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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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Summary

This CSAS meeting was called by DFO Habitat Policy and Habitat Management to seek Science guidance and advice on a standardized approach to assessing In-stream Flow Needs (IFN) for fish and fish habitat in Canada. The Canadian Rivers Institute of the University of New Brunswick produced a research document which serves as scientific input for this meeting. Science reviewed and clarified various definitions and terminologies commonly used in IFN methods/assessments. Science reviewed and compared various IFN methodologies, including the benefits and assumptions of each, and situations under which they are most appropriate and for which management purposes they were designed. Science also provided technical recommendations towards the standard(ized) assessment of IFN for the management of fish and fish habitat in the Canada.

Sommaire

La présente réunion du Secrétariat canadien de consultation scientifique (SCCS) a été convoquée par les responsables de la Politique de l’habitat et du Programme de gestion de l’habitat de Pêches et Océans Canada, afin d'obtenir des lignes directrices et un avis scientifique au sujet d'une approche normalisée d’évaluation des débits réservés des cours d’eau pour les poissons et leur habitat au Canada. Le Canadian Rivers Institute de l'Université du Nouveau-Brunswick a produit un document de recherche qui a servi de base scientifique lors de cette réunion. Le Secteur des sciences a révisé et étudié diverses définitions et terminologies communément utilisées dans les méthodes et évaluations du débit réservé des cours d'eau. Il a également revu et comparé diverses méthodologies pertinentes, y compris leurs bienfaits et hypothèses de base. Il a également déterminé les situations dans lesquelles ces méthodologies sont les plus appropriées et à quelles fins de gestion elles étaient conçues. Le Secteur a en outre formulé des recommandations techniques concernant l'évaluation normalisée des débits réservés, pour la gestion des poissons et de leur habitat au Canada.

INTRODUCTION

The purpose of this meeting as outlined in Terms of Reference (Appendix 1) was to review, clarify and compare definitions, terminologies, methodologies and assessments of In-stream Flow Needs (IFN). A draft Working Paper (WP) was prepared and circulated to participants prior to meeting to help meet the objectives of the meeting.

In accordance to the agenda (Appendix 2) presentations were made to the participants (Appendix 3) by the co-chairs to provide an overview of goals and objectives of the workshop, followed by a presentation from Habitat Policy to give some perspectives of their request. The Terms of Reference for this advisory process were slightly adjusted at the onset of the meeting to help address the operational requirements of pending legislative changes to the *Fisheries Act.* The WP and a recent paper by Mike Bradford, "Test of an environmental flow release in a British Columbia river: does more water mean more fish?" were distributed to participants prior to the meeting and presented at the meeting (these reports will be published as a research document and posted on the CSAS website). A presentation on hydrology and hydraulic methods supplemented the presentation of the WP. Presentations were also made by the province of B.C, Alberta and Ontario on their IFN approaches and methods. A presentation on in-stream flow strategies from the U.S. provided an international best practice. Much of the focussed discussions were on information provided by the presentations.

MEETING OBJECTIVES

a) Peer review the Working Paper indicated above.

b) Review and clarify the various definitions and terminologies commonly used in IFN methods/assessments.

c) Review and compare the various IFN methodologies, including the benefits and assumptions of each, and situations under which they are most appropriate and for which management purposes they were designed.

d) Provide technical recommendations towards the standard(ized) assessment of IFN for the management of fish and fish habitat in the Canada, including:

   - Pan-Canadian Framework with regionalization based on river (hydrological/flow regime/ecological) regions/types (suggested flow-chart/infographic);
   - IFN monitoring considerations and adaptive management;
   - Addressing data gaps in Canada and knowledge gaps in general; and,
   - Addressing uncertainty in IFN assessment.

The co-chairs noted that this advice is in response to DFO's Habitat Management's request relating to IFN and not to be interpreted as advice to other jurisdictions or water licensing agencies.

PRESENTATIONS

REVIEW OBJECTIVES OF HABITAT POLICY

Presenter: Nick Winfield (Director, Habitat Policy)
Rapporteur: Boumy Sayavong

The presentation provided the context of several provisions of the *Fisheries Act* relate to managing impacts arising from flow alterations. The specific sections of the *Act* are S. 20: Minister may require fish-ways to be constructed, S. 22: The Minister may require sufficient flow of water for the safety of fish and flooding of spawning grounds as well as free passage of fish during construction, S. 32: No killing of fish by means other than fishing without Ministerial authorization, and S. 35: No harmful alteration, disruption or destruction of habitat without Ministerial authorization.

