Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories: Overview Report

Version 4.0

Prepared for:

Water Resources Division
Indian and Northern Affairs Canada
P.O. Box 1500
Yellowknife, Northwest Territories X1A 2R3

Prepared – September 2008 – by:

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List of Acronyms

AEMP	-	Aquatic Effects Monitoring Program
AL	-	action levels
AMP	-	Adaptive Management Plan
AOC	-	areas of potential concern
CCME	-	Canadian Council of Ministers of the Environment
CEA	-	cumulative effects assessment
CEAA	-	Canadian Environmental Assessment Act
CIMP	-	Cumulative Impact Monitoring Program
COPC	-	chemical of potential concern
CSM	-	conceptual site model
DQO	-	data quality objective
DDT	-	p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, o,p'-DDD, and any metabolite or degradation product
EA	-	Environmental Assessment
EDD	-	electronic data delivery
EQG	-	environmental quality guideline
EQO	-	environmental quality objective
FSP	-	field sampling plan
GIS	-	geographic information system
GLUPB	-	Gwich'in Land Use Planning Board
GLWB	-	Gwich'in Land and Water Board
HSP	-	health and safety plan
INAC	-	Indian and Northern Affairs Canada
K_{oc}	-	organic carbon partition coefficient
K_{ow}	-	octanol-water partition coefficient
LOAEL	-	lowest observed adverse effect level
LOE	-	lines-of-evidence
LOQ	-	level of quantification
LWB	-	the Land and Water Board
MVEIRB	-	Mackenzie Valley Environmental Impact Review Board
MVLWB	-	Mackenzie Valley Land and Water Board
MVRMA	-	Mackenzie Valley Resource Management Act
NOAEL	-	no observed adverse effect level
NTWA	-	Northwest Territories Water Act
NTWB	-	Northwest Territories Water Board
NWT	-	Northwest Territories
PBMS	-	performance-based measurement system
QAPP	-	quality assurance project plan
QA/QC	-	quality assurance/quality control
RPD	-	relative percent difference

SAP	-	sampling and analysis plans
SLUPB	-	Sahtu Land Use Planning Board
SLWB	-	Sahtu Land and Water Board
SOP	-	standard operating procedure
TK	-	Traditional knowledge
USEPA	-	U.S. Environmental Protection Agency
VEC	-	valued ecosystem component
WLWB	-	Wek'eezhii Land and Water Board
WQG	-	water quality guideline
WQO	-	water quality objective

Chapter 1 Introduction and Scope

1.0 Introduction

In the Northwest Territories, project proponents are often required to develop and implement an Aquatic Effects Monitoring Program (AEMP) under the terms and conditions of Type A water licences. However, neither the regulatory agencies or the land and water boards have prepared specific guidance documents to inform project proponents about their expectations for AEMPs. In addition, Aboriginal governments/organizations have not been provided with an opportunity to clearly articulate the role of Traditional Knowledge and community-based monitoring in the AEMP development and implementation process. As a result, project proponents are unclear about the expectations of regulatory agencies and Aboriginal governments/organizations regarding AEMPs. This problem has lead to the development of a number AEMPs that do not meet the reviewers' expectations and require substantial efforts on behalf of all parties to resolve differences regarding the scope and design of the AEMPs.

In recognition of the need for consistent guidance on the development of AEMPs, Indian and Northern Affairs Canada (INAC), NT Region, initiated an AEMP Guidelines project in 2006 to support the preparation of a guidance document that would provide project proponents with a better understanding of expectations regarding the development and implementation of AEMPs. This three-year project will initially culminate in the development of a draft AEMP Guidelines document (i.e., this report). It is anticipated that the resultant document will be reviewed by representatives of Aboriginal governments/organizations, federal and territorial governments, regulatory agencies, land and water boards, environmental impact review boards, monitoring agencies, and industry. A workshop will be convened in October, 2008 to provide reviewers with further opportunity to comment on the draft AEMP guidelines. Following incorporation of the comments received, the document will be finalized.

1.1 Intended Scope of the Aquatic Effects Monitoring Program Guidelines Document

The AEMP Guidelines are intended to provide project proponents clear guidance on the development and implementation of AEMPs in the NWT. More specifically, the AEMP Guidelines are intended to:

- Describe current best practices related to monitoring and assessment of aquatic effects of development in the NWT and northern Canada;
- Establish guiding principles for aquatic effects monitoring in the NWT;
- Establish a framework for designing and implementing effective aquatic effects monitoring programs in the NWT; and,
- Define the roles of Traditional Knowledge and contemporary science in the design and implementation of AEMPs in the NWT.

Although the AEMP Guidelines are focussed on the NWT, the intent is that they could be adapted and applied in Nunuvut or Yukon, if the regulatory bodies in these jurisdictions so choose.

1.2 Approach to Development of Aquatic Effects Monitoring Program Guidelines

This project is focussed on the formulation of guidelines for the development and implementation of AEMPs in the NWT. This project consisted of four main steps, including:

- Convening a technical workshop to determine the interests and needs of industry and regulatory agencies relative to AEMPs (completed April, 2006);
- Convening a series of meetings to determine the interests and needs of Aboriginal governments/organizations, monitoring agencies, regulators, and land and water boards relative to AEMPs;

- Conducting focussed reviews of the scientific literature on aquatic effects monitoring;
- Compiling the information obtained during the course of the project into a draft AEMP Guidelines document;
- Convening a workshop to review the draft AEMP Guidelines in October, 2008 (to be attended by representatives of Aboriginal governments/ organizations, regulatory agencies, land and water boards, environmental impact review boards, monitoring agencies, and industry); and,
- Incorporating reviewer's comments and finalizing the AEMP Guidelines document.

1.3 Benefits of the AEMP Guidelines

In the NWT, AEMPs are required to provide the data and information needed to effectively manage and mitigate the effects of development projects. More specifically, AEMPs are needed:

- To determine the short-term and long-term effects on the aquatic environment that occur in conjunction with the construction and/or operation of a project;
- To evaluate the accuracy of the predictions that are made in environmental assessments regarding the impacts of a project;
- To assess the efficacy of impact mitigation measures that are used to minimize the effects of the project on the aquatic environment; and,
- To identify additional impact mitigation measures that are needed to reduce or eliminate project-related effects on the aquatic environment (i.e., within an adaptive management framework).

AEMPs should also provide the data and information needed to evaluate the cumulative effects on the aquatic environment that may occur due to the presence of

multiple human activities within an area or region. In this context, project-specific AEMPs must support regional cumulative effects assessments.

The AEMP Guidelines provided in this document are intended to assist project proponents in developing AEMPs that are acceptable to Aboriginal governments, regulatory agencies, and other interested parties. By doing so, these AEMP Guidelines should enable project proponents to develop AEMPs that can be reviewed and approved in a timely manner by the responsible land and water boards.

1.4 Organization of this Report

The AEMP Guidelines that emerge from this project are intended to provide project proponents and others involved in the monitoring and assessment of northern ecosystems with general guidance on the steps that should be taken to support the development and implementation of AEMPs in the NWT. To provide ready access to this information, this document has been organized into an overview report and a series of technical guidance documents, which are intended to provide more detailed information on each step in the AEMP development process. The overview report is organized as follows:

- Introduction and Scope (Chapter 1);
- Background on Water Management in the NWT and the Need for Aquatic Effects Monitoring (Chapter 2);
- Guiding Principles for Developing and Implementing Aquatic Effects Monitoring Programs in the NWT (Chapter 3);
- Role of Traditional Knowledge in the Development and Implementation of Aquatic Effects Monitoring Programs (Chapter 4);
- Overview of the Recommended Framework for Designing and Implementing Aquatic Effects Monitoring Programs in the NWT (Chapter 5);
- Summary and Conclusions (Chapter 6); and,
- References Cited (Chapter 7).

In addition to the overview report, a series of technical guidance documents have been prepared to provide more specific guidance on the development and implementation of AEMPs, as follow:

- Recommended Procedures for Identifying Issues and Concerns Associated with Development Projects: AEMP Technical Guidance Document - Volume 1.
- Recommended Procedures for Developing Problem Formulation to Support the Design of Aquatic Effects Monitoring Programs: AEMP Technical Guidance Document - Volume 2.
- Recommended Procedures for Developing Data Quality Objectives and a Conceptual Study Design: AEMP Technical Guidance Document - Volume 3.
- Recommended Procedures for Developing Detailed Designs for Aquatic Effects Monitoring Programs: AEMP Technical Guidance Document - Volume 4.
- Recommended Procedures for Documenting Conceptual and Detailed Designs for Aquatic Effects Monitoring Programs: AEMP Technical Guidance Document - Volume 5.
- Recommended Procedures for Evaluating, Compiling, Interpreting, and Reporting Data Collected Under Aquatic Effects Monitoring Programs: AEMP Technical Guidance Document - Volume 6.
- Recommended Procedures for Adaptively Managing Development Projects Using the Results of Aquatic Effects Monitoring Programs: AEMP Technical Guidance Document - Volume 7.

These technical guidance documents were prepared to provide interested parties with detailed information in each element of the framework for developing and implementing AEMPs.

Chapter 2 Background on Water Management in the Northwest Territories and the Need for Aquatic Effects Monitoring

2.0 Introduction

The NWT is characterized by an abundance of freshwater of exceptional quality. The responsibility for conserving water resources, while facilitating the development and utilization of renewable and non-renewable resources, has been delegated from the Minister of INAC to a number of public boards through implementation of the Mackenzie Valley Resource Management Act (MVRMA). The Mackenzie Valley Environmental Impact Review Board (MVEIRB), Gwich'in Land Use Planning Board (GLUPB), and Sahtu Land Use Planning Board (SLUPB) play essential roles in environmental impact assessment and in land use planning processes. By comparison, the Mackenzie Valley Land and Water Board (MVLWB), Sahtu Land and Water Board (SLWB), Gwich'in Land and Water Board (GLWB), and Wek'eezhii Land and Water Board (WLWB) play central roles in the management of land and water use through the issuance of land use permits and water licences for development projects. Effective integration of the land use planning, the environmental assessment, and the land use permitting and water licencing processes are intended to provide a basis for effective co-management of lands and waters within the Mackenzie Valley. In the Inuvialuit Settlement Region, the NWT Water Board issues land use permits and water licences under the NWT Waters Act (NWTWA). This chapter briefly describes the existing water management process under the NWTWA and the MVRMA.

2.1 Water Management Under the Northwest Territories Waters Act

On June 23, 1992, the Northwest Territories Waters Act (NTWA) was proclaimed by the Government of Canada to support water management in the NWT. The NTWA

established a legal and administrative framework for water use and waste disposal. The NTWA also established the Northwest Territories Water Board (NTWB) to provide for the conservation, development, and utilization of territorial waters in a manner that would provide the optimum benefit therefrom for all Canadians and for the residents of the NWT.

The NTWB fulfills this mandate through the issuance of water licences which include terms and conditions for use of water and/or deposition of waste into receiving waters. The terms and conditions are intended to ensure that the use of waters and/or the deposit of waste proposed by an applicant will not adversely affect the use of waters within or outside the water management area. The NTWA further requires that any waste produced by an undertaking be treated and disposed of in a manner such that any applicable water quality standards and any applicable effluent standards would be met.

