow of surface water into Great Bear Lake and could potentially release material into the lake. Key objectives of the permafrost research program include:

- monitoring the extent of permafrost in the Sahtu Biosphere Reserve;
- monitoring ground temperatures in areas of permafrost over time;
- determining the ground ice content of permafrost at representative locations in the Sahtu Biosphere Reserve; and,
- determining the effects of changes in permafrost over time.

6.1 Baseline soil temperature conditions at Délı̨nę

Changes in snow depth affect ground temperature regime. Thawing of ice-rich permafrost may result in slumping of slopes, changes in vegetation, changes in drainage patterns, and ground instability. Thawing permafrost may also release materials into the surface waters. Infrastructure related to in-ground waste storage may be affected by changes in ground temperatures.

The project will establish a monitoring plot near Délı̨nę where active layers, soil temperatures and snow depths will be measured. These measurements could be carried out in conjunction with other measurements of snow cover and depth. Measurements would be conducted twice per year.

6.*2* Baseline soil temperature conditions in the SBR

The rationale for this study is the same as that of 7.1, however the study will establish monitoring plots at other sites in the SBR where active layers, soil temperatures and snow depths will be measured. These measurements could be carried out in conjunction with other measurements of snow cover and depth. They would be conducted twice per year.

7.0 Fisheries Research and Monitoring

While the fisheries of the SBR are considered to be relatively pristine, the distribution, status and general biology of the fish in the SBR are not well enough understood to be able to protect the resource, or to understand the impact of changes in the environment. Demands and stresses on the fish stocks in Great Bear Lake and the lakes and streams of the watershed are likely to increase with new economic initiatives such the start-up of additional lodges and outfitters, and the possible effects on fish habitat and water quality in relation to climate change, hydroelectric development, mineral development and hydrocarbon development. Species such as lake trout, whitefish, herring (cisco) and grayling continue to have nutritional, social and cultural significance to the residents of Déline as traditional foods. Outfitting and guiding for anglers also provides income in the community and in the lodge industry. In order to maintain these fisheries at optimal levels, up-to-date information is required on the general biology, stock structure, distribution and movements of fish in the lake and watershed, and on the numbers harvested by residents of Délı̨nę and by tourists.

A 4 year angler survey was conducted between 2006-2009. The last two years of the study were greatly impacted by the economic decline in the USA so only the first two years are used. The harvest (kept fish) is significantly lower than in the late 80's as a result of catch and release. Also, CPUE in 2006-07 is similar, if not higher than in 1990. That said, fisheries managers need an update on what the sport fishery is harvesting from lakes and streams in the rest of the watershed. As well, co-managers have little information on the extent and impact of unguided anglers on Great Bear Lake fish stocks. Subsistence fish harvests were determined over a 3-year period as a component of the Sahtu Harvest Study administered by the SRRB but additional research may be needed before "the Sahtu minimum needs level" can be determined.

To manage lake trout and other species on Great Bear Lake the catch by various fisheries (subsistence, sport and commercial) and the resilience of the stocks involved must be determined. Biological assessments by DFO are currently underway for Keith Arm fish stocks ***(Current status? Recommendations?)*** and the above-mentioned

subsistence harvest study was recently completed by the SSRB. However, knowledge of the total harvest is of major importance, especially in this area of the lake where fish stocks support more than one type of fishery. When “Basic Needs Levels” are set for Sahtu beneficiaries of the claim, harvest statistics for all users; the food fishery; guided and unguided sports fishers and any commercial fishing activity will be required by co-managers to allocate the resource.

The key objectives of this program include:

- monitoring the harvest of fish by all user groups; subsistence, sports and commercial;
- prioritizing species and water bodies/areas of the SBR for study based on results of harvest studies and literature review,
- monitoring population abundance, catch rates and biological characteristics of harvested and unharvested fish stocks in the SBR;
- comparing genetic relationships among fish from different locations to determine stock structure;
- documenting the morphological variation of the major fish species (identification of different morphotypes within species);
- determining movement patterns and critical habitats of (migration timing and location) of migratory fish species;
- identifying and characterizing critical fish habitat; spawning, rearing, overwintering areas, migratory corridors; and,
- determining mortality rates of fish released in the sport fishery.

7.1 Guided angler fish harvest

The last harvest study of guided anglers was completed in 1990 and is overdue for an up-date. The goal for Great Bear Lake is to manage for a very high quality trophy fishery; therefore, considering the low productivity of the lake, harvest levels need to be maintained at relatively low level. Catch and possession limits for lake trout are legislated at conservative levels and quotas have been recommended for each of the areas fished by sports lodges, except for Keith Arm. Until reassessed, these quotas should not be exceeded if a high quality fishery is to be maintained or in some cases rebuilt. Both resource managers and lodge management need to periodically assess the results of their conservation efforts. Additionally, catch and possession limits should be reviewed to ensure they support the goal of high quality sport fisheries on Great Bear Lake.

This project will update the catch, release and harvest statistics and biological information on fish caught by lodges and outfitter anglers on Great Bear Lake using a guide conducted survey, sampling to determine the size composition of trout retained for shore-lunch and a recording of the number of trout over 9 kg (20 lb) caught, kept or released in the fishery. The survey should be conducted each season for three years in a row each decade. The surveys would be extended to further years if lodge management doesn’t get the participant rate up to 60%.

7.2 Unguided angler fish harvest

There are unknown numbers of anglers who travel to the lake by aircraft or jet-boat who sport fish unguided on the lake. Although their numbers may not be great and it appears they do not harvest a great number of fish compared to other users, it is still necessary

to account for this portion of the total harvest, particularly since most unguided anglers fish close to Délı̨nę in what is likely the most heavily exploited area of the lake.

The GBL special sport-fishing license was designed to provide statistics on the numbers of unguided anglers using the lake or at least intending to do so. To date, statistics have not been made available to managers.

Délı̨nę feels a lack of control and even a lack of knowledge regarding this group of anglers. Likewise, the SRRB, the SBRG and DFO are as much in the dark regarding this group of resource users.

