Vulnerability Assessment of the Slave River and Delta

Summary report for the Community Workshop convened in Fort Smith, January 24–26, 2012

Prepared for the Slave River and Delta Partnership

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Preamble: The NWT Water Stewardship Strategy and the Slave River and Delta Partnership

Northern Voices, Northern Waters: The NWT Water Stewardship Strategy[1] ('the Strategy') was created in partnership by Government of Northwest Territories, Aboriginal Affairs and Northern Development Canada (AANDC) and Aboriginal governments. The vision of the strategy is to ensure the "*waters of the NWT remain clean, abundant and productive for all time"*. One of the methods identified to achieve this goal is using an ecosystem-based approach within watersheds for research and monitoring, and to work with all partners in water stewardship. *NWT Water Stewardship: A Plan for Action 2011-2015*[2] ('the Action Plan') was released in 2011 and outlines a series of *Keys to Success* (actions) for achieving the vision of the Strategy. One of the identified *Keys to Success* is the development of community-based monitoring programs.

The Slave River and Delta Partnership (SRDP) was formed in 2010 when community concerns about the health of fish were brought forward to Environment and Natural Resources (ENR). These concerns led to a series of conference calls with representatives from Aboriginal governments, territorial and federal government agencies, non-profit organizations and academic institutions to discuss past and current monitoring activities and the potential for community-based monitoring initiatives along the Slave River and the Slave River Delta. It resulted in the formation of the SRDP, with the main goal of supporting community-based monitoring activities in the area. Community engagement in research and monitoring, increased information about changes occurring in the Slave River and Delta, and the use of an ecosystem-based approach in SRDP activities, are all aspects of the SRDP that support the vision and goals of the Strategy and Action Plan.

The Partnership has included members of the following organizations:

- Smith Landing First Nation
- Salt River First Nation
- Deninu K'ue First Nation
- NWT Métis Nation
- Fort Resolution Métis Council
- Fort Smith Metis Council
- Hamlet of Fort Resolution
- Town of Fort Smith
- Aurora Research Institute
- Aurora College

[1] For more information, or to view the Strategy, please visit nwtwaterstewardship.ca

[2] Available at nwtwaterstewardship.ca

- Government of the Northwest Territories (GNWT), Environment and Natural Resources (ENR)
- GNWT, Municipal and Community Affairs
- Parks Canada
- Environment Canada
- Fisheries and Oceans Canada

A number of academic partners collaborate with the SRDP on various research and monitoring projects, based on community questions and priorities. Current and past academic partners include:

- Wilfrid Laurier University
- University of Waterloo
- Canadian Water Network
- University of Saskatchewan
- University of New Brunswick
- University of Alberta
- Trent University

In 2010, the SRDP successfully applied for funding from AANDC's Cumulative Impact Monitoring Program (CIMP)[3] for the 2011/2012 cycle to support the development of a community-based aquatic ecosystem health monitoring program. The goals of this CIMP-funded project were to 1) synthesize all available information on the Slave River and Delta from western science and traditional knowledge to facilitate cooperation between monitoring programs (State of the Knowledge report[4]), 2) assess the vulnerability of the Slave River and the Delta to environmental stressors and cumulative impacts (vulnerability assessment, this report), 3) to identify monitoring and research priorities (prioritization activity, this report), and 4) to answer questions about changes in contaminant deposition over time in sediments in the Slave River Delta (sediment core project). Both western science and traditional and local knowledge were included in the State of the Knowledge report, vulnerability assessment and prioritization activity. The SRDP also held an aquatic ecosystem health indicators workshop[5] in 2011, which sought to answer the following questions:

1. What are the human activities causing potential impacts to the Slave River and Slave River Delta? And why do they matter to you?

2. What are the indicators for measuring the aquatic health of the Slave River and Delta? What would you measure and where/when would you find it?

[3] Following Devolution, the NWT-CIMP program is now a territorial program.

[4] for more information, please see the report entitled *State of the Knowledge of the Slave River and Slave River Delta: A Component of the Vulnerability Assessment of the Slave River and Delta* (Pembina Institute, 2016) available at nwtwaterstewardship.ca

[5] for more information, please see the report entitled *Our Water, Our Stewardship Working Together To Monitor The Slave River And Slave River Delta A Summary Report Of The Community Workshop: Monitoring The Health Of The Slave River And Slave River Delta – Fort Smith, NWT* (2011), available at nwtwaterstewardship.ca

3. How can communities best contribute to monitoring activities?

The outcome of this workshop was a list of issues of concern regarding the river and delta, a list of key aquatic ecosystem indicators that could be used for research and monitoring, and identification of opportunities for partners to work together. The list of indicators was then used in the development of the Vulnerability Assessment and prioritization exercise, which are the basis of this report[6]. The priorities outlined in this report guide the direction of the SRDP's community monitoring program, and will be continually updated as more information is gathered and/or as community priorities change.

The development of the SRDP's monitoring program follows and validates the NWT CIMP Pathways Approach[7], which outlines best practices for collaborative and concern-driven monitoring in the north. Through the validation of CIMP's Pathways Approach and participation in the Peace-Athabasca Delta Ecological Monitoring Program (PADEMP), the Slave River and Delta Partnership and other community-based monitoring initiatives, ENR has developed the 'Aquatic Ecosystem Health Community-based Monitoring Initiative', to guide development of community-based aquatic ecosystem health monitoring programs across the NWT (Appendix A).

[6] Pembina Institute is the author of this report, which was provided to the SRDP and ENR-GNWT for review in 2012. SRDP and ENR-GNWT provided input and minor updates/additions post-2012 into the final report. It is important to note, that since the original report was compiled in 2012, work has been undertaken by the SRDP and its partners on many of the top monitoring priorities, including water quality (via the NWT-wide Community-based Monitoring Program), muskrat health, sediment deposition, fish health, benthic invertebrates and other areas. See *State of the Knowledge of the Slave River and Slave River Delta: A Component of the Vulnerability Assessment of the Slave River and Delta* (Pembina Institute, 2016) for details on past and ongoing research and monitoring initiatives.

[7] for more information, please see the report entitled *Pathway to Better Monitoring in Canada's North: A Step-by-step Guide to Designing Northern Monitoring Programs,* NWT CIMP (n.d.), available at http://www.enr.gov.nt.ca/sites/default/files/pathway_to_better_monitoring_in_canadas_north_0.pdf

Executive Summary: Vulnerability Assessment of the Slave River and Delta

On January 24–26, 2012, members of the Slave River and Delta Partnership (SRDP) gathered in Fort Smith, NWT, for a three-day workshop to assess the vulnerability of the Slave River and Delta ecosystem and provide direction on monitoring priorities for future work. This vulnerability assessment workshop was part of the Sediment Coring and State of the Knowledge and Vulnerability Assessment project that was supported by the NWT Cumulative Impact Monitoring Program (CIMP).

Pelicans over the Slave River. **Photo: J. Dagg**

In breakout groups, workshop participants discussed current knowledge, observations of change, vulnerability and monitoring questions for six ecosystem components: hydrology and sediment load, water quality, fish and insect/benthic communities, wildlife, vegetation and air and climate. The group then gathered to identify the top five monitoring priorities for each topic, to rank these five priorities in importance, then to rank the six ecosystem components for priority in monitoring. Participants also ranked the vulnerability of each ecosystem component on a scale of one (not vulnerable) to five (highly vulnerable) and provided rationale (lack of information or observed changes) for the vulnerability ranking.

Many important priorities were identified, and it was recognized that all ecosystem components are interlinked. A number of crosscutting issues and approaches were brought up in all ecosystem components, including:

- Sample extreme water events to capture the range of variability
- Compare the Slave River to reference sites
- Recognize that hydrology and climate influence all other ecosystem components
- Need for more information on groundwater and permafrost
- Identify which changes are natural and which are non-natural
- Human and environmental health should be considered for all research or monitoring programs
- Determine why changes are occurring, rather than just observing change

- Maximize use of information that already exists
- Maximize use of land users for community-based sampling and monitoring
- Coordinate monitoring efforts between jurisdictions and partners
- Communicate the results in a meaningful and timely way

Participants identified monitoring priorities and ecosystem components in the following order:

1. Water quality – Establish ongoing monitoring for water quality, contaminants and metal concentrations at various points in the river.
2. Hydrology and sediment load – Determine why flow is reduced and why seasonal patterns have changed.
3. Wildlife – Monitor muskrat and beaver populations because they are both important fur species and could be indicators of water quality and quantity.
4. Air and climate – Look at wind direction, intensity and seasonal changes, and monitor links to contaminants in air, rain and snow.
5. Vegetation – Look at sediment cores to assess flood cycles as indicated by vegetation growth. Use this assessment of flood cycles to determine the normal range of flooding.
6. Fish – Monitor fish tissue to assess changes in texture, taste and contaminants with respect to human consumption.
7. Insects – There is too little information available on insects to determine vulnerability or compare against other ecosystem components.

All ecosystem components were ranked as fairly vulnerable, with wildlife and water quality ranked as the most vulnerable. Most participants felt that lack of information and observed changes were relevant factors for most ecosystem components, but observed changes were the main reason for ranking of wildlife, air and climate, and hydrology and sediment, and lack of information was the main reason for the ranking for vegetation, water quality and fish.

1. Introduction and background

1.1 Vulnerability assessment workshop

On January 24–26, members of the Slave River and Delta Partnership (SRDP), including the communities of Fort Smith and Fort Resolution, Aboriginal, municipal, territorial and federal governments, and academic and scientific researchers gathered together in Fort Smith, NWT, for a three-day workshop. A full list of participants can be found in Appendix B.

The goal of the workshop was to assess the vulnerability of the Slave River and Delta ecosystem and provide direction on monitoring priorities for the SRDP.

Pelicans over the Slave River. **Photo: J. Dagg**

The objectives of the workshop were to:

- Discuss, and add input into, the results and information gaps identified in the draft of the State of the Knowledge report (please see Preamble, and Appendix A, for more information on the State of the Knowledge report).
- Identify monitoring questions based on community observations and concerns about the Slave River and Delta ecosystem.
- Rank the vulnerability of ecosystem components and discuss reasons for the ranking.
- Prioritize monitoring questions for moving forward with SRDP activities.

The first day of the workshop (January 24, 2012) was limited to local and traditional knowledge holders representing communities and Aboriginal governments along with facilitators and note-takers. On the second and third days (January 25 and 26, 2012), participants from the first day were joined by a number of western scientists and representatives from government agencies.

The workshop was composed of breakout sessions with participants rotating between stations that were divided into six ecosystem components (hydrology and sediment load, water quality, fish and insect/benthic communities, wildlife, vegetation and air and climate), with a final plenary to discuss the findings with the whole group. During the breakout sessions, workshop participants discussed current knowledge, observations of change, vulnerability and monitoring questions for six ecosystem components.

The group then gathered to identify the top five monitoring priorities for each topic, to rank these five priorities in importance, then to rank the six ecosystem components for priority in monitoring. Participants also ranked the vulnerability of each ecosystem component on a scale of one (not vulnerable) to five (highly vulnerable) and provided rationale (lack of information or observed changes) for the vulnerability ranking.

The workshop agenda can be found in Appendix C.

1.2 Background to vulnerability assessments

A vulnerability assessment is a process that captures the state of an ecosystem and its components. Ecosystem vulnerability is a function of 1) the influence of stressors on the ecosystem components, 2) the importance of ecosystem components to the overall ecosystem and to local residents, and 3) the strength of linkages between the ecosystem component and other components.

The purpose of assessing the vulnerability of an ecosystem is to:

- Identify changes in the ecosystem that are the result of human activities.
- Assess the quality and quantity of information available from both traditional knowledge and western science sources.
- Determine information gaps or uncertainties.
- Identify monitoring and research requirements.

More information on vulnerability assessments, and the methodology and guiding questions used in this workshop can be found in Appendix D.

1.3 Outline of workshop report

Section 1 of this report provided an introduction and background information to the vulnerability assessment workshop, the process of vulnerability assessments and the SRDP. Section 2 provides summaries of the breakout sessions on ecosystem components. Section 3 provides a summary of monitoring questions that were identified, a summary of themes that were brought up across a number of topics, and a prioritization of the monitoring questions.

2. Summary of breakout sessions

Participants divided into smaller groups to discuss ecosystem components while answering the questions presented in Appendix D. Below are overall summaries of the breakout group discussions. These summaries reflect the many and varying observations, priorities and concerns raised among workshop participants. For detailed results, please see Appendix E. The identified concerns, impacts, observations and potential monitoring priorities raised in the breakout groups helped to determine SRDP monitoring priorities going forward (see Section 3).

