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Indicator Framework Report

A report for the Coordinated Aquatic Monitoring Program

Charles Thrift

March 2015

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This report has been prepared for the Coordinated Aquatic Monitoring Program.

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Background

Manitoba Hydro and the Province of Manitoba have partnered to develop a Coordinated Aquatic Monitoring Program (CAMP) for the purpose of monitoring the water systems in which Manitoba Hydro operates and selected representative water systems outside of Manitoba Hydro's influence. The program was developed in part from existing monitoring programs, and elements such as methodology and site selection were influenced by these programs. The design was shaped by input from experts from other agencies, including the federal government, universities and consultants.

The information gathered by CAMP is extensive in terms of spatial and temporal scope, parameters sampled, and the number of indicator metrics that are directly measured or that can be calculated under the program. The first formal report produced under CAMP was the *Three Year Summary Report*, which covered the first three years of the program (i.e., the pilot program: 2008–2010). The pilot phase report was intended to be comprehensive and examine all parameters measured as part of CAMP to assist with selecting key parameters and metrics that appear to be most suitable for long-term detailed analysis. Due to the comprehensive nature of the report, it was approximately 4,000 pages long. The long-term objective for CAMP reporting was to identify a list of measured parameters and appropriate metrics for reporting in the future (i.e., indicators).

The use of indicators for reporting on ecological conditions measured under large-scale, comprehensive monitoring programs is common practice and provides the advantage of a high-level overview of the system's integrity, highlighting key areas where mitigation action or further investigation of the detailed background data is warranted.

CAMP currently focuses on seven components: hydrometrics, water quality, benthic macroinvertebrates, fish community, mercury concentrations in fish, phytoplankton and sediment quality. In addition, aquatic habitat surveys are conducted each year at one or more water bodies. Of the seven key components, four form the core of the program: hydrometrics, water quality, benthic macroinvertebrates and fish community/fish mercury.

The International Institute for Sustainable Development (IISD) has facilitated a neutral, open and transparent process to develop a set of standard indicators that provide a high-level view of aquatic ecosystem health for the system. CAMP participants provided technical expertise and knowledge about the existing parameters monitored, baseline data, and future program needs and directions. These indicators will provide regulators and other interested stakeholders with key information and trends of aquatic ecosystem health.

This report outlines and summarizes the process that was used to identify indicators, presents the short-list of key indicators that has resulted from this process, and identifies why each indicator was selected by participants to be part of the indicator set. It is not intended to be used as a public explanation of aquatic ecosystem indicators of health, either broadly or for CAMP. Other materials will be produced for that purpose.

Process and Outcomes

The process included two workshops and a number of smaller meetings to gather the various expert perspectives and develop consensus around a set of aquatic ecosystem health indicators. IISD seeded these discussions with insights about the use of indicators, as well as examples of indicators used for a variety of reporting and decision-making processes. The approach involved consulting key technical and regulatory stakeholders, both individually and in group settings, to give these stakeholders multiple opportunities to share insights, knowledge and preferences. The process included four main stages: (1) scoping, (2) first workshop, (3) refinement of workshop results and (4) second workshop. Each of these is discussed below.

1. Scoping

The scoping stage involved making sure key technical and regulatory stakeholders agreed on the primary objectives of the indicators, the audience, the broad indicator categories that need to be tracked, the types of indicators that were to be included, the indicator criteria and an approximate number of indicators. The following scope was determined in consultation with Gary Swanson and Warren Coughlin at Manitoba Hydro, Stuart Davies and Megan Cooley at North/South Consultants, and Don Macdonald with the Province of Manitoba.

Two primary objectives were identified:

1. To develop a set of 10 to 20 highlight indicators for CAMP that describes the state of ecosystem health. This would function as a condensed summary for the public and stakeholders.
2. To help the people who are operating the system to determine if there are any significant changes occurring in these systems. The indicators should operate as metaphorical “canaries in the coal mine” to tell operators if anything is going wrong.

While the ultimate objective is to define ecosystem health, or to demonstrate the state of ecosystem health in an objective manner, this is a significant challenge, especially as these are not pristine systems. The approach we have agreed to use here is an intermediate step: to compare values from the same system to themselves over time. This should give us a sense of the state of ecosystem health in the context of what has been done to these systems, and should let us know when significant changes to ecosystem health are occurring.