The NTWB has the authority to issue two types of water licences for terms not to exceed 25 years. Type A water licences are generally required for undertakings that use more than 300 m^3/day of water, have water storage requirements of greater than 60,000 m^3, mill capacity greater than 100 tonnes/day of ore, or deposit significant quantities of wastes into receiving waters. Type B water licences are generally required for smaller operations, although some exceptions also apply. The NTWB may issue a Type A water licence only with the approval of the Minister of Indian and Northern Affairs Canada. Since proclamation of the MVRMA, the NTWB only issues water licences in the Inuvialuit Settlement Region of the NWT.

2.2 Water Management Under the Mackenzie Valley Resource Management Act

On December 22, 1998, the Mackenzie Valley Resource Management Act (MVRMA) was proclaimed, creating an integrated co-management structure for public and private lands throughout the Mackenzie Valley, an area that includes the entire NWT with the exception of the Inuvialuit Settlement Region and Wood Buffalo National

Park (INAC 2001). A number of public boards were established under the MVRMA, including:

- Mackenzie Valley Land and Water Board (MVLWB);
- Mackenzie Valley Environmental Impact Review Board (MVEIRB);
- Gwich'in Land and Water Board (GLWB);
- Gwich'in Land Use Planning Board (GLUPB);
- Sahtu Land and Water Board (SLWB);
- Sahtu Land Use Planning Board (SLUPB); and,
- Wek'eezhii Land and Water Board (WLWB).

These boards were established to prepare regional land use plans to guide development, to carry out environmental assessment and reviews of proposed projects in the Mackenzie Valley and to regulate the use of land and water (INAC 2001). The MVRMA also includes provisions for monitoring cumulative impacts on the environment and for conducting independent environmental audits.

The MVLWB and its regional panels are responsible for regulating the use of land and waters and the deposit of waste so as to provide for the conservation, development, and utilization of land and water resources in a manner that will provide the optimum benefit of all Canadians and in particular for residents of the Mackenzie Valley. The MVLWB fulfills this mandate by issuing land use permits and water licences on land in unsettled claim areas within the Mackenzie Valley. In contrast, the regional land and water boards, including the GLWB, SLWB, and the WLWB are responsible for issuing land use permits and water licences in their respective settled land claim areas on public and private land (see Figure 1 for a map showing settled and asserted land and areas in the NWT). The MVLWB processes land use and water licence applications for projects that cross both settled or unsettled land claim boundaries (i.e., transboundary applications). The MVLWB is also responsible for ensuring consistency in the application of the legislation throughout the Mackenzie Valley and for administering land use permits and water licences that were issued prior to the MVRMA.

While the MVMRA defines the legal and administrative framework for managing land and waters in the Mackenzie Valley, it cannot be applied alone to address land and water use management issues in the north. In addition, the NTWA and Northwest Territories Water Regulations form part of the legal and administrative framework that was established for managing land and water use under the MVRMA. Accordingly, the procedures for determining if a water licence is required for a particular activity, identifying the type of water licence needed, and applying for a water licence are consistent under the NTWA and the MVRMA. In addition, opportunities for public involvement and consultation are similar under both water management frameworks. Similarly, the Minister of INAC is responsible for approving all Type A water licences, while the chairperson of the responsible land and water board approves most of the Type B water licence applications. Inspectors employed by INAC are responsible for enforcing the provisions of the NTWA and MVRMA and associated regulations.

All prospective development projects are evaluated to assess their potential impacts on human health and the environment. In the Mackenzie Valley, the MVEIRB is responsible for the environmental impact assessment process. The Canadian Environmental Assessment Act (CEAA) in the Inuvialuit Settlement area. There are three stages to the environmental impact assessment process, including preliminary screening, environmental assessment, and environmental impact review. All prospective development projects undergo preliminary screening of land and water applications by the Land and Water Boards (LWBs), after which it is decided whether it must proceed to a full environmental assessment or go straight to the regulatory phase.

In the final phase of the process (whether or not an environmental assessment is completed), the project follows the regulatory process for permitting and/or licencing. Under the MVRMA, developmental projects have been classified into several categories to facilitate the establishment of licencing criteria, including industrial, mining and milling, municipal, power, and agricultural, conservation, recreational, and miscellaneous undertakings.

The need for and type of water licence required is dictated by the scope of the activity that is proposed, the type of watercourse affected, the quantity of water affected, the nature of the waste produced, and the procedure for disposing of the waste. A Type

A water licence is required for activities of broad scope, that have significant potential for adversely affecting human health or the environment, and/or require substantial volumes of water. A Type B water licence is required for activities of limited scope, that have limited potential for adversely affecting human health or the environment, and/or require relatively small volumes of water. The licencing criteria for each of these general categories of undertakings are presented in Schedule IV, V, VI, VII, and VIII of the MVRMA, respectively.

In general, the water licencing process in the NWT consists of a number of steps. As a first step, an application for a water licence is submitted to the appropriate land and water board, along with any supporting documentation that the proponent has prepared. As was the case for the environmental assessment phase, this information is posted on the public registry and affected communities and/or Aboriginal governments/organizations are notified of the application. Typically, interested parties are then provided with opportunities to request further information about the project and to submit comments to the board in the form of an intervention. For projects with substantial potential to adversely affect human health or the environment, a public hearing is convened to provide interested parties with an opportunity to make presentations to the board. Subsequently, a water licence is drafted and distributed to interested parties for review and comment. The proponent is permitted to respond to any comments that are submitted to the board on the draft water licence. Type A water licence applications are submitted to the Minister of INAC for approval. The MVRMA provides no option for the Minister to modify the water licence; however, the Minister may attach terms and conditions such as a provision for a security deposit, a requirement for water quality and quantity measurements, and a requirement for closure and reclamation plans (Figure 2). The water licence is provided to the proponent following ministerial approval.

2.3 Interests and Needs Relative to the Water Management Process

Consultation is the cornerstone of the MVRMA (INAC 2001). Accordingly, the water management process established under the MVRMA is characterized by

extensive public consultation, as evidenced by the numerous opportunities to request further information on water licence applications, participate in technical sessions to identify issues and concerns regarding applications, prepare and deliver interventions at public hearings convened by the boards, serve on technical committees struck to provide the boards with input on water licence terms and conditions, and comment on draft water licences.

Input provided during various consultative processes established by the MVRMA boards indicates that participants often have similar interests and needs. For example, testimony provided at the public hearings that were convened to support licencing of the three diamond mines in the NWT indicated that virtually all participants recognized that northern ecosystems represent unique aquatic resources that must be protected and conserved for future generations. In addition, such testimony confirmed that maintenance of the existing uses of water resources is a high priority that cannot be compromised by renewable and non-renewable resource development schemes. Addressing the diverse interests and needs of participants within an effective water management framework represents one of the key challenges facing the land and water boards established under the MVRMA.

2.4 Need for Aquatic Effects Monitoring to Support the Water Management Process in the Northwest Territories

As described above, management of water resources in the NWT is conducted using a step-wise process that includes land-use planning, environmental impact assessment, and project permitting and licencing. Data and information on the characteristics of aquatic ecosystems is required to support all three steps in the water resources management process. First, information on the physical, chemical, and biological conditions of aquatic ecosystems are required to identify land uses that are compatible with the goal of protecting and conserving the unique characteristics of the watersheds that fall under the jurisdiction of each land and water board. Second, baseline data on the physical, chemical, and biological conditions of a water body is needed to accurately predict the potential effects of a land or water use development in that watershed. Third, monitoring data need to be collected during project

construction, operation, and closure and reclamation to evaluate the actual effects of the project on the aquatic ecosystem.

Aquatic effects monitoring encompasses an array of activities designed to provide information on the physical, chemical, and biological characteristics of a receiving water system. These activities typically involve the design and implementation of on-going monitoring programs to support water quality management. However, special, one-time or limited-duration surveys may also be conducted to provide additional information for predicting and/or assessing project-related effects. Data and information collected under such programs provide a basis for defining baseline conditions and evaluating the effects that anthropogenic activities have on physical, chemical, and/or biological characteristics of a water body. In turn, this information can be used to refine the management of the facility to mitigate effects and/or refine the tools that are being used to regulate the human activity within an adaptive management framework. In this way, aquatic effects monitoring provides the data and information needed to make informed decisions regarding the current and future uses of aquatic ecosystems (Ward *et al.*1986; Kilgour *et al.* 2006).

Chapter 3 Guiding Principles for Developing and Implementing Aquatic Effects Monitoring Programs in the NWT

3.0 Introduction

In April 2006, Indian and Northern Affairs Canada and its partners convened a workshop to support the formulation of guidelines for developing and implementing AEMPs in the NWT. As part of the pre-workshop preparations, a series of interviews were conducted with interested parties in the northern monitoring and assessment process (Terriplan Consultants 2006). The results of these interviews provide salient information for defining the role of AEMPs in water management and for establishing guiding principles for the development and implementation of AEMPs in the NWT (see Appendix 1 for more information).

3.1 Purpose of Aquatic Effects Monitoring Programs in the NWT

AEMPs must be designed and implemented as a requirement of the water licencing process in the NWT. More specifically, AEMPs are required to provide the data and information needed:

- To determine the short-term and long-term effects on the aquatic environment that occur in conjunction with the construction and/or operation of a project;
- To evaluate the accuracy of the predictions that are made in environmental assessments regarding the impacts of a project;
- To assess the efficacy of impact mitigation measures that are used to minimize the effects of the project on the aquatic environment; and,

- To identify additional impact mitigation measures that are needed to reduce or eliminate project-related effects on the aquatic environment (i.e., within an adaptive management framework).

In addition to these primary objectives, AEMPs should also provide the data and information needed to evaluate the cumulative effects on the aquatic environment that may occur due to the presence of multiple human activities within an area or region. In this context, project-specific AEMPs must support regional cumulative effects assessments.

3.2 Guiding Principles for Aquatic Effects Monitoring Programs in the NWT

In advance of the April 2006 AEMP workshop, a series of interviews were conducted with representatives of selected Aboriginal governments/organizations, federal and territorial governments, regulators, monitoring agencies, consulting firms, and industry to support determination of expectations and best practices related to baseline and aquatic effects monitoring (Terriplan Consultants 2006). As part of this survey, respondents were asked to identify a series of principles that could be used to guide the development of AEMPs. In response to that request, the interviewees provided focussed input that supports establishment of guiding principles for AEMPs in the NWT (Terriplan Consultants 2006). These responses were reviewed and utilized to establish the following guiding principles for developing and implementing AEMPs in the NWT:

- AEMPs must be developed in a rigorous and scientifically-defensible manner, incorporating both contemporary science and traditional knowledge (TK);
- AEMPs must have clearly-defined objectives that are used to guide the design of the monitoring program;

- AEMPs must be designed to determine the short- and long-term effects on human health and aquatic environment associated with project-related activities;
- AEMPs must provide an effective basis for early detection of changes in aquatic environmental quality and project-related effects;
- AEMPs must be designed to provide a basis to distinguishing between random variability and project-related effects in aquatic ecosystems;
- AEMPs must be designed to provide the data and information needed to assess the effectiveness of impact mitigation measures and to identify any additional impact mitigation measures needed to reduce or eliminate adverse effects on human health or the aquatic environment;
- AEMPs must be designed to consider the potential effects of the project on the physical, chemical, and biological characteristics of aquatic ecosystems, including water quality, water quantity, sediment quality, biological health and integrity, and human health;
- The design of the AEMP should be initiated prior to collecting baseline data to ensure comparability between baseline and AEMP-generated data (i.e., to facilitate before-after comparisons of the resultant data);
- The evaluation and selection of reference areas should be considered to be an integral component of the overall AEMP design process (i.e., to facilitate control-impact comparisons of the resultant data);
- AEMPs must be designed to provide data that contribute directly to a broader regional cumulative effects monitoring programs;
- AEMPs must be designed and implemented in a manner that facilitates the use of the associated results to support effective adaptive management of the project, such that the nature, magnitude, duration, and spatial extent of any effects that occur are minimized and do not exceed those identified in the Environmental Assessment;
- Consultation must occur throughout the AEMP development and implementation process to ensure that the interests and needs of Aboriginal governments/organizations, territorial and federal government departments, land and water boards, non-governmental organizations, and other interested parties are understood and appropriately addressed;

- The implementation of AEMPs must be guided by detailed field sampling plans (FSPs), quality assurance project plans (QAPPs), and health and safety plans (HSPs; collectively referred to as sampling and analysis plans; SAPs);
- The data and information that are generated under AEMPs must be evaluated, compiled, and managed in a manner that assures their quality and their accessibility by the proponent, Aboriginal governments/organizations, regulators, government departments, and the public; and,
- The results of AEMPs must be disseminated in a timely manner, in formats that are readily understood by communities, regulators, and scientists.

