The Need to Monitor and Report Ecosystem Service Change for the Keeyask Generation Station

Provided to the Clean Environment Commission
for the Keeyask Generation Project Proceedings

Prepared For:

MANITOBA WILDLANDS

Prepared By:

Submitted:

November 24, 2013

EXECUTIVE SUMMARY AND ORGANIZATION OF REPORT

This document defines the need to inventory ecosystem services and apply ecosystem and economic frameworks to decisions about the Environmental Impact Statement (EIS) for the proposed Keeyask Generation Project. Ecosystem services are increasingly being used to integrate estimations of biodiversity and ecosystem degradation into decision-making. The primary objective of this research was to provide information to the Clean Environment Commission regarding the projected effects to water quality and biodiversity. The purpose of this report is to:

- Describe ecosystem services;
- Establish public interest based on ecology, human health and statutory basis for incorporating ecosystem services monitoring and reporting frameworks into development decisions in Manitoba, with particular regard to water quality and biodiversity within the Keeyask Generation Project;

To this end, Coldstream Ecology has reviewed the EIS Guidelines and proposed Environmental Monitoring Programs to provide recommendations for including ecosystem service valuation in completing the Environmental Impact Statement of the Keeyask Generation Project. Key findings include:

- The current EIS approach does not incorporate ecosystem goods and services;
- Baseline information for ecosystem services related to water quality and biodiversity is not presented;
- No valuation of ecosystem services was conducted; and
- No comparison of trade-offs for ecosystem services loss or replacement has occurred for mitigation purposes; or it was not reported as such.

Based on the key findings, we recommend that the Environmental Impact Statement should have included:

- Identification and definition of the ecosystem services relevant to Keeyask Generation Project;
- Inventory of ecosystem services using accepted metrics and standards to establish a baseline of information;
- Application of valuation methods for biodiversity and ecosystem services;
- Long-term adaptive monitoring and reporting frameworks based on ecosystem services and the changes to ecosystem service flows observed over time and space;
- Assessment of ecosystem service loss and changes to ecosystem services; and

- Integration of information on ecosystem services into adaptive management, monitoring, construction, operation and development decisions for Keeyask Generation Project and other proposed projects in this northern Manitoba multi project area.

The EIS guidelines do not directly require ecosystem services or ecological economic assessments. However, the overarching principles of identifying valued ecosystem components (VEC's) and the protection of the socio-economic environment can only be achieved through the use of metrics for ecosystem services and ecological economics.

We hope that the information contained in this report and presentation will assist the Clean Environment Commission in the review of the Keeyask Generation Project EIS and the decisions which will affect the local and regional environment. It is also hoped that this may stimulate further discussion on the integration of ecosystem services into the ESA process for hydropower and other resource development projects in Manitoba and other northern watersheds, including the regulations, in an effort to protect biodiversity, ecosystems and the services that all of life depend on.

CHAPTER 1: INTRODUCTION – ECOSYSTEM SERVICES DEFINED

This report assumes that the reader has no prior experience with the principles of ecosystem services or ecological economics. The report first introduces the concept of ecosystem services based on scientific literature and industry documents. Examples of the adoption of ecosystem service assessments are presented and the rationale for including ecosystem services valuation in environmental site assessments is established.

CHAPTER 2: RELEVANT WATER STANDARDS, GUIDELINES AND REGULATIONS

The Government of Manitoba, Government of Canada, and the United Nations have all published water policies that are relevant to the application of ecosystem services inventory and valuation. These policies are presented to demonstrate their compatibility to ecosystem service valuation.

CHAPTER 3: ECOSYSTEM SERVICES RELEVANT TO KEEYASK GENERATION PROJECT

The ecosystem services directly affected by the proposed Keeyask Generation Project are identified first to inform the CEC about the EIS Guidelines and Environmental Monitoring Programs in the following chapters.

CHAPTER 4: ENVIRONMENTAL IMPACT STATEMENT REVIEW

A review of several Keeyask Generation Project EIS documents was conducted to determine the degree to which ecosystem services was considered in the completion of the EIS with regard to water-quality and biodiversity. Documents in the review included:

- Response to EIS Guidelines

- Environmental Monitoring Programs
    - Aquatic Effects Monitoring Plan
    - Terrestrial Effects Monitoring Plan
    - Physical Effects Monitoring Plan
- Cumulative Effects Assessment Summary

Coldstream Ecology also submitted information requests (IR's) to clarify questions and supplement the review. Through the IR process, it was determined that ecosystem services and the economic value of the affected ecosystems were not considered in the EIS.

CHAPTER 5: ENVIRONMENTAL MONITORING PROGRAMS REVIEW

The proposed environmental monitoring programs were reviewed to determine the degree to which they may inform ecosystem service assessments in the future. Despite being based around the concept of "valued ecosystem components" (VEC's), the proposed monitoring programs are not designed to assess or maintain ecosystem services or changes to services, or to estimate economic losses or changes to service value over time.

CHAPTER 6: METRICS FOR ADAPTIVE MONITORING BASED ON ECOSYSTEM SERVICES

The practical application of ecosystem service valuation is presented based on existing accepted protocols and tools. The methodologies presented are not without inherent limitations and uncertainties, so the effective communication and presentation of ecosystem services inventory, assessment and valuation is also discussed.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

The findings of our reviews on the proposed Keeyask Generation project materials are presented as well as recommendations for incorporation of ecosystem services assessments and implementation of ecological economics in this and future environmental impact statements. The recommendations are intended to be constructive and guide ecosystem service inventory, assessment and valuation for hydro projects in this region and would contribute significantly to improvement of environmental effects assessments in Manitoba.

TABLE OF CONTENTS

EXECUTIVE SUMMARY AND ORGANIZATION OF REPORT ii

Chapter 1: Introduction – Ecosystem Services Defined iii
Chapter 2: Relevant Water Standards, Guidelines and Regulations iii
Chapter 3: Ecosystem services relevant to Keeyask Generation Project iii
Chapter 4: Environmental Impact STatement Review iii
Chapter 5: Environmental Monitoring Programs Review iv
Chapter 6: Metrics for adaptive monitoring based on ecosystem services iv
Chapter 7: Conclusions and Recommendations iv

Table of Contents v

List of Tables and Figures vii

Acronyms viii

Chapter 1: INTRODUCTION – ECOSYSTEM SERVICES DEFINED 1

1.1 What are Ecosystem Services? 1
1.1.1 Goods and Services 1
1.1.2 Linking Ecosystem Services, Biodiversity and Water Quality 1
1.1.3 Human well-being 3
1.2 Global Acceptance 3
1.2.1 Local and Global Call to Monitor and Report Ecosystem Service Change 4
1.3 Why monitor and report on ecosystem services in Environmental Effects Assessments? 5
1.3.1 Global ecosystem integrity and health is declining 5
1.3.2 Current Mitigation, Restoration and Rehabilitation Practices are Not Effective and are Costly 6

Chapter 2: Water RELEVANT STANDARDS, GUIDELINES, AND REGULATIONS 7

2.1 Clean Water is a human right 7
2.1.1 United Nations / World Health Organizations Resolutions 7
2.1.2 The Future We Want: Our Common Vision 7
2.2 Selected National and Provincial Policy, Regulations and Guidelines 8
2.2.1 The CCME Vision: Setting Strategic Directions for Water 8
2.2.2 The Council of the Federation: Water Charter 2010 9
2.2.3 Province of Manitoba – Water Protection Act 9
2.2.4 Manitoba Water Strategy and policies 10

2.2.5 Keeyask Generation Project- Ecosystem-based Management 11
2.3 recommended sustainability assessment criteria and frameworks 11
Chapter 3: ECOSYSTEM SERVICES RELEVANT TO KEEYASK GENERATION PROJECT 13
3.1 Production or Provisioning Services 13
3.2 Regulating Services 13
3.3 Cultural Services 13
3.4 Supporting Services 14
Chapter 4: ENVIROMENTAL IMPACT STATEMENT REVIEW 15
4.1 Information Requests Regarding Keeyask Generation Project 15
4.2 Responses to Information Requests 15
4.3 Critique of Responses - Particular Concerns 17
4.3.1 Ecosystem services were not considered 17
4.3.2 VECS do not inherently capture water quality and biodiversity related ecosystem services 17
4.3.3 Cumulative effects to ecosystem services are not Assessed 18
4.3.4 Costs to degrading ecosystem services are not included 18
4.3.5 Climate Change Assessment on ecosystem services is not conducted 19
Chapter 5: ENVIRONMENTAL MONITORING PROGRAMS REVIEW 20
5.1 Monitoring to Inform Management Decisions and Policy Actions 20
5.2 Monitoring Approach within Keeyask Generation Project 20
5.3 the current EIS process is not facilitating informed decision-making 22
Chapter 6: ADAPTIVE MONITORING BASED ON ECOSYSTEM SERVICES 23
6.1 What to Monitor and How? 23
6.2 Baseline Data 23
6.3 Data to Support ecosytem services monitoring and reporting 23
6.4 Collecting the Right Data? 24
6.5 Local and Global examples of frameworks and metrics 24
6.2.2 Challenges: Uncertainty and complexity 26
6.6 Reporting Monitoring Results 28
Chapter 7: CONCLUSIONS AND RECOMMENDATIONS 29
7.1 Conclusions 29
7.2 Recommendations 29
REFERENCES 31
Appendix A 36

LIST OF TABLES AND FIGURES

Table 1: Examples of Direct Driver 2

Table 2: Examples of Partnership responses to Information Requests regarding the ecosystem services relevant to Keeyask Generation Project 16

Table 3: Potential problems with Keeyask GS Proposed Monitoring Programs 21

Table 4: Examples of Toolboxes, Guides, and Methods for ecosystem services accounting and valuation techniques 25

Figure 1: Examples of ecosytem services generated by the water cycle 27

Table 5: Examples of freshwater aquatic ecosystem services 36

ACRONYMS

AEMP	Aquatic Effects Monitoring Program
AES	Aquatic Ecosystem Services
CCME	Canadian Council of the Ministers of the Environment
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
GS	Generation Station
IISD	International Institute for Sustainable Development
IPBES	Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
LSA	Local Study Area
MEA	Millennium Ecosystem Assessment
NatCap	Natural Capital Project
CNAES	Canadian Network for Aquatic Ecosystem Services
OECD	Organization for Economic Cooperation and Development
PES	Payment for Ecosystem Services
RSA	Regional Study Area
Rio+20	UN Conference on Sustainable Development June 2012
SEAA	System of Environmental Accounting for Water
SEcoRA	Sediment-ecosystem Regional Assessment
SOPC	Stressor of Potential Concern
SPU	Service Providing Unit
TEEB	The Economics of Ecosystems and Biodiversity
TEMP	Terrestrial Ecosystem Services
TCN	The Nature Conservancy
UN	United Nations

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UNSD	United Nations Statistics Division
USAID	United States Agency for International Development
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WCD	World Commission on Dams
WHO	World Health Organization
WRI	World Resources Institute
WWF	World Wide Fund for Nature

CHAPTER 1: INTRODUCTION – ECOSYSTEM SERVICES DEFINED

1.1 WHAT ARE ECOSYSTEM SERVICES?

Environmental management can be improved by the consideration of environmental systems in a holistic way, and human beings are increasingly being considered a part of the system. Both humans and non-humans alike depend on the complex interactions of the abiotic (i.e., environment) and biotic (i.e., species) components of intact ecosystems, which contribute to, and provide life support for the social and ecological functions of ecosystems that we depend on. Ecosystem functions encompass "the habitat, biological, or systems properties or processes of ecosystems," (Costanza et al 1997). A functioning ecosystem delivers specific services in perpetuity that sustain and improve human and non-human life (Brummett et al 2012). Thus, the foundation of human well-being is reliant on the contributions of functioning ecological systems. These contributions are called ecosystem services (Munns et al 2002).