In order to help meet management's needs in this respect, Habitat Management sought science advice on predicting the impacts of flow modification to sustain "fisheries" as there are several major water users seeking regulatory certainty and standardized approaches for gathering information for regulatory decision making.

Key messages from the presentation are:

1) The regulated sectors supports the standardized approach based on sound science for predicting impacts of flow on fisheries;
2) Practitioners can understand and interrupt predictive models to best inform regulatory decision making; and,
3) The decisions makers and the public can understand the trade-offs involved with various scenarios.

Discussions

There is a movement by Habitat Management to move away from protecting fish habitat for the sake of habitat which assumes that protecting a fish habitat will save fisheries. Their shift now is on trying to sustain the fisheries not knowing all the details of how it is linked to fish habitat.

Participants asked management for their definitions of a "fisheries" or does management really just mean "fish habitat". A "fishery" as defined by Habitat Management is fish of commercial, recreational, cultural and ecological value and this also include potential fisheries. Habitat management indicated that this definition is not the same definition as in the *Fisheries Act.* Management also responded that Fisheries is not narrowly focussed just on the organism but involves their whole life cycles, including its habitat, and its users.

Participants also raised some questions with regard to Species at Risk and Biodiversity. Management stated this is another issue that is going on within the department. Habitat Management's concern at this workshop is focused on major projects that affect or have impacts on commercial, recreational, aboriginal, and ecology value that will trigger regulations.

Management mentioned currently DFO is not setup to consider "trade-offs" in its management program and there is no policy on "trade-off" analysis. Management thinks it needs to introduce the word "trade-off" into the language of practitioners.

Decision

Following this presentation and discussion, a decision was made to modify the scope and objectives of the meeting to address the operational requirements of pending legislative changes to the *Fisheries Act*. Participants were directed to provide recommendations for a general framework for the assessment of ecological flow requirements for fisheries in Canada rather than technical recommendations towards the standard(ized) assessment of IFN for the management of fish and fish habitat in the Canada indicated in the Terms of Reference.

For the purposes of the SAR, science advice is provided towards management of "the flow regimes and water levels required to provide for the ecological function of the fisheries present within that water body and its margins".

INTRODUCTION AND TERMINOLOGY

Presenter: T. Linnansaari
Rapporteur: Boumy Sayavong

The presenter provided an introductory presentation of his working paper with some background on freshwater resource consumption and non-consumptive use leading to flow alternations in rivers. Due to the wealth of literature concerning environmental flow assessment methods, the author largely relied on numerous existing review articles and emphasised on recent articles describing different IFN approaches while not discounting older literature. In his opinion he believed that the information described in older literature would be contained within numerous recent reviewed articles on this subject and that more recent articles are typically built upon the former knowledge which may have potentially addressed deficiencies that the older methods may have included. His WP only considered large systems due to limited resources, time and so many different methods of assessments. The WP excluded small rivers, intermittent systems and hydro peaking systems. Because IFN is still a relatively “young science”, terminologies are still in flux. From the lack and disagreement of consistently used terminology, the presenter identified some terminology on “environmental flows” that the participants should agree upon during the workshop.

Discussions

Two terminologies were identified by the author for discussion and agreement. The terms ”Environmental flow” and “ecological flow” are often used interchangeably. To move forward the group felt that either “environmental flow” or “ecological flow” needs to be chosen.

The following two definitions are described:

1) Environmental Flow (Brisbane Declaration 2007) - "Environmental flow describes the quantity, quality and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems".

2) Ecological Flow (New Zealand Ministry of the Environment 2008) - “The flows and water levels required in a water body to provide for the ecological function of the flora and fauna present within that water body and its margins”.

The group felt that “environmental flow” contains consideration of “sustain(ing) freshwater ecosystems and the human livelihoods”, which are broader social considerations and beyond the scope of the science advice. For the context of the IFN workshop discussion, participants agreed that “ecological flow” definition would meet the needs of the IFN advisory discussion with minor modifications of the definition.

Participants also recognize that “instream flows” definition includes the broader set of objectives (including social, recreational, community health, etc). For the IFN advisory it was agreed that “ecological flow” would be used instead of “environmental flow”. The modification agreed upon would replace the following words “flora and fauna” with the word “fisheries” in the original definition for “ecological flow”. The modified definition for the purposes of the Science Advisory would then be:

Ecological flow (DFO, CSAS Workshop on Standardized Framework for the Assessment of In-stream Flow Needs in Canada, March 2012) – “The flows and water levels required in a water body to provide for the ecological functions of the fisheries within that water body and its margins.”