These principles provide general guidance for the development and implementation of AEMPs in the NWT. More specifically, these guiding principles articulate the areas of agreement among all interested parties on how AEMPs should be developed and implemented in the NWT. As such, AEMPs that are developed in accordance with these guiding principles are likely to be generally acceptable, thereby enhancing the prospects for timely review and approval of the AEMP by all of the parties involved in the process.

Chapter 4 Role of Traditional Knowledge in the Development and Implementation of Aquatic Effects Monitoring Programs

4.0 Introduction

Traditional knowledge (TK) is the cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living things (including humans) with one another and the environment. According to the Mackenzie Valley Environmental Impact Review Board (MVEIRB 2005), there are three important elements of TK that contribute to our understanding of the environment. First, TK provides factual knowledge about the environment that is based on direct observation and experience, shared information within the community, and an oral history spanning multiple generations. Such factual knowledge includes specific observations, patterns of biophysical, social, and cultural phenomena, inferences relative to cause and effect, and predictions of the impacts of human activities. Second, TK provides essential information on the use and management of the environment. In this context, TK enhances our understanding of cultural practices and social activities, land use patterns, archeological sites, harvesting practices, and harvesting levels, both now and in the past. Furthermore, TK provides information on the values that people place on the environment. By articulating moral and ethical values regarding the relationships between people and the environment, TK helps to identify the "right way" to do things (MVEIRB 2005).

Many project proponents have expressed an interest in better understanding how to integrate TK into the AEMP development process. While it is important to define the role of TK in the development and implementation of AEMPs, the AEMP Guidelines does not represent the most appropriate vehicle to deliver such guidance. Rather Aboriginal governments/organizations will explicitly define the applications and uses of TK on a project-by-project basis. To complement project-specific TK requirements, the framework for developing and implementing AEMPs in the NWT presented in the ensuing chapters of this document highlights the steps that would

benefit from consultations with TK holders. This chapter briefly describes the importance of incorporating TK into the AEMP development process.

4.1 Contributions of Traditional Knowledge to the Aquatic Effects Monitoring Program Development Process

Information on northern ecosystems and on the impacts of anthropogenic developments on plants and animals that utilize these habitats can be acquired through the application of TK and contemporary science. Because the information from both sources is unique, valuable, and complementary, it is strongly recommended that project proponents design AEMPs in a manner that utilizes both approaches for acquiring information. Some of the reasons for including TK in the AEMP development process include:

- TK provides an understanding of baseline conditions within the study area;
- TK provides an understanding of the structure and function of the aquatic ecosystem within the study area. This is particularly important in the NWT where little or no contemporary scientific data have been collected for many areas;
- TK provides a historic perspective and understanding of the variability associated with aquatic ecosystems. Such information can support the design of baseline sampling programs and/or AEMPs that need to characterize that variability;
- TK enhances understanding of the linkages between environmental components, which can help to identify exposure pathways and key receptor groups;
- TK can be used to predict the effects of development activities on the ecological receptors that utilize habitats within the study area. Impacts on human health and/or the traditional uses of the aquatic ecosystem (i.e., the water environment) can also be predicted using TK. This information contributes to the environmental impact assessment process and to problem formulation during AEMP design;

- TK provides a basis for monitoring environmental conditions within the study area, thereby representing a key element of well-designed AEMPs; and,
- TK supports the identification of candidate mitigation measures that can be used to minimize or avoid the impacts of development projects on the aquatic ecosystem and/or its uses. TK can also be used to evaluate the efficacy of such mitigation measures.

4.2 Traditional Knowledge Requirements for Aquatic Effects Monitoring Program Development and Implementation

An overview of the recommended framework for developing and implementing AEMPs in the NWT is provided in Chapter 5 of this document. Chapters 6 to 13 further describe each of the eight steps in this process. While opportunities to engage Aboriginal governments/organizations and TK holders in the process are explicitly identified in the description of each step of the process, a partial list of TK requirements is presented here to support TK acquisition planning. More specifically, the following tasks should involve TK holders:

- Documentation of interests and concerns relative to the development project and its potential effects on the aquatic ecosystem and its uses;
- Identification of sources of information on the study area, including the location and expertise of TK holders;
- Description of the structure and function of aquatic ecosystems within the study area;
- Identification of valued ecosystem components associated with aquatic ecosystem;
- Description of traditional resource uses and management within the study area;

Proponents should develop a TK Acquisition Plan early in the process, in consultation with aboriginal governments/ organizations

- Characterization of the linkages between the plants and animals that utilize aquatic habitats within the study area;
- Selection of assessment and measurement endpoints;
- Evaluation of the Conceptual AEMP Design;
- Evaluation of the feasibility of implementing the sampling program;
- Evaluation and analysis of the results of the AEMP, including TK components;
- Identification of data gaps;
- Evaluation of candidate mitigation options; and,
- Assessment of the efficacy of selected mitigation measures.

Project proponents are encouraged to document TK requirements and discuss them with TK holders at or near the beginning of the AEMP development process to ensure that a plan to acquire the necessary information can be developed and implemented (i.e., a TK Acquisition Plan). In developing such a plan, it is important to understand that TK is an extremely valuable source of information that can require substantial time to acquire and document. In addition, directed approaches are needed to facilitate its acquisition (e.g., workshops, site visits, interviews, interpreters, nomenclature development). Therefore, resource requirements and schedules should be developed in consultation with TK holders to ensure that project requirements can be satisfied. Effective partnerships with TK holders, built early in the process and in a manner that respects the significance of this information, will help to streamline many of the ensuing steps in the AEMP development and implementation process.

Resource requirements and schedules should be developed in consultation with TK holders

Chapter 5 Overview of the Recommended Framework for Designing and Implementing Aquatic Effects Monitoring Programs in the NWT

5.0 Introduction

In the NWT, AEMPs must be designed and implemented as a requirement of the water licencing process for projects that are anticipated to have adverse effects on the aquatic ecosystem (i.e., activities for which Type A water licences are required). Such AEMPs must be designed and implemented in an manner that will provide the data and information needed to evaluate short- and long-term adverse effects in the aquatic ecosystem (i.e., water environment) resulting from the project, to evaluate the accuracy of impact predictions, to assess the effectiveness of impact mitigation measures, and to identify additional impact mitigation measures to reduce or eliminate environmental effects. The guiding principles for developing and implementing AEMPs in the NWT were presented in Chapter 3. This chapter presents a framework for designing AEMPs that are consistent with these guiding principles and are intended to meet the expectations of Aboriginal governments/organization, regulatory agencies, land and water boards, and other interested parties.

5.1 Recommended Framework for the Development of Aquatic Effects Monitoring Programs in the NWT

The recommended framework for designing and implementing AEMPs in the NWT provides a step-wise process for guiding the development of monitoring programs to assess the physical, chemical, and biological characteristics of aquatic ecosystems within which development activities have been, or are proposed to be, conducted. Importantly, this framework is intended to support the design of monitoring programs conducted ***prior to*** project development (i.e., to collect baseline data to support environmental assessment), during project construction and operations, and during project closure and reclamation. In addition, TK needs to be acquired and used

throughout all steps of the AEMP development and implementation process. The recommended framework consists of the following steps (Figure 3):

- Step 1: Identification of issues and concerns associated with a development project relative to potential effects on the aquatic ecosystem;
- Step 2: Problem formulation for aquatic effects monitoring;
- Step 3: Development of data quality objectives and conceptual study design;
- Step 4: Development of a detailed study design;
- Step 5: Documentation and verification of the sampling design;
- Step 6: Implementation of the AEMP;
- Step 7: Evaluation, compilation, interpretation, and reporting of aquatic effects data and information; and,
- Step 8: Application of AEMP results within an adaptive management framework.

Each of these steps in the AEMP development and implementation process is briefly described in the following sections of this chapter and detailed in the subsequent chapters of this guidance document. Because standardized methods for conducting intensive aquatic environment monitoring programs is available for Canadian jurisdiction [i.e., apart from Environmental Effects Monitoring (EEM) guidance], the AEMP Guidelines have been based, in part, on guidance available from the U.S. Environmental Protection Agency (USEPA) and the International Standards Organization.

5.1.1 Step 1: Identification of Issues and Concerns Associated with a Development Project

The first step in the AEMP development process involves the identification of issues and concerns associated with the proposed development activity relative to potential effects on the aquatic ecosystem. It is important to identify these issues and concerns early in the process because such information provides the proponent, Aboriginal

governments/organizations, regulators, and other interested parties with a basic understanding of the project and the effects that may be associated with its implementation. This step is usually initiated when the proponent prepares a project description, which typically describes the nature and scope of the project-related activities and generally defines the scope of the study area. In addition, the project description should include information on the characteristics of the receiving water system, existing and future land use patterns in the study area, the characteristics of effluents that may be discharged from the development site (and those of other discharges in the study area). In turn, this information provides a preliminary basis for identifying chemicals of potential concern and areas of potential concern in the study area.

Following its preparation, the project description should be distributed to Aboriginal governments/organizations (including TK holders), regulators, and other interested parties to facilitate the identification of issues and concerns associated with the proposed project. Initial consultations with these groups should be convened at this time to support the identification of existing sources of TK and contemporary scientific information on the watershed and to develop a list of valued ecosystem components. Furthermore, it may be beneficial to conduct one or more site visits with Traditional Knowledge holders, regulators and/or other interested parties to further explain the nature of the project and the scope of the potential effects. Such face-to-face meetings also provide an opportunity to establish a **project review team** and to identify the roles and expectations for each of the participants. Such a project review team can assist the project proponent throughout the AEMP development and implementation process by clearly articulating expectations and identifying the refinements needed to ensure that these expectations are met.

A Project Review Team may be established by the proponent to provide a formal mechanism for consulting with interested parties. It could be comprised of key representatives of each group with an interest in the project. The project proponent would provide resources to facilitate participation in this process and the members of the team would assume responsibility for soliciting input from other members of their organization

Provision of the project description and associated information to Aboriginal governments/organizations, regulators, and other interested parties early in the process is beneficial for several reasons. First, this information will provide all participants with a

common understanding of the structure, function, and status of the aquatic ecosystem, of historic land and resource use patterns, and of the socioeconomic characteristics of the study area. In addition, evaluation of this background information provides a basis for identifying data gaps that will need to be addressed as the process progresses. Furthermore, identification of the issues and concerns by reviewers will assist the proponent in preparation for the environmental assessment process, if required. Finally, and of utmost importance, consultation with Aboriginal governments/organizations and others early in the process will help to foster a sense of trust and teamwork that should expedite the subsequent steps in the AEMP development process.