The primary audiences are Manitoba Hydro and the Province of Manitoba. First Nations, affected communities and the general public are another audience.

Indicator criteria were established to assist in the selection of indicators:

a) **Credible:** Selected indicators are comparable to what has been done elsewhere or in the literature.
b) **Relevant:** Indicators should be linked to Manitoba Hydro operations’ pathways of effects.
c) **Linkable:** Criteria should be linked to guidelines, reference levels or benchmarks where helpful.
d) **Understandable:** A non-specialist audience should understand the criteria.
e) **Sensitive:** Indicators should be sensitive to change, but without too much natural variation.
f) **Powerful:** Indicators can be used to show change over time.

Thematic categories: The four regularly monitored CAMP components were identified as the broad indicator categories that need to be monitored:

1. **Hydrometrics: water flow and level information.** Manitoba Hydro's operations directly affect water flow and levels. Within CAMP, these are considered the drivers that exert pressures on the environment. Several indicators were proposed for this theme, including absolute water flows and water levels, as well as flows and water-level changes per biologically relevant time frames. Hydrometric data will be presented as contextual information; hydrometric factors are a major pathway of effect through which Manitoba Hydro operations may affect other aspects of the aquatic ecosystem.
2. **Water quality.** CAMP tracks dozens of parameters related to water quality. The indicators selected for the framework are limited to nutrients, primary productivity, dissolved oxygen and suspended solids. In addition to the indicators presented in Table 1, some supporting variables were also identified (i.e., pH, conductivity, temperature, and Secchi disk depth).
3. **Benthic macroinvertebrates.** Abundance and composition of benthic invertebrates are influenced by the characteristics of an ecosystem, and are therefore good indicators to assess the state of ecosystem health.
4. **Fish community/fish mercury.** Abundance, diversity and health of fish are all influenced by the health of the ecosystem in which they live. Monitoring the health of fish populations is important to the communities and First Nations that live on the waterways that are part of Manitoba Hydro's system.

2. First Workshop

The first workshop was used to (a) ensure broad acceptance of the overall process and scoping and (b) come to an agreement on the overall framework and issues/indicators that need to be tracked. This workshop was held on March 4–5, 2014, and resulted in the initial selection of indicators. Approximately 25 people participated in the workshop. The range of experience and knowledge roughly aligned with the four main CAMP components (hydrometrics, water quality, fish community and benthic macroinvertebrates), and participants came from a range of organizations (primarily the provincial government, Manitoba Hydro, North/South Consultants, the University of Manitoba and the federal government).

The workshop started with an overview and discussion of the scope and process. The need for higher level indicators was highlighted and one presentation focused on the use of indicators in a variety of other contexts to measure change and prioritize elements of decision-making. The remainder of the workshop was spent delving into the indicators via breakout groups and plenary sessions. Several individuals commented that the format allowed for, and resulted in, input from most or all participants. The workshop agenda can be found in Appendix A: Agenda, CAMP 2014 Spring Workshop, and the participant list can be found in Appendix B: Participant List for Spring 2014 CAMP Workshop.

Based on the four components, and the list of parameters that are currently tracked by CAMP, participants of the workshop put forward a short list of key indicators that are important for flagging changes in the health of the ecosystem health (see Table 1).

Table 1. Short list of key indicators.

Indicators of aquatic ecosystem health		
Water quality	**Benthos**	**Fish**
Total phosphorus (TP)	Total abundance	Mercury – parts per million wet weight (ppm ww)
Phytoplankton (chlorophyll a)	Proportion/composition of major groups	Abundance – catch per unit effort (CPUE)
Dissolved oxygen (DO)	Total number of families	Diversity – Hill's effective richness
Total suspended solids (TSS)	Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa	Growth – length-at-age; weight-at-age
Total nitrogen (TN)	A diversity measurement (e.g., Simpson's diversity or equitability)	Condition – condition factor
Hydrometrics: Contextual information/drivers of change in water quality, benthic macroinvertebrates and fish communities. To be determined.		