1.1.1 GOODS AND SERVICES

Ecosystem Services have been defined as the market and non-market benefits individuals, households, communities and economies receive from ecosystems. They are delivered to society as goods (e.g., clean water, food, shelter, electricity) and services (e.g. purifying drinking water, waste decomposition, flood regulation, climate regulation, recreation) and both humans and non-humans rely on them for survival. From here forward in this report, they are referred to as ecosystem services.

The most basic example of a vital service is a daily supply of clean fresh water. Simply put, terrestrial and freshwater systems provide the services of gathering, purifying, providing, and delivering the good, which is water. Another simple example is the production of food, which is completely reliant on the services that both aquatic ecosystems (e.g., water-related services) and terrestrial ecosystems provide (e.g. the production of necessary browse material to support moose populations). The local and regional terrestrial and aquatic ecosystem services in the Keeyask Generation Station contribute to the provision of food for local people, which is accessed via hunting and fishing.

1.1.2 LINKING ECOSYSTEM SERVICES, BIODIVERSITY AND WATER QUALITY

Ecosystem services and biodiversity are inherently connected. Biodiversity plays an important role in the creation, support and maintenance of all ecosystem services (Kandziora et al 2012). In turn, land and water ecosystem services also conserve biodiversity. A reduction in ecosystem function, and consequently services, has been directly linked with a decrease in the diversity of species, or biodiversity. Biodiversity and water quality, while not ecosystem services in themselves, are directly related to both aquatic and terrestrial ecosystem services. They are viability and health indicators of the result of ecological services that supply water, and filter and absorb pollutants, (Lautenback et al 2012) and buffer coastal communities from extreme weather events, for example. As the climate continues to rapidly change, the maintenance of biodiversity and ecosystem services will play an important role in ecosystems' ability to adapt to change and remain resilient, while continuing to provide essential

services. Table 1 below depicts how drivers of ecosystem change impact ecosystems and the consequent risk to biodiversity and ecosystem services. Generation Station construction, dike and levee construction, reservoir creation, water diversions, draining of wetlands, land use change, and emission of climate altering air pollutants are examples of drivers that relate to Keeyask Generation Project and this review. Benefits derived specifically from freshwater ecosystems are also dependent on certain services that local and regional terrestrial ecosystems provide. (Brauman et. al 2007) Table 5 in Appendix A, describes aquatic ecosystem services relevant to the Keeyask Generation Project.

TABLE 1: EXAMPLES OF DIRECT DRIVERS (ADAPTED FROM MILLENNIUM ECOSYSTEM ASSESSMENT PROGRAM 2005)

Human Activity (Direct Driver)	**Impact on Ecosystems**	**Examples of Services at Risk**
Dam, Generation Station construction	alters timing, level and quantity of river flows. May create reservoir, Water temperature, nutrient and sediment transport, delta replenishment, blocks fish migrations, fragmentation by roads	provision of habitat for native species, subsistence and commercial fisheries, maintenance of deltas or large water bodies and their economies, productivity of estuarine fisheries, supporting services of lake or river if reservoir is created
Dike and levee construction	destroys hydrologic connection between river and lake habitat, maintains reservoir, GHG emissions, fragmentation by roads	habitat, subsistence and commercial fisheries, natural riverine and lake fertility, natural flood control, diminishes flushing flows
Diversions	changes river and stream flow, changes river stem into reservoirs, inundation, disturbs water system shores and river beds, releases GHGs	habitat, subsistence and commercial fisheries, recreation, pollution dilution, flushing flows, water quality, water supply, hydropower, transportation
Draining or flooding of wetlands	eliminates key component of aquatic ecosystem	natural flood control, habitat for fish and waterfowl, recreation, natural water purification
Deforestation/land use	alters runoff patterns, inhibits natural recharge, fills water bodies with silt, debris and sediment	Water supply quality and quantity, fish, birds, and wildlife water habitat, transportation, flood control
Release of polluted water effluents	diminishes water quality	water supply, water quality, habitat, subsistence and commercial fisheries, recreation
Overharvesting	depletes species populations, changes migration patterns, replacement patterns of species, etc.	Subsistence and commercial fisheries, waterfowl, other biotic populations

Introduction of exotic species	eliminates native species, alters production and nutrient cycling, changes natural predator prey cycles	subsistence fisheries,, water quality, fish and wildlife habitat, transportation
Release of metals and acid forming pollutants into the atmosphere water and land	alters chemistry of rivers and lakes	habitat, fisheries, recreation, water quality , affects diet, adds human health risks
Emission of climate altering air pollutants	potential for changes in ice patterns from increase in water temperature and changes in precipitation	water supply, hydropower, transportation, fish and wildlife habitat, pollution dilution, recreation, fisheries, flood control

1.1.3 HUMAN WELL-BEING

Ecosystem services contribute to human welfare and their economic value is essential to the global economy (Costanza 1997; Costanza, et al. 1997; Hooper et al. 2005; Millennium Ecosystem Assessment Program 2005). Ecosystem services are vital to climate change adaptation and mitigation and have been directly linked to human health and well-being (Myers et al 2013). The collective goods and services that ecosystems and biodiversity supply and maintain ultimately sustain human well-being (UNDP 2012, Myers et al 2013).

The ongoing loss of biodiversity and consequent reduction in ecosystem services has global human health implications. For example, potential sources of pharmaceuticals (which are used to study disease), and the wild relatives of important food crops that the majority of global population depends on are being lost as ecosystem services are degraded. Consequently, biodiversity loss has been linked to infectious diseases, human dietary health, and nutrition (Myers et al 2013).

1.2 GLOBAL ACCEPTANCE

The contributions of biodiversity and ecosystem services to humans and society are increasingly being recognized as paramount (Munns et al 2002, Daily et al 1997, Constanza et al 1997, Millennium Ecosystem Assessment Program 2005). In 2005, 1,360 experts from ninety five countries contributed to The Millennium Ecosystem Assessment (MEA) which evaluated the state of the world's ecosystems. In this consensus document, the authors concluded "any progress achieved in addressing the Millennium Development Goals of poverty and hunger eradication, improved health, and environmental sustainability is unlikely to be sustained if most of the ecosystem services on which humanity relies continue to be degraded," (Millennium Ecosystem Assessment [MEA] Program 2005). Concurrently, the Director General of the World Health Organization (WHO) stated that "Nature's Goods and Services are the ultimate foundations of life and health," (MEA and World Health Organization 2005). Follow up projects such as The Economics of Ecosystems and Biodiversity (TEEB 2010) and the TEEB for Business Coalition have raised awareness of ecosystem services, garnered global acceptance and have produced toolboxes and guides to immediately begin gathering information and reporting on ecosystem services to inform decision-making.

1.2.1 LOCAL AND GLOBAL CALL TO MONITOR AND REPORT ECOSYSTEM SERVICE CHANGE

The leading body of international research on ecological monitoring points to a critical need to gather data regarding ecosystem services that will inform environmental decisions at various spatial and temporal scales. Environmental management that is inclusive of ecosystem services will benefit humans and other organisms more than traditional reductionist approaches which tend to isolate the system, or project, from the larger environment (Munns et al 2002). This is especially important in assessing environmental impacts in a rapidly changing climate. Using adaptive monitoring, evaluating the changes to aquatic and terrestrial ecosystem services is the most socially and technically acceptable method to conduct environmental risk evaluations (Van Hecken and Bastiaensen, 2010; Chapman 2012).

Indeed, a paradigm shift in fish conservation and the management of biodiversity and freshwater aquatic ecosystems is underway combing traditional fisheries management with the concept of ecosystem services (Cowx and Portocarrero Aya 2011). Specifically, the following list provides examples (and is not intended to be comprehensive) of supranational institutions, national and international institutions and global think tanks which all strongly recommend the immediate and sustained monitoring of ecosystem services for biodiversity health and water quality:

- United Nations General Assembly
- United Nations Humans Rights Council
- United Nations Environment Program World Conservation Monitoring Center (UNEP-WCMC)
- United Nations Development Program (UNDP)
- World Health Organization (WHO)
- International Institute for Sustainable Development (IISD)
- World Resources Institute (WRI)
- The GLOBE International Commission on Land Use Change and Ecosystems
- International Union for Conservation of Nature (IUCN)
- World Business Council for Sustainable Development
- World Wildlife Fund (WWF)
- The Nature Conservancy (TNC)
- Environment Canada
- Canadian council of the Ministers of the Environment (CCME)
- NSERC Canada
- Ducks Unlimited Canada
- US Environmental Protection Agency (USEPA)
- US Department of Agriculture (USDA)
- US Agency for International Development (USAID)
- The Center for Sustainable Water Management in the U.K.

1.3 WHY MONITOR AND REPORT ON ECOSYSTEM SERVICES IN ENVIRONMENTAL EFFECTS ASSESSMENTS?

1.3.1 GLOBAL ECOSYSTEM INTEGRITY AND HEALTH IS DECLINING

Current standards of practice for development projects and mitigation are not improving or reducing the global decline in biodiversity, ecosystem integrity and health. Consequently, the benefits, including human health benefits, which society depends upon in the form of ecosystem goods and services, are also declining. This is more pronounced with regards to freshwater ecosystems. The majority of the world's people lives within 50km of a water source that is impounded, diverted, polluted or running dry and has consequently been classified as impaired (Barlow 2013). Many of the world's aquifers are becoming depleted and watersheds are not necessarily providing water any longer. By 2030, the Organization for Economic Cooperation and Development (OECD) predicts that nearly half of the world's population will be under sever water stress (UNDP 2012). Furthermore, the rate of the degradation of these life supporting services is increasing, rather than slowing down. In addition, climate change will likely exacerbate the rate of degradation, although changes will have both positive and negative effects on different regions.

As of 2005, two-thirds of all the fresh water flowing into the oceans was obstructed by approximately 800,000 hydropower projects (i.e., more than 45,000 large dams; 750,000 small dams) (Giller 2005, Myers et al 2013). This hydropower demand adds to additional stressors on freshwater and aquatic systems. These stressors (e.g., climate change, changing land use, changing nutrient cycles, and changing demands on water resources) will continue to increase and are often associated with environmental costs (eutrophication, loss of drinking water source, the possible spread of toxic algae, loss of habitat, water abstraction, etc.) Some of these stressors are recognized in the Response to EIS Guidelines for the Keeyask Generation Project RSA and LSA (i.e., loss of Gull Rapids; an increase in sediment load; a decrease in water flow, etc.). The most likely outcome of debates regarding multiple uses and values of aquatic ecosystems in the 21st century is not the conservation of species and freshwater ecosystems, but rather the degradation of functional freshwater ecology, fisheries, in addition to local disenfranchisement (Brummet et al 2012). This degradation is happening in part, because it is rare that the goods and services that ecosystems provide have been accounted for or fully valued in today's economic paradigm and decision making frameworks (Maberly and Elliot 2011, Healthwaite 2010, TEEB 2010).