This gap in harvest information needs to be addressed in two ways. 1. License statistics for Great Bear Lake need to be examined to see if they are useful in tracking the number of unguided anglers using the lake. If addresses and phone numbers are available information on harvest could be estimated from a mail out or phone survey. 2. A boat from Délı̨nę would be used to survey anglers in Keith Arm through monitoring patrols. Surveys would be conducted in July and August on an annual basis with periodic winter surveys when the ice road is in place. A pilot study was conducted during the 2004/05 fishery. ***(Current status? Recommendations?)***

7.3 Food fishery harvest

The objective of this study is to provide co-managers with harvest estimates for Keith Arm and other arms of the lake as well as inland lakes and streams and to identify “basic needs levels” as required by the land claims agreement. This project would entail a continuation of the SRRB harvest study or similar study.

The basic requirements of the project are to have quarterly reporting of subsistence, non-resident and commercial harvest. Improved plans would increase the rate of reporting to monthly levels of all forms of harvest

7.4 Commercial fishery harvest

There are presently no regulated commercial fisheries in the SBR. If they do occur, co-managers need to know when, where and how much fish of each species is being harvested by this sector. If unregulated trade is occurring, co-managers need to know if the harvest is being recorded under the food fishery. The objective of this project is to provide co-managers with annual harvest statistics if regulated commercial fisheries or unregulated trade occurs in the watershed.

If organized commercial fishing is initiated within the watershed, a field technician(s) from Délı̨nę would be contracted to monitor the fishery for at least the first two years. In subsequent years, log book program for fishers that would provide catch and effort information would be implemented. It requires a willingness and capacity to fill out log books on fishing actions. A technician would run the program and compile and summarize data collected. Biological samples of the catch, including length, weight and aging structures would be collected as well. A biologist would be needed to support and administer the program and analyze and interpret the resulting information.

The study would be initiated at the outset, if and when a commercial fishery begins.

7.5 Fish abundance and biological characteristics

Until recently there were no studies on the biology of fish stocks in Keith Arm and the last studies of fish stocks in other arms of the lake were carried out in the early 1980s. Updated biological information is required for all areas of Great Bear Lake in order to adequately manage fish stocks and determine sustainable harvest levels.

The Department of Fisheries and Oceans, with support from the SRRB and Déline RRC, is currently ***(Current status? Recommendations?)*** collecting biological data on all fish species in the Déline area of Keith Arm with a focus on lake trout. This research has been intensive and multi-year in nature in order to gather accurate information on the stock size and status of trout in this previously unassessed arm of the lake. Although the research in the Délı̨nę area is extremely valuable, it is also limited since this is just a small portion of the lake. Further data should be collected from lake trout in other areas of Keith Arm and Great Bear Lake since different stocks of lake trout are likely to occur in this areas and since it is expected that future outfitting in Keith Arm may need to be carried on outside the special harvesting area near the community of Délı̨nę. A study by DFO and the SRRB to update biological information on fish stocks in the McVicar, McTavish, Dease and Smith Arms was initiated in 2003. ***(Current status? Recommendations?)***

Very little biological information has been collected on subsistence fisheries in the watershed and what has been collected is out of date. The exploitation of fish, particularly in small inland lakes, is an important stressor on stocks. In order to measure the impact of subsistence fishery harvest on fish stocks in lakes and streams, studies are needed to determine basic biological information about the fisheries in the watershed. In addition to harvest, managers need information on the species composition of the catch (what kinds of fish are being caught), the catch per unit of effort (CPUE) and the size and age composition of the fish being harvested in lakes and streams other than Great Bear Lake.

The project objective is to determine the population abundance and biological characteristics of fish stocks in Great Bear Lake and the watershed.

Researchers would use gill nets, seine nets and electrofishing to capture a representative sample of fish species of various sizes/ages in a given area. Sites selected for study would be chosen in consultation with the community of Délı̨nę. The following information would be collected from captured fish:

- CPUE (number of fish caught/species/unit of net/time period);
- fork length, total weight and aging structures;
- sex, maturity, gonad weight and fecundity;
- stomach contents;
- muscle samples for contaminants, stable isotopes and genetic analyses; and,
- model data to estimate population abundance, mortality and recruitment and develop biological indices of growth rate, age and size at maturity, age and size structure, and fecundity.

The basic project needed to collect the necessary information would involve the collection of the above detailed biological information over a consecutive 5 year period for each arm of Great Bear Lake or water body within SBR. This could be followed by

more basic sampling of biological information (catch rates and possibly length, weight, age) on a continuous basis by locally trained field monitors. A more detailed sample could be collected once every 5-10 years thereafter. The highest priority species are lake trout and whitefish, while others, such as lake cisco and grayling are a lower priority over the short term. For all of the above described actions it would be preferable to collect information from all arms of Great Bear Lake simultaneously, rather than staggering data collection across years.

For Great Bear Lake, research on lake trout and lake whitefish should take place over the short term (1-5 years) while information on other species (cisco and grayling) is required over the medium (5-10 years) and long term (all other species). For species in the lakes and rivers of the watershed, data are required on the harvested species in the short term (1-5 years), while other species should be assessed in the long term (10+ years).

7.6 Structure of fish stocks

The stock structure of lake trout and other harvested species within the SBR is unknown. .A major impediment in the management of the lake trout populations in Great Bear Lake is the lack of information regarding the distribution of fish within the lake. The major question is whether there are several individual populations of trout in the individual arms of the lake, or whether there is just one population distributed through the lake. The question has significant implications for establishing the catch limits and the conservation of trophy-size fish.

The Department of Fisheries and Oceans is currently collecting genetic tissue samples of all species in conjunction with their population assessment work on Great Bear Lake. These samples can be used to analyze the genetic structure of various species within the lake. DFO has also issued tissue sample kits to lodges on the lake in an effort to collect tissue samples from shore lunch trout that can be used for genetic analysis. To date they have managed to collect a small number of trout samples from each area with which they have conducted a pilot analysis of the mitochondrial DNA. Larger sample sizes and further lab work using microsatellite DNA are in progress. ***(Current status? Recommendations?)***

The basic project plan is to collect 100 tissue samples from each major stock of harvested fish within the lake or watershed. Microsatellite DNA would be analyzed in the fish samples and results would be used to model stock structure and migration patterns within a given water body or area. The enhanced level of this project would be to collect and analyze a larger number of samples (200) from each of the harvested stocks as well as spawning aggregations. Tissue samples could be collected as part of any studies involving biological sampling of fish populations .