Note: Further information on individual indicators is provided below.

3. Refinement of Workshop Results

This stage of the process involved the compilation of workshop results, assessment of the state of the framework (identifying unanswered questions, gaps in knowledge, weaknesses in the framework, etc.), and resolving any issues via discussion with stakeholders and experts (e.g., to help fill gaps in knowledge or answer questions).

The most significant issue arising during this stage was the suggestion that the hydrometric indicators might be better presented separately, as drivers of ecosystem health, rather than combined with the other indicators of ecosystem health. Framed as drivers, the hydrometric indicators can be selected via predictive power on the selected indicators of ecosystem health. Which hydrometric indicators might be the best predictors of ecosystem health is somewhat uncertain at this point, so these indicators will need to be revisited periodically to ensure the best indicators have been selected.

This stage also involved a pilot of the selected indicators for one study region of CAMP (the Winnipeg River system), carried out by North/South Consultants Inc., in order to compile an example of what indicator data will look like in practice, which could be helpful in determining if the indicators are adequate for the needs of CAMP. This pilot also allowed the CAMP team to work through any issues related to the selected indicators and reporting. North/South Consultants put together a report summarizing the findings of the pilot (*Six Year Summary Report: Winnipeg River Region CAMP Workshop Backgrounder*), which was circulated prior to the second workshop. At the second workshop, North/South Consultants

presented data from the report and provided some discussion of a broader array of metrics measured under CAMP (e.g., comparison of the sensitivity of a larger list of metrics).

4. Second Workshop

The second workshop was held on November 25, 2014, and involved approximately 30 participants. The range of experience and knowledge roughly aligned with the four main CAMP components (hydrometrics, water quality, fish community and benthic macroinvertebrates), and participants came from a range of organizations (primarily the provincial government, Manitoba Hydro and North/South Consultants). The workshop agenda can be found in Appendix C: Agenda, CAMP 2014 Fall Workshop, and the participant list can be found in Appendix D: Participant List for Fall 2014 CAMP Workshop.

The workshop involved a presentation of the recommended indicators, as well as the results from the pilot. Groups were established for water quality, fish community and benthic macroinvertebrates, and participants were asked for final feedback prior to finalizing the indicator set. The groups were asked to focus on the following questions related to indicator criteria:

1. Is the indicator credible (scientifically defendable and comparable to what has been done elsewhere)?
2. Is the indicator linkable to a guideline or credible reference level or benchmark (either another location or another point in time) that can be cited and used as basis to assess the status of the indicator?
3. Is the indicator sensitive (shows change over time and does not have significant natural variation)?
4. Is the indicator understandable to a non-specialized audience?

A majority opinion emerged that the selected indicators met these criteria (with some caveats; see Table 2), and agreement on the indicators was obtained. The group agreed that hydrometric indicators should be presented as contextual information, but that additional work will be required to determine what information should be provided.

Table 2 shows breakout group responses for each indicator regarding the indicator criteria. All indicators were deemed credible, with some caveats around sampling methods and interpretation in the Fish component.

Some of the indicators are linkable to credible benchmarks – primarily water quality indicators – but most of the indicators do not have applicable benchmarks. There are no readily applicable benchmarks for fish or benthic macroinvertebrate indicators. However, there are a variety of approaches that can be used to develop CAMP-specific benchmarks. It was suggested that comparing indicators from a water body against itself over time may be the most relevant approach.

Sensitivity refers to whether the indicator shows change over time and does not have significant natural variation - that it is sampled at a level that is relevant as an indicator of aquatic ecosystem health (i.e., Will this indicator be sensitive enough to be helpful in assessing changes in aquatic ecosystem health over time?). It should be noted that at this point, no analysis has been done to determine the sensitivity of the indicators to detect change – responses were subjective.

Table 2. Breakout group responses regarding indicators and criteria.