2.1 Hydrology and sediment load

Concerns/impacts

- **Water flow**
  - Volume of water is much lower now
  - Wetlands, fens, channels and lakes are drying
  - These changes may be caused by a combination of river regulations as a result of upstream hydro development, climate change and water withdrawals for upstream industrial activities
  - Water flow is slower now and the river is wider due to river bank material slumping
- **Ice**
  - Ice is thinner and forms later in the fall
  - Quality of the ice is worse — softer, turns black in the spring, candles
  - Many safety concerns when crossing river
  - Water releases from the dam create air pockets and overflow
- **Seasonal flow patterns**
  - Ice breakup is much faster and less violent
  - Less frequent spring flooding allows sediment and debris to build-up in the channels
  - Winter flow is higher which affects ice quality
- **Sediment and travel accessibility**
  - Increased sedimentation that blocks access to channels and lakes
  - Significant impact on people's ability to hunt, fish and access their traplines
- **Groundwater and permafrost**
  - Lower water table due to melting permafrost

  - People store meat in holes — now have to dig deeper
  - Lack of knowledge on groundwater
- **Other concerns**
  - Concern and sadness for the state of the river and the loss of water
  - Suggestion that timing of water releases at the dam should be communicated to downstream residents to minimize safety risks
  - The value of water needs to be recognized in a monetary way in order to communicate with industry the importance of water to the downstream residents
  - Need to be aware and concerned of proposed hydro development (e.g., Site C in B.C. or Dunvegan in Alberta)
  - Need to be careful if minimum water flow levels are set in the Transboundary Agreement - downstream jurisdictions may see that as a maximum level that can be used
  - Industry needs to do better in recycling water. Residents need to do better in conserving water in everyday use

Impacts of hydrology and sediment load on other ecosystem components

- More sediment, less ice scouring allows greater vegetation growth in channels
- Beaver, muskrat, otter and mink populations are linked to water levels
- Fewer migratory geese and birds landing in delta because of drying, fewer frogs heard/found in the Slave River and Delta, moose are moving away from the Slave River
- Sedimentation blocks fish from accessing spawning habitat
- Low flow means less dilution of contaminations
- Lack of flooding in lakes may mean reduced water quality
- Trees are affected by melting permafrost and changes to groundwater (trees have been observed to be drying)

Monitoring priorities

- Determine root causes of why flow patterns have changed through modeling of water flow to look at effects of climate, water withdrawals and regulation on water flow; the Slave River could be compared to an unregulated river to identify effects of regulation
- Monitor ice thickness at ice crossings and bridges that are commonly used and share information with land users
- Determine characteristics of groundwater flow (this has been done in the past with isotopes)
- Establish bio-indicators related to water level and monitor these components
- Identify the critical thresholds of water volume that are required to maintain normal ecosystem functioning
- Sample water at high and extreme low events. Local people can collect these samples as they observe changes to flow
- Compare the effects of reduced ice-jam flooding with the Salt River where flooding still occurs because the banks are lower
- Assess the impacts of high winter flow on initial ice formation

2.2 Water quality

Concerns/Impacts

- **Water quality**
  - Water temperature is higher now than in the past
  - River water is murky and brown-coloured and tastes strange
  - Many participants are concerned about the safety of the water from the river and stated that they no longer drink it
  - Concerns were raised that the sewage lagoon in Fort Resolution may sometimes overflow and add nutrients to the water
- **Algae and foam and debris**
  - Increased algal growth in the last 5-6 years
  - Brown foam that forms in the eddies
  - Oily film on boats
  - Garbage is sometimes seen in the water
- **Metals, contaminants and health concerns**
  - Concerns about contamination in Slave River water. Potential sources of contamination include oil sands, mines, agricultural activities, and garbage dumps
  - Natural oil seeps also contribute to oiliness in the water
  - Concerns about mercury from both natural and human sources
  - Concerns about high cancer rates in Fort Smith and Fort Resolution — kidney and liver cancers in particular are affecting a wide demographic (youth to elders); concerns were raised that cancers could be connected to water quality
  - Unknown effects of chlorine from municipal water treatment plants on human health
- **Other concerns**
  - Participants felt that the onus is on downstream jurisdictions to prove the impacts of industrial development through collection of good baseline data
  - Participants felt that we need to be confident that we are monitoring all the right parameters to capture the full range of impacts

Impacts of water quality on other ecosystem components

- Higher sediment means the water is murkier and it is harder for fish and birds to feed
- Contamination in the water could prevent it from freezing as quickly or could reduce the quality of ice

Monitoring priorities

- Ensure appropriate information sharing and communication between communities, the territorial government, federal governments, and industry
- Monitor for water quality, contaminants and metals; sample through all seasons and at multiple locations
- Compare upstream water quality (where the Athabasca and Peace Rivers meet the Slave) as well as downstream water quality (in both the tributaries to the Slave River and the main Slave River) to help determine location and source of contaminants

- Sample ice to see if contamination is preventing it from freezing as quickly or reducing the quality of ice
- Develop a system for extreme water events so that people are sampling (using comparable methods) as the water moves down the river, and inputting the data into a database
- Establish bio-indicators related to water quality (such as frogs) and assess the population and the observations of decline
- Obtain information about bacteria such as E. coli in the water — very little information available
- Design and carry out a study on health and cancer in Fort Smith and Fort Resolution
- Assess algal growth and sample oily foam and film
- Assess the difference in water chemistry between groundwater and snowmelt water, since it is likely that groundwater is contributing a greater volume of water to the river now
- Monitor pelicans as they may be a good indicator species for water quality due to their position at the top of the trophic system

2.3 Fish and insect/benthic communities

Concerns/Impacts

- **Fish population**
  - Observations of a decline in some fish species (whitefish and chub) but an increase in others (dogsalmon and trout)
  - Participants suggested that changes to fish population are due to water withdrawals or contaminants, not due to changes in fishing pressure
  - Seasonal patterns of fish movement and spawning seem to be shifting (spawning is occurring later in fall)
- **Fish health**
  - Observations of a decrease in size and weight of fish
  - Observations that fish flesh from the Slave River is often soft and mushy, and sometimes has a strange taste
  - Participants are concerned about eating the fish from the river because of fish health and contamination impacts on human health
  - Sores, worms, deformities, tapeworms and marks from lamprey parasitism have been observed more frequently
  - Causes of the decline in fish health stated by participants include: warmer water, lower flow, agricultural inputs, contaminants from oil sands and mines and garbage in the water
- **Insect/benthic communities**
  - Observations of changes to insect populations and species (e.g. there are fewer bees, yellowjackets, and mosquitoes, bulldogs (a type of fly) are present for longer) but there is very little information available about insects
- **Other concerns**
  - Participants emphasized the importance of answering community-driven questions and then communicating those results back to residents

Impact of fish and insects on other ecosystem components

- Need healthy fish and insect populations to support bird and animal populations
- Fish are an important part of community members' diets. Unhealthy fish, or decreasing fish populations, can negatively impact human health and wellbeing.

Monitoring priorities

- Monitor fish tissue to assess changes in texture, taste and contaminants with respect to human consumption
- Monitor overall fish health including monitoring deformities and contaminants.; determining whether Slave River fish are migrating from Lake Athabasca or from Great Slave Lake would be helpful in knowing the types and amount of contaminants and the potential origins of contaminants in fish
- Assess and monitor fish populations in Great Slave Lake, Slave River and Delta; compare the Slave River fish to the commercial fishery on Great Slave Lake
- Identify preferred fishing sites of locals and monitor changes in populations, species and behavior at these sites with traditional knowledge
- Establish a baseline assessment of insect species
- Determine how lampreys are affecting fish
- Monitor the movement of fish in and out of shallow lakes
- Assess the productivity of Slave River spawning grounds
- Assess how warmer water temperatures and reduced flow impact oxygen levels under ice

2.4 Wildlife

Concerns/impacts

- **Birds**
  - Geese and ducks seem to be using the Slave River Delta as a staging area during migration less frequently in recent years
  - Ducks and geese seem to have less body fat, taste different and sometimes have worms
  - Ptarmigan sightings are becoming more rare
  - New species (e.g., magpies) in the Slave River area
  - Productivity of pelicans has declined
  - Songbird (e.g., whiskeyjacks, spruce grouse and robins) populations appear to be declining and the forest is quieter because bird songs are absent
- **Frogs**
  - Decline in frogs, caused by drying of ponds and creeks and/or contaminants in the water
- **Moose**
  - Moose have moved farther north or the population has declined

  - This movement may be caused by hunting pressure, fires that have reduced food availability, predation, and/or the movement of deer into the Slave River area (either direct competition for food or introduction of ticks which are detrimental to moose health)
- **Aquatic furbearing species**
  - Muskrat, beaver, otter and mink are heavily affected by changes to water levels, but it is not clear whether the populations are stable, declining or increasing
  - Beavers were noted by some participants as declining, but others stated that the population is stable
  - Difficulty in accessing traplines in the fall because of lack of ice makes it more difficult for trappers to observe population changes
- **Other species**
  - Deer and cougars are moving northward into the Slave River area
  - Muskox are moving south into the Slave River area
  - Observations of a recent increase in bear, porcupine and skunk populations
  - Observations of a recent decrease in marmot, rabbit and lynx populations
  - It is unclear whether the wolf population is stable, declining or increasing
- **Other concerns**
  - Importance of inviting youth to these meetings so that they understand these issues and can pass knowledge on to them
  - Need to be concerned about health of wildlife as well
  - Wildlife is an important food source for members of the community. If wildlife populations decline can negatively impact human health by reducing access to country foods
  - Declining wildlife populations could be detrimental to the economy, as hunting is a draw for tourists

Impacts of wildlife on other ecosystem components

- Beaver dams have an impact on hydrology through controlling of surface water flow

Monitoring priorities

- Monitor muskrat and beaver populations because they are both important fur species and could be indicators of water quality and quantity
  - In the short-term, assess beaver populations in the spring of 2012 to determine how they were affected by high water levels in late fall of 2011
  - Determine if muskrat and beaver population changes are linked to fluctuating water levels after ice has formed
- Monitor moose population and determine if the moose population has declined or if moose have moved, and why these changes have occurred
- Use pelicans (or other fish-eating birds) to monitor contaminants, and determine path of how contaminants are passed between trophic levels
- Assess the impact of predators (wolves and bears) on other animals, especially in spring.
- Assess populations of songbirds and migratory birds (and species diversity, timing or migration)

- Assess the simultaneous shifts in species distribution (moose, deer, muskox, etc.) and identify cause of shifts
- Investigate the decline in frogs and red-sided garter snakes

2.5 Vegetation

Concern/Impacts

- **Vegetation shift**
  - Prairies, fens and wetlands are becoming overgrown with vegetation (willows), beaches are now covered with weeds
  - Changes may be caused by reduced flow, reduced flooding, reduced scouring, fire management and natural changes
  - Willow growth limit access to hunting, fishing and trapline areas
- **Berries**
  - Decline in the abundance and quality of berries (i.e., dried out)
- **Forest infestation**
  - Spruce budworm was a major problem a few years ago, plus aspen leaf miner, willow bug and drying pine trees
- **Invasive plant species**
  - New/invasive species observed in the Slave River area
- **Fire**
  - Fire is important in maintaining vegetation in the Slave River area. Less frequent prescribed burning is a factor in increased willow growth
  - Fires are occurring earlier in the spring, and there have been some observations of increased severity in fire but the natural variation in fire regime makes this difficult to assess

Impact of vegetation on other ecosystem components

- Drying of prairies and mudflats affects waterfowl, frogs, muskrat, moose, and other species
- Forests and permafrost affect each other (forest cover insulates permafrost, permafrost stabilizes soil to support tree growth)

Monitoring priorities

- Look at tree pollen in sediment cores to assess flood cycles as linked to vegetation growth; use this assessment of flood cycles to determine the historical range of water level
- Survey frequency and severity of forest insect infestations and assess the implications of infestations for fire frequency
- Survey distribution and abundance of invasive plant species
- Monitor plant species that take up contaminants (e.g., cattails)
- Monitor plant species that are important wildlife food sources (e.g., lilies for moose, rat root for muskrat)
- Assess the impact of reduced human harvest of wood for heating on fires and vegetation density

- Update mapping of vegetation shift on the delta with GIS and traditional knowledge, and use this mapping to model vegetation under future hydrological regimes
- Assess slumping associated with permafrost melt and link to forest growth and productivity
- Assess productivity and distribution of aquatic and riparian plants
- Model changes in overall vegetation community composition and distribution to take into account the effects of new grazing species (e.g., deer) and new plant species (e.g., thistles)

2.6 Air and climate

Concerns/Impacts

Clouds over the Slave River. **Photo: J. Dagg**

- **Temperatures**
  - Warmer weather in winters and summers
  - Freezing delayed in fall, early breakup
  - Higher temperatures affect human health, food storage, transportation
- **Moisture in the air**
  - Frost and fog are more frequent
  - Summers are wetter and winters are drier
- **Rain, storms and wind**
  - Rain falls harder and faster
  - More frequent and violent storms: hail, wind and freezing rain
  - Wind comes more frequently from the south — concerns that winds may be carrying emissions from the oil sands
- **Snow**
  - Less snow than there used to be
  - Texture of snow has changed — it is fluffier, and melting and re-freezing create crusts
  - Snow melts quickly, evaporates rather than entering water systems
- **Air quality**
  - Concerns about air emissions and lack of monitoring
  - Lack of knowledge on health impacts of air emissions, and deposition of air emissions in water
- **Other concerns**
  - Participants question the value of monitoring because it doesn't solve the problems

  - Concerns about the global nature of climate change – the whole world is struggling and not able to solve this problem

Impacts of air and climate on other ecosystem components

- Frequency of moose ticks increasing with warmer temperatures
- Crusts on snow (from melting and re-freezing) make feeding difficult for many species
- Stronger winds blow snow off the muskrat pushups, making them more vulnerable to predators
- Air temperature is linked to anthrax outbreaks in bison
- With warmer fall weather, fur on animals does not prime as early
- Less snow and higher evaporation of snow in spring has impacts on permafrost and hydrology
- Reduced moisture leads to reduced berry quality

Monitoring Priorities

- Monitor air quality and contaminants in snow in the Slave River area
- Look at wind speed, direction and changes over time and examine if they are linked to contaminants, and in what ways
- Analyze data to corroborate observations of a decline in snowpack
- Develop program for local residents so they can record weather observations

3. Identification of monitoring priorities

3.1 Cross-cutting issues

In the afternoon of the third day of the workshop, participants gathered in a plenary session to discuss and rank the monitoring priorities from the breakout sessions and overall vulnerability. As monitoring priorities were presented for each ecosystem component, a number of topics and approaches were raised repeatedly across all breakout sessions. It was agreed that all monitoring programs or activities would take into account these topics and approaches.