The data for this study should be collected in the short term (1-5 years) for lake trout, the medium term (5-10 years) for whitefish and in the long term (10+ years) for lake cisco.

7.7 Variation among lake trout, lake cisco and lake whitefish stocks

Research by DFO and/or traditional knowledge indicates that lake trout, lake cisco and possibly lake whitefish in Great Bear Lake exhibit considerable phenotypic variation and may be comprised of more than one form. This situation has also been observed in other large lakes such as Great Slave Lake and the Laurentian Great Lakes however the variation has been extinguished in these more southerly populations due to

overexploitation. Experience from these other large lakes has shown that, in both lake trout and cisco, some types are more vulnerable to fishing than others and that in restocking and rehabilitation efforts, some types seem to recover their abundance more readily than others.

Although Great Bear Lake is located further north it shows many parallels with the southern Great Lakes. The presence of within-species variation in Great Bear Lake adds an element of risk to managing the fishery since productivity and resilience to harvesting may vary among types. The documentation/preservation of natural variability is an important consideration in the conservation of these species. Furthermore, we need to gain an understanding of the productivity, relative abundance, and habitat requirements of different morphotypes and we need to know if distinct types represent ecologically, and or reproductively isolated (genetically unique) populations.

The project will document the morphological variation within lake trout and cisco species (and possibly lake whitefish) in Great Bear Lake using body measurements from digital images of fish taken in the field. Additional measurements and counts may also be collected from fish heads if retained. The research will identify key characteristics that will allow resource users to identify putative types. The measurements will be conducted from a one-time collection of 100 digital images (and fish heads, if available) per species from each arm of GBL and at spawning grounds as they are identified through migration studies and TK. A one-time collection of 100 whole fish/species near the community of Délı̨nę will be used for calibration of measurements from digital images. More advanced levels of this project would include collecting this type of data from all fish collected as part of the stock assessment studies. This data could be collected as part of any studies involving biological sampling of fish populations (e.g., knowledge gap I). Such data could be combined with genetic studies (as described in 10.6) to determine if different phenotypes are genetically unique.

This study should be conducted in the near future (1-5 years) for lake trout and lake cisco and in the medium term (5-10 years) for lake whitefish.

7.8 Fish migration patterns and critical habitats of species within the SBR

The objective of this research is to determine the extent of movements and the time and location of spawning, rearing and overwintering for harvested fish populations in the SBR. There is currently little or no information on migration patterns and corridors and habitats critical to sustainability of the major species, including lake trout, lake whitefish, lake cisco and grayling. The emphasis in this study will be on species identified from the harvest statistics as being of immediate concern to the people of Déline. The immediate benefit of the research will be to identify migration corridors and critical habitat (particularly spawning grounds) for protection and stock management.

The study would involve marking about 1000 fish/species per arm of GBL or watershed lake or stream with floy tags and radio tagging with aerial tracking of approximately 30 fish /species/arm of GBL or watershed lake or stream. One arm of the lake would be investigated per year. An enhanced level of the project would include a larger number of fish, or to conduct the work in more than one location in the same year. Much of the work could be conducted by trained residents of Délı̨nę who could be involved in the tagging and surveys.

For Great Bear Lake, data for this study should be collected in the short term (1-5 years) for lake trout and lake whitefish, the medium term (5-10 years) for lake cisco and grayling and in the long term (10+ years) for other species. For harvested species in the Sahtu Biosphere Reserve, data should be obtained in the short term (1-5 years).

7.9 Mortality rates of fish released in the sport fishery

One of the major questions facing the managers of the fishery of lakes such as Great Bear Lake is the rate of mortality and injury that occurs in lake trout and grayling that have been caught and released. This issue has also been raised at several workshops in Délı̨nę because of the concerns that fish caught by anglers, particularly trophy fish, are returned to the lake but may not survive. Estimates currently being used for the Great Bear Lake trout fishery were determined from a study of lake trout captured in Great Slave Lake in the 1970s and there have been no studies on grayling.

This project will conduct a basic catch and release study in an area near Délı̨nę to determine the rate of release mortality of sport fish. Up-to-date experimental methods will be used. The number of fish needed will be determined at the time of the study. The study will need to be conducted one time only and could be run near the community of Délı̨nę. Data for lake trout should be obtained over the short term (1-5 years) and in the medium term (5-10 years) for grayling.

7.10 Current baseline conditions for fish habitat

In Great Bear Lake, judicious habitat management would ensure that the spawning areas for all stocks of the major fish species are protected, which will help to ensure the protection of the fish species in the lake. To accomplish this protection, however, work needs to be done to identify important spawning areas and the resources required by the fish stocks to continue. Project objectives are: to provide information on important and critical fish habitat features in the SBR, to assist in the maintenance and protection of the productive capacity of fish habitat and to maintain the maximum natural capability of habitats to produce healthy fish, and to support aquatic organisms upon which fish depend.

Identifying critical fish habitat in Great Bear Lake involves studies at several levels. This project potentially would create a detailed map of fish and benthic invertebrate habitat for the entire near shore area. It would identify suitable spawning habitat and identify productive regions in the lake in relationship to fetch patterns and substrate types. The project also could be expanded into neighbouring lakes and large rivers. Shoreline and littoral zone classification would be accomplished initially by using satellite imagery and by modeling fetch patterns in relationship to climatic variables. A community visit (year one) to collect TEK on spawning areas would be required to document those habitat types for input into search strategies. Aerial photography of the entire lake shore and ground-truthing of the photography with a single beam acoustic lakebed classification system and bottom grabs would be done in the second year.

8.0 Aquatic Ecology Research and Monitoring

Although there is a major emphasis on studying and understanding the fisheries in Great Bear Lake, major questions remain about the rest of the aquatic biological community. Very little information is available for Great Bear Lake which makes it very difficult to predict what may happen to the lake with increased development, increasing population

and the effects of changes in environmental quality due to climate change or the long-range transport of contaminants. Moreover, Great Bear Lake has special features including very clear waters which are a consequence of low nutrient levels, lake size, and a short summer, all of which limit microscopic plant growth. Increased nutrient inputs (with population development) and warming could result in a change in water clarity and the overall features of Great Bear Lake.