	Notes (what is measured, why it should be included)	Credible	Linkable	Sensitive	Understandable
Water quality					
Total phosphorus (TP)	A key nutrient controlling algal growth and algal blooms. Linked to hydro operations via flows and changes in residence time and flooding of terrestrial materials.	Yes	Yes	Yes.	Somewhat
Total nitrogen (TN)	An important nutrient that, with TP, controls algal growth. Linked to hydro operations via flows and changes in residence time and flooding of terrestrial materials.	Yes	Yes	Yes.	Somewhat
Chlorophyll a (Chl a) concentration	A ubiquitous algal pigment used to estimate phytoplankton biomass. Important because algae are the base of the food web and may develop into excessive algal blooms.	Yes	Yes	Yes	Somewhat
Dissolved oxygen (DO) concentration	An essential element for aquatic life. Links to hydro activities through flooding, changes in organic matter (e.g., phytoplankton), and changes in water levels and flows.	Yes	Yes	Yes	Somewhat
Total suspended solids (TSS)	Impacts aquatic life through changes to light penetration/water clarity and may have direct adverse effects on biota including fish and invertebrates. Links to hydro activities include effects of hydrological changes on shoreline erosion, sediment resuspension and settling.	Yes	Yes	Yes	Somewhat
Benthic macroinvertebrates					
Total abundance	Total number of all individuals in a sample. Useful for deriving compositional measures (e.g., % Ephemeroptera that are Baetidae; EPT:C ratio).	Yes	No readily applicable benchmarks for benthic macroinvertebrate metrics. CAMP-specific benchmarks can be developed.	Yes	Can be made understandable
Composition of major groups	Proportional abundance of major invertebrate groups. Useful for describing the community in terms of tolerant and intolerant taxa.	Yes		Yes	Can be made understandable
Taxa richness	Number of taxa present at the family level. Useful for describing the community in terms of tolerant and intolerant taxa.	Yes		Yes	Can be made understandable
Ephemeroptera, Plecoptera and Trichoptera (EPT) richness	Number of EPT taxa at the family level. In general, high numbers of EPT taxa indicates good water quality. Useful measure to describe the nearshore habitat.	Yes		Yes	Can be made understandable
Diversity indices	Measures of the number (richness) and/or equitability (relative abundance) of the taxa making up the community (e.g., Simpson's, Shannon's, Hill's). Generally, diverse and equitable communities are indicators of good water quality.	Yes		Yes	Can be made understandable
Fish					