5.1.2 Step 2: Problem Formulation for Aquatic Effects Monitoring

Problem formulation is the process of defining the questions that need to be addressed by an AEMP and involves six key activities. The activities included in the problem formulation process are:

1. Refinement of the list of chemicals of potential concern (COPCs) and other stressors;
2. Evaluation of the effects of each stressor on human health and the environment;
3. Identification of contaminant transport and fate, ecosystems potentially at risk, and complete exposure pathways;
4. Development of a conceptual site model (CSM);
5. Selection of assessment and measurement endpoints; and,
6. Development of an AEMP Analysis Plan.

Collectively, these activities provide a basis for determining which components of the aquatic ecosystem may be at risk as a result of the proposed developmental activity and what the adverse effects on human health or the environment could be. By considering multiple stressors originating from various aspects of the project and/or stressors originating from other human activities that affect the receiving water system, it is possible to account for and evaluate the cumulative effects on the aquatic ecosystem. This step will provide clear linkages between the AEMP and regional

cumulative effects assessment programs. In this way, the problem formulation process provides the information needed to focus resources on monitoring the ecosystem characteristics that are most likely to be adversely affected by project development.

Problem formulation is an iterative process that can and should be used to refine the AEMP as information on the study area expands and data gaps are filled. Importantly, preliminary problem formulation should begin as soon as the project description has been completed. In this way, baseline data collection efforts can be focussed in the ecosystem components that are most likely to change in response to project development. Hence, the baseline data are likely to be useful for before-after comparisons of environmental conditions, a key approach to aquatic effects assessment. The preliminary problem formulation should be refined following the collection of baseline data and completion of the environmental assessment (i.e., when changes to the project descriptions and/or further mitigation measures are likely to be identified). The problem formulation should be further refined periodically during project operation and in advance of project closure and reclamation. Such refinements to the problem formulation will ensure that the project proponent and all interested parties are provided with the information needed to ensure that the AEMP is appropriately revised and refined to meet its stated objectives.

Following completion of the problem formulation process, project proponents must consult with Aboriginal governments/organizations, regulators, and other interested parties

Problem formulation is intended to support the development of data quality objectives and the conceptual study design and data quality objectives. To ensure that the subsequent steps can proceed efficiently, it is imperative that project proponents consult with Aboriginal governments/organizations, regulators, and other interested parties following the completion of the problem formulation process. The goal of this consultation is to achieve agreement on six main items, including:

- The stressors of concern;
- Assessment endpoints;
- Exposure pathways;
- Risk questions;

- Measurement endpoints; and,
- Analysis plan.

The conceptual site model (CSM) and associated diagrams provide efficient tools for communicating this information to interested parties and developing consensus on these items. Lack of agreement between the project proponent, Aboriginal governments/organizations, regulators, and other interested parties on the CSM will almost certainly impair the selection of measurement endpoints and the development of the study design. As indicated previously, project proponents are encouraged to establish a project review team to provide timely input on the problem formulation and on other steps in the framework.

5.1.3 Step 3: Development of Data Quality Objectives and Conceptual Study Design

The third step in the AEMP development process involves the formulation of the data quality objectives (DQOs) and conceptual study design. The DQOs development process determines the type, quantity, and quality of data needed to reach defensible conclusions regarding the effects of the project on the aquatic ecosystem and those receptors that depend on the aquatic ecosystem (i.e., aquatic-dependent wildlife and human health). This step in the AEMP development process culminates in the preparation of a report that documents the conceptual design of the AEMP and analytical methods that will be use to evaluate and analyse the data that are collected under the monitoring program (i.e., the AEMP Design document). The analysis plan that is incorporated into the AEMP Design document should identify critical effect sizes that will trigger additional management actions at the site (e.g., a 20% increase in the concentration of copper compared to background conditions). In this way, the AEMP will become a central element of the overall adaptive management framework that will be used to mitigate project-related effects at the site (see Section 7.8 for a further description of the AEMP analysis plan).

As indicated previously, the design of the project can change over time. Such changes in the project description will affect the CSM and necessitate its revision from time to time. In turn, refinements in the CSM to reflect project modifications will necessitate periodic revision of the AEMP design and the associated analysis plan

(Figure 4). At minimum, the AEMP design should be reviewed every three years and revisions in the design of the monitoring be undertaken as necessary.

Following the completion of the AEMP design and analysis plan (as documented in the AEMP Design document), follow-up consultations shall be convened with Aboriginal governments/ organizations, regulators, and other interested parties. The objective of these consultations is to establish agreement on:

Consultations with Aboriginal governments/organizations, regulators, and other interested parties should follow the completion of the AEMP design and analysis

1. The selection of approaches for evaluating the aquatic effects of the project; and,
2. The selection of data evaluation, reduction, and interpretation methods.

Consultations with Aboriginal governments/organizations, should occur to develop a TK Acquisition Plan if TK represents an element of baseline data collection and/or the overall AEMP design

The AEMP Design document should also specify how inferences will be drawn from the measurement endpoints to the assessment endpoints (i.e., how the data collected under the AEMP will be used to evaluate the status of the valued ecosystem components). Consultation at this stage of the process is essential to ensure that any concerns with the approach to aquatic effects monitoring can be addressed prior to the development of the sampling and analysis plan (SAP). If TK represents an element of the overall AEMP design, then a TK Acquisition Plan should be developed in consultation with Aboriginal governments/organizations.

5.1.4 Step 4: Documentation and Verification of the Sampling Design

The fourth step in the AEMP development process involves the documentation and verification of the sampling design. More specifically, a SAP is prepared that translates the conceptual AEMP design and associated analysis plan into tangible procedures that can be followed by staff involved in field sampling, laboratory

analysis, and data validation, compilation, and interpretation. The SAP typically consists of three elements, including:

- Field sampling plan (FSP);
- Quality assurance project plan (QAPP); and,
- Health and safety plan (HSP).

The FSP is intended to provide guidance for all field work by providing a detailed description of the sampling and data-gathering procedures to be used for the project (USEPA 1997). By comparison, the QAPP describes the steps that need to be completed to generate data that meet the project DQOs (see USEPA 2001a for detailed guidance on the development of QAPPs). The HSP describes how the health and safety of project participants will be safeguarded during the data collection programs.

Before the SAP is implemented, it is important to verify that samples specified in the FSP can be collected at the site. During field verification of the sampling design, the testable hypotheses, exposure pathway models, and measurement endpoints are evaluated for their appropriateness and implementability (USEPA 1997; see Chapter 9 for further details). More specifically, information obtained previously and the feasibility of sampling should be verified through one or more visits to the site. For abiotic media, such as water and sediment, it is important to determine if the selected sampling methods are appropriate and applicable to the conditions at the site. For biological sampling, it is important to confirm that target species occur at the site, to determine if adequate numbers of individuals of the required species can be collected, and to evaluate the efficacy of various sampling methods. In this respect, TK provides essential information for field validating the sampling design. The level of effort required to collect the required number of samples can be determined with such detailed information on sampling logistics. At this state of the process, it is prudent to develop a number of contingency plans that can be used to direct field sampling efforts if unexpected conditions are encountered (e.g., fish sampling contingency plan).

The FSP and QAPP should be reviewed by the Aboriginal governments/organizations, regulators, and other interested parties prior to implementation of the AEMP. Any

changes to the design of the monitoring program in response to field verification efforts must be made with the agreement of the responsible authority and other reviewers (i.e., project review team). It is important to demonstrate that the assessment endpoints and testable hypotheses developed during problem formulation are still being addressed by the revised AEMP. In addition, any new measurement endpoints must be evaluated according to their utility for assessing the status of the assessment endpoints and their compatibility with the CSM (USEPA 1997). Final agreement on the AEMP design will be considered to have been achieved when the AEMP Design document, FSP, QAPP, and HSP have been approved by the responsible land and water board. This general approach to planning should be applied during baseline data collection, data collection during project construction and operation, and project closure and reclamation. Once the AEMP documents have been approved, the AEMP can be implemented through a combination of field sampling and laboratory analysis.

Aboriginal governments/ organizations, regulators, and other interested parties should be consulted if deviations from the FSP or QAPP are required

5.1.5 Step 5: Implementation of the Aquatic Effects Monitoring Program

Implementation of the AEMP involves the collection and analysis of environmental samples in accordance with the FSP and QAPP. During the implementation stage, it is important to adhere to the DQOs and to any requirements for synoptic sampling activities (e.g., collection of sediment samples for evaluation of whole-sediment chemistry and whole-sediment toxicity from a sample homogenate prepared from one or more grab samples). Failure to collect even one sample properly or to coordinate samples temporally can significantly affect interpretation of the data (USEPA 1997). Changing field conditions and/or new information on the nature and extent of contamination can require a change in the FSP (USEPA 1997). Importantly, any deviations from the FSP or QAPP must be fully documented to enable interested parties to determine if the requisite information has been collected and to support interpretation of the data. Such deviations need to be discussed with the responsible authority, Aboriginal governments/organizations, regulators, and other interested parties in an open consultative process, with decisions on the actions needed to address the deviations ultimately made by the responsible authority.

While the project proponent is responsible for implementing the AEMP Plan, FSP, QAPP, and/or TK Aquisition Plan as written, the responsible land and water board and/or their designate should be prepared to provide oversight on sampling and analysis activities. More specifically, field sampling activities should be audited on site to ensure that environmental samples are being collected using the agreed-to methods and procedures. In addition, the laboratories that have been selected by the project proponent should be periodically audited to confirm that they are generating reliable data. Furthermore, a portion of the environmental samples that are collected under the AEMP should be split or duplicated and analysed at an independent laboratory to provide interested parties with confidence that the data generated by the proponent are comparable to those that are generated by regulatory agencies (i.e., to confirm that systematic biases do not occur). Ultimately, the DQOs provide the technical basis for evaluating the extent to which the data generated meet the requirements of the AEMP.

5.1.6 Step 6: Evaluation, Compilation, Interpretation and Reporting of Aquatic Effects Data and Information

This step in the AEMP development and implementation process consists of four activities, namely data evaluation, data compilation, data interpretation, and data reporting. Each of these activities are briefly described below.

Data Evaluation – All of the data that are generated under the AEMP must be evaluated to determine if they can be used in the assessment of project-related effects. More specifically, the data must be evaluated relative to the project DQOs. The performance criteria for measurement data that are established as part of the overall DQOs process provide a systematic basis for evaluating the accuracy, precision, sensitivity (i.e., detection limits), completeness, and representativeness of the AEMP data (see USEPA 2001a; 2006 for more detailed information on performance criteria for measurement data). This data evaluation should be conducted as soon as the data are received from the laboratory because sample re-analysis may be required under some circumstances and such re-analysis may not be possible if sample holding times have been exceeded or if samples have been discarded. The results of such data evaluation will determine if the data can be used directly, if the data need to be qualified prior to use, or if

the data should be rejected. Ultimately, it is the responsibility of the project proponent to ensure that sufficient quantities of data of appropriate quality are generated to support effective evaluation of project-related effects. Therefore, it is important to report any issues related to data usability to the responsible land and water board and regulators immediately, along with any corrective actions that are proposed for addressing these issues.