Key objectives of this program include

- determining the primary features of the aquatic ecology in Great Bear Lake through focused studies at a Master station in the vicinity of Délįnę;
- training members of the Délįnę community to conduct much of the detailed sampling at the Master station;
- fostering research partnerships for shorter term and/or more specialized studies;
- surveying Great Bear Lake to assess how these features vary between the major arms and the inshore versus offshore;
- conducting important rate measurements including plant and bacterial growth rates, small animal (zooplankton) feeding rates, and predation rates of forage fish and small animals;
- determining food web and contaminant pathways, and
- conducting similar studies in smaller lakes and tributaries located inside the drainage basin.

8.1 Aquatic ecology in Great Bear Lake in the vicinity of Délįnę

To provide fundamental information on the presence and growth of single-celled plants and zooplankton and other, it is important to begin studying the aquatic ecology of Great Bear Lake. These studies will determine plant and animal cycles and what types of food support the fish populations. The most basic studies sample aquatic plants and animals and determine their abundance and composition. More advanced studies measure their growth rates and feeding rates. Experiments can be conducted to add plant nutrients to determine what limits plant growth and/or how increased inputs would affect the microscopic plants. In some areas further south, new species of phytoplankton, rooted plants, and invertebrates have colonized lakes and rivers, with many of these species having nuisance properties. The likelihood that such species may be transported into the north and successfully colonize lakes and rivers is increasing. It is important that programs be established to determine the current features of the Great Bear Lake plant and invertebrate communities and monitor for change.

A Master station which allows the sampling of plants and animals in the water column would be established near Délįnę. This would be the same station as the water quality station discussed in project 7.3 and elsewhere. The basic plan of the project calls for the collection of samples bi-weekly during the open water season. Microscopic plant cells and bacteria would be collected from the same depths as the water quality samples and preserved for later analysis using high magnification microscopes. Zooplankton would be collected with the water samples or with vertical net tows. Organisms on the bottom of the lake would be collected with a bottom grab at stations of at least two depths. Nearshore forage fish will be collected with beach seines and electrofishing at fixed locations, e.g., rocky areas, sandy areas, marshy areas. The enhanced level of the project would conduct samples quarterly during the year and bi-weekly during the summer. Studies conducted over winter would provide information on how microscopic plants and animals survive the winter. Throughout the year, experimental studies could

be conducted to measure plant growth rates, factors limiting phytoplankton growth (nutrients and metals), zooplankton grazing and vertical migrations, adaptations to low light levels during periods of long ice cover, the seasonal accumulation and loss of lipid (fat) reserves, etc. Studies also could be conducted investigating the movement of material to the lake floor. This program would be linked to meteorological mooring studies and contaminant cycling studies.

8.2 Spatial variations in the aquatic ecology of Great Bear Lake

Great Bear Lake is a large lake with five major arms and a central area. The shallow areas, especially those in protected waters and near tributary inflows, are probably the most important areas in the lake for plant and animal growth, including fish. However, apart from studies conducted in the 1960s, little is known about how the aquatic ecology of Great Bear Lake varies from one arm to another and from the nearshore to the offshore.

A general survey of the aquatic ecology of Great Bear Lake waters is required to determine inshore-offshore differences in these features, and to determine the effects of tributary inputs on the ecology and productivity of the major arms of the lake. Such a study would be linked with tributary studies, water quality studies, fisheries studies, and studies of the heat budget of the lake. They also would be linked with satellite imagery studies, to provide estimates of plant cell abundances through chlorophyll measurements. Measurements of plant growth rates (primary productivity) could be applied to the entire lake based on frequent sampling at Délı̨nę, lake wide surveys, and satellite imagery.

The basic project to address this knowledge gap will be to conduct a single lake wide survey of water chemistry, plankton profiles and abundance and sediment-dwelling organisms in the major arms and the offshore region of the lake. This study would take 3-4 weeks to complete depending on the number of measurements made. With planning and sufficient resources, this study could be linked to studies using acoustics to measure lake depths (bathymetry) and fish and plankton populations (a sophisticated fish finder). Primary production rates would be measured at some sites. The enhanced version of this project would include a complete set of analyses in more arms of the lake (e.g. 2-3 arms).

8.3 Contaminant pathways in Great Bear Lake food webs

Contaminants such as PCBs, toxaphene, and mercury are of concern to Great Bear Lake because fish are relatively old and hence have accumulated contaminants over a long period. The concentrations are not sufficiently high to merit consumption advisories but should be monitored from time to time.

The other issue is how contaminants enter and move through the food web. Unlike Great Slave Lake, Great Bear Lake has very clear water. Contaminants such as PCB and toxaphene may move faster into Great Bear Lake food web and into the fish than in Great Slave Lake. This is why PCBs and toxaphene may be higher in Great Bear Lake trout than in Great Slave Lake. Mercury has different pathways and watershed inputs may be very important in bringing in mercury into the lake in the forms in which it most readily moves into the food web.

Contaminant pathways studies can be conducted in many ways. The simplest is the determination of contaminant levels in different levels of the food web – mud, small

animals, small fish, and larger fish. More precise studies can be conducted by measuring how contaminants enter the lake from the air and watershed, how contaminants sink o the lake floor (and hopefully become buried) and how contaminants are loss from a lake. These studies would be linked with other studies (e.g., sediment trap studies, meteorological studies, etc. Detailed studies of this nature allow the system to be modeled and future trends to be predicted. Such an approach is commonly used on the Great Lakes and is easily adapted to Great Bear Lake by bringing in similar specialists.

The basic project would include the analysis of plankton and fish samples collected at the Master station at Délı̨nę in one year. A similar set of samples would be analyzed in one of the other arms of the lake would be analyzed the following year. More detailed studies would analyze mercury and other contaminants in the aquatic food web and sediments at the Master station and at an offshore station in Keith Arm. Similar samples at more sites around the lake would help to define the transfer of mercury and other contaminants in the lake as a whole.

More detailed studies would analyze mercury and other contaminants in the aquatic food web and sediments at the Master station and at an offshore station in Keith Arm. Similar samples at more sites around the lake would help to define the transfer of mercury and other contaminants in the lake as a whole.