Many of the benefits that ecosystems provide are typically overlooked because they are not currently captured as part of the market economy, and rarely accounted for in day to day decisions by businesses and citizens. However, water storage projects influence the environment in both positive and negative ways, and these influences have associated monetary costs as well as benefits (Hearnshaw et al 2010). Therefore it is be important for governments and citizens to incorporate the value of the services, and the affiliated costs of affecting the flow of ecosystem services in decision-making. Ecosystem services should therefore be valued. This economic value depends on the local and regional individual and social goals and objectives. Valuation may be achieved by surveying the providers that own and/or manage the natural capital in land and water systems, as well as the benefactors of the ecosystem services. The following steps, outlined in TEEB (2010), help assign values to specific services:

- Who benefits and depends on these services?
- Are the services at risk?
- How do policies and development decisions affect the value of existing Natural Capital and supply of ecosystem services?

The result of ecosystem services valuation efforts would facilitate decision making by equating all metrics to an equivalent dollar value. Without the inclusion of the full monetized value of the services ecosystems provide to society, the Millennium Development Goals may be compromised to deliver and sustain the ecosystem services needed globally (Heathwaite 2012). Because Keeyask Generation Station has omitted ecosystem services assessments and ecological valuation techniques, it is also compromising the achievement of these goals.

1.3.2 CURRENT MITIGATION, RESTORATION AND REHABILITATION PRACTICES ARE NOT EFFECTIVE AND ARE COSTLY

Mitigation is the most widely utilized global practice for minimizing adverse environmental effects to ecosystems in hydroelectric development projects. The World Commission on Dams notes (2000) that in the case of fish passage mitigation has failed or only worked sporadically. Additionally, only 20% of the ecosystem impacts were mitigated effectively. The significance, as well as the cumulative effects of the failed mitigation practices is still largely unknown for most of the hydroelectric projects (WCD 2000). Failed mitigation ultimately costs society money. The UNDP recognizes “Methods of accounting for national wealth usually fail to reflect the value of biodiversity and ecosystem services to the economy, and the potential cost of replacing these if they are lost or damaged, for example if a water purification plant needs to be built to replace the services provided by a destroyed wetland,” (2012). Mitigation, rehabilitation costs, and the costs of industrial business are far more than anticipated, and society is increasingly bearing those costs, rather than industry.

In a recent report commissioned by the TEEB for Business Coalition, TruCost (2013) conducted an assessment estimating the total unpriced environmental costs of global region sectors. A region sector is a particular industry in a particular region, e.g., water supply in North America. One hundred direct environmental impacts were condensed into 6 categories of unpriced natural capital consumption: water use, greenhouse gas (GHG) emissions, waste, air pollution, land and water pollution, and land use. Out of the top 20 region-sectors, results indicated that none would be profitable if environmental costs were fully incorporated into the costs of doing business (TruCost 2013). Another study recently released estimated the annual global ecosystem service loss at US $740 billion (UNDP 2012). Current investments in infrastructure and mitigation are capturing only part of the environmental costs to society, and they comprise mostly the short-term costs (Brummett et al 2012). The majority of the costs are displaced, from the time of the project planning, construction, and operation into the future. With development proposals like Keeyask Generation Project, the long–term costs of what often can be permanent management, mitigation and restoration interventions need to be budgeted during project planning. Costs would further need to be included in monitoring and auditing during construction and operation phases for the project.

CHAPTER 2: WATER RELEVANT STANDARDS, GUIDELINES, AND REGULATIONS

Water quality was one of the main topics of Coldstream Ecology's Keeyask EIS review. The Government of Manitoba, Government of Canada, and the United Nations have all published water policies and guidelines which address water quality and that are relevant to the application of ecosystem services inventory, assessment and valuation. These policies are presented to demonstrate their compatibility to ecosystem service valuation.

2.1 CLEAN WATER IS A HUMAN RIGHT

Every day, people depend on clean water for nearly every aspect of their lives. Below is a quote from a recent article in the journal Climate Change that defines this dependency from a First Nation's perspective (Cozzetto et al 2013):

"Water is sacred. This is tradition. In contrast to the non-tribal utilitarian view of water, Native Americans revere water and water is life. It is integral to many Native American practices such as purification and blessing rituals and is used to acknowledge all relations and to establish connection to Mother Earth and Father Sky. Water is a holistic and integrating component connecting continents, humans, animals, and plants through a continuous cycle of liquid, solid, and vapor states. Without water, life would not exist as we know it. Water is the one thing we all need, all of us, all of life. As Native Americans, we honor and respect the tradition of water and must protect it always."

2.1.1 UNITED NATIONS / WORLD HEALTH ORGANIZATIONS RESOLUTIONS

Access to clean water has been recognized as an international, legal entitlement. On July 28, 2010, during the UN General Assembly, one hundred and twenty two countries, including China, Russia, Germany, France, Spain and Brazil formally recognized the right to water in Resolution 64/292: The Human Right to Water and Sanitation:

"The General Assembly recognizes the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights." – UN General Assembly, 2010

On September 30, 2010, the UN Human Rights Council adopted binding Resolution A/HRC/RES/18/1, again affirming the human rights to water and sanitation. In May 2011, the World Health Organization (WHO) adopted Resolution 64/24: Drinking Water, Sanitation and Health:

"to ensure that national health strategies contribute to the realization of water- and sanitation-related Millennium Development Goals while coming in support to the progressive realization of the human right to water and sanitation" – World Health Organization, 2011

2.1.2 THE FUTURE WE WANT: OUR COMMON VISION

In June of 2012 at Rio+20, the United Nations Conference on Sustainable Development, the official statement of the summit, titled *The Future We Want* included a formal recognition of the human right

to clean drinking water and sanitation:. It also elucidated the UNDP's mandate to maintain biodiversity, ecosystems and the provision of ecosystem services. *Sections 121-124 read:*

> *121. We reaffirm our commitments regarding the human right to safe drinking water and sanitation, to be progressively realized for our populations with full respect for national sovereignty. We also highlight our commitment to the 2005-2015 International Decade for Action "Water for Life."*
>
> *122. We recognize the key role that ecosystems play in maintaining water quantity and quality and support actions within the respective national boundaries to protect and sustainably manage these ecosystems.*
>
> *123. We underline the need to adopt measures to address floods, droughts, and water scarcity, addressing the balance between water supply and demand including where appropriate non-conventional water resources, and to mobilize financial resources and investment in infrastructure for water and sanitation services, in accordance with national priorities.*
>
> *124. We stress the need to adopt measures to significantly reduce water pollution and increase water quality, significantly improve wastewater treatment, and water efficiency and reduce water losses. In order to achieve this end we stress the need for international assistance and cooperation. – UNDP, 2012*

As pointed out in Section 122, ecosystems provide the services which lay the foundation of water quantity and quality, purification, delivery and other support actions. Ecosystems must continue to provide the service of clean water to society, which is now guaranteed as a human right. Consequently, governments must start taking into account the full value that ecosystems provide in services which support and sustain the provision of water.

2.2 SELECTED NATIONAL AND PROVINCIAL POLICY, REGULATIONS AND GUIDELINES

2.2.1 THE CCME VISION: SETTING STRATEGIC DIRECTIONS FOR WATER

The Canadian Council of the Ministers of the Environment (CCME) set strategic directions for water that encompass and prioritize valuation of biodiversity and ecosystem services. Manitoba's government participated in the setting of these strategic goals and arriving at contents in guidance documents etc. It released two reports that specifically recommend monitoring and valuation of ecosystem services to aid in decision-making:

1. CCME Water Valuation Guidance Document (2010); and
2. CCME Selected Tools to Evaluation Monitoring Networks for Climate Change Adaptation (2011)

"The CCME Water Valuation Guidance Document (2010) is a Canada wide reference document designed for water resource decision makers…to help establish how water valuation can assist in addressing water management issues, particularly in relation to conservation actions, infrastructure investment, water quality standard setting, water pricing, water allocation and compensation for use or damage… It is

intended to enable decision-makers to determine: (i) how and when water valuation might be appropriate; (ii) which valuation method(s) should be applied; and (iii) how to interpret water valuation evidence."

The second document, *CCME Selected Tools to Evaluation Monitoring Networks for Climate Change Adaptation* (2011) was developed to help determine if water monitoring networks provide the right data needed to support, plan for and adapt to a changing climate. This document sets priorities for Canadian water monitoring networks for climate change adaptation. The first documented priority is to conduct basic valuation methods for ecosystem services. Furthermore, the CCME determined that basic valuation methods for ecosystem services are flexible, and therefore applicable at all scales, do not require a lot of expertise and require a limited amount of data that is collected and likely freely available. This priority method specifically deals with water monitoring networks and relevant ecosystem services that are related to hydrologic systems.

2.2.2 THE COUNCIL OF THE FEDERATION: WATER CHARTER 2010.

In 2010, Manitoba became a signatory of The Council of Federation Water Charter. The Council of the Federation is a country wide table for the premiers of all provinces and territories in Canada. The Council identifies critical public policy and planning topics, and determines common values and approaches for the provinces and territories.

Currently the Water Stewardship Council of the Council of the Federation, which is comprised of senior government officials in every province and territory, is guided by the Water Charter, has an initiative focused on the Value of Water. As noted by the Council of the Federation (2013):

"Value of Water: Many Canadians lack understanding about water's contribution to their health, security and prosperity, and its role in supporting critical ecosystems that lay the foundation for their livelihoods and thriving communities. Outreach materials that present a broad picture of water will help raise awareness of the value and importance of water, as well as the associated costs and challenges."

In addition, In the Charter, Manitoba agrees to cooperate and share information on water conservation and water quality by enhancing the water monitoring effort. To meet its goals, projects like Keeyask Generation Project must start measuring, monitoring and reporting ecosystem services (including losses and changes that contribute to and sustain the value of water. Finally, The Government of Manitoba and the Canadian Council of the Ministers of the Environment (CCME) pledge to observe The Council of Federation Water Charter.

2.2.3 PROVINCE OF MANITOBA – WATER PROTECTION ACT

Biodiversity and water-related ecosystem services are directly linked to Manitoba government water laws. The laws suggest high water quality and aquatic ecosystems require protection, and licenses can be denied or suspended to ensure protection and maintenance of aquatic ecosystems. Because the ultimate goal of protecting aquatic ecosystems is to protect the services that biologically diverse aquatic ecosystems provide to society, these laws should apply directly to ecosystem services. Relevant sections from the Water Protection Act (2005) are quoted below:

"Whereas an abundant supply of high quality water is essential to sustain all ecological processes, life-support systems and food production, and is paramount to the environmental, economic and social well-being of Manitoba now and in the future."

Purpose of the Ac t

Section 2

(a) that Manitoba's social and economic well-being is dependent upon the sustained existence of a sufficient supply of high quality water;

(c) that water resources and aquatic ecosystems require protection to ensure the high quality of drinking water sources;

(d) the importance of applying scientific information in decision-making processes about water, including the establishment of standards, objectives and guidelines;

Protecting and Maintaining Aquatic Ecosystems – Section 9

9.1 (2) The minister may refuse to issue a license if…the action authorized by the license would negatively affect an aquatic ecosystem

9.2 The minister may suspend or restrict the rights under a license for a specified period if

(a) in the minister's opinion, (i) a groundwater lever,(ii) a water body level, or(iii) an in-stream flow, Is insufficient to ensure that aquatic ecosystems are protected and maintained; and

(b) the minister's opinion is based on scientific information about protecting and maintaining an aquatic ecosystem of the type under consideration.