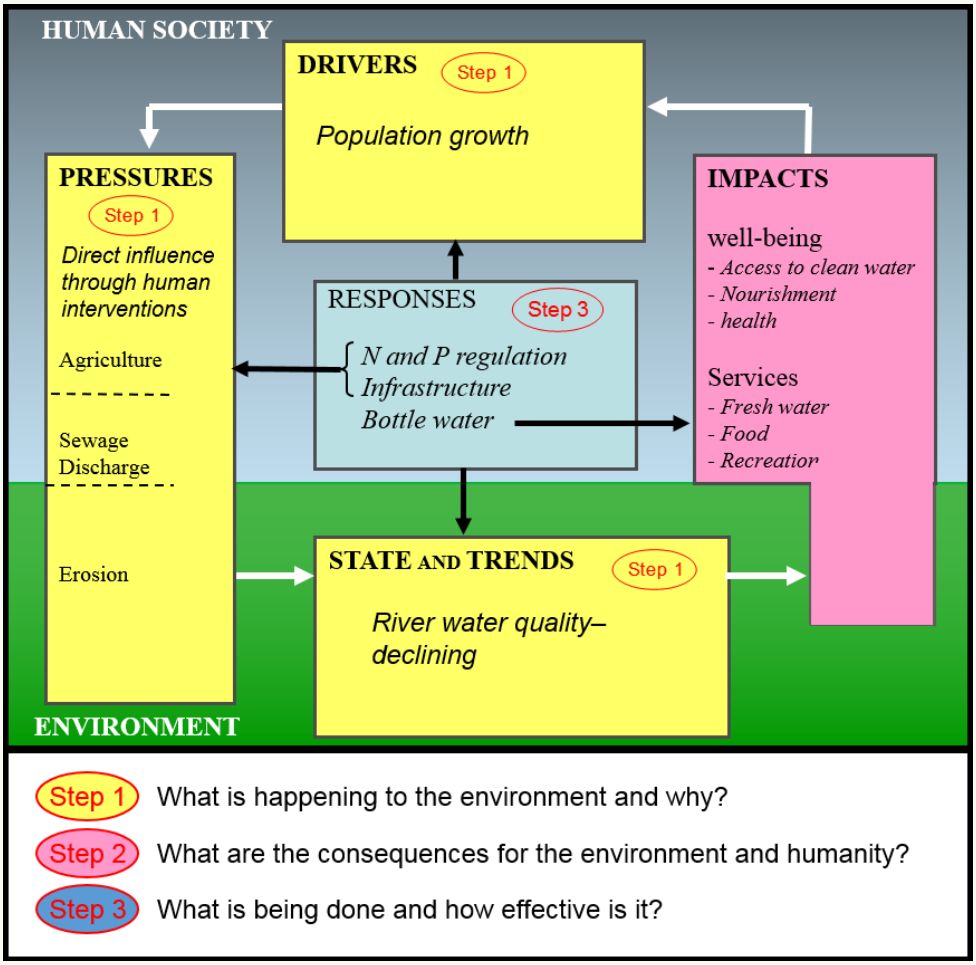
	Notes (what is measured, why it should be included)	Credible	Linkable	Sensitive	Understandable
Mercury (parts per million wet weight)	Measures the concentration of mercury in fish, which is a concern among the general public.	Yes	Guidelines exist (Health Canada is reviewing, so these may change).	Yes, with appropriate sample size.	Yes, understandable, but there are also existing mis-understandings.
Abundance – catch-per-unit-effort (CPUE)	Measure of the abundance of fish. The abundance of fish can be affected by many stressors, some of which may be driven by hydro operations.	Yes, with caveat of interpretation.	No readily applicable benchmarks for fish metrics. CAMP-specific benchmarks can be developed.	Yes	Yes
Hill's effective richness (diversity)	Measure of the number (richness) of taxa making up the community.	Yes, with caveats around sampling methods (driven by evenness and number of species? Which species are caught with equipment used?).	No readily applicable benchmarks for fish metrics. CAMP-specific benchmarks can be developed.		Concept of diversity: yes
Growth – length-at-age and weight-at-age	Measures of growth, which can be affected by many factors, some of which may be related to hydroelectric generation operations.	Yes, with caveats (sample size; with no competition, growth is quick; density dependent; climate/ temperature)	No readily applicable benchmarks for fish metrics. CAMP-specific benchmarks can be developed.	Yes	Yes
Condition – condition factor	A measure of the condition of fish (i.e., girth or "fatness"), which can be affected by many potential factors, some of which may be related to hydroelectric generation operations.	Yes, with caveat: need to account for body size.	No readily applicable benchmarks for fish metrics. CAMP-specific benchmarks can be developed.	Yes, with caveats.	Yes

The second workshop was also used to obtain feedback related to potential formats, frameworks and narratives to communicate the results. There was general agreement with the stated objective of the CAMP partners of making the next three-year report significantly more concise than what had been prepared for the pilot three-year report, as well as more narrative and descriptive. The primary suggested method of simplifying and shortening the report was to limit text, tables, and figures to summary statements and overall conclusions (i.e., all indicators will be reported on for all CAMP water bodies, but the level of discussion will be at a higher level).

Some felt that there should be a hierarchy of reporting: that extra data should be put in appendices, or that a longer report also be prepared to capture everything so that all the extra data collected not be lost. The creation of an online information system was not considered feasible at the moment, but may become a longer-term goal.

To provide context to the discussion around narrative and framework, an exercise was used. Each breakout group was asked to develop a narrative for one indicator using the Driving force-Pressure-State-Impact-Response (DPSIR) framework (see Figure 1). The DPSIR framework is used widely in integrated environmental assessment reporting. It is used, for instance, by the OECD, the United Nations Environment Program and the European Environmental Agency to relate human activities and well-being to the state of the environment. The DPSIR framework provides a systems view and helps identify links in the causal chain that can be strengthened or broken by policy action. Using such a framework is a way of putting the indicators into context, allowing for a more integrated picture.

Figure 1. DPSIR framework.