Topics

- **Sample extremes**: Need to sample at extremes of the system (e.g., high water and low water events) as well as seasonal sampling, to better understand the range of natural variation.
- **Compare to reference sites**: Need to identify and sample other rivers and deltas that can be compared to the Slave River and Delta to help identify trends and patterns.
- **Natural vs. non-natural**: The changes that have been observed are likely a mix of natural and human-induced. Better methods for separating the effects of these stressors should be investigated.
- **Health first:** Any research on contaminants needs to be strongly linked with human health and environmental health.
- **Hydrology and climate change:** These components will affect all other ecosystem components, and all monitoring should take into account changes that have already occurred, and are expected to occur, in the climate and hydrological systems.
- **Increase understanding of groundwater and permafrost:** Groundwater and permafrost changes are likely having an impact on all ecosystem components, but understanding these connections is difficult.

Approaches

- **Ask why**: We need to determine why change is occurring, rather than just observing or documenting change.
- **Use information that already exists:** Monitoring programs should maximize use of data that is already available. There is a need to establish a system for collecting and incorporating local and traditional knowledge into research and monitoring. Research and monitoring information needs to be stored in a centralized, accessible location and updated regularly.
- **Community-based sampling and monitoring**: Land users can collect samples with little effort or cost, and can sample during unusual events as they occur. There is a need to develop a protocol for sampling and data collection and to provide training to local residents.

- **Coordinate**: More information is needed from upstream jurisdictions about what activities and contaminants are impacting the water. There is a desire to work towards an integrated monitoring system with upstream jurisdictions. There is also the ongoing need to coordinate and share information within the Slave River and Delta Partnership groups.
- **Communicate:** Researchers need to communicate the results of their work to local residents in a meaningful and timely way.

3.2 Identification of top monitoring priorities

The goal of this session was to identify the top monitoring priorities out of the list identified in the breakout groups, while recognizing that all monitoring ideas would provide valuable insight into the functioning of the Slave River ecosystem.

In plenary, participants were presented by a selection of the top five most frequently mentioned monitoring priorities as identified by the note-takers and facilitators. Participants then added items to the list that they felt were important or that had not already been stated in the breakout sessions. Participants then voted once for their top priority in each topic. However, it should be emphasized that because participants could only vote for their top choice, some important monitoring priorities may not have received any votes, but should still be considered relevant and important.

The results are presented below in order of votes:

Hydrology and sediment load

Monitoring priorities	Votes
Determine why flow is reduced and why seasonal patterns have changed	**21**
Monitor ice thickness at river crossing and share information with land users	6
Determine characteristics of groundwater	1
Research why speed of flow is declining and river is wider	0
Assess sediment geology for contribution to contaminants	0

Water quality

Monitoring priorities	Votes
Ongoing monitoring for water quality, contaminants and metals at various points in the river	**16**
Compare upstream water quality (from where Peace and Athabasca enter the Slave) to water in the Slave River and tributaries to help determine location and source of contaminants	11
Sample ice to determine if contamination is preventing it from freezing as quickly or reducing the quality of ice	5
Assess the frog population and explore how frogs can serve as a bioindicator of water quality	0

Fish and insect/benthic communities

Monitoring priorities	Votes
Assess fish tissue for changes in texture, taste and contaminant exposure with respect to human consumption	**14**
Monitor fish health and population (including deformities and contaminants)	9
Assess and monitor fish populations in Great Slave Lake, Slave River and Delta	8
Identify preferred fishing sites of locals and monitor changes in populations, species and behavior at these sites with traditional knowledge	2
Baseline assessment of insects species	x

It was recognized that there is very little information available about insects and it was difficult to compare insects against other topics where more information is available. Due to this lack of information, insects were set aside as a separate topic, and were not prioritized or assessed for vulnerability (section 3.3.1 and 3.3.2).

Wildlife

Monitoring priorities	Votes
Monitor muskrat and beaver populations because they are both important fur species and could be indicators of water quality and quantity	**20**
Monitor moose population and determine why moose population has declined or moose have moved	14
Use pelicans (or other fish-eating birds) to monitor contaminants	8
Assess the impact of predators (wolves and bears) on other animals, especially in spring	7
Assess populations of songbirds and migratory birds (and species diversity, timing or migration)	1
Assess the simultaneous shifts in species distribution (e.g., moose, deer, muskox, etc.) and identify cause of shifts	1

Vegetation

Monitoring priorities	Votes
Look at sediment cores to assess flood cycles as indicated by vegetation growth. Use this assessment of flood cycles to determine the normal range of flooding	**20**
Survey frequency and severity of forest insect infestations and assess the implications of infestations for fire frequency	2
Survey distribution and abundance of invasive plant species (e.g., cattails)	1
Monitor plant species that are important wildlife food sources (e.g., lilies for moose, rat root for muskrat)	0
Monitor plant species that are wildlife indicators (e.g., lilies for moose, rat root for muskrat)	0

Air and climate

Monitoring priorities	Votes
Look at wind direction, intensity and seasonal changes and monitor links to contaminants in air, rain and snow	**18**
Monitor snow depth, spring melt characterization and freeze-up	6
Monitor frequency of storms (rain, snow, hail)	4

3.3 Prioritization of monitoring topics

3.3.1 Prioritization of ecosystem components

Participants were asked to vote once on which ecosystem component they would like to see monitored as the top priority, while recognizing that all topics are important and interrelated. Figure 1 presents the results of this vote.

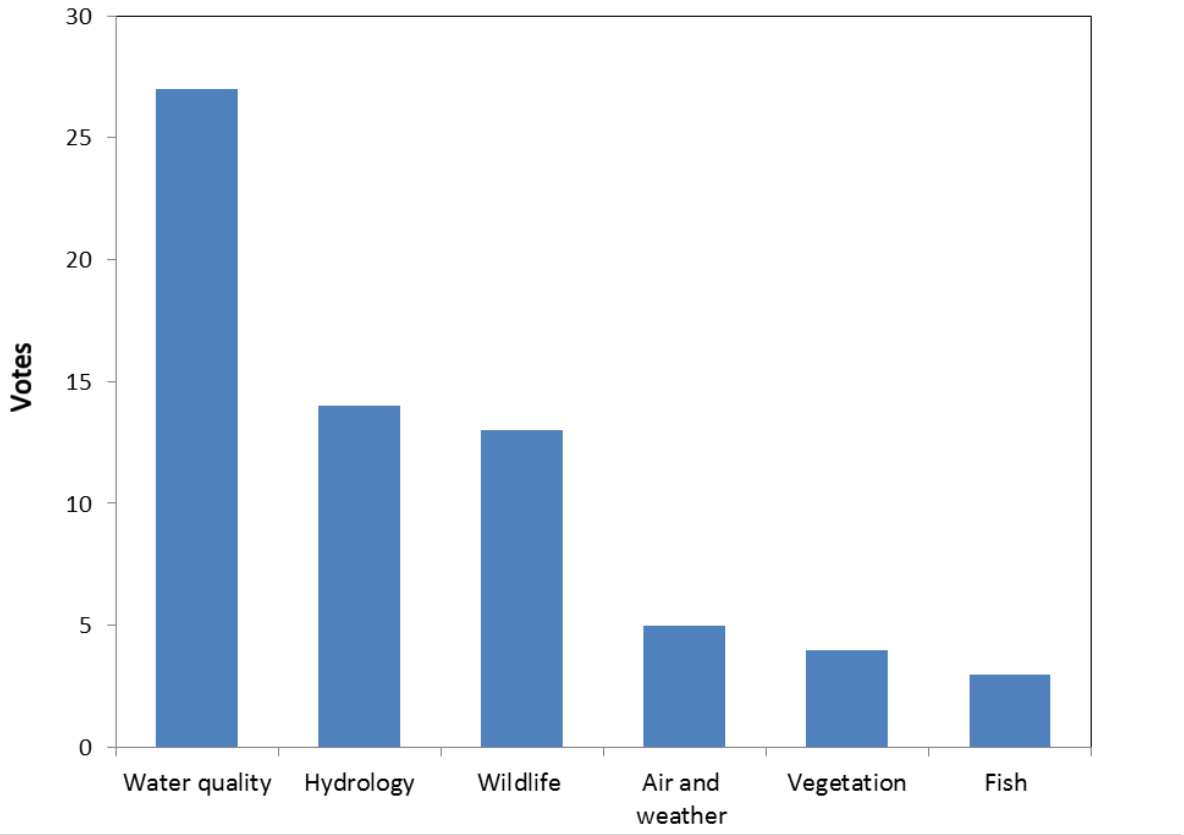

Figure 1: Votes for importance of ecosystem components

Water quality emerged as the strongest monitoring priority, followed by hydrology and wildlife. However, participants discussed how all ecosystem components are linked to the others through natural ecosystem functions and processes. See detailed results in Appendix F.

3.3.2 Vulnerability ranking

Participants were then asked to rank the vulnerability of ecosystem components on a scale of 1 to 5, where one was Not Vulnerable and five was Highly Vulnerable. Figure 2 presents the averaged results of this ranking.

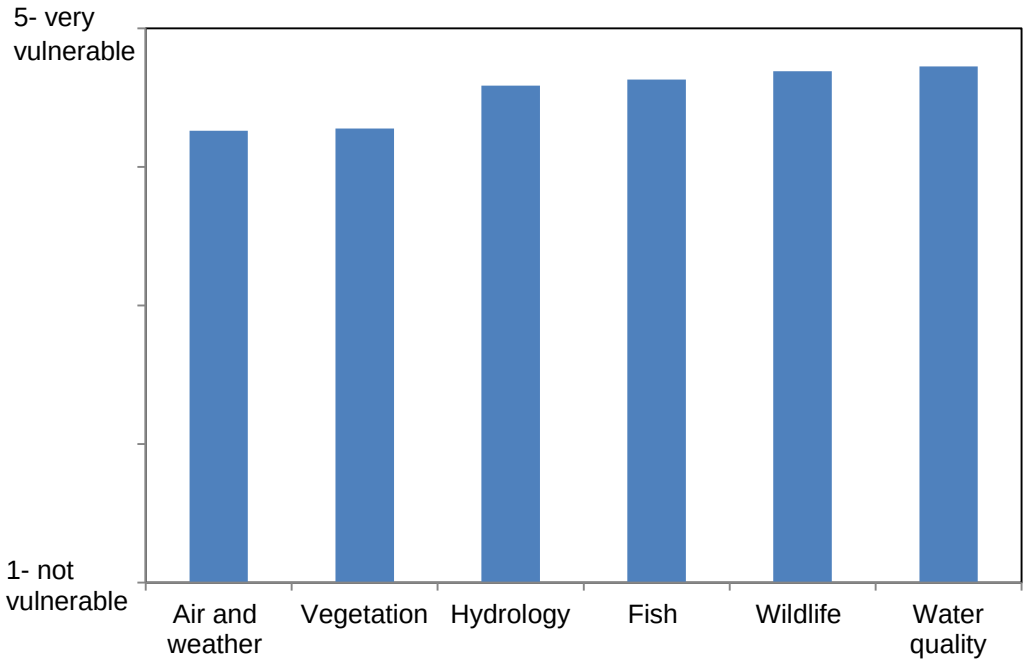

Figure 2: Averaged vulnerability ranking for ecosystem components

All ecosystem components were ranked as fairly vulnerable, but wildlife and water quality were ranked the highest.

Participants were asked why vulnerability was ranked at certain values, based on changes that have been observed, the amount of information that is available about the ecosystem component, or both. Figure 3 presents the results of this survey. For example, according to Figure 3, approximately 50% of the workshop participants felt that wildlife is vulnerable as a result of a lack of information about the ecosystem component and approximately 70% felt wildlife was vulnerable because of observed changes.