There was also a discussion that the use of “minimum flow” should be avoided for management purposes as it pre-supposes minimum ecological needs and does not help in negotiating flow regimes. Ontario does not use a minimum flow definition.

There was discussion about “Base flow”. There was agreement that “Base flow” is either from groundwater contribution plus augmented flow (from natural or man-made) reservoirs.

Base flow (United States Geological Survey 2005) - "That part of the stream discharge that is sustained primarily from groundwater discharge. It is not attributable to direct runoff from precipitation or melting snow.”

BROAD CATEGORIES OF IFN METHODOLOGIES

Presenter: T. Linnansaari
Rapporteur: Boumy Sayavong

The presenter provided background review of approaches and methods to assess environmental flows across Canada and internationally. He presented four general categories of environmental flow assessment methodologies:

1) Hydrological;
2) Hydraulic rating;
3) Habitat simulation; and,
4) Holistic methodologies.

The four categories differ considerably, based on differing viewpoints regarding how to sustain the biotic integrity of rivers. Specifically, hydrological and hydraulic rating categories assumes that a reduction in water availability will also reduce available habitat and/or impair ecosystem function, while the habitat simulation techniques suggest that there is an "optimum" flow where the ecosystem function is sustained.

Hydrological method

The hydrological methods are the simplest, quickest and most inexpensive (this method does not require any fieldwork) way to provide information on threshold flow levels, provided hydrological records can be obtained for a number of years.

Hydrological methods are based on analysis of historic (existing or simulated) flow data, independent of specific species and aims to provide an overall flow regime to conserve the biotic integrity of a stream. It is widely used internationally because it is easy to use, its low cost and it does not require field visits. Commonly used hydrological methods include:

- The Tenant method and its derivatives, which assumes some proportion of the mean annual flow (MAF) is required to sustain the biological integrity of a river ecosystem. A greater than 30% MAF was considered to provide flows where the biological integrity of the river ecosystem as a whole was sustained. Other derivatives include different percent of MAF; More frequent time step; Local modifications to better accommodate the variations in hydrologic regime in various geographic areas. The Tennant methods seems to work well in low gradient streams <1% but not representative of high gradient streams.
- Flow duration curve methods define the proportion of time a certain flow threshold level is equaled or exceeded in the particular river or region. The duration curve is calculated based on multiple years of data, preferably using more than 20 years worth of data. The indices based on flow duration curves are referred to using a Qx notation, where the subscript x indicates the exceedence percentile. Recent trend to use Qx only as a cut-off values are not very useful for aquatic ecological processes.
- The Indicators of Hydrologic Alteration (IHA) represents a subset of 33 ecologically-important hydrological parameters based on variability of the annual flow regime e.g., magnitude and frequency. The Range of Variability Approach (RVA) identifies flow targets as ranges for each of the IHA variables. The RVA analysis divides each IHA variable under natural flow (or before a change in water use) into three categories (low, middle, and high). Ideally, RVA is based on 20+ years of daily hydrological data because this amount of data is required to capture all the natural variability of a system.
- Percentage of flow (POF) methods define environmental flows in terms of the proportion of natural flow which can be abstracted instantaneously without compromising ecosystem integrity.

POF methods have been increasingly used to define regional environmental flow regimes in lieu of more detailed methods and various proportions of natural flow have been suggested depending on different river classification criteria. After a review of case studies in the USA and UK, the presumptive standard (Figure 4B) suggests that;

- A high level of ecological protection is provided when flow alterations are within 10% of the natural flow;
- A moderate level of protection is provided when daily flow alterations are within 10-20%; and,
- Moderate to major changes in riverine ecosystem are to be expected if alterations are > 20% of the natural flow, with an increasing risk for alterations with a higher deviation from the daily natural flows.

The guideline is considered to be conservative and precautionary. However, authors remind that the standard may be insufficient to protect the riverine ecosystem in hydropeaking facilities where more specific guidelines should be applied. In addition, minimum flow levels when all water abstraction should stop may be required to the above standards during the low-flow periods.

Discussions

In the Hydrological method there is never a long enough data series. It was agreed and the general rule is that a good set of hydrological data should represent at least 20 years worth to cover two decadal periods. However, beyond 20 years the availability of data may not be available based on short records. There was mention that when using frequency analysis to generate hydrological data, non-stationary data should not be used.