Data Compilation – The data that are generated under the AEMP must be compiled in a format that facilitates access by data analysts, the responsible land and water board, Aboriginal governments/organizations, regulators, and other interested parties. To facilitate broad access to the data and to support diverse data analyses, it is recommended that AEMP data be compiled in a GIS-compatible, relational database in MS Access format. Although a wide range of database systems are available, MS Access is recommended because most data users have access to this software and because it is sufficiently powerful to meet the needs of most all data users. In addition, this database is compatible with most electronic data delivery systems, which reduces the need for manual data entry. Nevertheless, all of the data that are compiled in the project database need to be verified against the original data source to assure data quality. The AEMP data should be delivered to the responsible land and water board, Aboriginal governments/organizations, regulators, and other interested parties in electronic format and in an annual AEMP data report.

Data Interpretation – The procedures for interpreting the AEMP data are specified in the analysis plan that was prepared during problem formulation and refined thereafter (i.e., in the DQOs process). Therefore, data interpretation involves implementation of the agreed-to analysis plan to evaluate the status and trends of key indicators of aquatic environmental quality. The results of these analyses should be presented in an annual AEMP interpretive report and in a more detailed interpretive report every three years, or as required by the responsible land and water board. These interpretive reports should describe any changes in the abiotic characteristics of the ecosystems that have occurred, any effects on aquatic receptors, aquatic-dependent wildlife, or human

Consultations with responsible land and water board, Aboriginal governments/ organizations, regulators, and other interested parties should occur during refinements of the AEMP Design document and associated SAP

health that been documented, and any cumulative effects that have occurred, based in interpretation of individual lines-of-evidence (LOEs) and integration of multiple LOEs (see Chapter 9 for more information). ***Both technical and plain-language versions of each report should be prepared by the project proponent.*** Any data gaps that are identified should be reported to the responsible authority and to the members of the project review team in the annual interpretive report. Identification of these data gaps provides the necessary and sufficient rationale for refining the AEMP Design document and associated SAP to ensure that the data gaps are addressed in a timely manner. However, consultations with the responsible land and water board, Aboriginal governments/organizations, regulators, and other interested parties should be convened at this stage of the process to establish agreement on the most appropriate way to address data gaps.

Data Reporting – Review of the reports prepared under the AEMP represents an essential step in the overall aquatic effects assessment process. Facilitation of such reviews necessitates timely dissemination of the AEMP data, the AEMP data reports, and the AEMP interpretive reports. In addition, it is strongly recommended that workshops be scheduled on an annual basis to present the data and the results of data analyses to the responsible land and water board, Aboriginal governments/organizations, regulators, and other interested parties. It is important to recognize that reviewers are likely to provide a diverse variety of comments, some of which may necessitate additional analysis of the data, reformatting of reports, and/or revision of conclusions. It is expected that the project proponent will systematically and respectfully address the comments provided on each document, prepare a detailed responsiveness summary that describes how each comment was addressed, and finalize each document in an appropriate manner (i.e., by incorporating all of the relevant comments).

5.1.7 Step 7: Application of Aquatic Effects Monitoring Program Results within an Adaptive Management Framework

Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed polices and practices. In the NWT, adaptive management should be integrated into every development proposal since our understanding of northern ecosystems and the effects

of anthropogenic activities on them is incomplete. As a result, predictions of the impacts of development projects on aquatic ecosystems are often inaccurate and the efficacy of associated mitigation measures is often uncertain. For this reason, aquatic effects monitoring has become a central element of the overall natural resource management process in the NWT.

To be effective, however, the AEMP must be integrated into the overall project management framework. More specifically, the environmental assessment process (when required) provides a vehicle for developing hypotheses regarding the effects of the project on the environment and the efficacy of mitigation measures. In turn, development and implementation of a well-designed AEMP provides the data and information needed to evaluate the accuracy of these hypotheses. By helping to identify any incorrect hypotheses that have been made relative to effects and/or mitigation, the results of the AEMP can and should be used to develop alternate management policies, approaches, strategies and/or practices that are expected to be more effective in terms of meeting project goals and objectives. For example, a project proponent may hypothesize that nutrient releases from its facility represent minor contributions to the aquatic ecosystem and that eutrophication will not be an issue in receiving waters. If properly designed, the AEMP should provide the data needed to confirm or refute this hypothesis. If the hypothesis is refuted, then additional mitigation will be required to address project-related effects and ongoing monitoring results will provide the information needed to determine if that mitigation is effective. Hence, the AEMP represents a central element of the overall adaptive management plan that is established for a project. Ongoing review and refinement of the AEMP ensures that it will continue to be relevant for supporting decisions on the management of the project as a whole. The Adaptive Management Plan for the project needs to be reviewed by Aboriginal governments/organizations, regulators, and other interested parties with ultimate approval provided by the responsible land and water board.

Chapter 6 Summary and Conclusions

6.0 Introduction

In recognition of the need for consistent guidance on the development of AEMPs, INAC initiated the AEMP Guidelines project in 2006. The project is intended to support the preparation of a guidance document that would provide project proponents, Aboriginal governments/organizations, regulatory agencies, and other interested parties with greater certainty regarding requirements and expectations for developing and implementing AEMPs in the NWT. As a first step, INAC convened a multistakeholder workshop in April, 2006 to establish guiding principles for AEMPs and evaluate best practices regarding aquatic effects monitoring. Subsequently, a series of literature searches were conducted to acquire further information on approaches to, and procedures for, aquatic effects monitoring. This information was used to develop a preliminary framework for designing AEMPs. Next, a number of meetings were convened with Aboriginal governments/organizations, land and water boards, and other interested parties to obtain feedback on a preliminary framework for aquatic effects monitoring. This report integrates input provided to date from all sources to recommended a framework for designing and implementing AEMPs in the NWT. A second stakeholder workshop will be convened during October, 2008 to solicit further input on the recommended framework and to facilitate finalization of the AEMP Guidelines by INAC.

6.1 Overview of the Recommended Framework

Considerable effort has been expended in Canada and elsewhere worldwide to develop guidance for monitoring the effects of human activities on aquatic ecosystems. These efforts have resulted in a variety of guidance documents that could be used to support the design of AEMPs (e.g., Ecological Monitoring and Assessment Network, Environmental Effects Monitoring, International Organization for Standardization, USEPA). While project proponents are encouraged to review such guidance documents during the AEMP design process, it would be a mistake to

assume that any one of these guidance documents applies directly to the development of AEMPs within the NWT or elsewhere in the NWT. Such guidance documents are not directly applicable to this geographic area because they were typically developed for use in other areas that have already been degraded to a greater or lesser degree by anthropogenic developments. In the case of Environmental Effects Monitoring (EEM), the guidance was developed to identify those situations where adverse effects on aquatic ecosystems were occurring due to discharges of effluents from existing facilities (i.e., to identify the worst situations). None of the available guidance was explicitly developed to support the design of monitoring programs in areas that have been essentially unspoiled by human activities. Therefore, monitoring programs developed from such guidance are unlikely to be sufficiently sensitive to identify effects on pristine northern ecosystems.

The recommended framework for designing and implementing AEMPs in the NWT is intended to provide a step-wise process for guiding the development of monitoring programs for assessing the physical, chemical, and biological characteristics of aquatic ecosystems within which development activities have been, or are proposed to be, conducted. Importantly, this framework is intended to support the design of monitoring programs conducted ***prior to*** project development (i.e., to collect baseline data to support environmental assessment), during project construction and operations, and during closure and reclamation of the project. Traditional Knowledge needs to be acquired and used throughout the AEMP development and implementation process, in consultation with Aboriginal governments/organizations. The recommended framework consists of the following steps (Figure 3):

- Step 1: Identification of issues and concerns associated with a development project relative to potential effects on the aquatic ecosystem;
- Step 2: Problem formulation for aquatic effects monitoring;
- Step 3: Development of data quality objectives and conceptual study design;
- Step 4: Development of a detailed study design;
- Step 5: Documentation and verification of the sampling design;
- Step 6: Implementation of the AEMP;

- Step 7: Compilation, evaluation, interpretation, and reporting of aquatic effects data and information; and,
- Step 8: Application of AEMP results within an adaptive management framework.

A series of AEMP Technical Guidance documents have been prepared to provide detailed information on each of these steps in the framework.

6.2 Application of the Recommended Framework

The framework presented in this document is explicitly recommended for developing and implementing AEMPs for development projects in the NWT. It is important to understand that adherence to this framework throughout the life of the project will maximize the effectiveness of the AEMP in terms of determining the effects of the project on the water environment, evaluating the accuracy of impact predictions, assessing the efficacy of impact mitigation measures, and identifying the need for additional mitigation measures to reduce or eliminate environmental effects.

The recommended framework should be used to support the collection and interpretation of baseline data prior to environmental assessment and project licencing, to design and implement the AEMP for the project construction and operation periods, and to evaluate effects on the aquatic ecosystem during and following project closure and reclamation. By doing so, the data and information that are collected throughout the life of the project are likely to be as comparable as possible, making long-term trend assessment possible and before-after effects assessment more reliable. Each of the steps in the framework identifies opportunities for consultation with key participants in the AEMP development process. Project proponents are strongly recommended to avail themselves of these opportunities to strengthen the AEMP design, to streamline the AEMP approval process, to solicit involvement during AEMP implementation (i.e., through establishment of a Project Review Team), and to enhance interpretation of AEMP results.

6.3 Linkage of Aquatic Effects Monitoring Programs to Project Management

To support effective water resources management and the long-term sustainability of aquatic ecosystems, the results of well-designed AEMPs must be used to guide decisions regarding the management of the development project as a whole. That is, the AEMP results must be used to identify the need for further mitigation to avoid or minimize project-related effects on the aquatic ecosystem and/or its uses. To do so, project proponents must be willing to adopt an adaptive management approach to their developments and responsible land and water boards must ensure that project proponents establish adaptive management plans that include conservative Action Levels and utilize these benchmarks to implement mitigative measures in a timely manner (i.e., before project-related effects exceed environmental assessment predictions).

An AMP represents a useful management tool only if it appropriately identifies key issues relative to effects on the aquatic ecosystem and its uses, establishes Action Levels that are sufficiently conservative to provide adequate time to implement any required mitigation measures, and presents decision rules that are sufficiently specific to ensure that all participants in the process understand what actions will be taken by the project proponent when each Action Level is exceeded. Accordingly, it is not appropriate to include risk assessments as one on the options that would be considered if the Action Levels are exceeded. Because background conditions are likely to be used to define certain types of Action Levels, it is essential that adequate baseline monitoring data are available to establish background conditions prior to water licencing and that procedures for calculating background concentrations are defined on an *a priori* basis.

6.4 Conclusions

In the NWT, AEMPs are required to provide the data and information needed to effectively manage and mitigate the effects of development projects. More specifically, AEMPs are needed:

- To determine the short-term and long-term effects on the aquatic environment that occur in conjunction with the construction and/or operation of a project;
- To evaluate the accuracy of the predictions that are made in environmental assessments regarding the impacts of a project;
- To assess the efficacy of impact mitigation measures that are used to minimize the effects of the project on the aquatic environment; and,
- To identify additional impact mitigation measures that are needed to reduce or eliminate project-related effects on the aquatic environment (i.e., within an adaptive management framework).

AEMPs should also provide the data and information needed to evaluate the cumulative effects on the aquatic environment that may occur due to the presence of multiple human activities within an area or region. In this context, project-specific AEMPs must support regional cumulative effects assessments. This objective can be met through appropriate problem formulation and AEMP planning.

The AEMP Guidelines provided in this document are intended to assist project proponents in developing AEMPs that are acceptable to Aboriginal governments/ organizations, regulatory agencies, and other interested parties. By doing so, these AEMP Guidelines and the series of AEMP Technical Guidance documents should enable project proponents to develop AEMPs that can be reviewed and approved in a timely manner by the responsible land and water boards.