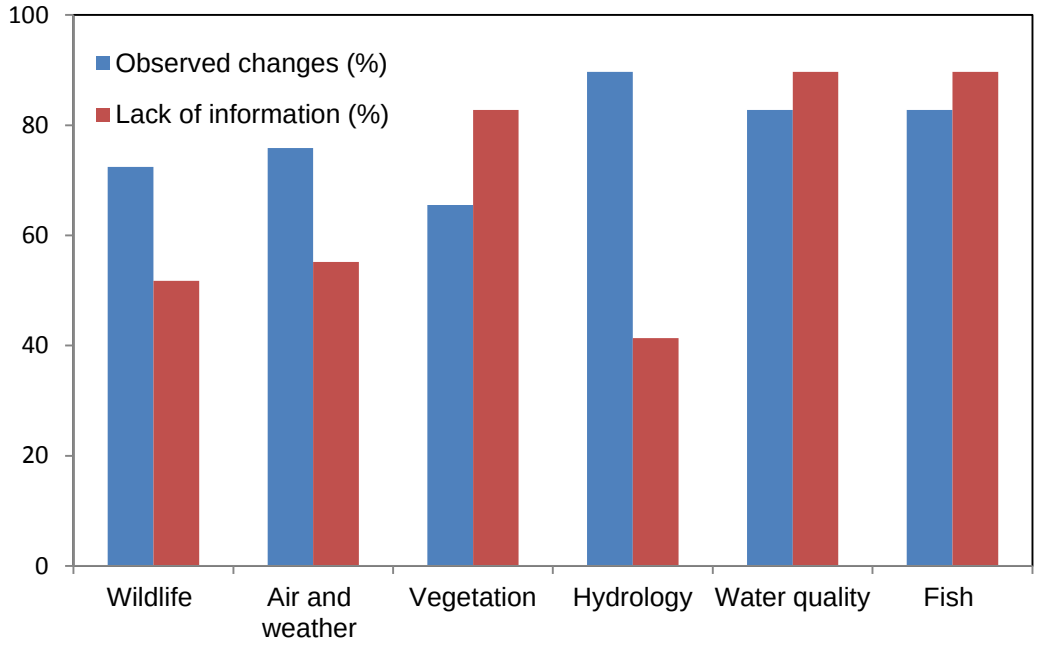

Figure 3: Rationale for ranking of vulnerability for ecosystem components

Participants felt that observed changes for wildlife, air and climate, and hydrology and sediment were the main reason for the vulnerability ranking. Lack of information was the main reason for the ranking for vegetation, water quality and fish. See detailed results in Appendix F.

3.4 Summary and next steps

Overall, water quality was rated as the greatest monitoring priority, and within that component, the highest priority was for monitoring of hydrocarbons and metals.

However, it was repeatedly mentioned that all ecosystem components are linked, especially water quality with hydrology. The high level of vulnerability given by participants to all ecosystem components reflects the large amount of change seen by residents as well as the lack of information that exists or that is properly communicated about the ecosystem.

SRDP members will now work together to pursue research and monitoring efforts according to these monitoring priorities. Through research and monitoring, we will improve our understanding of ecosystem functioning, in an effort to provide timely and relevant responses to questions and concerns from community members.

Appendix A. Aquatic Ecosystem Health Community-based Monitoring Initiative

The development of the Slave River and Delta Partnership's monitoring program follows the principles of the NWT CIMP Pathways Approach[8], which outlines best practices for collaborative and concern-driven monitoring in the north. Through the validation of CIMP's Pathways Approach and participation in the Peace-Athabasca Delta Ecological Monitoring Program (PADEMP), the Slave River and Delta Partnership and other community-based monitoring initiatives, ENR has developed the 'Aquatic Ecosystem Health Community-based Monitoring Initiative' ('the Initiative') to guide development of community-based aquatic ecosystem health monitoring programs across the NWT.

The Initiative addresses community concerns and links western science with traditional and local knowledge. Implementation of the Initiative builds community capacity through training opportunities, analysis of past and current related monitoring and research, and participation in monitoring priority development and program design, which allows for decreased duplication among programs and cost-effective monitoring.

The process of developing State of the Knowledge and Vulnerability Assessment reports was originally used by PADEMP. This process was adapted to fit NWT community needs, and to shorten timelines between information gathering, prioritization and implementation of monitoring actions.

Key to the Initiative is the design and implementation of community-concern driven projects during the development of the Vulnerability Assessment. Research projects early on in the process can address some community concerns while monitoring programs are being set up, which can shorten time periods between initial community meetings and on-the-ground actions with results. For the Slave River and Delta Partnership, the community-concern driven project focused on contaminants in sediments in a lake in the Slave River Delta (in partnership with Wilfrid Laurier University and University of Waterloo[9]), to address community questions about increases in contaminants (particularly ones related to oil sands development) in the Slave River over time.

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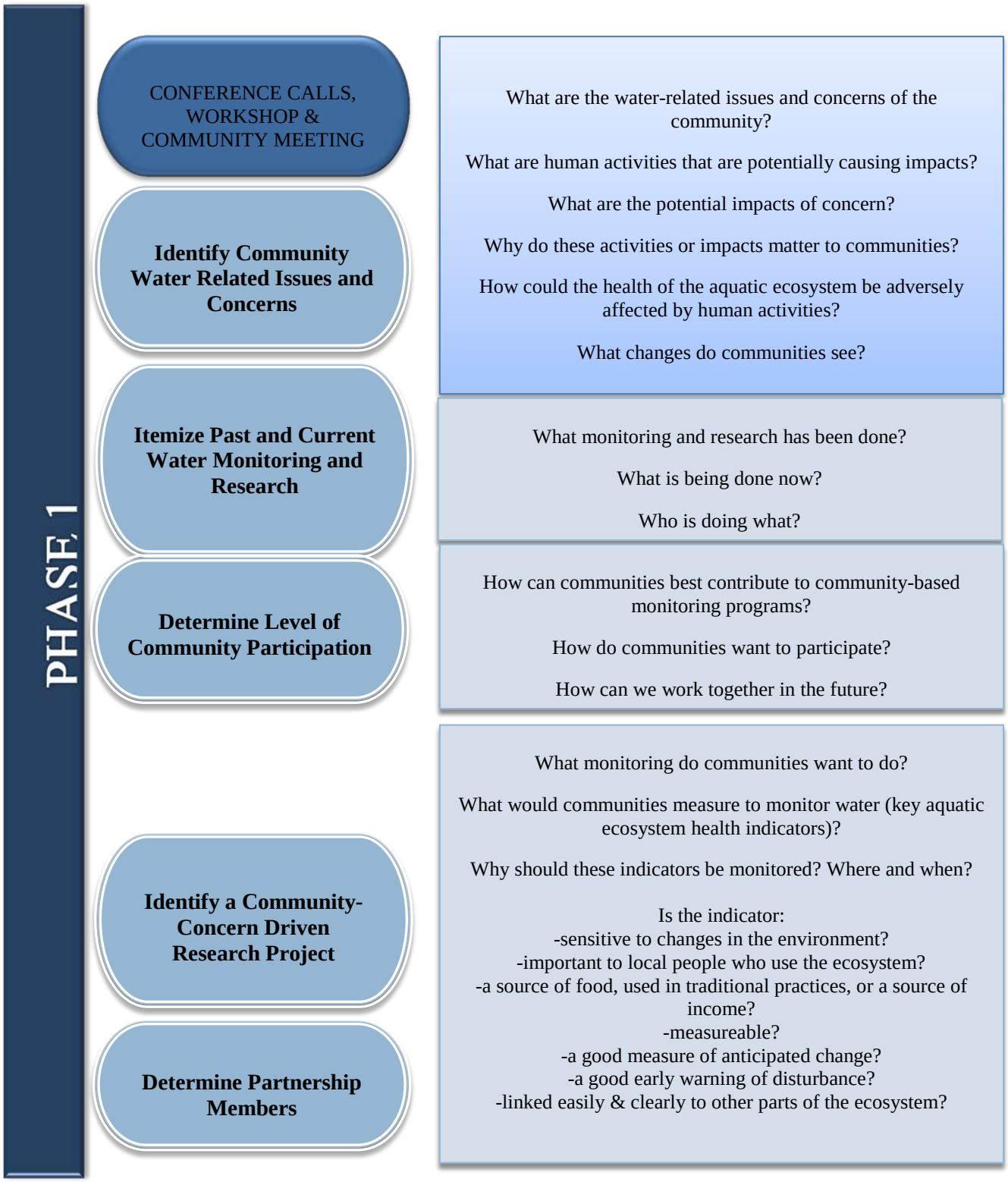
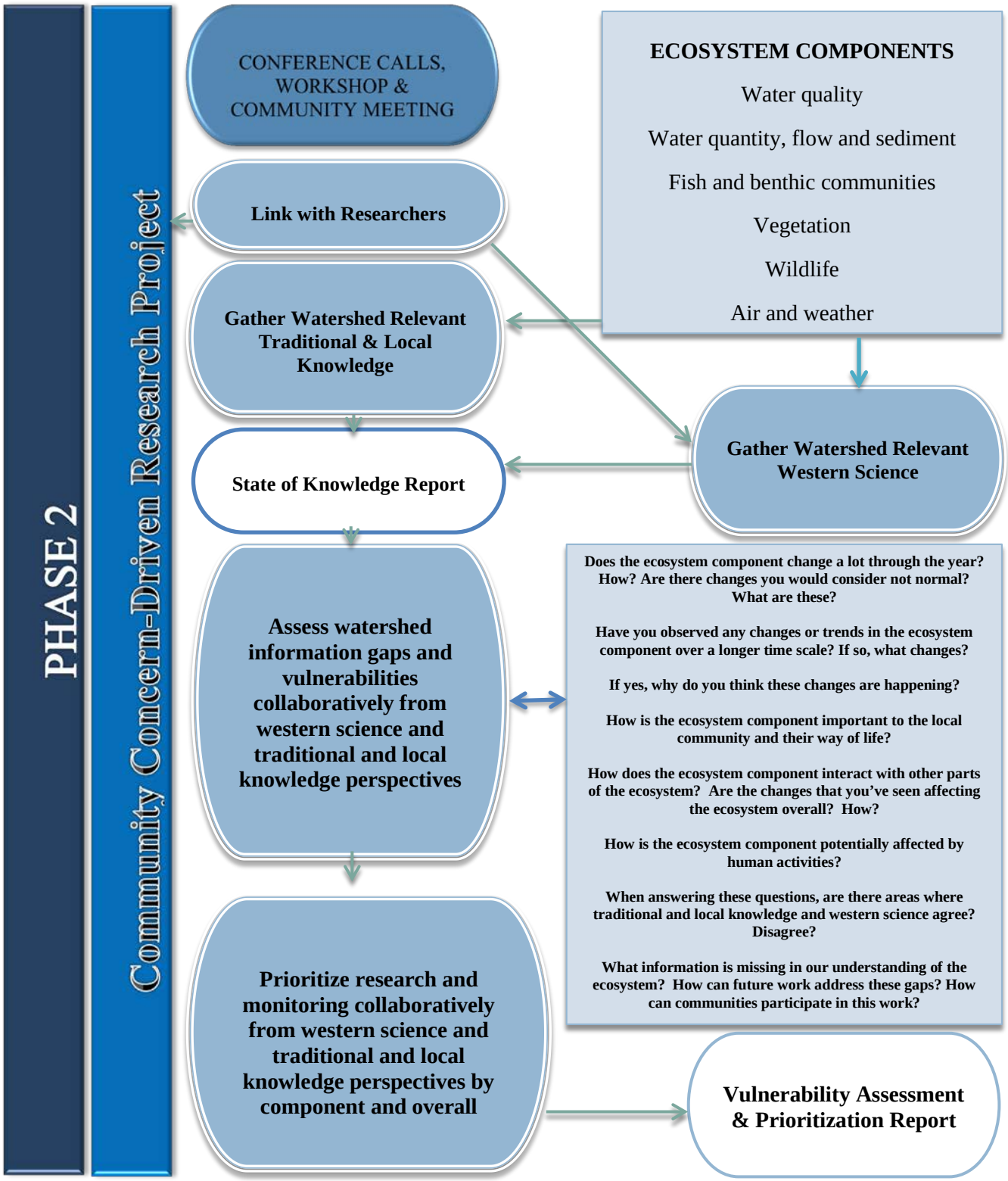
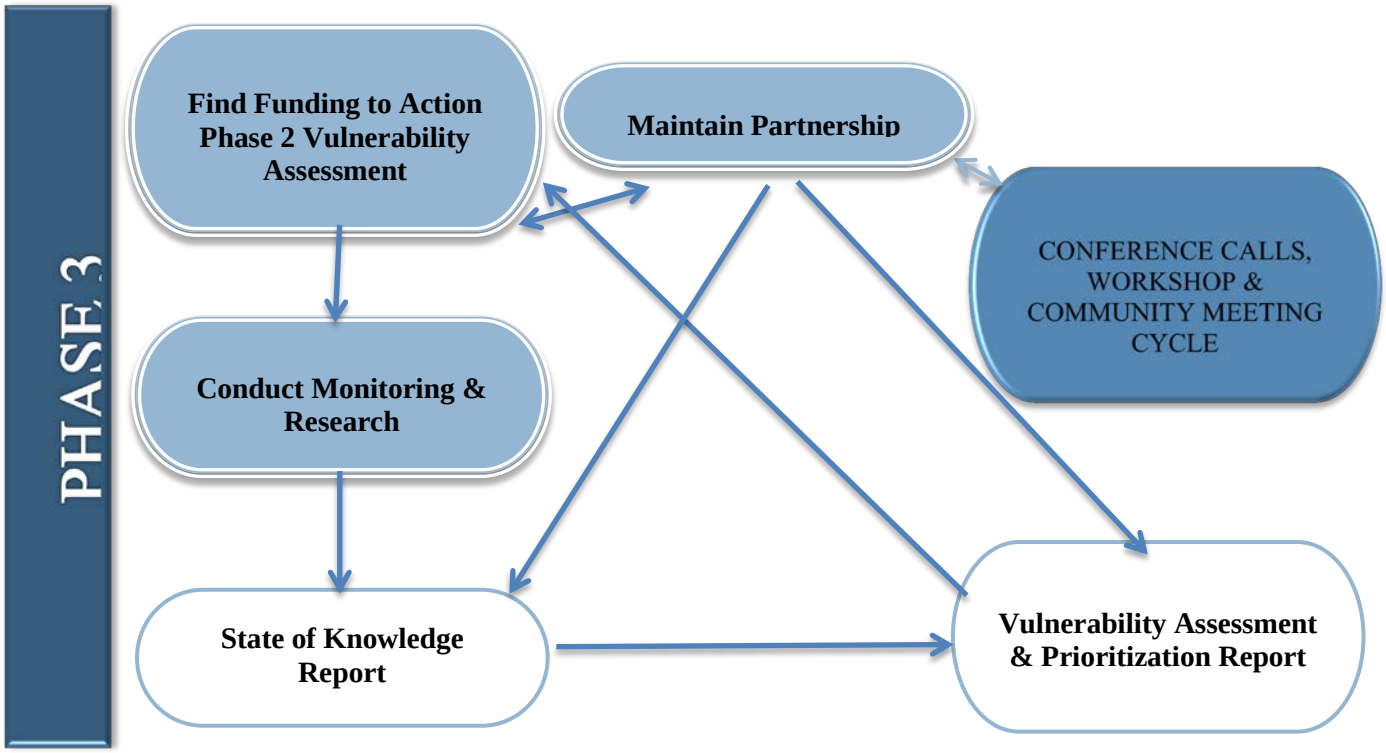
[8] for more information, please see the report entitled *Pathway to Better Monitoring in Canada's North: A Step-by-step Guide to Designing Northern Monitoring Programs,* NWT CIMP (n.d.), available at http://www.enr.gov.nt.ca/sites/default/files/pathway_to_better_monitoring_in_canadas_north_0.pdf