2.2.4 MANITOBA WATER STRATEGY AND POLICIES

The Manitoba Water Strategy, which is supported by the Government of Manitoba, is developing a watershed planning framework that is focused on managing water resources at the watershed, basins and aquifer scale. Among other priorities, it establishes that drinking water sources are essential and should be preserved. The Strategy states (2013):

"Watershed management plans must be adequately maintained and enforced to be effective. Watershed plans must also be flexible to develop an integrated approach between provincial, basin, watershed, conservation district, aquifer, planning district, municipal, First Nation and large scale land and water use plans. Obtaining the participation of Manitoba Hydro, the resources sector, agricultural producers, industry and others will also be essential."

The Manitoba Water Strategy supports a watershed planning framework with guidelines that are consistent with 1) the principles of sustainable development; and 2) have conservation as a priority. It

also represents a commitment to use the Manitoba Water Policies as a foundation to build on, and ensure the sustainable development of water resources. The Water Quality Policy aims to "protect and enhance our aquatic ecosystems by ensuring that surface-water and ground water quality is adequate for all designated uses and ecosystem needs."

Under Manitoba Water Quality Standards, Objectives and Guidelines (relevant to Manitoba Water Policy 1.1) the Keeyask Generation Project is in an area that could be dedicated as 'high quality' or 'exceptional value' because it supports populations of rare or endangered flora or fauna (e.g., Lake Sturgeon). Furthermore, it stipulates that water quality should be enhanced through management (Policy 1.2); and policies need to be applied in all phases of water management from planning to decision-making. Keeyask Generation Project will manage water resources in the immediate and regional project area, and consequently has a responsibility to enhance water supply. To apply Manitoba's Water Strategy and Water Policies, information on aquatic ecosystem services needs to be incorporated into adaptive monitoring and management. Within the current EIS and monitoring plans, it is uncertain, and unlikely that Keeyask Generation Project will be consistent, with the purpose and provisions of Manitoba's Water Strategy, Manitoba's Water Policies, and Manitoba's Water Quality Guidelines.

2.2.5 KEEYASK GENERATION PROJECT- ECOSYSTEM-BASED MANAGEMENT

Keeyask Generation Project EIS materials subscribe to an ecosystem-based approach for the Environmental Impact Assessment. Ecosystem-based approaches are increasingly inclusive of ecosystem services. For example, Ecosystem-based Adaptation (EBA) can be defined as a strategy that uses ecosystem services and biodiversity to facilitate adaptation to the adverse effects of climate change (UNDP 2012), i.e. incorporating nature's services into solutions. The review of the Response to EIS Guidelines, the Cumulative Effects Assessment Summary, the proposed environmental monitoring plans and the Partnership Responses to Information Requests illustrate that the Keeyask Generation Project approach does not follow an ecosystem-based, or ecosystem based-adaptation approach according to the definitions used above which include ecosystem services.

2.3 RECOMMENDED SUSTAINABILITY ASSESSMENT CRITERIA AND FRAMEWORKS

Conducting an EIS inclusive of ecosystem services is consistent with sustainability assessment recommendations. Expert witness Dr. Robert B. Gibson. (called by the Consumer's Association of Canada (CAC- Manitoba Branch) recommend a proposed set of evaluation and decision criteria for the Keeyask Generation Project (Gaudrea and Gibson 2013). These sustainability assessment criteria are consistent with current standards and guidelines and should be utilized to inform decisions regarding the Keeyask EIS. The top Goal and Theme of the proposed framework identified ecological services and regulation as a priority for evaluation and decision criteria:

"Topic: Improving the ecological basis of our livelihoods and wealth

- *Goal - Build human-ecological relations to establish and maintain the long-term integrity of socio-biophysical systems and protect the irreplaceable life support functions upon which human as well as ecological well-being depends.*

- *Themes*
    - *Maintenance of ecological services and regulation*
    - *Improvement of habitats and habitat intactness*
    - *The ecological basis of traditional livelihoods*
    - *Climate change mitigation*
    - *Appropriate immediate and long-term adaptive planning*
    - *Management of adverse effects"*

CHAPTER 3: ECOSYSTEM SERVICES RELEVANT TO KEEYASK GENERATION PROJECT

Ecosystem services are broad, many and varied. They comprise the benefits that household's communities and economies receive from nature and they support and maintain humans and non-humans alike. The Millennium Ecosystem Assessment (MEA) separates them into four categories: provisioning services, regulating services, supporting services, and cultural services (Millennium Ecosystem Assessment Program 2005).

3.1 PRODUCTION OR PROVISIONING SERVICES

Ecosystems produce or provide many goods to society as food, extractable renewable raw materials, freshwater, biological resources that aid in supporting human health, and non-renewable raw materials. Examples (of which are not intended to be comprehensive) of goods and services included in this category are as follows:

- Food: fish, grains, wild game, fruit, vegetables;
- Renewable raw materials: fuel, fiber, fodder;
- Freshwater supply: use and storage for consumption and non-consumption (e.g. power and transport);
- Biological resources: biochemicals that can be developed as pharmaceuticals for medicine or commercial use; and
- Abiotic resources: metals, rock, stone, lime.

3.2 REGULATING SERVICES

Ecosystems processes are naturally regulated, and the services render a habitable environment as the benefit. Services that contribute to natural regulations include:

- Natural air and water filtration;
- Water treatment and regulation;
- Climate regulation;
- Disease regulation;
- Water purification;
- Buffering flood flows;
- Erosion control through water /land interactions;
- Flood control; and
- Flushing flows.

3.3 CULTURAL SERVICES

Cultural services comprise the nonmaterial benefits obtained from ecosystems. They include:

- Cultural heritage; significant sites, historic sites;
- Sense of place;
- Spiritual and religious;
- Aesthetics;
- Recreation and ecotourism;
- Inspirational; and
- Educational.

3.4 SUPPORTING SERVICES

Supporting services provide for the production of all other ecosystem services and enable ecosystems to flourish. Biodiversity facilitates these services in supporting resistance and resilience in surrounding ecosystems. Examples include:

- Biodiversity;
- Soil formation;
- Nutrient cycling;
- Primary Production,

CHAPTER 4: ENVIRONMENTAL IMPACT STATEMENT REVIEW

A review of several Keeyask Generation Project EIS documents was conducted. The primary focus was to determine to what extent ecosystem services were included in the Keeyask Generation Station EIS. with regard to water quality, biodiversity and habitat during construction and operation of the proposed project. Documents in the review included:

- Response to EIS Guidelines
- Environmental Monitoring Programs
    - Aquatic Effects Monitoring Plan
    - Terrestrial Effects Monitoring Plan
    - Physical Effects Monitoring Plan for the proposed Keeyask Generation Project
- Cumulative Effects Assessment Summary

4.1 INFORMATION REQUESTS REGARDING KEEYASK GENERATION PROJECT

Several Information Requests (IRs) were filed through Manitoba Wildlands requesting materials and explanations regarding aspects of biodiversity and water quality. Specifically, questions aimed to gather if and how ecosystem services were used to inform the EIS and how the proponent for the Keeyask Generation Project evaluated the short and long term effects on water-quality and biodiversity related ecosystem services in the RSA and LSA. Information requested consisted of indicators and/or information that could be used to support any type of ecosystem service assessment and monitoring to inform decisions.

Typical inquiries included:

- Which ecosystem services were identified as being relevant to Keeyask Generation Project?
- How were ecosystem services used to form conclusions in the EIS?
- How did the EIS Guidelines prove that Keeyask Generation Project would not have significant adverse environmental impacts on ecosystem services relevant to water quality and biodiversity?
- How were/are/ will ecosystem services be monitored or incorporated into monitoring programs?
- Was a cost-benefit analysis using ecosystem services or environmental valuation conducted or included in the EIS?
- Which data could be used to inform an ecosystem services assessment of the Project, watershed or cumulative effects assessment?

4.2 RESPONSES TO INFORMATION REQUESTS

Information requests were submitted for clarification on the relevance and apparent omission of ecosystem services from the EIS. Responses were then assessed and reviewed. The message in the

responses was consistent: ecosystem services were not considered relevant to the EIS and the regulatory process. A few of the Partnership's direct responses are quoted below in Table 2 for discussion. Finally, critiques and concerns are addressed below.

TABLE 2: EXAMPLES OF PARTNERSHIP RESPONSES TO INFORMATION REQUESTS REGARDING ECOSYSTEM SERVICES RELEVANT TO KEEYASK GENERATION PROJECT

CEC Round 1 MB-Wildlands-0026a	*"As discussed in the AE SV Section 2.3.1, existing water quality conditions were compared to Manitoba Water Quality Standards Objectives and Guidelines and the Canadian Council of Ministers of the Environment guidelines for the protection of aquatic life (PAL) to describe the suitability for aquatic life.* *"For the purposes of the EIS, the effect of water quality on functions [and ecosystem services] such as water regulation, water supply, erosion control and sediment retention and waste treatment was not relevant."*
CEC Round 1, Round 2 CAC-0011	*"The bio-physical and socio-economic VECs that were selected (along with supporting topics) capture the services provided by nature that are of benefit to people. Human benefits (i.e., ecosystem services) are either directly or indirectly represented by the KCNs evaluations or the socio-economic and resource use VECs and supporting topics.* *"For the purposes of the regulatory assessment, cumulative effects to ecosystem services are captured through the overall effects assessment for each VEC."*
CEC Round 2 MB Wildlands-0095	*"As discussed in CEC Rd 1 MB Wildlands-0025, the Partnership has completed its assessment of the potential environmental effects of the project and the development of long-term mitigation and monitoring plans, in accordance with guidelines issued by the regulatory authorities and standard environmental assessment methodology. The assessment guidelines to not require the partnership to specifically provide an ecosystem services assessment…"*
CEC Round 1 MB Wildlands-0031	*"The assessment guidelines do not require the partnership to undertake an economic valuation of natural capital within the project area, nor is this standard environmental assessment practice. Similarly, the Partnership has not completed a Cost-Benefit Analysis or a Cost-Benefits Loss Analysis for the Project. It is possible that information collected through the monitoring programs could inform a valuation of natural capital for the project area; however the programs have not been designed for this purpose. The utility of the information collected through these programs for economic valuation purposes would need to be assessed by those interested in undertaking such an analysis."*

4.3 CRITIQUE OF RESPONSES - PARTICULAR CONCERNS

4.3.1 ECOSYSTEM SERVICES WERE NOT CONSIDERED

The Keeyask Generation Station Response to Information Request for Round 1 and Round 2 demonstrate that ecosystem services, which sustain the biodiversity, ecology, and water quality of the Keeyask Generation Project area, were not specifically considered in the EIS. Valuation of ecosystem services was also stated to be irrelevant to identification and evaluation of significant adverse environmental effects. Without taking into account the value of the services that affected ecosystems generate, and then potential loss or change in those ecosystem services, it is not possible for the proponents to prove that Keeyask Generation Project will not have significant adverse environmental effects on relevant biodiversity and water related ecosystem services.

4.3.2 VECS DO NOT INHERENTLY CAPTURE WATER QUALITY AND BIODIVERSITY RELATED ECOSYSTEM SERVICES

The Keeyask Generation Project VEC and subtopic list includes: Water Quality, several fish species, ecosystem diversity, intactness, wetland function, priority plants, bald eagle, Canada goose, Mallard, Common Nighthawk, Olive-sided flycatcher, Rusty Blackbird, Beaver, Caribou, Moose and several socio-economic indicators.