Opinions of the narrative and framework were mixed. Some agreed that using a Pressure-State-Response (PSR) or DPSIR-type approach added value by putting the indicators into context, making it clear why the indicators are relevant and how they are connected.

Others disagreed, feeling that moving to a new way of reporting may be premature, that such a framework is too simplistic (and would therefore not be supported by the scientific community), that the framework would be prone to misunderstandings by members of the community (if the magnitude of importance of the linkages is not shown, it might be seen as pointing fingers).

A number of other approaches were also discussed, including Pathways of Effect (which documents and identifies causal relationships between aspects of a given problem), but no agreement was reached on what framework should be used going forwards. The discussions highlighted a need to understand and report on the causal or other linkages between the parameters and indicators.

Next Steps

Amongst the primary stakeholders of CAMP—Manitoba Hydro and the Province of Manitoba—there is an understanding that CAMP can contribute to a better understanding of overall ecosystem health and also help in strategic planning and decision making in the context of watersheds, particularly those affected by hydro development. With this goal in mind, over the coming months, a number of activities are anticipated:

1. Selection of hydrometric indicators to be used as contextual information for the ecosystem health indicators.
2. Decisions regarding scope, framework and format of the upcoming three-year summary report:
    a. Data and information needs assessment.
    b. Types of summary graphics, reading level, approximate length of report, etc.
    c. Framework to be used: thematic and data focused (i.e., current CAMP framework) versus thematic and narrative using DPSIR or PSR.
3. Preparation of the next three-year report (covering the first 6 years of the program).

Appendix A: Agenda, CAMP 2014 Spring Workshop

WORKSHOP AGENDA

Location: Holiday Inn Airport West, 2520 Portage Avenue, Winnipeg, MB
Dates: March 4 & 5, 2014

Agenda Day 1 – March 4, 2014

8:30 am	Continental breakfast
9:00 am	Welcome, introductions – MB Hydro
9:10 am	Overview and background of CAMP – MCWS
9:30 am	Identifying Indicators of Watershed Health: workshop objectives, scope and process – IISD
10:00 am	Breakout group session for identifying indicators of watershed health
10:30 am	*Break (refreshments and snacks provided)*
10:45 am	Breakout group session and presentations – IISD
12:00 pm	***Lunch (provided)***
1:00 pm	Plenary session on indicators of watershed health – IISD
2:30 pm	*Break (refreshments and snacks provided)*
3:00 pm	Open discussion – MB Hydro
4:30 pm	Adjourn

Agenda Day 2 – March 5, 2014

8:30 am	Continental breakfast
9:00 am	Summary of Day 1 and indicator selection and discussion – IISD
10:00 am	*Break (refreshments and snacks provided)*
10:15 am	Presentation and discussion of indicator selection results – IISD
11:00 am	Open discussion and closing remarks – MCWS
12:00 pm	*Lunch (provided)*
1:00 pm	**Adjourn**

Appendix B: Participant List for Spring 2014 CAMP Workshop

Name	Organization	Component / Expertise
Darren Swanson – no assigned table.	IISD	Facilitator
Table 1: Hydrometrics		
Brian Giesbrecht	MB Hydro	Hydrometrics
Paul Chanel	MB Hydro	Hydrometrics
Martin Hunt	MB Hydro	Hydrometrics / Ecohydraulics
Joel Hunt	MB Hydro	Instream Flow Needs
Rob Matthews	MCWS	Hydrometrics
Puru Singh	MCWS	Hydrometrics
Jeff Long	MCWS	Instream Flow Needs
Stuart Davies	NSC	Fish
Pauline Gerrard	IISD	Facilitator
Table 2: Water Quality		
Don Macdonald	MCWS	Fish
Amber Lahti	MB Hydro	Water Quality
Bill Brown	MB Hydro	Water Quality
Megan Cooley	NSC	Water Quality
Dimple Roy	IISD	Facilitator
Mike Paterson	IISD	Water Quality
Table 3: Benthic Macroinvertebrates		
Ginger Gill	NSC	Benthic Inverts
Brenda Hann (only March 4)	U of M	Benthic Inverts
Gary Swanson	MB Hydro	Fish
Scott Higgins	DFO	Benthics
Table 4: Fish Community and Fish Mercury		
Derek Kroeker	MCWS	Fish Community
Geoff Kline	MCWS	Fish Community
Patrick Nelson	NSC	Fish Community
Wolfgang Jansen	NSC	Fish Community
Warren Coughlin	MB Hydro	Fish
Karla Zubrycki	IISD	Facilitator