[9] for more information, please see the report entitled *State of the Knowledge of the Slave River and Slave River Delta: A Component of the Vulnerability Assessment of the Slave River and Delta* (Pembina Institute, 2016) available at nwtwaterstewardship.ca. See also: Wolfe, B.B and Hall, R.I. 2012. *Research Report–November 2012. Sediment Core Sampling to Assess Contaminant Deposition to the Slave River Delta Over Time*, and, Wolfe, B.B and Hall, R.I. 2014. *Research Report–April 2014. Sediment Core Sampling to Assess Contaminant Deposition to the Slave River Delta Over Time*. Available at nwtwaterstewardship.ca


PHASE 1
CONFERENCE CALLS, WORKSHOP & COMMUNITY MEETING
Identify Community Water Related Issues and Concerns
What are the water-related issues and concerns of the community?
What are human activities that are potentially causing impacts?
What are the potential impacts of concern?
Why do these activities or impacts matter to communities?
How could the health of the aquatic ecosystem be adversely affected by human activities?
What changes do communities see?
Itemize Past and Current Water Monitoring and Research
What monitoring and research has been done?
What is being done now?
Who is doing what?
Determine Level of Community Participation
How can communities best contribute to community-based monitoring programs?
How do communities want to participate?
How can we work together in the future?
Identify a Community-Concern Driven Research Project
What monitoring do communities want to do?
What would communities measure to monitor water (key aquatic ecosystem health indicators)?
Why should these indicators be monitored? Where and when?
Is the indicator:
-sensitive to changes in the environment?
-important to local people who use the ecosystem?
-a source of food, used in traditional practices, or a source of income?
-measureable?
-a good measure of anticipated change?
-a good early warning of disturbance?
-linked easily & clearly to other parts of the ecosystem?
Determine Partnership Members


PHASE 2
Community Concern-Driven Research Project
CONFERENCE CALLS, WORKSHOP & COMMUNITY MEETING
Link with Researchers
Gather Watershed Relevant Traditional & Local Knowledge
State of Knowledge Report
Assess watershed information gaps and vulnerabilities collaboratively from western science and traditional and local knowledge perspectives
Prioritize research and monitoring collaboratively from western science and traditional and local knowledge perspectives by component and overall
ECOSYSTEM COMPONENTS
Water quality
Water quantity, flow and sediment
Fish and benthic communities
Vegetation
Wildlife
Air and weather
Gather Watershed Relevant Western Science
Does the ecosystem component change a lot through the year? How? Are there changes you would consider not normal? What are these?
Have you observed any changes or trends in the ecosystem component over a longer time scale? If so, what changes?
If yes, why do you think these changes are happening?
How is the ecosystem component important to the local community and their way of life?
How does the ecosystem component interact with other parts of the ecosystem? Are the changes that you've seen affecting the ecosystem overall? How?
How is the ecosystem component potentially affected by human activities?
When answering these questions, are there areas where traditional and local knowledge and western science agree? Disagree?
What information is missing in our understanding of the ecosystem? How can future work address these gaps? How can communities participate in this work?
Vulnerability Assessment & Prioritization Report


PHASE 3
Find Funding to Action Phase 2 Vulnerability Assessment
Maintain Partnership
CONFERENCE CALLS, WORKSHOP & COMMUNITY MEETING CYCLE
Conduct Monitoring & Research
State of Knowledge Report
Vulnerability Assessment & Prioritization Report

Appendix B. Workshop Participants

Name	Organization
Stanley Beck	Deninu K'ue First Nation
Lawrence Fabien	
Harvey Mandeville	
Dave Pierrot	
Robert Beaulieu	
Lena McKay	Fort Resolution Métis Council
Tyler Delorme	
Warren Delorme	
Pete King	
Eric Beck	
Charlie Desjarlais	Fort Smith Métis Council
Johnny Desjarlais	
Leonard Desjarlais	
Henry Heron	
Ron Mabbit	
Cec Heron	Smith's Landing First Nation
Jeff Dixon	
Judy Poitras	
Julie Abraham	
Benjy (Kelly) Mandeville	
John Vermillion	
Ken Youngman	
Fred Beaulieu	Salt River First Nation
Ray Tourangeau	
Phil Macdonald	
Agnes Moreau	

Liz Fortier	
Kirsten Bradley	Town of Fort Smith
Doug Robertson	
Jack Van Camp	
Jacques Van Pelt	
Leonard Beaulieu	Hamlet of Fort Resolution
Dennis King	
Henry McKay	
Kerry Pippy	Environment Canada
Derek Faria	Aboriginal Affairs and Northern Development Canada
Juanetta Sanderson	
Deanna Leonard	Department of Fisheries and Oceans
Jeff Shatford	Parks Canada
Rhona Kindopp	
Stuart MacMillan	
Sarah Rosolen	Aurora College
Kevin Smith	
Allicia Kelly	ENR - Ft. Smith
Paul Jones	University of Saskatchewan
Gila Somers	Canadian Water Network
Jim McGeer	Wilfrid Laurier University
Katie White	Observer - Student
Jennifer Dagg	Pembina Institute
Erin Kelly	ENR - Land and Water Division
Jennifer Skelton	
Katherine Trembath	
Mike Smith	Data Manager

Appendix C. Workshop Agenda

January 24, 2012 – Community groups/TK holders only

10:00-10:30	Welcome Introduction: Vulnerability Assessment	The format of the workshop, the concepts of vulnerability and vulnerability assessment, and the task groups and the questions to answer will be introduced.
10:30-12:00	Ecosystem component stations	The drafted information for each ecosystem component will be presented in different stations. The workshop participant will provide input and information at each station that will answer the vulnerability questions. A brief overview of the State of the Knowledge report will be presented. **Hydrology and sediment load** **Vegetation** **Fish and Insect Communities**
12:00- 13:00	Lunch	
13:00- 14:15	Ecosystem component stations	A brief overview of the State of the Knowledge report will be presented. **Air and Climate** **Water Quality and Sediment** **Wildlife**
14:15- 14:30	Health break	
14:30- 15:30	Continue ecosystem component stations	
15:30- 16:00	Wrap-up	Discuss linkages and overall grading.

January 25, 2012 – Community groups/TK holders and western science participants

10:00-10:30	**Intro**	Welcome Icebreaker Summary of agenda, rationale for approach Summarize results from Day 1
10:30-12:00	Ecosystem component stations	**Hydrology and sediment load** **Vegetation** **Fish and Insect Communities** Participants will rotate through 3 stations and will review vulnerability questions and rank the vulnerability

12:00- 13:00	Lunch	
13:00- 14:15	Continue ecosystem component stations	
14:15- 14:30	Health break	
14:30- 15:30	Canadian Water Network	Representatives from the Canadian Water Network will talk about its involvement in the NWT Water Strategy and community-based monitoring.
15:30- 16:00	Wrap-up	Discuss linkages and overall grading.

January 26, 2012 – Community groups/TK holders and western science participants

9:00- 9:15	**Introduction**	Brief summary of results from the State of the Knowledge and Day 1
9:15-10:30	Ecosystem component stations	**Air and Climate** **Water Quality and Sediment** **Wildlife** Participants will rotate through 3 stations and will review vulnerability questions and rank the vulnerability
10:30-10:45	Health break	
10:45- 12:00	Continue ecosystem component stations	
12:00- 13:00	Lunch	
13:00- 14:15	Continue ecosystem component stations	
14:15-14:30	Health break	
14:30- 15:30	Overall assessment of the Slave River and Delta	Discuss linkages and overall grading.
15:30- 16:30	Future and monitoring and research.	Discuss monitoring and research questions. How will this assessment inform future activities in the area?
16:30	Wrap-up	

Appendix D. Vulnerability assessment background and questions

An assessment of the vulnerability of an ecosystem requires good knowledge of ecosystem components, including abundance and composition of species, functioning, range of variation, and observations of stressors placed on the system and the corresponding impacts.

Vulnerability is assessed using both traditional knowledge and western science perspectives. These two perspectives may diverge in how they arrive at monitoring questions, but may converge on determining the importance of ecosystem components. The use and access of people to the land, water and resources is a key component of this vulnerability assessment. Another key element is the impact or connectivity of ecosystem components to each other. While one ecosystem component may not be vulnerable in itself, it may be affected by other vulnerable ecosystem components.

On Day 1 of this workshop, local residents who are holders of traditional and local knowledge of the ecosystem gathered to discuss the vulnerability of ecosystem components and of the ecosystem as a whole. On the second and third day, local residents were joined by holders of western science information. These two different group compositions provided key information and discussion for identification of monitoring priorities.

Participants were presented with summaries of the draft State of the Knowledge report to provide them with a summary of information gaps that had been identified through the literature review. This list of gaps was intended as a starting point for discussion, revision and input. Participants were asked to review a list of questions (below), designed to determine how and why an ecosystem component is changing, determine the importance of that ecosystem to people and other parts of the ecosystem, and to identify monitoring priorities for that component and how research and monitoring programs can be designed to include all partners.

1. Does the ecosystem component vary a lot through the year (natural variation)? How? Are there changes that you would consider not normal? What are these?
2. Have you observed any changes or trends in the ecosystem component over a longer time scale? If so, what changes?
3. If yes, why do you think these changes are happening?
4. How is the ecosystem component important to the local community and their way of life?
5. How does the ecosystem component interact with other parts of the ecosystem? Are the changes that you've seen affecting the ecosystem overall?
6. How is the ecosystem component affected by human activities?
7. When answering these questions, are there areas where traditional and local knowledge and western science agree? Are there areas where they disagree?
8. What information is missing in our understanding of the Slave River and Delta? How can future work address these gaps? Would you like to participate in this work?

Appendix E. Detailed Results of Breakout Sessions

This section includes detailed results of the breakout group discussions, and reflects the many and varying observations, priorities and concerns raised among workshop participants.

E.1 Hydrology and sediment load

E.1.1 Concerns and impacts

Water flow

- Almost all participants noted the overall volume of water has been reduced over the past few decades. Some estimated that the water level has been reduced by 8 to 9 feet in the river, or by more than half the overall volume. It was also noted that the water level in Great Slave Lake has also declined up to four feet. Many participants commented that the rocks at the Slave River rapids were exposed during the summer of 2011.
- Due to the decline in water levels, wetlands, fens, channels and lakes on the Delta have shown increases in drying and shrinking. Participants noted that the Rat River, which used to connect the Taltson River to the Slave River, is completely dry for most of the year.
- Most participants felt that hydro development, climate change and water removals for industrial operations in combination are responsible for this decline.
    - Hydro development, both existing (Bennett Dam and Taltson Dam) and potential (Site C and Slave River Dam) were mentioned as concerns. Participants stated that hydro development has caused large changes to water volume and seasonal water flow patterns.
    - Climate change was identified as an issue by all participants, as they found that flow in small creeks and undammed rivers is also declining. It was noted that there is less rain, less snow, and the snow is melting faster (due to more wind and higher temperatures), and evaporating instead of entering the groundwater system. When water does enter the ground, it moves more quickly due to reduced permafrost. Research has suggested that the climate has been in a very wet period for the last 200-300 years and it is now switching to a drier period.
    - Water removal for oil sands operations was also identified as a concern, especially with the large proposed expansion in oil sands operations.
    - At a more local scale, one participant noted that human activities can also affect hydrology. A test hole for ore bodies that was drilled but not plugged caused the draining of a swamp found between Fort Resolution and Hay River.