8.4 Aquatic ecology in streams and rivers

In addition the Great Bear Lake and the tributaries flowing into it, there are numerous smaller lakes and streams in the watershed. Many lakes have traditional importance in fishing (e.g., Lac Ste. Therese, Kelly Lake). There also is good tourist potential for these lakes. Thus, it is important to obtain baseline information on the aquatic ecology of these lakes and their tributaries to help support the traditional fishery. The range of aquatic ecology studies and items sampled is the same as for Great Bear Lake.

The project design for this project recommends a minimum a collection of a limited number of samples once a summer in major lakes and tributaries in the watershed. The samples would include surface samples for phytoplankton and zooplankton. More advanced studies would include the summer set of samples, but also include limited number of winter studies as well.

8.5 Ecosystem modeling of Great Bear Lake

Ecosystem modeling is a powerful tool which can be linked with other components of research and monitoring on Great Bear Lake. The model development should include watershed hydrology modeling perhaps local identified sub- basins, and modeling of the fundamental characteristics of the lake which impact on the water quantity, quality, nutrient distribution, aquatic ecology and the important fisheries questions.

This study would be linked with include lake monitoring (surveys and in situ observations, island observations, etc) for the basic meteorology (air temperature, water surface temperature, wind speed, wind direction, solar and long wave radiation) of Great Bear Lake. There also would be strategically located temperature moorings with some year-round moorings, transmissometer (light penetration into water), and current observations. Researchers can use these data to model heating and cooling cycles in Great Bear Lake, water movements, the mixing of waters from one area of the lake to another, and describe fish habitat based on temperature requirements. These models

also can be used in to develop water quality and fisheries habitat models as well as investigate climate change.

8.6 Remedial actions for elevated mercury levels in fish in small lakes

Elevated mercury levels are a common feature in fish inhabiting small lakes and where the fish population is relatively old. Higher mercury levels appear to be due in part to the nature of mercury movement in small lakes. In brief, mercury is more easily converted into a form that moves into the food web in small lakes than large lakes. In addition, mercury levels increase with fish age: the older the fish population the higher the mercury levels. While these general principals are known, there has not been a good study of mercury pathways in a lake in the Northwest Territories nor of possible remedial actions.

This study would be focused study of mercury pathways from deposition into snow and rainfall into the watershed, to its transformations in wetlands into organic forms and subsequent movement through the food web into top predators. A second element of the study is the detailed assessment of the growth features of the fish population and the overall productivity of the lake. This would set the framework for potential remedial actions, if possible, for the elevated mercury levels. One possibility is to reduce mean fish age through increased harvesting of the older fish. Another possibility may be to alternate the nature of the food web through various manipulations. A study of this nature also can address questions as to how increased warming may affect mercury levels in fish. Because this study would be intensive and complex, there are a multitude of opportunities for community involvement and training.

The ideal location would be Lac Ste. Therese with a field/research camp set up for the 2-3 years this study would require.

9.0 Neh Karila K'ets'Edi Research and Monitoring Plan

Neh Karila K'ets'Edi is Slavey for "these places: we're protecting them". Neh Karila K'ets'Edi have a combination of important cultural, historic, traditional and/or ecological values that need a higher level of protection than is provided by the Special Management Zone policies, conditions and prohibitions of the Sahtu Land Use Plan.

Neh Karila K'ets'Edi are very important to the residents and communities of the Sahtu settlement area, and indeed to all to Canadians. They are important contributors to wildlife and ecological systems, to socio-economic sustainability and to the existing and future social, cultural and economic well-being of the Sahtugot'ine.

The Sahtu Land Use Plan includes two forms of Neh Karila K'ets'Edi protection: Conservation Zones (CZs) and Proposed Conservation Initiatives (PCIs). Site-specific policies, conditions and prohibitions are set out in the Sahtu Land Use Plan.

Conservation Zones (CZs) are significant traditional, cultural, heritage and ecological areas in which specified land uses are prohibited. Permitted land uses (anything not prohibited, or grandfathered uses) are subject to the general Conformity Requirements and applicable special management Confirmity Requirements set out in the Sahtu Land Use Plan.

Proposed Conservation Initiatives (PCIs) are areas for which formal legislated protection is being sought through the Protected Areas Strategy, pursuant to commitments under the SDMCLCA, or under Parks Canada's legislation. The establishment of a protected area is the intended use of PCIs and is permitted. PCIs have the same status as Conservation Zones in the Plan until they are protected under other legislation.

Established Protected Areas (EPAs) is the designation given in the Sahtu Land Use Plan to all legislated protected areas once they are fully established. Once an area is designated as an Established Protected Area, the Plan no longer provides direction to these areas. Instead, they are managed according to their sponsoring legislation and management plans (where applicable).

Research and monitoring in and around all Ne Karila K'ets'Edi is needed to ensure these places remain ecologically and culturally intact, and that they continue to contribute to the health of the watershed and Sahtugot'ine.

The key objectives of this initiative include:

- determining if areas other than those shown as protection zones need either surface or subsurface protection, such as additional areas of cultural importance or areas that contribute to ecoregion representation in the NWT;
- determining if any CZs should be pursued as PCIs;
- determining the legislative and governance frameworks for those PCIs moving to permanent protection;
- better understanding of the complex relationship between development and ecological integrity and change;
- developing reference sites within Neh Karila K'ets'Edi as benchmarks to monitor, assess and mitigate the impacts (including cumulative impacts) of activities elsewhere in the SBR;
- setting appropriate use and land management protocols that are consistent with the ecological and cultural integrity of these places;
- ensuring activities outside of Neh Karila K'ets'Edi are consistent with the ecological and cultural integrity of these places; and,
- contributing to our overall understanding of these areas, and our ability to communicate their importance.

9.1 Conservations Zones to permanent protection

The Sahtu Land Use Plan identifies a number of areas as CZs. A process to determine which, if any, CZs should be given permanent protection.

A 2-3 day workshop would be held in Délı̨nę to determine whether permanent protection is desirable for any Neh Karila K'ets'Edi, including discussion of the management regime that would apply. Additional workshops and studies will be needed if the decision is taken to advance any CZs toward permanent protection.