Chapter 7 References Cited

Angermeier P.L. and R.A. Smogor. 1995. Estimating number of species and relative abundances in stream-fish communities: effects of sampling effort and discontinuous spatial distributions. Canadian Journal of Fisheries and Aquatic Sciences 52:936-949.

ASTM (American Standards and Testing Methods). 2007. Guide for collection, storage, characterization, and manipulation of sediments for toxicological testing and for selection of samplers used to collect benthic invertebrates, E1391-03. Annual Book of ASTM Standards. Volume 11.05. West Conshohocken, Pennsylvania.

Bailey, R.C., R.H. Norris, T.B. Reynoldson. 2003. Bioassessment of Freshwater Ecosystems - Using the Reference Condition Approach. Kluwer Academic Publishers. Boston.

BBL (Blasland, Bouck, and Lee, Inc). 2006. Baseline problem formulation for Operable Unit 4 of the Anniston PCB site. Revision 2. Prepared for United States Environmental Protection Agency. Atlanta, Georgia. Prepared by BBL. Anniston, Alabama.

BCE (British Columbia Environment). 1997. Waste Management Act: Contaminated Sites Regulation. B.C. Reg. 375/96. Schedule 2. Victoria, British Columbia.

Blocksom, K.A. and J.E. Flotemersch. 2005. Comparison of macroinvertebrate sampling methods for non-wadeable streams. Environmental Monitoring and Assessment 102:243-262.

Busch, W.D.N. and P.G. Sly. (Eds.) 1992. The development of an aquatic habitat classification system for lakes. CRC Press . Boca Raton.

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian environmental quality guidelines. Guidelines and Standards Division. Environment Canada. Winnipeg, Manitoba. (Updated annually).

CCME (Canadian Council of Ministers of the Environment). 1987. Canadian water quality guidelines. Eco-Health Branch. Environment Canada. Ottawa, Ontario.

Clark, M.J., M.C. Laidlaw, S.C. Ryneveld, and M.I. Ward. 1996. Estimating sampling variance and local environmental heterogeneity for both known and estimated analytical variance. Chemosphere 32(6):1133-1151.

Conquest, L.L., S.C. Ralph and R.J. Naiman. 1994. Implementation of large-scale stream monitoring efforts: sampling design and data analysis issues. Pp. 69-90. In Biological Monitoring of Aquatic Systems (Loeb, S.L. and A. Spacie, Eds.). Lewis Publishers. Boca Raton, Florida.

Corkum, L.D. 1992. Spatial distributional patterns of macroinvertebrates along rivers within and among biomes. Hydrobiologia. 239:101-114.

Cott, P.A., A.M. Gordon, K.J. Bourassa, M. Lange and B.A. Zajdlik. 2009. Effects of forest fire on young-of-the-year northern pike in the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences. In press.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. United States Department of the Interior. Fish and Wildlife Service. Washington, District of Columbia. Jamestown, North Dakota: Northern Prairie Wildlife Research Center Home Page: http://www.npwrc.usgs.gov/resource/1998/classwet/ classwet.htm (Version 04DEC98).

DDMI (Diavik Diamond Mining Inc.). 2007. Lakebed sediment, water quality and benthic invertebrate study. A418 Dike - Baseline Results. A154 Dike - Year 3 Results. Yellowknife, North West Territories.

Environment Canada. 2002. Metal mining guidance document for aquatic environmental effects monitoring, June 2002. National Environmental Effects Monitoring Office. Gatineau,Quebec.

Environment Canada. 2003. Revised technical guidance on how to conduct effluent plume delineation. March 2003. National Environmental Effects Monitoring Office. Gatineau,Quebec.

Environment Canada. 2004. Pulp and Paper EEM guidance document. May 2004. National Environmental Effects Monitoring Office. Gatineau,Quebec

Environment Canada. 2008. Understanding the pulp and paper environmental effects monitoring program. http://www.ec.gc.ca/eem/English/Publications/ web_publication/EEM101 /EEM101.cfm

Flotemersch, J.E. and K.A. Blocksom. 2005. Electrofishing in boatable rivers: Does sampling design affect bioassessment metrics? Environmental Monitoring and Assessment 102:263-283.

Flotemersch, J.E., J.B. Stribling and M.J. Paul. 2006. Concepts and approaches for the bioassessment of non-wadeable streams and rivers. EPA/600/R-06/127. United States Environmental Protection Agency. Cincinnati, Ohio.

Frissell, C.A., W.J. Liss, C.E. Warren and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification, viewing streams in a watershed context. Environmental Management 10:199-214.

Gorman, O.T. and J.R. Karr. 1978. Habitat structure and stream fish communities. Ecology 59:507-515.

Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. Wiley Interscience. Chichester, England.

Hawkins, C.P. and M.R. Vinson. 2000. Weak correspondence between landscape classifications and stream invertebrate assemblages: Implications for bioassessment. Journal of the North American Benthological Society 19(3):501-517.

Hawkins, C.P., R.H. Norris, J. Gerritsen, R.M. Hughes, S.K. Jackson, R.K. Johnson and R.J. Stevenson. 2000. Evaluation of the use of landscape classifications for the prediction of freshwater biota: synthesis and recommendations. Journal of the North American Benthological Society 19:541-556.

Heino, J., H. Mykrä and J. Kotanen. 2008. Weak relationships between landscape characteristics and multiple facets of stream macroinvertebrate biodiversity in a boreal drainage basin. Landscape Ecology 23:417-426.

Hughes, R.M., S.A. Heiskary, W.J., Matthews and C.O. Yoder. 1994. Use of ecoregions in biological monitoring. In Biological Monitoring of Aquatic Systems (Loeb, S.L. and A. Spacie, Eds.). pp. 125-149. Lewis Publishers. Boca Raton, Florida.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Imhof, J.G., J. Fitzgibbon, and W.K. Annable. 1996. A hierarchical evaluation system for characterizing watershed ecosystems for fish habitat. Canadian Journal of Fisheries and Aquatic Sciences 53(S1):312-326.

INAC (Indian and Northern Affairs Canada). 2001. Mackenzie Valley Resource Management Act: A citizen's guide. Ottawa, Ontario.

Ingersoll, C.G. 2007. Quality assurance project plan (QAPP) for sediment toxicity testing associated with implementation of the Spring River/Tar Creek watershed management framework, phase 1. Agreement #DW 14-95225601-1. Prepared for United States Environmental Protection Agency, Kansas City, Kansas and Dallas Texas and the United States Fish and Wildlife Service, Columbia, Missouri.

Kilgour, B.W. M.G. Dube, K. Hedley, C.B. Portt, K.R. Munkittrick. 2006. Aquatic environmental effects monitoring guidance for environmental assessment practitioners. Springer Scioence - Business Media B.V. Online Publication.

Kokelj S.V., B. Zajdlik and M.S. Thompson. 2009. The impacts of thawing permafrost on the chemistry of lakes across the subarctic boreal-tundra transition, Mackenzie Delta region, Canada. Permafrost and Periglacial Processes. In review.

Leopold, L.B. 1994. A View of the River. Harvard University Press. Cambridge, Massachusetts.

Lyons, J. 1992. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. North American Journal of Fisheries Management 12:198-203.

MacDonald, D.D. 2006. Toward the development of Northern Water Standards: Review and evaluation of approaches for managing water use in the NWT. Prepared for: Water Planning and Management and the Water Resources Division. Indian and Northern Affairs Canada. Gatineau, Quebec and Yellowknife, Northwest Territories.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39:20-31.

MacDonald, D.D., C.G. Ingersoll, D.R.J. Moore, M. Bonnell, R.L. Breton, R.A. Lindskoog, D.B. MacDonald, Y.K. Muirhead, A.V. Pawlitz, D.E. Sims, D.E. Smorong, R.S. Teed, R.P. Thompson, and N. Wang. 2002a. Calcasieu Estuary remedial investigation/feasability study (RI/FS): Baseline ecological risk assessment (BERA). Technical report plus appendices. Contract No. 68-W5-0022. Prepared for CDM Federal Programs Corporation and United States Environmental Protection Agency. Dallas, Texas.

MacDonald, D.D., D.E. Smorong, D.A. Levy, L. Swain, P.Y. Caux, and J.B. Kemper. 2002b. Guidance on the site-specific application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. Prepared for Canadian Council of Ministers of the Environment, Winnipeg, Manitoba and Environment Canada, Ottawa, Canada.

MacDonald, D.D., R. Gale, W. Brumbaugh, C.G. Ingersoll, D.E. Smorong, S. Hamilton, and Y. Muirhead. 2008. Guidelines on the selection of analytical detection limits for generating water chemistry, sediment chemistry, and tissue residue data for use in aquatic risk assessments. Prepared for Office of Environmental Policy and Compliance. Department of the Interior. Washington, District of Columbia and Emergency Response Team. United States Environmental Protection Agency. Edison, New Jersey. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Mapstone, B.D. 1995. Scalable decision rules for environmental impact studies: effect size, Type I and Type II errors. Journal of Applied Ecology 5:401-410.

Marshall, I. B. and P. H. Schut. 1999. A national ecological framework for Canada. A cooperative product by Ecosystems Science Directorate. Environment Canada and Research Branch. Agriculture and Agri-Food Canada. http://sis.agr.gc.ca/cansis/nsdb/ecostrat/intro.html.

Maxwell, J.R., C.J. Edwards, M.E. Jensen, S.J. Paustian, H. Parrott, and D.M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Nearctic Zone). General Technical Report NC-176. St. Paul, Minnesota. United States Department of Agriculture. Forest Service. North Central Forest Experimental Station.

MDEQ (Michigan Department of Environmental Quality). 1997. Revision. GLEAS Procedure 51 - Qualitative Biological and Habitat Survey Protocols for Wadeable Stream and Rivers. Michigan Department of Environmental Quality.

Murray, C. and D. Marmorek. 2003. Adaptive management: A science-based approach to managing ecosystems in the face of uncertainty. Prepared for Presentation at the Fifth International Conference on Science and Management of Protected Areas: Making Ecosystem Based Management Work. Victoria, British Columbia. ESSA Technologies Ltd. Victoria, British Columbia.

MVEIRP (Mackenzie Valley Environmental Impact Review Board). 2005. Guidelines for incorporating Traditional Knowledge in Environmental Impact Assessment.

Newbury, R.W. 1984. Hydrological determinants of aquatic insect habitats. *In:* The Ecology of Aquatic Insects (Resh, V.H and D.M. Rosenberg, Eds.). pp. 323-357. Praeger, New York.

Ohio EPA (Environmental Protection Agency). 2006. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Ohio EPA Technical Bulletin EAS/2006-06-1.

Patton, T.M., W.A. Hubert, F.J. Rahel and K. G. Gerow. 2000. Effort needed to estimate species richness in small streams on the Great Plains in Wyoming. North American Journal of Fisheries Management 20:394-398.

Pienitz, R. J.P. Smol, and D.R.S. Lean. 1997b. Physical and chemical limnology of 24 lakes located between Yellowknife and Contwoyto Lake, Northwest Territories (Canada). Canadian Journal of Fisheries and Aquatic Sciences 54:347-358.

Pienitz, R. J.P. Smol, and D.R.S. Lean. 1997a. Physical and chemical limnology of 59 lakes located between the southern Yukon and the Tuktoyaktuk Peninsula, Northwest Territories (Canada). Canadian Journal of Fisheries and Aquatic Sciences 54:330-346.