It should be recognized that VECs should be used as proxies or indicators of services, however with full understanding that they are, in many cases proxies to the true service (Boyd and Banzhaf 2007). For example, water quality is an indicator that results from and is sometimes dependent on ecological services such as water purification and nitrogen retention, for example, but itself is not an ecosystem service (Brauman et. al 2007, Lautenbach 2012). While the current VECs likely do capture some ecosystem services that will be impacted by Keeyask Generation Project, all relevant ecosystem services are not captured in VECs and many services are not represented. For example, pest and disease regulation are not captured, and water purification services may not be fully captured. If, however, these services were captured within the VECs, this should be articulated in the assessment and reporting because the VECs need to be directly and explicitly linked to relevant ecosystem service measurement endpoints, service providing unites, or units of ecosystem account (Schafer 2012; Boyd and Banzhaf 2007).

End points need to be articulated and incorporated into the Keeyask Generation Project environmental assessment. Furthermore, Lautenback et al (2012) recommend mapping water quality regulation ecosystem services, such as nitrogen retention in combination with demand specific indicators such as water demand from communities or industry. Mapping that shows tradeoffs of ecosystem services that regulate water quality, for example, and is important information for decision makers. There is no evidence of assessment of tradeoffs of ecosystem services that affect water quality or biodiversity related ecosystem services (and the VECs) in the Response to EIS Guidelines, the Cumulative Effects Summary document, or recent powerpoint presentations by Keeyask panel members. Consequently, the conclusion that the project will have minimal to no significant effects on VECs, and therefore ecosystem services related to water-quality and biodiversity is not supported. The next section (4.3.3)

also discusses VECs, and focuses on mitigation efforts and the method used to determine that no significant effects will occur to VECs.

4.3.3 CUMULATIVE EFFECTS TO ECOSYSTEM SERVICES ARE NOT ASSESSED

The current Cumulative Effects Assessment (CEA) Summary document on VECs, , which was written in response to an Information Request, does not prove that no cumulative adverse environmental effects occur on water quality and biodiversity related ecosystem services. It is not explained if, and how the VEC indicators comprise end points directly linked to ecosystem services over space and time.

Within the Keeyask Generation Project Cumulative Effects Assessment Summary document, ecosystem services are not mentioned, and therefore not specifically assessed or reported. Additionally, with aquatic ecosystem services relevant to water quality, such as water supply or water purification, the end point, or consumption of the service is often different from the location of where the service is provided or produced (Lautenbach et al 2012, Brauman et al 2007). Consequently, ecosystem services are spatially explicit, and therefore assessments that comprise services should focus on service units that are spatially explicit, and mapped as such (Boyd and Banzhaf 2007). This spatially explicit assessment of services, even if they are inherently present in VECs, is not apparent in the Keeyask Generation Project Cumulative Effects Assessment. For the case of Keeyask Generation Project, what happens downstream of Keeyask Generation Project may benefit or harm upstream users or ecosystems, or vice versa. Therefore water quality related services, for example, tend to be regional in nature and the Response to EIS Guidelines should integrate this regional evaluation of services into the cumulative effects assessment.

Within the Cumulative Effects Assessment Summary, proposed mitigation measures for the VECs Intactness, and Ecosystem Diversity are proposed as “a rehabilitation plan that gives preference to rehabilitating the most affected priority habitat types using approaches that “go with nature” will be developed and implemented.” (Cumulative Effects Assessment Summary, Intactness and Ecosystem Diversity tab, no page number). This approach “Go with Nature” has not been documented as an acceptable method in scientific mitigation literature. Thus, it cannot be assumed that this method will effectively mitigate adverse environmental effects.

In the VEC Wetland Function, the Cumulative Effects Assessment Summary states that “12 ha of wetland marsh will be developed within or near the LSA to offset those lost by the project”. If the services that will be lost by the wetland of particular concern have not been valued or mapped, then it cannot be assumed that the services will be “offset” by a new wetland development (Cumulative Effects Assessment Summary, Wetland Function tab, no page number).

4.3.4 COSTS TO DEGRADING ECOSYSTEM SERVICES ARE NOT INCLUDED

Environmental valuation methods of ecosystem services were not used to inform assessments of services for the Keeyask Generation Station project. A cost-benefit analysis incorporating the value of services provided by ecosystems was also not conducted. In the response to information requests, the costs, which should affect tradeoffs considered in mitigation and no net loss commitments (e.g. important wetlands) were not considered to be relevant to the EIS assessment.

The Manitoba Sustainable Development Act, Schedule B, *Guidelines for Sustainable Development,* requires that resources are used efficiently. It stipulates in Section 1) (b) that projects must "employ full-cost accounting to provide better information to decision-makers." The Act defines full-cost accounting as a "means accounting for the economic, environmental, land use, human health, social and heritage costs and benefits of a particular decision or action to ensure no costs associated with the decision or action, including externalized costs, are left unaccounted for."

4.3.5 CLIMATE CHANGE ASSESSMENT ON ECOSYSTEM SERVICES IS NOT CONDUCTED

Climate changes effects on water-quality and biodiversity related services were not integrated in the cumulative effects assessment or the Response to EIS Guidelines. However, in the recent Manitoba Hydro Climate Change Report (2012) a number of studies are reportedly ongoing to characterize the hydrological and climatic conditions in the Nelson-Churchill watershed. Much of the modelling conducted within these studies is data intensive. While assessments on climatic changes to the flows of ecosystem services over space and time have not been conducted or reported, some past and present historic climate / hydrology analyses on ecosystem services could likely be conducted with the same data. Furthermore, current studies may be relevant to ecosystem services; if this is the case then they should be reported on in a way to facilitate integrated assessments on the effects of climate change on the flows of ecosystem services and the subsequent change in value to society.

CHAPTER 5: ENVIRONMENTAL MONITORING PROGRAMS REVIEW

5.1 MONITORING TO INFORM MANAGEMENT DECISIONS AND POLICY ACTIONS

"The Most effective and productive scientific monitoring is adaptive, and is based on assessment endpoints that comprise ecosystem services, in other words, the benefits of Nature to human beings." Peter Chapman, 2012

The purpose of monitoring is to ensure that the ecosystem services and goods are maintained, and to expose a problem if one occurs in project planning, construction or operation. If and when a problem is identified, then a management intervention can be planned to minimized or mitigate observed environmental effects.

Adaptive monitoring should be based on (Chapman 2012):

1. Value-based monitoring;
2. Stressor of Potential Concern (SOPC) based monitoring (e.g. what is the effect of a stressor on fishery SPU values?); and
3. Effects-based monitoring (e.g. the state of an ecosystem in terms of SPU (Service Providing Unit) values compared to reference or baseline conditions, and if so, what factors prevent it from being normal?

5.2 MONITORING APPROACH WITHIN KEEYASK GENERATION PROJECT

Several extensive long-term monitoring programs are planned that encompass the physical, chemical, human, ecological and economic environments. It is not clear why these monitoring plans have varying start and end dates, and timelines.

- Aquatic Effects Monitoring Program (AEMP);
- Physical Effects Monitoring Program (PEMP);
- Terrestrial Effects Monitoring Program (TEMP);
- Resource Use Monitoring Program (RUMP); and the
- Socio-Economic Monitoring Program (SEMP).

These monitoring programs all use a concept called VECs (Valued Ecological Components) to determine environmental effects to ecosystems, biodiversity and water quality. They aim to collect information, conduct modelling and assess changes to VECs at different spatial and temporal scales. These programs will primarily feed into Annual Data reports, technical and synthesis reports. These data, , if transparent, should also be able to feed into regional and watershed assessments that facilitate cumulative effects assessments.

In the Response to EIS Guidelines, Keeyask Generation Project uses the effects-based monitoring approach. The following questions can be used to guide the management of resources and ecosystems using an effects-based approach (Brauman 2007) that incorporates biodiversity and ecosystem services:

1. How do human activities, or the activities of the proposed Keeyask Generation Project, affect ecosystem service production in the RSA and LSA, and larger upstream and downstream areas?
2. How has ecosystem service changed relative to baseline conditions?
3. How will ecosystem services change with the proposed Keeyask Generation Project?

Using the above questions as guidance for a monitoring program review of Keeyask Generation Project, several potential issues have been identified with the monitoring content that has been used as a basis to form conclusions in the Response to EIS Guidelines. In CEC Round 1MBWildlands-0031, the Partnership states that while the data may be available to support valuation techniques, the programs were not designed with this in mind. Other potential problems are also observed in the proposed monitoring plans. The key finding is that the monitoring programs presently do not mention, assess or report on ecosystem services along with traditional parameters. A brief review of the proposed monitoring programs was conducted, and potential problems are listed in Table 3.

TABLE 3: POTENTIAL PROBLEMS WITH KEEYASK GS PROPOSED MONITORING PROGRAMS

Characteristic Reviewed	Potential Problem
Ecosystem Services	Not included in EIS No ecosystem inventory conducted No baseline or reference conditions No plan to integrate ecosystem services into long-term monitoring Essential flows of ecosystem services not established No changes to ecosystem services established No modelling of project effects on ecosystem services No spatially explicitly models of ecosystem services were
VECs	No VEC discussion in relation to ecosystem services Not explicitly inclusive of ecosystem services Not encompassing of all essential services Assessments and monitoring plans do not recognize that some VECs are proxies for services VECs not directly linked to final ecosystem services, or end points in assessment No physical environment component VECs identified or assessed in cumulative effects
Timeframe	Baseline conditions used already altered environmental state 30 years is stated time-frame in EIS; however current monitoring timeframes are short and inconsistent No long term mitigation or management interventions in proposed program
Integration and Scale-ability	No ability to scale up to a regional, or watershed ecosystem services assessment No ability to integrate ecosystem services into local or regional cumulative effects assessment No stated plans to integrate into regional or other monitoring programs in EIS that assess ecosystem services
Data	Metrics for ecosystem services not included, or not obvious No direct links stipulated from ecosystem function to ecosystem service provision

	No environmental valuation in assessment or planned Not designed for valuation techniques No trade-offs modelled explicitly using ecosystem services
Reporting	No comprehensive reporting on effects to ecosystem services No way to assess effects to human well-being Not readily assessable

5.3 THE CURRENT EIS PROCESS IS NOT FACILITATING INFORMED DECISION-MAKING

Excluding ecosystem services from the Response to EIS Guidelines and monitoring programs demonstrates that the current EIS process is not facilitating informed decision-making. Compliance with regulations, rather than science or ecology, has most often been found to be the driving factor influencing selection of indicators, or VECs. Unfortunately, monitoring simply to comply explicitly with regulatory requirements is demonstrated to not necessarily be useful for informing environmental management decisions (Chapman 2012) and often is not based on ecological principals (Ball et al. 2012). Consequently, case studies increasingly demonstrate that biodiversity, ecosystem functions and the resulting goods and services are not being protected in ecosystems.

Ball et al. (2012) conducted an analysis of 35 Environmental Impact Assessments in the South Saskatchewan River Watershed, reviewing the indicators (including VECs) used in the EIAs. They illustrated that current indicators do not capture the ecosystem services generated in the region. Furthermore, current EIAs do not facilitate scaling up from the project level to a watershed, or cumulative effects assessment. Thus, it cannot be determined that the projects will have no significant adverse environmental effects to the project area or region. Similarly, a study in the United States assessed several case studies in a special issue of Science of the Total Environment. Again, the results of the extensive review revealed the same problem (Schafer, 2012). Current EIA (Environmental Impact Assessment) guidelines do not capture the stress placed on watersheds and rivers (Noble et. al 2011). Upon examination of provincial and federal environmental assessment guidelines and the Response to EIS Guidelines for the Keeyask Generation Project, Manitoba hydro projects have not avoided these risks.