9.2 Potential terrestrial Conservation Zones

There is still a considerable amount of work to be done on documenting cultural sites within the SBR. Once on-the-land identification of areas of cultural importance is done, there will likely be other cultural areas identified that need protection.

Likewise once the considerable ecological information gaps have begun to be addressed, areas of ecological significance that require additional protection may be determined. There are 7 ecoregions in the Sahtu portion of the SBR. A report (*Conservation Suitability Analysis of the NWT: An Exploratory Approach*, Cizek Environmental Services, Sept. 2004) was done to design an ecologically-representative protected area network throughout the NWT. The report, though preliminary, shows a number of areas within the SBR that should be protected to meet the goal of adequate ecological representation.

A more detailed ecological gap analysis of the SBR should be completed to pinpoint areas of particular interest for subsequent field studies. Such work should be done in a collaborative, interdisciplinary manner and results from other studies (cultural and ecological) should be integrated in the analysis.

Once this revised gap analysis is completed, a community workshop to discuss potential additional sites will be undertaken. At that stage, additional ecological, non-renewable and cultural resource assessments may be needed.

9.3 Potential aquatic Conservation Zones

While some work has been done on protecting cultural areas important for fishing (such as special harvesting areas for whitefish), no work has concentrated on protecting important aquatic sites, nor has there been any work done on representation of types of smaller rivers and lakes. This type of representation is not as well documented as the terrestrial ecosystem representation. Some factors would likely overlap with terrestrial units such as geology and soil, but most factors would be specific to aquatic systems, such as stream gradient, size, water chemistry (e.g., temperature, pH), connectivity to wetlands and glaciers, benthic complexity, and aquatic focal species representation.

The project would develop an appropriate aquatic representation system, followed by a gap analysis to determine if any additional CZs, PCIs or EPAs are needed.

9.4 Long-term integrated Neh Karila K'ets'Edi management programs

Several federal and territorial agencies are involved in Neh Karila K'ets'Edi management and others may be in time. Management plans for individual Neh Karila K'ets'Edi should be coordinated with plans developed for other areas in order to gain a comprehensive understanding of these sites and the SBR as a whole.

This project involves two aspects:

- development and implementation of a system to document Neh Karila K'ets'Edi use, e.g. by tourists, outfitters, hunters/trappers, schools, etc
- development of access guidelines for important ecological and cultural areas, linked to rules and protocols for access and use of cultural sites.

9.5 International Biosphere Reserve designation

Délı̨nę has determined that it wishes to pursue International Biosphere Reserve designation for Great Bear Lake and that portion of the watershed within the Déline District. While this designation is honorary and does not add additional legislation protection, it does have many benefits, among them:

- review of management ideas by independent experts;
- access to sharing ideas globally;

- additional "watching eyes" to make sure commitments are met;
- additional local community capacity-building;
- possibilities for funding targeted at various projects within this research and monitoring plan;
- global celebration of the unique cultural and ecological values of the SBR; and,
- an enhanced role for Déline in the stewardship of the region.

A SBR Steering Committee representative of Délı̨nę agencies and interests was established in April 2014 and it has held several planning meetings in the community since. A draft nomination form has been completed, communication links have been established with federal, territorial and Sahtu agencies, UNESCO Canada, the Canadian Biosphere Reserve Association and several conservation foundations. All agencies contacted to date have promised their support (financial, in-kind and political as appropriate) in moving the nomination forward. More meetings are planned, with the intention of completing the nomination form by the end of 2014. At that point the nomination will move through the regional, territorial, federal, national and international approval processes.

9.6 Caribou crossings and migration routes

Identification and protection of caribou water crossings and migration routes is a key component of Mobile Caribou Protection Measures. To complement ongoing satellite-collar tracking employed to identify and map seasonal and annual ranges for barren-ground caribou, local traditional knowledge should be used to identify important caribou water crossings and migration routes within the watershed and to identify appropriate protection measures.

This project would follow up on initial efforts to develop caribou protection measures and ongoing work to develop caribou management plans for the Bluenose herds, with a focus on ensuring that traditional knowledge holders are fully involved in project planning and plan development and implementation.

10.0 Cultural Research and Monitoring

The Sahtu Biosphere Reserve is a special place for the people of Délı̨nę. Their ancestors have been part of and have cared for this place for countless generations. The oral tradition and stories that are tied to the land help to define who the Sahtugot'ine are as a people. Legends are from the land and these stories create maps for the people. Names that are given to the land often tell the story. Given the central importance of Great Bear Lake and its watershed, Délı̨nę elders strongly assert that all have a responsibility to treat the area with respect and to keep it healthy.

Cultural integrity is closely tied to ecological integrity (healthy land is needed for a strong culture). Second, the culture is not a material culture, so 'artifacts' *per se* are not the defining feature. The elders have described parts of the land as their 'libraries, schools and colleges'. It is through the use of the land that the culture continues. Cultural integrity and traditional knowledge permeate *all* aspects of the SBR Research and Monitoring Plan

Key objectives of cultural research and monitoring programs include the following:

- ensuring that the cultural integrity of the Sahtugot'ine relationship with the SBR is strengthened and maintained;
- collecting baseline data within the Sahtu Biosphere Reserve on significant sites, trails, gravesites and archaeological sites;
- developing the community's capability in the fields of cultural research, monitoring and management;
- documenting TK and land use practices for future generations and to continue to integrate this knowledge in all aspects of SBR management;
- designing, implementing and maintaining a long-term program to monitor cultural resources;
- documenting, promoting and communicating the cultural heritage of the SBR; and,
- encouraging the transmission of cultural knowledge by educating youth on the land in a traditional ways.

10.1 Core research capacity

One of the recommendations in "*Radekée Gok'é Godi: Places We Take Care Of*" was for a Sahtu Cultural Institute. This has not been done; however the need to research, protect and promote cultural resources still exists. Déline has been making efforts to establish a Délı̨nę Knowledge Centre, which would, as part of its mandate, include research and education related to cultural (and ecological) resources in the SBR. Related to that, or on in another capacity, there needs to be core research capacity developed in Délı̨nę to undertake all of these projects.

Further work needs to be done within Délı̨nę to determine the scope of the proposed Délı̨nę Knowledge Centre, resources required and possible funding and other partnerships, all in conjunction with the SBR.