Sandin L. and R.K. Johnson. 2000. Ecoregions and benthic macroinvertebrate assemblages of Swedish streams. Journal of the North American Benthological Society 19:462-474.

Sokal, R. and J. Rolf. 1995. Biometry. The principles and practice of statistics in biological research. W. A. Freeman and Company. San Francisco.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics. 3rd ed. McGraw-Hill, New York.

Stewart-Oaten, A. and J.R. Bence. 2001. Temporal and spatial variation in environmental assessment. Ecological Monographs 71:305-339.

Stewart-Oaten, A., W.W. Murdoch and K. R. Parker. 1986. Environmental Impact Assessment: "Pseudoreplication" in Time? Ecology 67:929-940.

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: The concept of reference condition. Ecological Applications 16:1267-1276.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Transactions of the American Geophysical Union 38:913-920.

Suter, G.W., R.A. Efroymson, B.E. Sample, and D.S. Jones. 2000. Ecological risk assessment for contaminated sites. Lewis Publishers. Boca Raton, Florida.

Terriplan Consultants. 2006. Guidelines for the monitoring and assessment of aquatic effects of development in the NWT. Discussion Paper. Prepared for Indian and Northern Affairs Canada. Prepared for discussion at Technical Workshop. Yellowknife, Northwest Territories. April 2006.

Thompson, Terrence, J. Fawell, S. Kunikane, D. Jackson, S. Appleyard, P. Callan, J. Bartram, and P. Kingston. 2007. Chemical safety of drinking-water: Assessing priorities for risk management. World Health Organization. Geneva, Switzerland.

Underwood A. J. 1989. The analysis of stress in natural populations. The Biological Journal of the Linnean Society 37:51-78.

Underwood, A.J. 1991. Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. Australian Journal of Marine and Freshwater Research 42:569-587.

Underwood, A.J. 1994. On beyond BACI: Sampling designs that might reliably detect environmental disturbances. Ecological Applications 4(1):3-15.

USEPA (United States Environmental Protection Agency). 1997. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. Environmental Response Team. Edison, New Jersey.

USEPA (United States Environmental Protection Agency). 2001a. EPA requirements for quality assurance project plans. EPA QA/R-5. EPA/240/B-01/003. Office of Environmental Information. Washington, District of Columbia.

USEPA (United States Environmental Protection Agency). 2006. Guidance on systematic planning using the data quality objectives process. EPA QA/G-4. EPA/240/B-06/001. Office of Environmental Information. Washington, District of Columbia.

Van Sickle J. and R.M. Hughes. 2000. Classification strengths of ecoregions, catchments, and geographic clusters for aquatic vertebrates in Oregon. Journal of the North American Benthological Society 19:370-384.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Voelz, N.J. and J.V. McArthur. 2000. An exploration of factors influencing lotic insect species richness. Biodiversity and Conservation 9:1543-1570.

Ward, R.C., J.C. Loftis and G.B. McBride. 1986. Forum: The "Data-rich but information-poor" syndrome in water quality monitoring. Environmental Management 10(3):291-297.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co. Philadelphia, Pennsylvannia.

Whitfield, P.H. 1988. Goals and data collection designs for water quality monitoring. Water Resources Bulletin 24(4):775-780.

Wiens, J.A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501-515.

Wilhelm, J.G.O., J.D. Allan, K.J. Wessell, R.W. Merritt and K. W. Cummins. 2005. Habitat assessment of non-wadeable rivers in Michigan. Environmental Management 36:592-609.

Zar, J.H. 1999. Biostatistical Analysis, Fourth Edition. Prentice Hall, New Jersey.

Figures

Figure 1. Map showing settled and asserted lands and areas in the NWT.

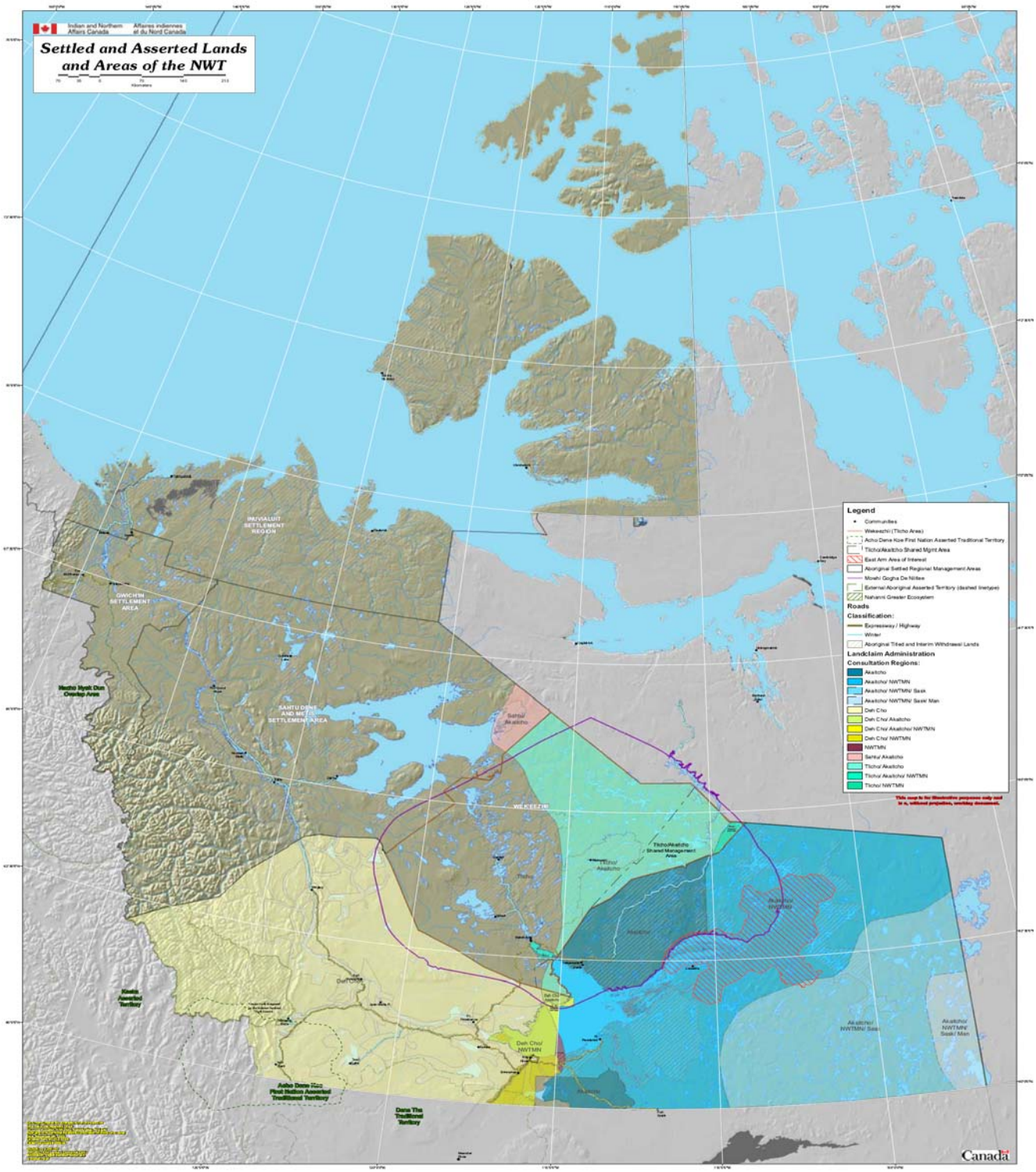


Figure 2. Key steps in the management of water resources in the NWT.

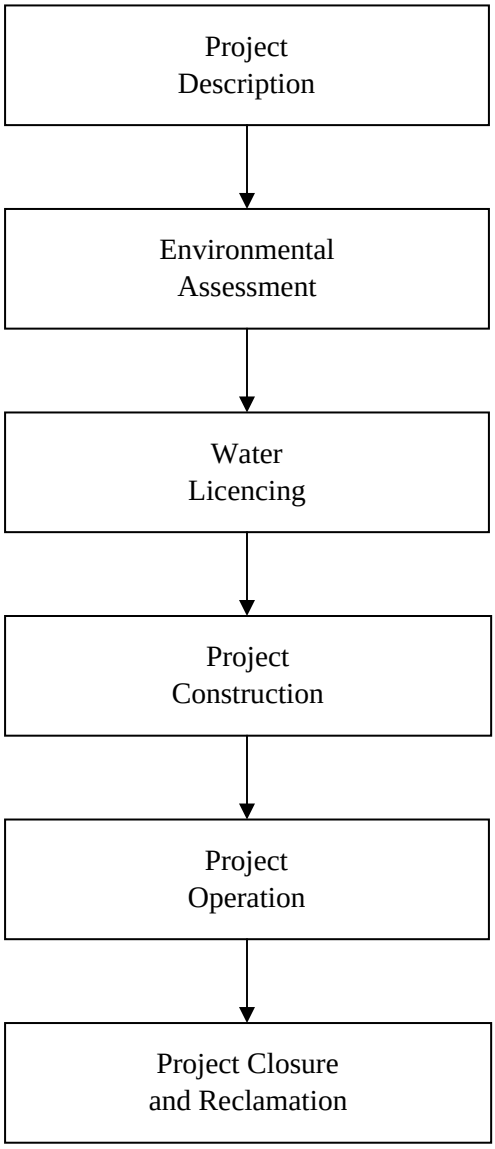


Figure 3. Recommended framework for developing aquatic effects monitoring programs