Ice

- Participants noted that the ice is thinner than it used to be on both the river and Great Slave Lake. It was mentioned that ice used to be 10 feet thick in the 1950s but now it is 3 to 4 feet thick. One participant stated that the ice on the river was only 8 inches thick in December, when in the past it would have been much thicker.
- Participants also noted that the quality of the ice appears to have declined recently. Ice is softer, solid white ice turns into weaker black ice in the spring more frequently, and ice is more likely to candle. Participants noted that it is more difficult to determine whether ice is safe to cross now.
- Many participants identified concerns in ice safety when crossing the river at the same places or same times as in the past. As a result they were not able to access traplines or fish or hunt as they would have in the past. They don't travel as frequently on the Slave River and don't use the land on the east side of the river as much now. It was also commented that ice roads have been less reliable and the open season has been growing shorter. This also creates additional costs to establish and maintain crossings. It was noted that there was open water on the Slave River even in January, which is very unusual.
- Participants noted that increased winter flow and alterations to flow at the Bennett Dam has impacts on ice formation and safety. A large water release in November of 2011 lifted the ice that was in place and caused air pockets to form underneath, making it dangerous to cross. They also noted that water releases from the dam can dislodge the ice that is anchored to the shores on the side of the river, creating overflow water which weakens the ice. Higher flow levels in winter also affects ice quality by melting it from underneath.

Seasonal flow patterns

- Participants noted that ice breakup now is much faster than it used to be. In the 1950s it took multiple weeks for the ice to breakup and spring floodwaters to subside; currently, breakup takes place in 3 to 4 days. It was also noted that water during breakup does not flow as fast, is less powerful, and is less noisy now. The ice is no longer thick enough to create a blockage at the mouth of rivers and cause flooding.
- The importance of big floods in the spring that would fill up the lakes and ponds and flush out sediment and debris from channels was noted by participants. Concerns were expressed that the lack of spring flooding is having an impact on sedimentation rates, wildlife and contaminants in sediment.
- It was noted that there is now higher flow in the winter than in the summer and that this is a reversal of normal seasonal patterns. The water under the ice appears murky.

Sediment and travel accessibility

- Almost all participants stated that sediment build-up has blocked access to channels and lakes, and that some smaller channels have now completely vanished. It was also noted that the river is getting wider, as the banks are falling into the river and sediment is being washed away. It was also commented that there seems to be an increase in deposition of sand particles, as compared to predominately clay particles in the past.
- Participants noted that barges used to be loaded at a sawmill in Nagle channel, but now the channel is significantly reduced in size and access by barge would be impossible. Decreased water flow has severely limited people's ability to access channels and lakes that used to be used for fishing and hunting, and some channels have disappeared altogether.

- It was noted that the lack of high water flow in spring allows sediment bars to become established, which are hazardous for boating. Creating floodwater, boat traffic and dredging are ways to maintain channels; however, dredging would stir up contaminants that have settled in the bottom of channels. Dredging of the channels used to occur to facilitate transportation by barge. The effects of the cessation of dredging must be considered when assessing the recent changes to sedimentation rate in Delta channels.
- It was also noted that there have been periods where there is significant amount of large debris (such as logs) coming down the river, which can get caught in sandbars and further restrict access. Another participant stated that perhaps because the banks of the river are not being regularly scoured with ice, trees and logs grow larger on the edges of the river until there is a flood, when they are suddenly displaced.

Groundwater and permafrost

- A number of participants expressed concern about the effects of melting permafrost on groundwater resources. Several noted that the water table has declined in recent years, and that without permafrost to hold water near the surface of the land, water will drain deeper. It was also noted that melting permafrost affects roads which are more likely to wash out.
- The contribution of groundwater to flooding was mentioned by a number of participants. In some places, groundwater contributes to river flow and in other places, river water drains into the ground (such as between Peace River and Peace Point).
- Participants noted that the distribution of permafrost has changed. Participants noted subsidence in some areas (particularly Rocher Island in the Taltson River) due to permafrost melt. It was stated that there is still permafrost in Fort Resolution area, around the Taltson River, Beniti Lake and at the base of the of the Caribou and Birch mountains, though it is necessary to dig deeper to find it (active layer depth is increasing).
- The reduction in permafrost extent and thickness has impacts on people who store meat in dug holes to keep it preserved.
- Participants expressed concern about lack of knowledge on groundwater. The Slave River area is karst (porous) and underground channels can collapse sometimes and change flow patterns in unpredictable ways.

E.1.2 Impacts on the other ecosystem components

Impacts on vegetation

- The increased sediment deposited on the sides of channels and islands has allowed increased vegetation growth (see more information in the Vegetation section).
- The reduced ice scouring on the sides of channels allows increased plant establishment on mudflats.

Impacts on wildlife

- Beaver, muskrat, otter and mink populations are linked to water levels. Widespread drying of the delta has destroyed habitat for these species. One participant stated that he now traps rabbit where they used to trap muskrat. However, participants noted that this past year there has been an increase in muskrat pushups. Dam releases that push up the ice cause overflow and impact beaver and muskrat habitat and overwintering dens. Participants commented that the areas now known as North Prairie and East Prairie used to be called Big Rat Slough but the water has declined so low that there are no longer any muskrats there.
- A number of participants noted that migratory geese and birds that used to stop in the Delta no longer do because the fens have dried up. Ring Lake was mentioned in particular as important bird habitat that is now drying.
- One participant attributed the movement of moose and other animals further north to the lack of solid winter ice in the Slave region.
- Many participants mentioned the decline in frog populations, stating that they no longer hear frog songs when they are out on the land.
- The arrival of pelicans in the Slave River region appears to be linked to the spring flood.

Impacts on fish

- Many participants stated fish populations are affected by lower water levels combined with increased sedimentation for a number of reasons:
    - Fish are unable to access spawning habitat
    - Spawning habitat may be covered with sediment
    - Sandbars are known to have low invertebrate populations which are a source of food for fish
    - Fish may be trapped in perched lakes as water levels drop during the summer and may be killed because of low oxygen or freezing during the winter
    - Fish eggs are frozen in shallow channels

Impacts on water quality

- Water quality is strongly linked with water levels. Higher flow in spring leads to higher sediment and contaminant loads. Under reduced water flow conditions, contaminant concentrations increase. Stagnant water in lakes on the Delta that are normally flushed with spring flood water may have consequences for aquatic life and vegetation.
- The reduced volume of water in the spring means that debris and contaminants are not cleaned out as regularly as in the past. Now, there is a multi-year accumulation of debris and contaminants, which means a very large pulse of materials when there is a flood event.
- It appears that productivity on Great Slave Lake has declined since the Bennett Dam has been in place because flow during winter is higher when ice blocks most of the sunlight and photosynthesis is low. This also may be due to an increasing proportion of nutrients being deposited in the Delta rather than flowing through to Great Slave Lake.

E.1.3 Monitoring priorities

- It was stated that water quality should be sampled during extreme high and extreme low events. If information could be communicated when water was going to be released, people along the river could collect samples as the pulse moves down. Methodology and data sharing would need to be coordinated.
- Ice thickness at ice crossings and bridges should be monitored by local residents (perhaps students paired with traditional knowledge holders), along with air and water temperature. This information should be provided to land users so they know when and where it is safe to cross the ice. Ground penetrating radar could be used so that holes are not repeatedly being drilled. Ice crossings that aren't freezing well could be assessed for reasons why ice integrity is failing (i.e., water depth, overflow, flow speed).
- A model of water flow able to partition effects of climate, regulation and water withdrawals on water flow should be developed to predict future impacts. There is a need to know how future development (e.g., new water licenses in the oil sands and proposed flow regulation like Dunvegan and Site C) will impact the Slave River.
- The effects of reduced ice-jam flooding could be assessed in more depth. We know from observation that there are impacts on sedimentation and debris collection, but it would be good to quantify this and determine if there are other effects. It was noted that flooding still occurs at the Salt River because the banks there are lower than those on the Slave.
- Sediment cores that provide insights on flood history could be compared to observations from traditional knowledge holders to identify where and how flooding took place.
- The sedimentation rates in the Slave River Delta could be compared to other deltas in unregulated rivers such as the deltas on Whitesand River, Yates River and Buffalo River at Buffalo Lake. Sedimentation rates could be compared to the amount of water removed from the system as well as flow pattern, seasonal changes.
- There is a need to identify the critical thresholds of water volume that are required to maintain normal ecosystem functioning and maintain the services that the land and water provide for local people. PADEMP is moving towards developing culturally-based indicators such as determining the minimum flow required for people to access areas to hunt and fish, seasonally and annually. The SRDP could consider doing the same.
- More knowledge on movement of groundwater, including flow volume, water chemistry and identification of sites where groundwater mixes with surface water, would be helpful in determining how groundwater contributes to surface water flow. It was mentioned that researchers have used isotopes in the past to trace the movement of groundwater for the Pine Point mine, and that this could be repeated for a wider area to get a better idea of groundwater movement.
- Bioindicators related to water level should be established. Participants suggested birds, muskrat and beaver as the most important indicators. Land users could collect information about abundance and distribution of these species and thus the costs of monitoring these species would be low.
- In addition to monitoring priorities, participants had a number of suggestions for better information sharing:
    - Data on how much water is being removed by upstream operations needs to be shared and distributed to Slave River and Delta residents
    - An independent body should review the results coming out of Alberta to ensure that information is accurate

- It was noted that there is a strong desire of people to be involved in monitoring, making the Slave region unique. In the transboundary agreement, there needs to be stipulations that each jurisdiction will be able to access information and perform monitoring in the other jurisdiction
- We need to know when dam releases are happening, and then we can follow the effects of the flow downstream
- It was a suggested that there is a need for a better way of documenting traditional knowledge. TK is the only long-term data set that exists, and while statistical analysis is not possible, it helps build the theory and argument of impacts. There was a concerted effort to have traditional knowledge documented during the Northern Rivers Basins Study, but this study has not been replicated

E.2 Water Quality

E.2.1 Concerns/Impacts

Water quality

- Participants expressed concern about water quality, such as:
  - Water temperature is higher now than in the past
  - The sewage lagoon in Fort Resolution may sometime overflow and add nutrients to the water
  - The water is murky and brown-coloured
  - The water tastes strange

- Some participants stated that they no longer drink river water, and there was mention of some people in town who won't drink treated water either. There was some discussion of water treatment, with participants stating that water treatment needs to be adjusted through the year as water quality changes, and that site-specific upgrades at water treatment plants are needed to ensure that communities have the best water treatment facilities possible.

Algae, Foam and Debris

- Many participants stated that there is increased algal growth in the last 5 to 6 years, especially when water levels are low. They noted that algae stick to fishing nets, sediment and vegetation. Some participants stated that the increased algal growth is connected to warmer water temperatures, while others connected it to increased inputs of agricultural fertilizers combined with lower water levels leading to greater concentrations. One participant noted that algae decrease after the Coney run begins, but then returns when the run is complete.
- Many participants also commented on foam that forms on the shores that leaves oily marks on boats; this is new in recent years.
- Participants also commented on garbage entering the river from upstream activities.

Metals, contaminants and health concerns

- Participants expressed concerns about contamination in Slave River water. They also expressed concerns that by the time effects of contamination are visible, levels are already quite high. It is very difficult to assess the impacts of sub-lethal effects of contaminants on the ecosystem.
- Potential sources of contamination identified by participants include:
    - Oil sands operations — through leaking tailings ponds and air pollution being deposited in snow and entering water
    - Relic material at the Pine Point mine site
    - Agricultural pesticides
    - Contaminants from Uranium City in Saskatchewan washing into Lake Athabasca and entering the Slave River
    - Historical equipment from NWT Power Corporation activities in Fort Resolution
    - Salt from highways draining into ditches and entering the river
    - Pulp mills on the Peace River
    - Giant Mine in Yellowknife
    - Water chemistry changes from the reservoir at the Bennett Dam
    - Garbage seepage from the dump
- Many participants noted that oil seeps occur naturally along the Athabasca, but expressed concerns that development is causing an increase in oil concentrations in the river. Participants have noted an oily sheen on the surface of the water and have seen trails in the water as ducks and muskrat swim.
- Mercury was also expressed as a strong concern, with participants noting Marlene Evans' research on changes in mercury levels in fish.
- Many participants expressed concerns about cancer rates in Fort Smith and Fort Resolution. They stated that cancer rates are much higher (up to 10 times higher) than average, with cancers of the kidney and liver mentioned frequently. Kidney and liver disease and diabetes were also stated as concerns, as well as cancers in children.
    - Many participants expressed concerns that cancers were connected to water quality, and cited elders who no longer feel that it is safe to drink the water
- Some participants also expressed concerns about the effects of chlorine on health, especially for Aboriginal people who may be more vulnerable to certain compounds (similar to the vulnerability to sugar/diabetes).

E.2.2 Impacts on the other ecosystem components

Impacts on wildlife

- Participants had concerns about contaminants in the water affecting fish, birds and all wildlife.
- Higher sediment means the water is murkier and it is harder for pelicans to feed.

Impacts on hydrology

- One participant stated that contamination in the water prevents it from freezing as quickly, affecting winter ice formation.