10.2 Cultural resources baseline data collection and analysis

Sahtugot'ine use of the SBR has traditionally focused on a number of traditional use sites where seasonally abundant resources are available and harvested in accordance with traditional practices. These locations, distributed throughout the entire watershed, were accessed through a network of well defined trails creating a complex use of land and resources, used over seasons and centuries. These locations and trails are still important today, providing access to food and other resources critical to Sahtugot'ine health and well-being. Understanding traditional land use can also help inform other aspects of cultural resources research and documentation, particularly in locating and interpreting archaeological and burial sites.

"*Radekée Gok'é Godi: Places We Take Care Of*" (Sahtu Heritage Places and Sites Joint Working Group, 2000) reported on a sample of the existing heritage places and sites important to the Sahtu Dene and Métis. Many of the places (such as Etirato/Whitefish River, and Turili/Johnny Hoe Fishery) are now CZs pursuant to the Sahtu Land Use Plan. However, as reflected in the report's recommendations, there is still much work to be done in collecting and documenting the oral histories of culturally significant sites (including traditional trails, burial sites and archaeological sites). Furthermore, it is far from certain that the extant research, which has been conducted as part of larger regional projects, represents a true and complete inventory of cultural resources on Great Bear Lake.

The first phase of the project is to conduct a review and gap analysis of extant information on cultural resources within the watershed (literature review). Phase II is to collect and record additional baseline data (locations, place names, oral histories, visual documentation) on significant sites, trails, gravesites and archaeological sites. Once the material is gathered, a data analysis is needed to assess cultural resource and land management implications.

It should be noted that cultural/heritage resources could also refer to artifacts or historical records. Section 26.2.7 of the Sahtu Dene and Métis Comprehensive Land Claim Agreement states that any such objects which have been removed from the settlement area should be returned, provided that appropriate facilities and expertise exist to ensure their proper care and maintenance. A further aspect of baseline data collection could thus involve researching the existence and whereabouts of historical artifacts and records, and working towards the development of an appropriate facility to house them upon being returned to the Sahtu.

Radekée Gok'é Godi: Places We Take Care Of notes several projects where oral history and archaeological research is needed. The story of Yamoria Eht'ene (Yamoria and the Giant Beavers) stands out. Its central importance to the people, its geographic extent across the lake, and the fact that it links so many terrestrial sites points to this as an important story to document properly.

10.3 Place names compilation and research

Traditional place names have been used for centuries to refer to important landmarks, cultural sites, and resource harvesting locales. Traditional place names are also used as mnemonic devices to help remember aspects of oral culture associated with place, and are therefore a window into both current and past land use. While this is an important part of all research, there is specific work associated with place names that is required. Researchers such as Cornelius Osgood (1928, 1953, 1975) and John Tetso (1980s and 1990s) and others have recorded many traditional names in the SBR and published them in a variety of forms. Two things are often missing from such works:

- the stories associated with each place;
- the spatial extent of the name (i.e., names are not 'dots' on a map, but have a specific geographic area they cover)

Furthermore, the results of place name research efforts have never been complied into a single resource.

Existing research, including stories and mapped spatial extent, should be compiled into one source and one map. From this, identifying gaps and devising additional research to address the missing components (particularly collecting and documenting the oral narratives associated with place) should be done.

10.4 Burial site documentation

The identification and protection of *burial sites* in the SBR is a priority for Délı̨nę, not only due to the general desire and right of all peoples to remember and respect their dead, but also because gravesites are physical manifestations of Sahtugot'ine ancestry and history that are inscribed on the landscape around the lake – they speak poignantly of the intimate historical relationship between a people and their environment.

While there have been several projects designed to record burials in various locations in the SBR, often as part of other research efforts, there has never been a systematic recording of all burials within the SBR. The best way to protect burial sites is to record their location and make the information available to agencies involved in land management.

Unlike other sites with material artifacts (which require investigation by an archaeologist for scientific investigation) burial sites are readily recorded in conjunction with other research projects. The recording of burial sites should be done as standard procedure, incorporated in all projects. Community members should also be encouraged to record burial sites. GPS units could be loaned to individuals willing to undertake this task while traveling within the SBR.

The records should include:
- latitude and longitude
- traditional place name (if known)
- other known name (if known)
- name of deceased
- genealogical information (if known)
- description of location
- description of grave

10.5 Traditional Ecological Knowledge

Over the generations, Dene people have evolved a rich body of ecological knowledge and subsistence practices. These have included an understanding of country food and furbearer resources, weather, and medicinal plants. As well, Dene culture has involved a rigorous set of protocols for ensuring proper respect for the land (land management). The elders of Délįnę have identified a need for documentation of traditional ecological knowledge and land use practices, including protocols, so that this knowledge resource can be harnessed by future generations and integrated into ecological research and monitoring activities. The Dene Cultural Institute's *Traditional Ecological Knowledge: A Pilot Project conducted in Fort Good Hope and Colville Lake, NT, 1989-1993* is a good starting point for developing a research program in this area. Studies conducted by the Tlicho could also provide useful ideas for the design and implementation of a similar project in the SBR.

The project would document TEK and land use practices through on-the-land work that involves elders, youth and researchers, maximizing opportunities for elders and youth to share and transmit knowledge. Project results would be made available to the Délįnę Renewable Resources Council, the Sahtu Land Use Planning Board and other land management agencies.

10.6 Long-term cultural integrity monitoring program

A long-term cultural integrity monitoring program would integrate the significant sites, trails, gravesites and archaeological sites research; land and cultural resource management information; data base integration; and legislation/enforcement considerations into a single cohesive long-term monitoring program. This plan should be closely integrated with long-term environmental monitoring activities, both to increase logistical efficiency and to reflect the real synthesis of ecological and cultural interests within the framework of Sahtugot'ine culture.

Community consultation should be the primary mechanism for developing such a plan, in order to ensure that it accurately reflects community priorities and preferences for which sites should be protected, and the most appropriate methods for ensuring long-term integrity. In other words, it is the Sahtugot'ine who should lead the development of appropriate methods for caring for their cultural places and resources.