This lack of information ultimately prohibits an informed decision-making process regarding the ecosystem services that society and all life depend upon. Consequently, projects are proceeding without adequately assessing and mitigating for adverse environmental effects to ecosystem services and their corresponding value. These regulatory reviews of EISs and EIAs echo the critical need for immediate monitoring to inform ecosystem services assessment and reporting at the environmental site assessment level for Keeyask Generation Project.

CHAPTER 6: ADAPTIVE MONITORING BASED ON ECOSYSTEM SERVICES

6.1 WHAT TO MONITOR AND HOW?

According to the US EPA Environmental Risk Assessment team (USEPA 1998) and a recent study by Chapman (2012) of Golder Associates, Ltd., several key considerations for monitoring ecosystems and assessing endpoints need to be considered when developing metrics to inform decision-making:

1. Ecological relevance;
2. Susceptibility to the stressor;
3. Have clear management relevance and necessity;
4. Be transparent, technically defensible, and subject to periodic review; and
5. Be integrative (internally and externally, linking with regional or other relevant monitoring programs).

Quantifiable measurements (i.e., measurement endpoints encompassing points 1-5 above), which can be directly linked to ecosystem services, should be the foundation of monitoring programs. Measurement endpoints can then be translated into ecosystem service losses (Munns et al 2009, Chapman 2012). Some services will derive benefit at the expense of the others (Brauman et al 2007) and ecosystem service losses can be used in trade-off analyses. Consequently, monitoring programs should aim to provide data to support evaluating trade-offs that affect the flow of ecosystem services.

6.2 BASELINE DATA

During the Response to EIS Guidelines, as well as the monitoring programs, baseline data is used to inform the effects-based environmental assessments. Baseline information or reference conditions explicitly for ecosystem services for the RSA and LSA was not included in the EIS. A report on the state of the current ecosystem, in relation to essential ecosystem service provision, was omitted from the assessment. Furthermore, references to baseline conditions were made regarding the state of the already impacted water-quality. However it may not be acceptable to assess effects to ecosystem services from an already impaired water source unless the discussion focuses on mitigation and rehabilitation.

6.3 DATA TO SUPPORT ECOSYTEM SERVICES MONITORING AND REPORTING

Ecosystem services have been expressed in many ways since the emergence of the concept three decades ago. If ecosystem services are to be characterized and tracked over time, the measured units must be clearly defined, consistently measured and work with both standard ecology and economic principles (Boyd and Banzhaf 2007). Ecosystem services metrics must comprise end points or final ecosystem services for valuation. In other words, ecosystem functions needs to relate directly to services. Final ecosystem services have been defined as “components of nature, directly enjoyed, consumed, or used to yield human well-being,” (Boyd and Banzhaf 2007). Ecosystem services are also

associated with important place-based quality differences. Thus services should be quantified in a spatially explicit way, for example using GIS mapping tools and integrated databases. Each service should be mapped at a fine resolution (Boyd and Banzhaf 2007) to identify possible trade-offs of specific services. Several units are used to quantify ecosystem services. A serviceshed, a concept proposed by the Natural Capital Project, is a geographic area that provides a specific ecosystem service to a specific beneficiary (Tallis et al. 2012). For example using water-related series, the catchment area upstream of the place where the benefits are realized or accessed is the serviceshed. This concept is particularly useful for identifying who is benefiting from the services, and therefore who is likely to me impacted by development options. Service Providing Units (SPUs) is also another way of expressing ecosystem services (Chapman 2012).

6.4 COLLECTING THE RIGHT DATA?

Metrics used to conduct ecosystem service assessments are complimentary with other data that are collected in long term monitoring programs. In fact, ecosystem service assessments rely on some of the traditional metrics and parameters regularly studied and monitored. Thus Keeyask Generation Project likely has a substantial amount of the required information to being to conduct ecosystem services assessments. However, this information should be accessible. In one of the responses, the Partnership states that it may have these data, however at the time of this review those data were not readily available.

6.5 LOCAL AND GLOBAL EXAMPLES OF FRAMEWORKS AND METRICS

Numerous governments, policy groups and researchers have explored quantification and valuation methods for ecosystem services. Consequently, many frameworks have been developed to quantify ecosystem services to facilitate their use environmental assessments. One example is RIOS, a Natural Capital Project Tool, which is specifically designed to assess tradeoffs for ecosystem services in watershed management (Vogl et al. 2012). RIOS focuses on changes in ecosystem services in relation to project investments while considering multiple objectives. Tools like RIOS should be explored to assist in developing an approach within Keeyask Generation Project with regards to tradeoff analysis of water-quality and biodiversity related services. Table 4 on the following page gives examples of frameworks, guides and metrics that have been used in ecosystem services accounting and valuation techniques.

TABLE 4: EXAMPLES OF TOOLBOXES, GUIDES, AND METHODS FOR ECOSYSTEM SERVICES ACCOUNTING AND VALUATION TECHNIQUES.*

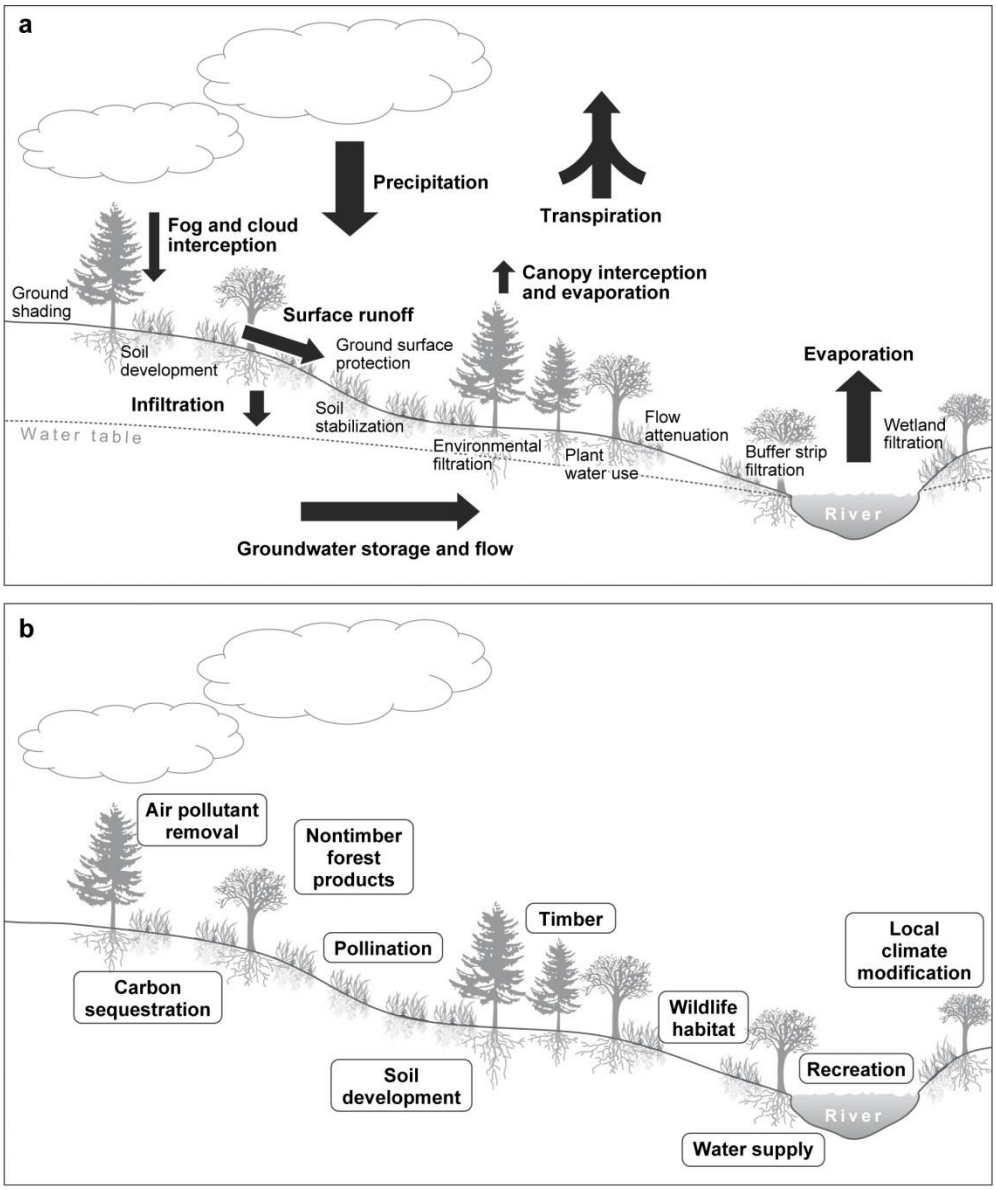
Framework	Tool Description
The Economics of Ecosystems and Biodiversity (TEEB)	"A report on the fundamental concepts and state-of-the-art methodologies for economic valuation of biodiversity and ecosystem services;"
TEEB for Business Coalition: The Economics of Ecosystems and Biodiversity in Business and Enterprise	"Provides important evidence of growing corporate concern about biodiversity loss, and offers examples of how leading companies are taking action to conserve biodiversity and restore ecosystems."
World Business Council for Sustainable Development	Guide to Corporate Ecosystem Valuation
Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES)	"A tool specifically focusing on biodiversity and ecosystem services, by providing assistance to countries in meeting their commitments to the three Rio Conventions and other multilateral environmental agreements. It targets improving the interface between science, policy and implementation…similar platform to the IPCC on Climate Change"
World Bank Wealth Accounting and Valuation of Ecosystem Services (WAVES)	"Seeks to promote sustainable development by ensuring that the national accounts used to measure and plan for economic growth include the value of natural resources. "
SEAA–Water, System of Environmental Accounting for Water. United Nations Statistics Division (UNSD)	Describe use and non-use valuation techniques for water: "An estimate of the total value of water should include all the use and non-use values. Use values refer to the use of water to support human life and economic activity. The values include (a) the direct use of water as a resource, (b) the indirect support provided by water ecosystem services, and (c) the value of maintaining the option to enjoy the direct or indirect use of water in the future (option values). Non-use values include the value of knowing the intrinsic value of water ecosystems (existence value) and that water and water ecosystems will be available to future generations (bequest value)."
NSERC Canadian Network for Aquatic Ecosystem Services (CNAES)	"The funding, from the Natural Sciences and Engineering Research Council … encourages large-scale, multidisciplinary, collaborative research projects that could improve Canada's economy, society and environment within the next decade. The CNAES is a consortium of 27 researchers from 11 universities, Canadian government scientists, industrial partners and environmental and technology associations that conducts research and training in aquatic ecosystems. The project applies the principles of Ecosystem-Based Adaptation—working to protect ecosystems and maintain essential ecosystem services in order to reduce the vulnerability of people to climate change impacts."
Canadian Council of the Ministers of the Environment (CCME)	-Water Valuation Guidance Document (2010); -Selected Tools to Evaluation Monitoring Networks for Climate Change Adaptation (2011)

US EPA Eco Health Relationship 'Browser	-Web based tool that shows the relationship between ecosystem services and human health: http://www.epa.gov/research/healthscience/browser/index.html
Natural Capital Project: InVEST	" InVEST is a free and open-source software suite to inform and improve natural resource management and investment decisions. InVEST quantifies, maps, and values the goods and services from nature that contribute to sustaining and fulfilling human life."
Natural Capital Project: RIOS	"The Natural Capital Project designed RIOS to provide a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities in order to maximize the ecological return on investment, within the bounds of what is socially and politically feasible."
Natural Capital Project: Servisesheds	-The Serviceshed approach presents a method to analyze mitigation potential, from the perspective of people and incorporates natural capital mitigation into infrastructure projects;
SEcoRA- Sediment-ecosystem Regional Assessment	Apitz,(2012) examines the role of sediments and pesticides in aquatic and terrestrial ecosystem services and provide examples of relevant Service Providing Units (SPUs).