Most of the common methods used worldwide are the Tennant method and its derivatives which assume some proportion of Mean Annual Flow (MAF) for threshold relative to width, depth and velocity of the system. There is also a lack of ecological validity and high uncertainty for hydrology and ecology relationships but this could be said about all the methods. Participants mentioned that percentage of flow does have a connection to the biological and geomorphic processes but there is a need to connect them.

The presenter discussed the pros and cons of each of the four methodology categories, their specific attributes (i.e. purpose, scale, scope, duration of assessment, and relative cost and use).

Table 1: Strengths, weaknesses and data requirements for hydraulic method.

Strengths	Weaknesses
Simple, quick and inexpensive way to provide information on threshold flow levels	Simple hydrological statistics can lead to ecologically detrimental flow thresholds
Does not require any additional fieldwork and use existing flow data	Not recommended for studies requiring a high level of detail
Can be used at planning level or to set up preliminary flow targets in low risk situations	Criticized for lack of ecological validity and high uncertainty for hydrology-ecology relationship
Can be used as an increased safety measure or a benchmark with other methods	Can lead to stable (i.e. flat-lined) environmental flow regime → lead to degradation over time

HYDRAULIC / CHANNEL MORPHOLOGY

Presenter: T. Linnansaari
Rapporteur: Boumy Sayavong

The presenter described the hydraulic rating methods as a relationship between some hydraulic measure of a river (usually wetted perimeter or depth) and discharge. This method assumes that the hydraulic measure is directly related to some habitat quantity or well-being of the river system as a function of discharge at some point in the river. Mathematical methods are used to determine the critical discharge (also known as the breakpoint) in the relationship between discharge rate and wetted parameter curve. The hydraulic rating methods are dependent on the channel form but finding an inflection point that can be used to establish flow level standards can sometimes be difficult.

Discussions

Participant agreed that this method requires a lot of data. Environment Canada uses the typical “C” shape river for its mathematical methods to determine critical discharge rate and wetted parameter curve. The additional strength for using this method is that data is available from Environment Canada’s Hydat database for the hydraulic methods.

This method can be can be used to validate other statistical analysis particularly for low flow systems. Some states in the USA use this method. However, the state of Wyoming found a lot of problems using this wetted method. There was agreement that the method can be used as a tool to recommend minimum flow but will still require a professional hydrologist to validate the flow. Participants also agreed that one must be willing to walk away from the method if they don’t make sense to use it.

HYDROLOGIC AND HYDRAULIC METHODS

Presenter: D. Caissie

The presenter provided mathematic equations used to define habitat attributes such as depth, width and flow rate of rivers. These equations are all power functions (a special case of power law relationship) related to discharge (hydraulic geometry). The use of differential equations play an important role in modelling flow to solved real-life problems.

Point of Maximum Curvature (PMC) of a Power Function as a function of “b”

Instream flow = 3.8 to 6.9 % MAF

$$k = \frac{b(b-1)Q^{b-2}}{\left[1 + (bQ^{b-1})^2\right]^{3/2}}$$

Unit Slope Approach Instream flow = 7.7% to 25 % MAF

$$\frac{dy}{dx} = bQ^{b-1} = 1$$

HABITAT SIMULATION MODELS

Presenter: T. Linnansaari
Rapporteur: Boumy Sayavong

The habitat simulation model is based on the belief that there is an underlying relationship between the level of flow and the "optimum" physical habitat conditions for the target species. The Habitat Simulation popularity stems from the establishment of the In-stream Flow Incremental Methodology (IFIM) framework that was developed for assessing the effects of flow manipulation on river habitats.

The IFIM is a holistic decision-making tool that includes, among other steps, quantifying of the incremental differences in physical habitat resulting from alternative flow regimes.

The habitat simulation methods consist of two integral parts that are linked together:

1) Hydraulic information (changes in the physical habitat as function of discharge); and,

2) Biological information (in response to the physical change in the environment).

The hydrological modeling is composed of data collection and modeling (depth, substrate, velocity, and roughness), water elevations, wetted width and bed topography and flow in and flow out. The biological component includes description of the animal's range by a means of a mathematical model and an assumption that local abundance reflects local habitat quality.

A preference curve is then established by integrating the two components (physical and biological) and a hydrodynamic model is then calibrated for the area and species of interest.