10.7 Communications and education

While communicating all research and monitoring information is an important part of all projects in this plan, there is a special need for more extensive communications and education work focused on culture resources. Simply finding sites and protecting them is not enough to ensure cultural integrity: the culture itself must be sustained. Effective communication and education among children, youth, adults and elders is needed. Dissemination of knowledge among partners and to the public at large is also important, as with other aspects of this plan.

Youth and elders need to be involved in the on-the-land activities, where cultural knowledge about the SBR can be shared and experienced. An ongoing newsletter series, website updates (either through a GBL website, or through the Déline community website), video, literature, signage/plaques on the land, can be part of the communications/education. Local/regional educators should be assisted with the development of teaching material that can be integrated into school curricula. Finally, a centre should be established in Délı̨nę (perhaps another function of a Délı̨nę Knowledge Centre) where visitors can become aware of the culture and history of the SBR and community members can develop traditional and new forms of cultural expression.

11.0 Economics Research and Monitoring

A central principle of the Great Bear Lake Watershed Management Plan and the Sahtu Land Use Plan is to ensure that activities in the SBR protect and promote the existing and future social, cultural and *economic* well-being of residents of the watershed. Economic development can and should take place within the context of sound environmental stewardship. Economic development also needs to be responsible, to return significant benefit to those on whose land development is taking place.

The biosphere reserve concept explicitly recognizes the need for economic development that benefits residents and ensures the integrity of the region. Projects in this section are intended to support the development of standards and parameters to ensure that current and future economic development initiatives are consistent with the principles for the management of the SBR.

Key objectives of economics research and monitoring projects include:

- collecting baseline data on the existing economic circumstances within the Sahtu Biosphere Reserve, including information on the basic needs of Délı̨nę;
- documenting traditional knowledge regarding 'economic' health;
- combining scientific and traditional knowledge on economics and communicate this to the community of Délı̨nę;
- developing indicators to define 'sustainable development' in a holistic and integrated way, including accounting for the qualitative aspects of life in the

community, the financial aspects, infrastructure, and the health of the SBR in general;

- developing a series of indicators to define measure economic and financial success in Délı̨nę's terms, and the capacity in Délı̨nę to measure that success;
- researching economic development opportunities that could maximize local jobs, produces goods locally for local and regional consumption, retain and enhance spiritual connection to the land, and reflect the political structures in Délı̨nę and the Sahtu;
- researching ways to build on existing opportunities and successes, such as the tourism industry and helping local businesses expand or diversify their operations;
- developing a capacity-building plan, that identifies the gaps in the workforce (in terms of Délı̨nę's needs and outside companies) and appropriate strategies to meet those gaps, in such a way that the whole community can benefit;
- developing standards to evaluate how economic development projects by corporations or groups other than Délı̨nę Land Corporation/ Sahtugot'ine interact with the ability of the Délı̨nę Land Corporation to pursue tourism, trapping and any other development projects they wish to pursue;
- developing a strategic plan to capitalize on the economic opportunities generated by the establishment of Neh Karila K'ets'Edi; and
- designing, implementing and maintaining a long-term program to monitor economic strength of Délı̨nę.

Specific projects need to be identified, along with primary research bodies, to undertake this work and meet these objectives. Work should begin immediately.

12.0 Conclusion

While there is only limited research and monitoring currently underway in the SBR, much information already exists and provides a good foundation for future work. Priority areas and specific needs are identified in this plan.

Délı̨nę's commitment to the protection and careful development of Great Bear Lake and its watershed, its desire to work with others who share similar ideals and its demonstrated leadership all bode well for the future of the SBR. Research and monitoring stations established in North America and elsewhere (including Lake Tahoe (USA), Lake Baikal (Siberia), and the very long-term programs on the Laurentian Great Lakes) may serve as positive examples for Délı̨nę and its partners to consider as the approach to research and monitoring in the SBR is developed further. Designation of Great Bear Lake and that portion of the watershed within the Délı̨nę District as an International Biosphere Reserve can catalyze and support Délı̨nę's leading role in the stewardship of the region.

Any funding (industry, academia and government) of research and monitoring in the SBR should consider the projects identified in this plan and demonstrate a clear link to the maintenance of the ecological and cultural integrity of the SBR. Communication with the community of Délı̨nę and coordination with other research and monitoring projects is essential.

References:
http://www.sahtulanduseplan.org/website/web-content/Maps/water_heart/31.05.05_GBLMgmtPlanCa.pdf

http://www.sahtulanduseplan.org/website/web-content/index.html

http://www.caff.is/terrestrial/terrestrial-monitoring-plan

http://www.caff.is/freshwater

Additional comments from reviewers:

……perhaps identifying priorities, partnership opportunities, and leads in the next phase of planning.

……I think our perspective has changed significantly on the impacts of climate change and how it is affecting NWT landscapes. Virtually every component of the ecosystem is being affected in some way and I think the SBR provides a unique opportunity to document and monitor these over the long term. I think this is embedded to some extent in various sections, but I think it's worth highlighting as a significant theme; SBR as a kind of canary in the minesite. Thinking about GBL, I suspect that thawing permafrost is having a significant impact on archaeological and palaeontological sites (as it is in the Gwich'in region); it's releasing organic-rich water, leading to rising mercury levels, perhaps bioaccumulating in trout and other top trophic predators; water quality changes associated with retrogressive thaw slumps may start to have an impact in GBL. Just a few ideas, but I think that the research potential of climate change is underrepresented in the paper generally.

The culture section is good; nice to see the bit on graves; I'd like to talk to you more about this when I have time. George Blondin told me once that the mouth of the Johnny Hoe River was an important fishery where the Tlicho and Slavey would meet in spring to build a fish weir. Knowing what we do now about mercury in fish in this drainage, I've often wondered if we could examine this over hundreds, perhaps thousands of years, by analyzing fish scales recovered from a stratified archaeological site? The mouth of the Johnny Hoe might be a good place to look for just such a site and could help make management decisions about the fishery.

…regarding small basin hydrology (5.2)…. It would be helpful to link this component of work to specific questions. These questions could come from communities, land & water boards, etc. This would then focus the research and have much greater application

….regarding historic climate and hydrologic conditions (5.3)….. Again, I would link this to specific questions, otherwise utility is lost.