Appendix C: Agenda, CAMP 2014 Fall Workshop

Coordinated Aquatic Monitoring Program - 2014 Fall Workshop

Location: Manitoba Hydro, 360 Portage Avenue, Winnipeg, MB
Dates: November 25, 2014

Agenda

8:30 am Continental breakfast

9:00 am Welcome, introductions – MB Hydro

9:10 am Summary and update from March 2014 workshop – MCWS

9:30 am Workshop objectives, scope and process – IISD

9:45 am **Part I: Review of Data:**

Presentation of indicators analysis from Winnipeg River Region

- Water Quality – NSC
- Benthic Macro Invertebrates – NSC
- Fish Community – NSC
- Fish Mercury - NSC

10:15 am Break (refreshments and snacks provided)

10:30 am **Part I: Review of Data (continued):**

Breakout group discussion regarding data and indicators

Breakout Group Questions:
1. Is the indicator credible? (scientifically defendable and comparable to what has been done elsewhere)
2. Is the indicator linkable to guidelines? (a guideline or credible reference level or benchmark [other location or point in time] exists that can be cited and used as basis to assess the status of the indicator status)
3. Is the indicator sensitive? (shows change over time and does not have significant natural variation)
4. Is the indicator understandable?

Hydrometrics – plenary discussion

12:00 pm Lunch (provided)

1:00 pm **Part II: From data to reporting on watershed health:**

Presentation – IISD

Breakout group discussion regarding narrative, framework, and format

Breakout Group Questions and Instructions
1. For one indicator in your component, what is the integrated story about watershed health based on this indicator (use the DPSIR analysis framework to tell story and see linkages with other indicators in your component and other components) 2. What other analysis frameworks have you used to report on watershed health or state of the environment? 3. What format should the report be communicated (a. online info system; b. website with jpg graphs; c. webpage only with digital report)

2:30 pm Break (refreshments and snacks provided)

2:45 pm **Part II: From data to reporting on watershed health (continued):**

Report back from breakout groups

Plenary discussion

4:30 pm Meeting close – MB Hydro

Appendix D: Participant List for Fall 2014 CAMP Workshop

Name	Organization	Component / Expertise
Darren Swanson – no assigned table.	IISD	Facilitator
Ginger Gill	North/South Consultants	Benthic Inverts
Charles Thrift	IISD	Facilitator
Dimple Roy	IISD	Facilitator
Karla Zubrycki	IISD	Facilitator
Don Macdonald	MCWS	Fish Community
Gary Swanson	MB Hydro	Fish Community
Stuart Davies	North/South Consultants	Fish Community
Warren Coughlin	MB Hydro	Fish Community
Derek Kroeker	MCWS	Fish Community
Geoff Klein	MCWS	Fish Community
Patrick Nelson	North/South Consultants	Fish Community
Wolfgang Jansen	North/South Consultants	Fish Community
Brian Giesbrecht	MB Hydro	Hydrometrics
Paul Chanel	MB Hydro	Hydrometrics
Rob Matthews	MCWS	Hydrometrics
Martin Hunt	MB Hydro	Hydrometrics / Ecohydraulics
Jeff Long	MCWS	Instream Flow Needs
Joel Hunt	MB Hydro	Instream Flow Needs
Amber Lahti	MB Hydro	Water Quality
Bill Brown	MB Hydro	Water Quality
Joy Kennedy	MCWS	Water Quality
Megan Cooley	North/South Consultants	Water Quality
Mike Paterson	IISD	Water Quality
Elise Watchorn	MCWS	Water Quality
Hank Venema	IISD	Water Quality
Kevin Jacobs	MCWS	Water Quality
Ray Hesslein	N/A	Water Quality
Rhonda Dyck	MCWS	
Richard Remnant	North/South Consultants	Fish Community

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