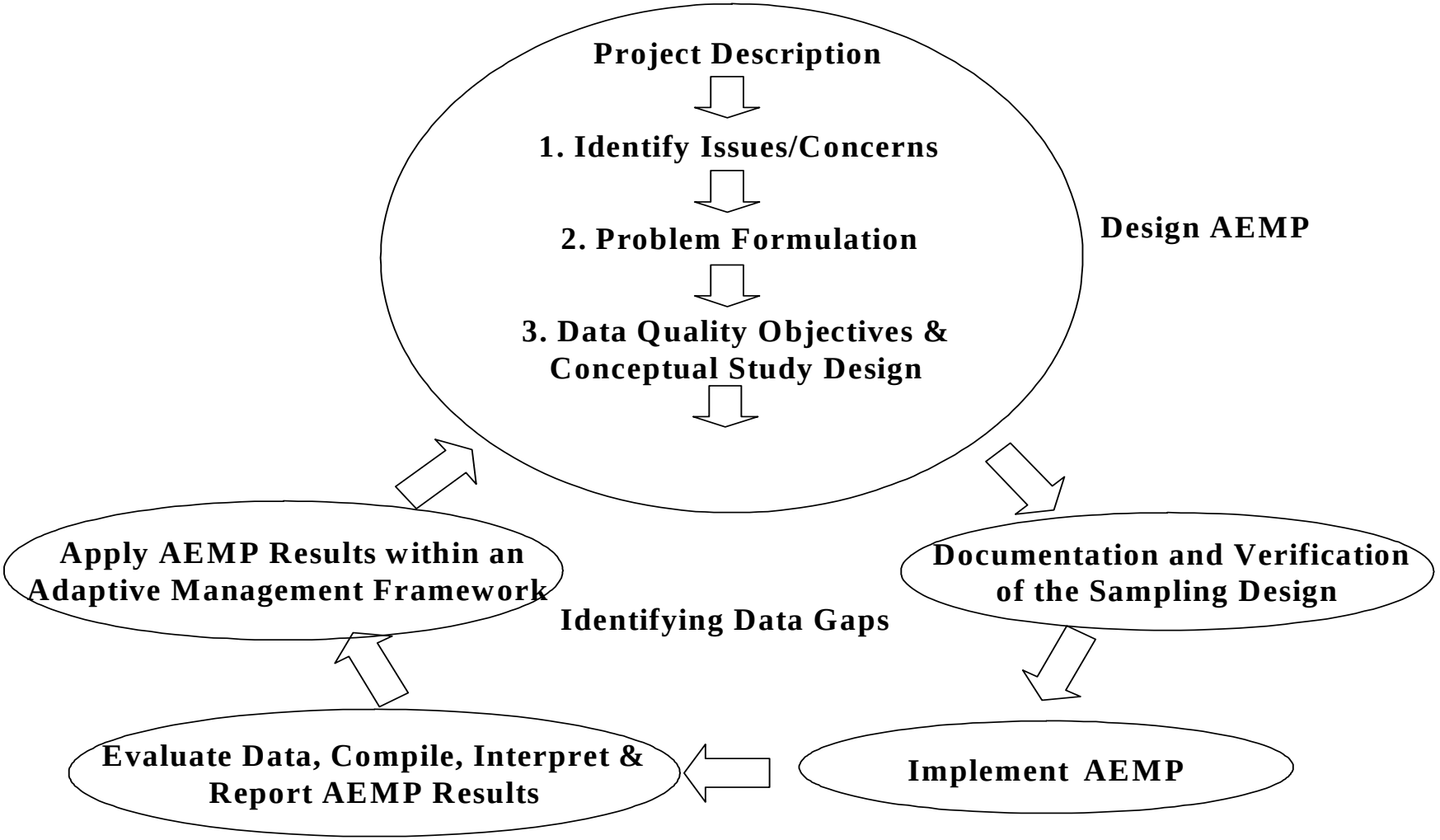
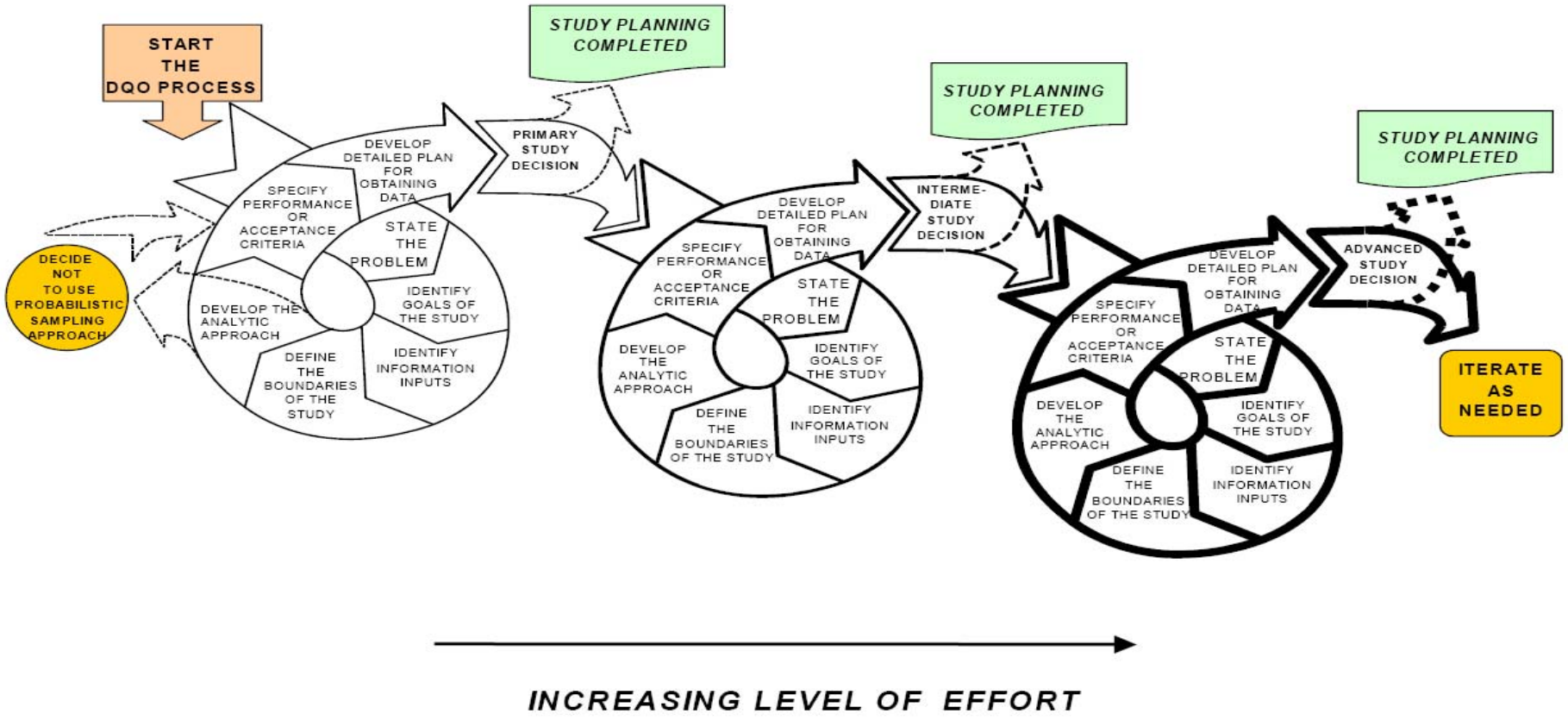


Figure 4. How the data quality objectives process can be iterated sequentially through the project life cycle (USEPA 2006).



Appendix

Appendix 1 Results of a Survey Conducted to Establish Guiding Principles to Guide the Development of Aquatic Effects Monitoring Programs in the NWT

A1.0 Survey Results

Terriplan Consultants (2006) conducted a series of interviews with representatives of selected Aboriginal governments/organizations, regulatory bodies, monitoring agencies, consulting firms, and industry to support determination of expectations and best practices related to baseline monitoring, limnological assessment, and aquatic effects monitoring. As part of this survey, respondents were asked to identify a series of principles that could be used to guide the development of AEMPs. In response to that request, the interviewees provided the following input (as reported in Terriplan Consultants 2006):

- AEMPs must be scientifically defensible and rigorous;
- The AEMP development process must be clear, transparent, realistic and enforceable;
- AEMP Guidelines should be fair and consistent to allow for sustainable development;
- AEMPs must be designed to detecting changes in the aquatic environment early in the project development process (i.e., provide an early warning of aquatic effects) so that proponents can respond to these aquatic effects in a timely manner (e.g. within an adaptive management framework);
- Baseline data should be collected in a manner that facilitates comparison with data collected during project construction and operation (locations, timing, frequency of sampling, determination of limits, etc.);
- An integrated and cost-effective approach to aquatic effects monitoring should be used in AEMPs;
- AEMPs should be designed to detect project-related effects with a specified level of confidence;
- AEMPs should contribute to broader cumulative effects assessment initiatives and enhance the understanding of stressors and variability that occur at a regional scale;

- AEMPs should be integrated within an adaptive management framework that maximizes the potential for early detection of effects and implementation of specific mitigation measures;
- A consistent approach to monitoring and the sharing of information should be used in the design and implementation of AEMPs;
- Clear objectives for AEMPs must be established early in the design process and the AEMP must be designed to support these objectives (i.e., an objective-driven approach should be used);
- AEMP Guidelines must be flexible and adaptable, so they can be applied to different projects in the north and to changing conditions (climate change, operational changes). Such flexibility is required to enable proponents to adjust management and mitigation to incorporate learning/ new information, and to incorporate unexpected results into management and mitigation plans;
- The Precautionary Principle should be applied in the AEMP development and implementation process (i.e., err on the side of caution because there are so many unknowns with respect to large-scale development in the north);
- Monitoring plans should be scaled to the size of the development;
- AEMPs should focus on common ecosystem components (benthos and algae), with a decreased focus on destructive parameters (e.g. lethal fish sampling) and how to interpret them;
- Traditional Knowledge and contemporary scientific knowledge should be equally considered in the AEMP development process;
- While providing consistency and standardized approach, the AEMP Guidelines should reflect project-specific and sector-specific differences. That is, the AEMP Guidelines should recognize that different projects occur in different environmental settings, and that the effects of, for example, a pipeline will be different from those of a diamond mine;
- Project proponents should focus on timely, clear and accurate communication of the results of AEMPs to all interested parties and the broader scientific community;
- Project proponents should be held accountable for properly developing and implementing AEMPs;
- Environmental protection should be identified as the primary goal of AEMPs and associated adaptive management initiatives;
- AEMPs should effectively identify the primary receptors in aquatic ecosystems (e.g., fish and water quality) provide the data and information needed to protect these resources;

- The monitoring and assessment required under the AEMPs must be conducted by the project proponents;
- The results of AEMPs must be communicated in such a manner that they are readily understood by communities, regulators and scientists;
- Monitoring requirements should be directly linked to the Environmental Assessment (EA). More specifically, the EA results should focus monitoring programs by determining what is important to monitor. In addition, some of the tools used for the EA can be carried over to monitoring programs (e.g. predictive models used for EAs can be added to, updated and refined during monitoring programs). This will improve understanding and forecasting and allow proponents to react to what was predicted;
- AEMPs must be designed to support the different types of monitoring that are needed to evaluate project-related effects, including: compliance monitoring (water licence, Environmental Agreements); operational monitoring (surveillance network programs); and regional cumulative effects monitoring;
- AEMPs must be designed to provide the data and information needed to evaluate: 1) The status of the aquatic environment (i.e. monitoring to evaluate the conditions in the receiving environment; i.e., do they meet the licence requirements, do they agree with the EA predictions, are water quality guidelines exceeded); 2) Trends in the characteristics of the aquatic environment (i.e., spatial and temporal trends; i.e., to determine if conditions changing over time or space); 3) The effects of project-related activities on the aquatic environment (i.e., there may be temporal trends, but they may not result in 'effects');
- The measures and indicators that are selected for inclusion in AEMPs must have clear purposes (i.e., monitoring programs must have a purpose and not be monitoring for the sake of monitoring);
- Clear criteria must be established for selecting indicators;
- Action Levels and the actions that will be taken if they are exceeded must be defined early in the AEMP development process;
- Difference between effects monitoring and research must be made clear (i.e., companies should focus on effects monitoring and if research is a requirement, it must be clear how this will add value to an AEMP);
- Limitations on the existing knowledge about arctic ecosystems should not stand in the way of decision making;
- AEMP programs should meet principles of smart regulation;
- Where AEMPs bump up against the limitations of scientific knowledge and Traditional Knowledge, decisions regarding the AEMP must be reasonable;

- Once a monitoring program is established, few changes should be made to the program as it must stand the test of time. Changes diminish the value of a program by making it impossible to compare results from one sampling time to another;
- Be clear about the difference between 'monitoring for no changes' and 'monitoring for changes' where change is predicted. Sampling and interpretation of data may be different. In general, standard sampling methods are designed to monitor to detect for no change and may not be useful for monitoring for change where change is predicted;
- Clarity of roles and responsibilities of interested parties: 1) It is the responsibility of the proponent to operate within the terms and conditions of water licences/permits and to manage environmental impacts of the project; 2) It is the responsibility and role of the intervener to participate in the approval process and stick by their decisions; and,
- Evaluation of projects that will significantly impact aquatic environments must combine monitoring and research components in a defensible and flexible (adaptive) manner, over time frames sufficient to meet management and scientific needs. A combination of short- and long-term evaluations is required.