**The list provides examples, is not intended to be comprehensive, and the descriptions are quoted from the programs themselves.*

6.2.2 CHALLENGES: UNCERTAINTY AND COMPLEXITY

Water quality and biodiversity related services are the result of inherent, complex, variable biotic and abiotic interactions at multiple spatial and temporal scales. Consequently, knowledge gaps do exist in our understanding of how services are generated and maintained. Figure 1 on the following page illustrates the complex ecosystem interactions of the hydrologic cycle as an example of how different ecosystem structure and functions interact to create ecosystem services that are produced as benefits to society.



Brauman KA, et al. 2007.
Annu. Rev. Environ. Resour. 32:67–98

FIGURE 1: EXAMPLES OF ECOSYTEM SERVICES GENERATED BY THE WATER CYCLE

(a) At the watershed scale, ecosystems affect water through local climate interactions, water use by plants, ground surface modification, and water quality modification, processes that are detailed in the text. Arrows indicate fluxes of water. The hydrologic cycle is driven by energy from the sun. Water vapor evaporated from oceans or surface water bodies forms clouds and falls as rain, fog, or snow onto Earth's land and oceans. On land, water infiltrates into groundwater or flows over the surface. Both ground and surface water eventually discharge into the oceans. Evaporation from surface water and oceans to the atmosphere completes the cycle. (b) In addition to hydrologic services, a watershed produces a variety of other services; examples of these are shown in the figure. (adapted from Brauman et al 2007).

6.6 REPORTING MONITORING RESULTS

Reporting relies on effective scientific adaptive monitoring programs to incorporate the most up to date information into decision-making. Reports should be used as a way to inform decisions and facilitate adaptive management by conveying relevant information to decision –makers, who then take that information and implement management actions and decisions. Keeyask Generation Project monitoring is currently conducted mainly to meet regulations; as stated in the Response to Information Requests (CEC Round 1, MB Wildlands- 0031; CEC Round 2, MB Wildlands-0095). Therefore reporting is submitted based on regulatory criteria. Unfortunately, regulations are often not clearly linked to ecology, and in particular ecosystem functions and services.

Within Keeyask Generation Project, monitoring reports will be produced for each of the identified monitoring programs and submitted to the regulator for review. Currently much of the standardized environmental assessment reporting is in the form of annual data reports, technical reports, and every few years a synthesis assessment and report is planned. According to Preliminary Project Monitoring Plans, the Aquatic Effects Monitoring Program (AEMP), the Terrestrial Effects Monitoring Program (TEMP), and the Physical Effects Monitoring (PEMP) the information will be presented to the regulator in an appropriate manner for the information. Tables, charts, and map will be used to present the monitoring results, depending on the method considered most appropriate for the information. An appropriate manner for the information was not disclosed in the proposed monitoring plans. Ultimately, a State of the Nelson-Churchill Watershed Ecosystems Assessment would be an optimal report. However, when developing reporting protocols, the appropriate manner for the information within Keeyask Generation Project should:

- Explicitly link VECs to relevant ecosystem services;
- Link direct and indirect project effects to relevant ecosystem services;
- Report in a way that facilitates evaluating the relative change in ecosystem service provision over time and space;
- Report on the cumulative effects of ecosystem service change for the Keeyask Generation Project RSA and LSA;
- Reporting in a way that facilitates adaptive management by incorporating monitoring results into actions and decisions;
- Report in a way that facilitates the integration of Keeyask Generation Project data with cumulative watershed assessments.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Based on the above review and assessment, we conclude that it may not be possible for the Clean Environment Commission to assess whether the project will have significant adverse environmental effects on water quality and biodiversity over space and time. This finding is based on the following:

- The Response to EIS Guidelines does not prove that the project will have no significant adverse environmental effects on the ecosystem services relevant to water quality and biodiversity, or other ecosystem services necessary to sustain all of life;
- Baseline information or reference conditions explicitly for ecosystem services for the RSA and LSA was not included in the EIS;
- Tradeoffs and alternatives for minimizing and mitigating effects to ecosystem services were not considered; ecosystem services were not explicitly used in any modeling;
- The current project plans and mitigation efforts will affect current water-quality and biodiversity related ecosystem services, however the Response to EIS Guidelines does not appear to quantify these effects. If they are quantified it is not reported in a way that the information is readily available; therefore it is impossible to determine *how* Keeyask Generation Project will affect changes to ecosystem services or service loss over space and time.

These findings highlight the current limitations of the Response to EIS Guidelines, cumulative effects assessment and proposed monitoring plans to assess essential ecosystem services and their corresponding benefits. They also elucidate restrictions and inherent problems within the current EIS process and regulatory framework. The current process does not protect ecosystems, biodiversity, water quality, or the related goods and services that provide for human well-being, and sustain society, all of life, and ultimately the economy.

7.2 RECOMMENDATIONS

Keeyask Generation Project is part of several infrastructure developments in the Nelson-River watershed. Consequently, it has a unique opportunity to address essential local and regional ecosystem services and the direct link to human well-being. Keeyask Generation Project is also in a position to establish and conduct a cumulative effects assessment of ecosystem services to the Nelson-Churchill Watershed and incorporate monitoring and reporting for ecosystem services into environmental assessments in a holistic, regional framework. While this report falls short of recommending specific ecosystem service indicators for Keeyask Generation Project, it provide examples of metrics and frameworks that can be used as a starting point for incorporating ecosystem services, and consequently sources of human well-being related to nature, into proposed projects. These indicators should be developed at the local level to make sure they are directly relevant to local ecology, people and management decisions.

To begin to take steps in this direction, it is recommended that Manitoba Hydro, the Keeyask Generation Project and related Manitoba resource development projects are required to, in advance of a decision for a license,

1. Conduct an Ecosystem Services Inventory for the RSA and LSA
    a. Identify measurable, quantifiable parameter end points that comprise the relevant ecosystem services.
    b. Establish a baseline of information, or reference conditions regarding ecosystem services and directly and explicitly link to VECs;
2. Assess and predict changes to ecosystem services and service loss within the Response to EIS Guidelines and cumulative effects assessment;
3. Establish the true costs of Keeyask Generation Project by conducting an environmental valuation of ecosystem services;
4. Incorporate ecosystem services into adaptive, long-term monitoring programs by directly liking ecosystem functions to services and service end points;
5. Report on the status of ecosystem services in the Regional Study Area and the Local Study Area in a way that can be integrated into watershed assessments and cumulative effects assessments;
6. Incorporate data from ecosystem services inventory, monitoring and reporting into management and policy decisions with the goal of sustaining the flow of key ecosystem services in the Regional and Local Study Areas.

REFERENCES

Apitz, S. 2012. "Conceptualizing the Role of Sediment in Sustaining Ecosystem Services: Sediment-Ecosystem Regional Assessment (SEcoRA)." *Science of the Total Environment* 415 (0): 9-30.

Ball, M., Noble, B., and Monique Dube. 2013. "Valued Ecosystem Components for Watershed Cumulative Effects: An Analysis of Environmental Impact Assessments in the South Saskatchewan River Watershed, Canada." *Integrated Environmental Assessment and Management* 9 (3): 469-79.

Barlow, M. 2013. "Blue Future - Protecting Water for People and the Planet Forever." : 125-141.

Boyd, J. and Banzhaf S. 2007. What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. *Ecological Economics* 63: 616 -626.

Brauman, K., Daily, G., Duarte, T., and Harold Mooney. 2007. "The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services." *Annual Review of Environment and Resources* 32: 67-98.

Brummett, R., Beveridge, M., and Ian Cowx. 2013. "Functional Aquatic Ecosystems, Inland Fisheries and the Millennium Development Goals." *Fish and Fisheries (Oxford)* 14 (3): 312-324.

Canadian Council of Ministers of the Environment (CCME). 2009. *CCME Setting Strategic Directions for Water*.

———. 2011. *Selected Tools to Evaluate Water Monitoring Networks for Climate Change Adaptation*. Ottawa, Ontario: CCME.

———. 2010. *Water Valuation Guidance Document*. Ottawa, Ontario: CCME.

Chapman, P. 2012. "Adaptive Monitoring Based on Ecosystem Services." *Science of the Total Environment* 415 (0): 56-60.

Cook, B. and Christopher Spray. 2012. "Ecosystem Services and Integrated Water Resource Management: Different Paths to the Same End?" *Journal of Environmental Management* 109: 93-100.

Cooke, S., Lapointe, N., Martins, E., Thiem, J., Raby, G., Taylor, M., Beard, T., and Ian Cowx. 2013. "Failure to Engage the Public in Issues Related to Inland Fishes and Fisheries: Strategies for Building Public and Political Will to Promote Meaningful Conservation." *Journal of Fish Biology.*

Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., et al. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387 (6630): 253-260.

Cowx, I., and M. Portocarrero Aya. 2011. "Paradigm Shifts in Fish Conservation: Moving to the Ecosystem Services Concept." *Journal of Fish Biology* 79 (6, Sp. Iss. SI): 1663-1680.

Cozzetto, K., Chief, K., Dittmer, K., Brubaker, M., Gough, M., Souza, R., Ettawageshik, F., Wotkyns, S., Opitz-Stapleton, S.,. Duren, S., and P. Chavan. 2013. Climate Change 120:569-584

Daily, G. 1997. "What are Ecosystem Services?" *AAAS Annual Meeting and Science Innovation Exposition* 163 (0): A6.

Everard, M. 2013. "Safeguarding the Provision of Ecosystem Services in Catchment Systems." *Integrated Environmental Assessment and Management (IEAM); Special Series: Ecosystem Services: From Policy to Practice.* 9 (2): 252-259.

Feld, C., da Silva, P., Sousa, J., de Bello, F., Bugter, R., Grandin, U., and Daniel Hering, et al. 2009. "Indicators of Biodiversity and Ecosystem Services: A Synthesis Across Ecosystems and Spatial Scales." *Oikos, Acta Oecologica Scandinavica* 118 (12): 1862-1871.

Gaudreau, K. and Richard Gibson . 2013*. Framework for Sustainability-Based Assessment for the Keeyask Hydro Project*: Prepared for the Consumers Association of Canada (Manitoba Branch).

Geijzendorffer, I. and Philip Roche. 2013. "Can Biodiversity Monitoring Schemes Provide Indicators for Ecosystem Services?" *Ecological Indicators* 33 (0): 148-157.

Geneletti, D. 2013. "Ecosystem Services in Environmental Impact Assessment and Strategic Environmental Assessment." *Environmental Impact Assessment Review* 40 (0): 1-2.

Government of Manitoba*. Applying Manitoba's Water Policies*. Winnipeg, Manitoba: Government of Manitoba.

Government of Manitoba. *The Water Protection Act*. 2005 *Bill 22, 3rd Session, 38th Legislature*.