E.2.3 Monitoring priorities

- Generally, it has been expressed that there is a need to ensure that monitoring programs are capturing the full range of contaminants in the system, that interactive effects between contaminants and other water quality parameters are understood and factored into the water quality standards, and that baseline data is needed to pinpoint stressors and impacts.
- Some participants expressed desire to conduct testing for contaminants at water intake pipes rather than only mid-stream sites to find out what levels people are exposed to. Another participant suggested that settling during the water treatment process removes sediment and associated contaminants.
- It was expressed that very little is known about levels of coliform bacteria, and this could be a potentially large human health risk.
- Some participants expressed desire for more knowledge on the effects of chlorine in the water on human health.
- Water quality sampling needs to capture the full profile of the river and so perhaps should have multiple samples at different depths for the same site. Testing should be sporadic and across time to better determine water quality at multiple monitoring stations. Water quality should be tested during high water events (when turbidity is high), and low water events (when dilution is low), which have significant impacts on water quality.
- It was suggested that dissolved oxygen be measured above and below Fort Fitzgerald and compared to below the rapids rather than measuring it in Fort Smith, as it would be unlikely to change between Fort Smith and Fort Resolution.
- Participants requested an assessment of cancer rates along the Mackenzie Valley from Fort Smith to Fort Good Hope. It was suggested that people's medical records could be assessed in relation to how they use traditional food and water.
- It was felt that an assessment of algal growth and distribution is needed, as well as looking at the impact of increased algal growth on aquatic plants and insects.
- It was suggested that the structure of the ice may be changed by contaminants in the water, and that ice and water should be tested for this.
- The foam that appears on boats in the river and in eddies should be sampled to determine its composition.
- Participants expressed desire for more knowledge about water quality chemistry of groundwater as compared to snowmelt water. This is important because it is likely that groundwater is contributing an increasing proportion of water to the overall flow.
- There was a desire to look at wind patterns in relation to pH and sulphur in the water to assess whether there are acidification effects.
- Bioindicators such as pelican and beaver may be useful in assessing water quality and impacts of changes to water quality. It was suggested that pelicans would be a good indicator species for water quality as they eat the fish and drink the water and are at the top of the food chain. Non-destructive sampling of pelican population could include sampling food (vegetation), feces and carcasses. It was suggested that beavers are good indicators of water quality because they live in the water and eat aquatic plants. Participants suggested that the observed decline in beaver population may be due to a decline in water quality.
- It was also stated that all research should look at water quality on a seasonal basis rather than annual averages, as averages may hide some of seasonal peaks and lows.

- It was suggested that all tributaries to the Slave be studied rather than just the Slave itself, to capture a more detailed picture of the watershed. Suggestions for additional sampling sites include:
    - Little Buffalo River
    - Sass River
    - Salt River
    - Dog River
    - Ryan Creek
    - Murdoch Creek
    - Ring Lake
    - Hook Lake
    - At the base of the Caribou Mountains before Buffalo Lake
    - Birch River in the base of the Birch Mountains
    - Pine Lake
    - Lane Lake
    - Parson Lake
- Participants suggested that water quality on the Slave be compared to the Dog, Tethul, Peel, Lockhart, Liard or Mackenzie River to assess the effects of a dam as these rivers are not regulated.
- It was suggested that monitoring should be done on the Taltson River as well, as it also flows towards the Mackenzie River and there are hydro developments and mines upstream in Saskatchewan.
- A number of information-sharing ideas were expressed by participants including:
    - More information on reclamation of tailings ponds
    - More information on how the water licensing process works in Alberta as compared to NWT
    - Development of an institution in Fort Smith to help facilitate water research
- There was a desire to link monitoring in NWT to monitoring in Alberta to contribute comparable data to a larger dataset, as well as to link to the work being done in the Peace-Athabasca Delta Ecological Monitoring Program.

E.3 Fish and insect/benthic communities

E.3.1 Concerns/Impacts

Fish population

- Many participants noted a decline in some fish species (whitefish and chub) but an increase in others (dogsalmon and trout). A few participants noted catches of grayling in the tributary lakes and rivers, which was noted as unusual.

- Most participants feel that changes to fish population are due to reduced water flow and/or contaminants, and not from changes to harvest pressure. Others stated that warm weather is making the spawning run later every year. Some participants felt that this decline is caused by an increase in sedimentation that is blocking and destroying fish habitat. Recent work by Fisheries and Oceans Canada on the commercial fishery on Great Slave Lake indicates that overall fish populations in the lake are healthy.
- A participant noted that there are fewer whitefish on the Taltson River now in the fall than when they were young, and that whitefish are now more likely to be found in mid-winter rather than the fall.
- It was commented that lampreys are fairly common in the Slave River, but this is not a recent change. It is not clear how much stress the lampreys are adding to overall fish populations.

Fish health

- Several participants noted that the size of fish (whitefish and coneys [inconnu] in particular) has declined on the Slave River since the 1940s or 1950s. One participant noted that the mesh size of nets have had to be adjusted to catch smaller fish.
- Many participants commented on the texture of fish flesh from the Slave River, saying that it is now soft and mushy, and sometimes has a strange taste. One participant commented that even fish in Resolution Bay and the Delta are soft.
- It was generally commented that people are suspicious of eating the fish and prefer to eat fish from inland lakes or the Taltson River. Two participants commented they had gotten sick from eating fish from the river, and that dogs that were given fish gave birth to puppies with health issues.
- A number of participants commented on incidences where fish had sores (such as pickerel and whitefish), as well as increased number of worms, tapeworms and marks from lamprey attacks. One participant stated that suckerfish tend to have red blisters in the springtime, and that mariah (also known as loche or burbot) livers are sometimes black instead of yellow.
- Potential causes of the decline in fish health mentioned by participants include: warmer water, lower flow, agricultural inputs, contaminants from oil sands and mines (such as Pine Point, Giant Mine and the diamond mines) and garbage in the water.

Insects/benthic communities

- Many participants stated observations about insect populations and species:
    - Insects are more frequent in spring but there are fewer in the fall
    - There are fewer bees and yellowjackets, but the bees are bigger and the yellowjackets are more aggressive
    - Bulldogs (a type of fly) come out earlier and stay for longer
    - There have been fewer horseflies in 2011 than in previous years
    - Mosquitoes have declined; people no longer a need to use lard or wood gum to protect themselves, and the community no longer sprays to reduce the population
    - There are many large water beetles in the fall now
    - Snow fleas have been observed, though it is not clear if this is a change
- It was stated that insects are important to the fish population, but that there is little knowledge about the population and distribution.

E.3.2 Connection with other ecosystem components

Impact on Wildlife

- Many participants expressed the need for healthy fish to support bird and animal populations. Pelicans, foxes, eagles, mink, otters and bears are all dependent on fish populations.
- Harassment from insects such as flies, mosquitoes and ticks can have significant impacts on the behaviour and distribution of some wildlife, as animals will seek areas where insects are less common. They can also have a significant impact on the health of some animals (such as deer ticks on moose).

E.3.3 Monitoring priorities

- There is a need to assess the productivity of Slave River spawning grounds and determine how and why spawning patterns are changing. There is a need to assess the impact on climate driven temperature changes (early or late spring) on fish movement.
- More information on insects is needed, as they are important to fish and it appears that populations are changing.
- It would be good to link data from the commercial fishery on Great Slave Lake with observations on the Slave River, as this is obviously important spawning ground for many lake fish.
- A study could identify preferred fishing sites of locals and monitor changes in populations, species and behaviour at these sites as well as gathering traditional knowledge on fish population, species, behavior patterns, abundance and changes from locals residents.
- There is a need to look at fish as an integrated part of water and ecosystem management rather than as a separate entity.
- Ongoing work on fish contaminants is needed, and the impacts of fish consumption and contaminants on wildlife species and humans should be assessed. If possible, studies could identify whether certain species should be avoided at certain times of the year.
- It would be helpful to determine whether fish in the Slave River are derived from Lake Athabasca or from Great Slave Lake in order to have a better sense of their contaminant load and health status. Work is already underway to compare migratory fish (like whitefish) to non-migratory fish.
- There is a need to determine how the lamprey populations are affecting other fish species.
- The movement of fish in and out of shallow lakes (like Mamawi Lake) where they risk being trapped by a decline in water levels and killed in winter could be monitored.
- A study could assess how warmer water temperatures and reduced flow are linked to reduced oxygen levels under ice.

E.4 Wildlife

E.4.1 Concerns/impacts

Birds

- Participants generally noted that geese and ducks did not stop as frequently in the Slave River area during migration. Suggested reasons for this were that they are seeking food elsewhere because the sedge prairies and mudflats have dried up on the Delta, and that the overall population is declining due to industrial development and hunting in other regions where geese are considered a pest species. One participant noted that they still stop at Simpson Island, so food sources must still be available there. It has also been noted that it is more difficult to access traditional hunting areas, and that people have to hunt birds as they fly overhead.
- Participants also found that ducks and geese were in worse health — they are skinnier, taste different and sometimes have worms.
- It was also stated that songbirds (such as whiskeyjacks and robins) are declining and that the forest is quieter. Spruce grouse and ptarmigan were also noted as declining.
- Some participants have noted magpies in the Slave River area as a new species. Magpies are aggressive and predatory and thus have impacts on other bird species.
- It was stated that the productivity of pelican families has declined since 1990 from one chick per nest to about 0.6 chicks per nest. The cause is unknown but might be predation since few carcasses have been found.
- Whooping cranes were seen in the bay at Fort Resolution and near Lutsel K'e this past summer, which is farther north than usual.

Frogs

- Numerous participants noted the decline in frogs and the lack of frog songs in spring. Reasons for the decline were stated as drying of ponds and creeks that were habitat for the frogs, or contaminants in the water. It was stated that the decline in frogs is occurring all over the boreal forest and is not unique to this region; frogs are being killed off by a fungus in the U.S. Frogs can be a good indicator of overall ecosystem health, but it can be difficult to determine the exact cause of frog decline.

Moose

- Many participants noted that moose around the Slave River region are less common. Most stated that the moose have moved farther north but also that the overall population has declined. One participant stated that the current moose population is the lowest in memory.
- Some participants stated that populations have declined due to hunting pressure, saying that some hunters kill cows and calves, and/or kill more animals than are needed. Other factors mentioned were repeated fires around the Taltson River, which have prevented vegetation from returning to the area, and increased predation (by bears and wolves).
- Other participants stated that moose have moved northward because they sense that the water in the Slave River is not clean, because flow is too low resulting in reduced food sources, and because deer have been moving northward (bringing ticks with them, which can be fatal to moose).

- A few participants from Alberta stated that moose are still found in normal numbers there.

Aquatic furbearers

- It was noted that muskrat are heavily affected by changes to water levels, but that there seem to be a fair number of pushups in 2012. Some favoured muskrat areas, such as Stan's Prairie and Ring Lake, are drying or not accessible. One participant stated that muskrats are moving towards the highways because the river is so low.
- Beavers were noted by some participants as declining, but others stated that the population is stable. Beavers could be affected this year by the high water levels in November and December that may have flooded their dens and caused them to drown.
- Many participants noted that furs are not as prime as they used to be because the weather is not cold enough. One participant noted that marten fur has declined in quality and changed colour.
- One participant noted observations of numerous otters, marten and wolverine but fewer mink.
- It was mentioned that because it is challenging to access traplines in the fall because ice is not safe to cross, it is more difficult for trappers to get a good sense of population changes. Changes to wildlife have impacts on the livelihood of trappers and on the food source of many residents. Wildlife is also important for tourism revenues.

Other species

- It was noted that deer are moving northward into the Slave River area. Woodland caribou also seem to be moving northward. Cougars appear to be following the deer into the area.
- Participants noted that muskox appear to be moving south, and one was seen at Taltson dam.
- Participants noted observations of an increase in porcupine and skunks but a decrease in marmots and rabbits.
- It is unclear whether the wolf population is stable, declining or increasing. Some participants thought the wolf population was declining but others thought it was strong, noting numerous sightings in the past year and reduced hunting pressure. One participant stated that perceived increase in buffalo suggests that the wolf population is going down.
- Lynx and rabbit both appear to be low right now, but these populations are known to be cyclical.
- There appears to be an increase in bears near Fort Smith and Fort Resolution. Bears have been known to feed on moose calves.

E.4.2 Connection to other components

Impacts on hydrology

- Beaver dams were also noted as having an impact on hydrology. Large and long-established beaver dams in Wood Buffalo Park affect water flow.

E.4.3 Monitoring priorities

- There is a need to understand the simultaneous shifting of multiple species (moose and deer northward, muskox southward). To do this, we could create an ecosystem model with all species to try to identify strength of relationships and trophic levels, and make the models work so that we can pull these and see how it affects the whole system. More information on how predatory species behave would be needed to build this model. We also need more information on population cycles to know the normal population range, and the effects of climate change (especially early spring weather and late freeze-up) on wildlife.
- The pathway for toxins travelling up the food chain should be investigated as toxins come from the water through algae and/or invertebrates.
- Should look at beaver populations this spring (2012) to determine how they were affected by the high water levels in late fall of 2011.
- There is a need to determine why moose populations have declined or why moose have moved northward. More information is needed on:
    - Vegetation changes (perhaps remotely monitored) with a focus on aquatic species that moose use as a food source
    - Information on predation of moose calves by bears and wolves
    - Distribution and severity of ticks on moose
- Monitoring bird populations was identified as being very important. Participants suggested:
    - Songbirds should be monitored as they are very important to the forest.
    - Ptarmigans should be monitored because they are very much an indicator of the environment.
    - In Alberta people are monitoring contaminants in bird eggs. This could be replicated here for geese and ducks.
    - Peregrine falcon should be studied because they are at the top of the chain.
- The reasons for the decline in frogs should be investigated more fully. Red-sided garter snakes should also be assessed.