Government of Manitoba. Sustainable Development Act. Winnipeg, Manitoba: Government of Manitoba.

Guo, Z., Xiao, X. and D. M. Li. 2000. "An Assessment of Ecosystem Services: Water Flow Regulation and Hydroelectric Power Production." *Ecological Applications* 10 (3): 925-936.

Hearnshaw, E., Cullen, R. and K. Hughey. 2010*. Ecosystem Services Review of Water Projects*. Lincoln University, New Zealansd: Australian Agriculrual and Resource Economics Society Annual Conference.

Heathwaite, A. 2010. "Multiple Stressors on Water Availability at Global to Catchment Scales: Understanding Human Impact on Nutrient Cycles to Protect Water Quality and Water Availability in the Long Term." *Freshwater Biology* 55 (Suppl. 1): 241-257.

Holland, R., Eigenbrod, F., Armsworth, P., Anderson, B., Thomas, C. and Kevin Gaston. 2011. "The Influence of Temporal Variation on Relationships between Ecosystem Services." *Biodiversity and Conservation* 20 (14): 3285-3294.

Hooper, D., Chapin, F., Ewel, J., Hector, A., Inchausti, P., Lavorel, S. and J. Lawton, et al. 2005. "Effects of Biodiversity on Ecosystem Functioning: A Consensus of Current Knowledge." *Ecological Monographs* 75 (1): 3-35.

Horwitz, P. and C. Finlayson. 2011. "Wetlands as Settings for Human Health: Incorporating Ecosystem Services and Health Impact Assessment into Water Resource Management." *Bioscience* 61 (9): 678-688.

Keeler, B., Polasky, S., Brauman, K., Johnson, K., Finlay, J., O'Neill, A., Kovacs, K. and Brent Dalzell. 2012. "Linking Water Quality and Well-being for Improved Assessment and Valuation of Ecosystem Services." *Proceedings of the National Academy of Sciences of the United States of America* 109 (45): 18619-18624.

Keeyask Hydropower Limited Partnership. 2013. *Keeyask Generation Project. Environmental Impact Statement. Cumulative Effects Assessment Summary*. Winnipeg, Manitoba: Keeyask Hydropower Limited Partnership.

———. . 2012. *Keeyask Generation Project: Response to EIS Guidelines* Winnipeg, Manitoba: Keeyask Hydropower Limited Partnership.

———. . 2012. *Preliminary Draft- Keeyask Geneation Project Aquatic Effects Monitoring Plan*. Winnipeg, Manitoba: Keeyask Hydropower Limited Partnership.

———. . 2013. *Preliminary- Physical Environment Monitoring Plan*. Winnipeg, Manitoba: Keeyask Hydropower Limited Partnership.

———. . 2013. *Preliminary- Terrestrial Effects Monitoring Plan*. WInnipeg, Manitoba: Keeyask Hydropower Limited Partnership.

Kremen, C. and R. Ostfeld. 2005. "A Call to Ecologists: Measuring, Analyzing, and Managing Ecosystem Services." *Frontiers in Ecology and the Environment* 3 (10): 540-548.

Lautenbach, S., Maes, J., Kattwinkel, M., Seppelt, R., Strauch, M., Scholz, M., Schulz-Zunkel, C., Volk, M., Weinert, J. and Carsten Dormann. 2012. "Mapping Water Quality-Related Ecosystem Services: Concepts and Applications for Nitrogen Retention and Pesticide Risk Reduction." *International Journal of Biodiversity Science Ecosystem Services & Management* 8 (1-2, Sp. Iss. SI): 35-49.

Layke, C., Mapendembe, A., Brown, C., Walpole, M. and Jonathan Winn. 2012. "Indicators from the Global and Sub-Global Millennium Ecosystem Assessments: An Analysis and Next Steps." *Ecological Indicators* 17 (0): 77-87.

Leschine, T. and A. Peterson. *Valuing Puget Suond's Valued Ecosystem Components.* Seattle, Washington: Seattle Distric, U.S. Army Corps of Engineers.

Mabery, S. and J. Elliot. 2012. " Insights from Long-Term Studies in the Windermere Catchment: External Stressors, Internal Interactions and the Structure and Function of Lake Ecosystems. ." *Freshwater Biology* 57 (2): 233-243.

Mandle, L., Tallis, H., Vogl, A., Wonley, S., Touval, J., Sotomayor, L., Vargas, S. and A. Rosenthal. 2013. *Can the PUCALLPA-CRUZEIRO DO SUL Road be Developed with no Net Loss of Natural Capital in Peru?A Framework for Including Natural Capital in Mitigation.*: Natural Capital Project, Stanford University.

Manitoba Clean Environment Commission. 2004. *Waskwatim Generation and Transmission Projects: Report on Public Hearings.* Winnipeg, Manitoba.

Manitoba Hydro. 2013. *Manitoba Hydro Climate Change Report*. Winnipeg, Manitoba: Manitoba Hysro.

———. . 2013. *Manitoba Hydro Climate Change Report: Needs for and Alternatives to: Appendix K.* Winnipeg, Manitoba.

Millennium Ecosystem Assessment Program. 2005. *Ecosystems and Human Well-being: Synthesis*. Washington, D.C.: Island Press.

Miranda, M., Mohai, P., Bus, J., Charnley, G., Doward-King, E., Foster, P., Leckie, J. and WR Munns Jr. 2002. " Miranda, M; Mohai, P; Bus, J; Charnley, G; Doward-King, E; Foster, P; Leckie, J; Munns, WR Jr. 2002.Interconnections between Human Health and Ecological Integrity: Policy Concepts and Applications. " In *Interconnections between Human Health and Ecological Integrity*, 15. Pensacola, Florida: SETAC.

Munns, W., Helm, R., Adams, W., Clements, W., Cramer, M., Curry, M., DiPinto, L. et al. 2009. "Translating Ecological Risk to Ecosystem Service Loss." *Integrated Environmental Assessment and Management* 5 (4): 500-514.

Myers, S., Gaffikin, L., Golden, C., Ostfeld, R., Redford, K., Ricketts, T., Turner, W. and S. Osofsky. 2013. "Human Health Impacts of Ecosystem Alteration." *Proceedings of the National Academy of Sciences of the United States of America* PNES Early Edition.

Salazar, J. *Accounting for Water Consumption in LCA with Available LCI Databases*. Ottawa, Ontario: Athena Sustainable Materials Institute.

Schäfer, R. 2012. "Biodiversity, Ecosystem Functions and Services in Environmental Risk Assessment: Introduction to the Special Issue." *Science of the Total Environment* 415 (0): 1-2.

Sheelanere, P., Noble, B. and Robert Patrick. 2013. "Institutional Requirements for Watershed Cumulative Effects Assessment and Management: Lessons from a Canadian Trans-Boundary Watershed." *Land use Policy* 30 (1): 67-75.

Slaney, P. and D. Zaldokas. 1997. *Fish Habitat Restoration Procedures.*: Watershed Restoration Program, Ministry of Environment, Land and Parks.

Tallis, H. et al. 2011. InVEST 2.1 beta User's Guide, Natural Capital Project, Stanford.

Tallis, H., Mooney, H., Andelman, S., Balvanera, P., Cramer, W., Karp, D. and Stephen Polasky, et al. 2012. "A Global System for Monitoring Ecosystem Service Change." *Bioscience* 62 (11): 977-986.

The Council of the Federation. "Water Charter." Council of the Federation Secretariat, Ottawa, Ontario.

United Nations Development Program (UNDP). 2012. *The Future we Want: Biodiversity and Ecosystems— Driving Sustainable Development. United Nations Development Programme Biodiversity and Ecosystems Global Framework 2012-2020.* New York.

United Nations General Assembly. July 2010. *Resolution A/RES/64/292*.

United Nations Statistics Division (UNSD). 2008. *SEAA –Water : System of Environmental Accounting for Water*: UN Department of Economic and Social Affairs: Statistics Division.

US Environmental Protection Agency (USEPA). 1998. *Guidelines for Ecological Risk Assessment.* Washington DC: USEPA Risk Assessment Forum.

Van Hecken, G. and Johan Bastiaensen. 2010. "Payments for Ecosystem Services: Justified Or Not? A Political View." *Environmental Science & Policy* 13 (8): 785-792.

Vogl, A., Tallis, H., Douglass, J., Sharp, R., Veiga, F., Benitez, S., Leon, J., Game, E., Petry, P., Guimeraes, J. and J.S. Lozano. 2012. *Resource Investment Optimization System (RIOS) User Manual.* Natural Captial Project, Stanford.

Voora, V. and Henry Venema. 2008. *An Ecosystem Services Assessment of the Lake Winnipeg Watershed.* Winnipeg, Manitoba: International Institute for Sustainable Development.

Woodward, G. 2009. "Biodiversity, Ecosystem Functioning and Food Webs in Fresh Waters: Assembling the Jigsaw Puzzle." *Freshwater Biology* 54 (10): 2171-2187.

World Health Organization (WHO). 2011. *Resolution 64/24: Drinking Water, Sanitation and Health*: World Health Organization (WHO).

Wortley, L., Hero, J. and Michael Howes. 2013. "Evaluating Ecological Restoration Success: A Review of the Literature." *Restoration Ecology* 21 (5): 537-543.

APPENDIX A

TABLE 5: EXAMPLES OF FRESHWATER AQUATIC ECOSYSTEM SERVICES PROVIDED BY FUNCTIONAL SYSTEMS

Category	Ecosystem Services
Production Services	• Food provision: extraction of aquatic organisms for human consumption • Energy: non consumptive use of the aquatic environment for energy generation, *i.e.,* hydropower • Water resources: abstraction of water for agricultural, domestic and industrial purposes • Freshwater supply: municipal and community water supply • Raw materials: extraction of minerals and organisms not for human consumption • Transport and navigation: use of waterways for shipping and communication
Regulation Services	• Climate regulation: balance and maintenance of the atmosphere, e.g. flooded forests and plant production • Disturbance and prevention: flood and storm protection by natural flooding processes; • Water regulation: hydrological flow regulation (e.g. minimum river flows, flushing flows) • Disease regulation: parasite and toxic algal regulation • Bioremediation of waste; effluent cycling and removal of pollutants by capture and sediments; fishes may maintain healthy aquatic systems that favour these processes • Fish as bioindicators
Cultural Services	• Cultural heritage and identity; value associated with freshwater environments themselves • Cognitive values: education and research resulting from freshwater ecosystems • Leisure and recreation: ornamentals and pleasure and sport fishing • Leisure and recreation: active and passive use of aquatic systems for non-consumptive human pleasure, stimulation and well-being • Psychological and physiological values • Religious symbols • Dietary symbols, particularly demonstrating wealth
Support Services	• Control of pest organisms: invasive non-native species (e.g., algae, mussels, etc.) • Resilience and resistance; life support by the freshwater environment and its response to pressures, including maintaining ecosystem balance • Biologically mediated habitat: habitat provided by aquatic organisms • Physical habitat: habitat provided by the physical (non-living) environment • Flood retention: management and control of flood risk • Flood forests: carbon capture • Nutrient cycling: the storage, cycling and maintenance of nutrients by aquatic environment • Nutrient transfer for upstream migration by anadromes in nutrient poor regions • Food base for mammalian, bird and reptile predators • Existence: value derived from the aquatic environment without using it

(Adapted from Cowx and Portocarrero Aya 2011 and Hearnshaw et.al 2010).