E.5 Vegetation

E.5.1 Concern/Impacts

Vegetation shift

- It was noted by numerous participants that prairies, fens and wetlands are growing in with vegetation (willows in particular). There is some concern that willows are choking out riparian communities perhaps because they can more easily access nutrients.
- Beaches along lakes and rivers that used to be sandy are now covered with weeds. Participants noted fewer aquatic plants.

- This growth is occurring because water levels have dropped, because flooding is less frequent and because scouring of the banks by ice no longer happens at the same intensity. Without a regular flooding regime, exposed mud flats are moving along the succession curve to become climax forests. There are now fewer riparian horsetails and sedge meadows. The lack of scouring of the banks by ice has also allowed greater growth of riparian vegetation. It was noted that black poplars only grow on the river banks after they have been scoured and so with reduced scouring, black poplars are likely also reduced.
- Most participants felt that regulation and water removals are the root cause of vegetation shift, but others also commented that the fire management regime may be contributing to the observed changes, as well as natural changes that deltas undergo.
- People noted the lack of access to certain areas because of thick vegetation growth.

Berries

- Participants generally noted a decline in the abundance and quality of berries. It was noted that berries are dried out earlier in the season, particularly Saskatoon berries and gooseberries. It was also mentioned that Saskatoon berries have experienced rust in recent years. A reduced number of cranberries was also mentioned by a number of participants, even in areas where berry harvest has been dependable in the past.

Forest infestation

- Participants noted an infestation of spruce budworm a few years ago that had severe impacts on forests around the river. Forest infestation in spruce was linked to forest fires by participants.
- An infestation on willows has been observed by multiple participants, which is apparent in June/July and can be seen along the road to Hay River.
- The effects of the leaf miner on the aspen were also noted.
- It was also noted that pine trees seem to be turning orange and/or dying. One participant suggested that they are drying out in the sun.

Plant species

- Some participants commented that medicinal species are less available now, though another commented that elders have stated that they are seeing species now that they haven't seen in years. It was discussed that people still use medicinal plants from the land, such as poplar and rat root.
- Participants noted a number of new species in the Slave River area, including Canada thistle, alfalfa, fox tail grass, Manitoba maple, timothy grass, small clover, snap dragons, caraganas, a purple plant similar to yarrow (name unknown) and a plant with big leaves and white flowers (name unknown).

Fire

- There was discussion of the role of fires in maintaining vegetation in the Slave River areas. Human-caused fires are common historically, through both prescribed burning or accidental fire.
- The connection between the snowpack and fire frequency was mentioned, as was the connection between spruce budworm-killed trees and increased fire frequency. It was also noted that springs have been drier in the past few years, and there have been some intense spring fires (such as the one in Slave Lake in Alberta).

- Prescribed burns took place from 1980s to mid-1990s but are less frequent now, contributing to the growth in vegetation. Prescribed burns took place in Grande Detour Area and upper Rat Lake (Stan's Prairie) to control vegetation and anthrax.
- Participants noted that succession after fire takes months to years, and sometimes fire provides opportunities for invasive species to establish. Fires can have a large impact on people who have traplines or cabins in the affected area.

E.5.2 Connection to other ecosystem components

Impacts on wildlife

- The drying and growth of trees and willows on mud flats has affected waterfowl, frogs, moose, ducks, beavers and muskrats that used these areas. Aquatic plants are important food for moose.
- Waterfowl in particular no longer use the Delta as a staging area because of vegetation shifts.

Impacts on Hydrology

- It was mentioned that trees and permafrost are interlinked because removal of trees will allow permafrost to melt, but also permafrost is important in providing stability for trees.

E.5.3 Monitoring priorities

- It would be helpful to assess the impact of reduced human harvest of wood for heating on fires and vegetation density. Currently, fewer people have woodstoves and so removal of biomass from the forest is reduced.
- Fire frequency information could be compared with snowpack data to look at the relationship between fire frequency and snow.
- The forest ecosystem should be modeled to try to predict future vegetation cover while considering the effects of reduced water flow. There is a need to make the linkage between what's happening in the water and on the land, and also expand research focus beyond the river and delta into an integrated ecosystem model.
- Research should look at if and how new and abundant willow growth that limits travel could be reduced or slowed, through harvest or other controls.
- The mapping of vegetation changes that took place in the mid-1990s as part of the Northern River Basins Study should be updated and correlated to traditional knowledge. People could travel to sites along the river and monitor changes over time with GPS.
- Slumping associated with permafrost melt could be assessed through looking at old aerial photos in comparison to satellite imaging, and connected to tree growth.
- There is a need to assess productivity and distribution of aquatic plants, because their habitat is declining with reduced water flow.
- There is a need for a systematic survey of invasive species.
- The combined effect of drought and insect infestation on trees should be assessed.

E.6 Air and climate

E.6.1 Concerns/Impacts

Temperature

- Participants noted that the weather, especially in the winter of 2011/2012, has been much warmer than in the past. They stated that the average temperature in winter used to be -45°C to –50°C but currently the average temperature is no lower than –20°C to –30°C.
- They noted that in the past the river would freeze in early fall (around October) but this year it did not freeze until December. Participants noted that they can still use boats in November, and they can't access traplines until December.
- Participants stated that temperatures in summer are now much hotter than in the past, and that warm weather lasts for longer (earlier spring and later fall).
- Participants also noted that they used to hang fish and moose outside in the fall and early winter to keep it preserved, but now they have to freeze or smoke meat to prevent it from going bad.
- A few participants stated that warmer weather has an impact on human health, because germs are no longer killed in deep cold weather. They noted a greater frequency of colds and pneumonia in Fort Smith.

Moisture in the air

- A number of participants noted that the air seemed to contain more moisture now than in the past, which affects visibility and transportation. Evidence cited for this included:
    - More hoar frost, especially around the river
    - Windows on vehicles need to be scraped regularly, where in the past frost only appeared in the fall and spring.
    - More fog in the air in the fall, caused by the open water on the river lasting later into the year.
    - One participant noted that elders have stated that the moon does not shine as brightly now. This may be due to increased moisture in the air and more clouds.
- It was also noted that moisture patterns of the seasons are changing —summers are now wetter and winters are drier, while in the past, there was drier weather in the summer and more snow in winter.

Rain, storms and wind

- Many participants noted that the rain falls harder and faster than it used to, and that it doesn't sink into the soil the same way as in the past.
- They also noted more frequent and violent storms, recalling wind funnel and hailstorm events, and storms happening in the early fall and spring now which was uncommon in the past. Participants noted more dramatic rainfalls and freezing rain (for example, there has been three freezing rain episodes from November to January). They also noted a significant hailstorm in the summer of 2011.
- Participants suggested that more extreme weather is caused by the extension of the ice-free season on Great Slave Lake.

- Participants noted more wind, and that it seems to come more frequently from the south. Participants were concerned that south winds would be carrying particulates and emissions from the oil sands and could carry acid rain.
- They also noted warm and fast winds that rapidly melt snow and evaporate water. One of the effects of the wind is pushing the ice up against the shore on Great Slave Lake.
- Many participants noted that the weather is often unpredictable, and that old ways of predicting the weather (by observing sunsets, the moon, sundogs or aurora) are no longer accurate.

Snow

- Participants commented widely that there is now less snow than there used to be. In the past (30 years ago), snow used to be deep (3 to 4 feet) and snowshoes were required when travelling on the land, but now the tops of grass are often still visible in the middle of winter.
- Participants noted differences in texture of snow, however some noted that it is harder and others stated that it was fluffier. A few participants noted the hard crust on the snow, and layers of crust with successive melting and freezing events.
- Participants noted that fluffy snow is not good for making water from snow for tea. Participants commented that many people in town use bottled or tap water for making tea, but that people still use snow for tea in the bush. Participants were also concerned that fluffy snow contained less meltwater, contributing to the overall drying trend of the Slave River area, and that it disappears very quickly in the spring due to evaporation rather than entering the water system.

Air quality

- Participants noted concerns about air emissions from a number of human activities that produce emissions including oil sands operations, diamond mines, planes and helicopters, vehicles, and burning wood.
- Participants noted that in Fort Chipewyan, air emissions from Fort McMurray can be smelled when the wind blows out of the south and southwest. One participant noted that the smell of the air in Fort Smith has changed recently.
- A number of participants noted that the snow has particulates and looks darker when the wind blows from the south.
- One participant expressed concerns over lower oxygen content and that the air seems to be stale.
- Impacts of air emissions stated by participants include: greater frequency and duration of symptoms of asthma and head colds, having to scrape a layer away from snow before melting it to drink, and concerns about water contamination.

E.6.2 Impacts on other ecosystem components

Impacts on wildlife

- Participants observed that moose are more likely to get ticks in warmer conditions, and that ticks can have a severe impact on the moose population.
- When the temperature rises and then falls, the snow melts and then freezes with a hard crust, which makes it difficult for moose, rabbit and other animals to feed. This crust is also caused by rain in the winter.

- The strong winds blow snow off the muskrat pushups, making them more vulnerable to predation.
- Participants noted that air temperature has been linked to anthrax outbreaks in bison.
- With warmer winter temperatures, fur on animals is not prime (high quality). This makes trapping not as viable, especially during the early winter.

Impacts on hydrology

- Participants noted that warming temperatures lead to thawing permafrost, which may be why there is less water on the land.
- Participants noted that warm fall weather means that the muskeg does not freeze before there is a heavy snowfall. The snow weighs down the surface of the muskeg and creates more overflow water on the edges of creeks and lakes. Overflow water has significant impacts on people who are travelling on the land or accessing their traplines.
- It was noted that the lack of meltwater when the snow melts (due to less moisture in the snow or greater evaporation) means that there is less water sitting on the surface of the land. This has impacts on permafrost distribution and surface water flow.

Impacts on vegetation

- Participants stated that the lack of rain in the spring has reduced number of berries available.
- Some participants stated that warmer weather is allowing expansion of southern plant species into the Slave River area.
- A number of participants noted that without cold weather to kill off pine beetle and spruce budworm, these forest pests are becoming increasingly prevalent.
- A participant noted that that in August of 2011, leaves were falling off the trees much earlier because the weather was so dry.

E.6.3 Monitoring Priorities

- Contaminants in air and snow should be sampled in the Slave River area. Snow should be sampled for emissions from planes, trucks, wood burning, dust from the diamond mines and oil sands. It would be necessary to differentiate between the various types of emissions in order to determine sources. The upcoming federal oil sands environmental monitoring program may provide data and answers to some of these questions. More knowledge about the movement of air could help identify where the best location would be to set up an air quality monitoring station to capture the extent of deposition that is taking place.
- Tree cores are being sampled in Wood Buffalo National Park to provide a picture of changing contaminant deposition over time. Trees could be sampled in old-growth areas, and this monitoring could be linked to existing work in creating forest inventories.
- Some participants expressed concern about ongoing radiation from the 1978 Cosmos Satellite that crashed into Great Slave Lake. They suggested ongoing assessment and monitoring for contaminants in Fort Resolution.
- Wind speed, direction and changes over time could be monitored easily by analyzing directional data from a wind rose (which measures directional wind data).
- A participant suggested that the effect of warm, dry fall weather on foliage in the following spring should be assessed.

- It was noted that Aboriginal Affairs and Northern Development Canada has collected snowpack data for over 30 years for 20 sites. This data should be gathered, analyzed and results distributed to corroborate observations of a decline in snowpack.
- It was noted that Parks Canada has monitored soil humidity in the past, and this data could be assessed to look at changes in evaporation versus infiltration.
- An assessment of opening and closing dates for ice roads could provide a good data history of changes in weather.
- Local residents should record their observations of snow depth, weather conditions, wind and ice with notebooks, GPS and cameras to start building a database of records.

Appendix F. Detailed results of identification of monitoring priorities

Table 1: Votes and ranking for overall prioritization of monitoring topics

	Votes	Ranking
Water quality	27	1
Hydrology and sediment load	14	2
Wildlife	13	3
Air and climate	5	4
Vegetation	4	5
Fish	3	6

(Participants were allowed to vote once).

Table 2 presents the results of the voting for vulnerability categories. Average rankings are the sum of the proportion of the number of votes divided by the total votes, multiplied by the value of the ranking (e.g. for wildlife- 21 votes/29 total votes multiplied by 5, plus 7 votes/29 votes multiplied by 4, etc.).

Table 2: Votes and average vulnerability for ecosystem components

Vulnerability Ranking	Ranking of 5	Ranking of 4	Ranking of 3	Ranking of 2	Ranking of 1	Total votes	Average Ranking
Wildlife	21	7	1	0	0	29	4.7
Air and climate	12	10	5	0	0	27	4.3
Vegetation	11	15	3	0	0	29	4.3
Hydrology	20	6	3	0	0	29	4.6
Water quality	22	6	1	0	0	29	4.7
Fish	17	10	0	0	0	27	4.6