The author also presents some of the strengths and weaknesses.

Table 2: Strengths, weaknesses and data requirements for habitat simulation models.

Strengths	Weaknesses
Links one aspect of ecology (i.e. quantity of habitat) to changes in flow for "valued" species	Considerable amount of field work & expertise required; time consuming & expensive
Can address river specific issues in high-risk situations	Many modelling assumptions are not always considered, and uncertainty is often neglected
	Mis-application is common; amount of habitat is interpreted as abundance
	May lead to flat-lined environmental flows

Discussions

There were discussions that both the Meso and Habitat Simulation models have the same pitfalls because they both try to reduce costs. Meso takes a short cut to get the answers for large systems while Habitat modeling does not have habitat quality (habitat simulation modeling is more about habitat preference then actually reflecting habitat quality). However, both Meso and Habitat models can be wrong the least time compared to other methods and models. The Meso and Habitat models are tools used in the negotiation process for habitat assessments.

It was mentioned that modeling use to be expensive but with advances in technology and decreasing computing costs, the cost of 2D models are becoming cheaper for users. In reality with budget constraints, organization looking for efficiencies, it will be difficult to go out to lay transacts and make measurements these days of entire ravine systems, making validation of model data very important and a requirement.

If model data match in-situ data you will need to go to the biological to validate the biology aspect. If fish is involved in the method one will need to find out what the fish likes, then find out why (E.g. salmon is territorial while other fish is not). Although the habitat method may have the words "habitat" and "fish", people may want to use it because of the words. People think there is a link but there may not be. It is mostly the secondary benefit that is linked to fish.

There was agreement that more information is required for other fish other than salmon and that more preference curves are needed for difference fish. However, some of these preference curves of difference species studied in different areas may be transferable depending on how similar their habitat suitability criteria are.

Participants stated that the word “preference” in “preference curves” really means “association” and that transferring of habitat preference curves can be dangerous.

Collection of data for the system is needed if you cannot take a preference curve from some other similar system.

Participants also mentioned that if society does not want to pay to collect the proper data set before major project is done in a river then maybe the project should not be done. Participants at the workshop also agreed that proponents may say it is not their job to collect fish information/data for DFO. Participant agreed that this is the minimal method for a recipe for negotiating with proponents. This method can provide something in common to look at so people can have the same ideas and dollar amounts.

During the discussion a question was asked about what are the scientific criteria to determine flow related to a Harmful Alteration, Disruption or Destruction (HADD). The answer provided was that there are no guidelines for the criteria (e.g. species, life stages…etc). Stakeholders typically use consensus based on criteria and recognize that there is uncertainty in using such structured, decision making process to come up with consensus. A participant was mentioned that the state of Wyoming uses the Physical Habitat Simulation System (PHABSIM) with hydrology. PHABSIM is an interpretive tool, providing a problem-solving outline for water resource issues in streams and rivers as an aid to in-stream flow decision making.

Participants agree that there is a need for a checklist for each modeling technique. It is hoped that the research document will produce some guidelines and checklist to work from. Science should start to think about the data needs. Participant agree that part of the SAR should contain something about communicating information early to determine what data is required, particularly in regulated rivers because early data identification will provide better reporting.

Day 2

Before the presentations started on the second day further discussions and recap from the first day took place. The main points discussed were as follows:

- There needs to be another category “needs for validation” in the SAR;
- A bullet or something that says early and on-going engagement of managers and scientists in ecological flow assessment process should strongly be recommended in the SAR;
- A table of ecological requirements is not enough, Science needs to identify the minimum requirements for ecological flow;
- There is a need for a more strategic approach, for example a holistic approach method that gives consideration for ecological assessment within broader scale of water shed-scale planning;
- Efforts from science and management need to be scaled to the level of risk and uncertainty associated with the projects;
- Include ravine “category”
- Include consideration of “data availability”
- A question was asked about the category of rivers and if it would be possible to make the table based on their category.

- There were discussions about what engagement meant. Some agreed that engagement does not mean you need to wait until you have the project going. If there is an idea, there should be discussion about scale, project, and species….etc. In any publications there are bad, good and not so good. It is best to have early engagement to work out the best requirements.
- Participants agree that it is better to state up front the required method that should be used instead of using preliminary methods because any method or a combination of methods could be used. Most of the time the simplest methods may be used – if you tell proponents to use a preliminary method, proponents will use it and will not be happy when the preliminary method(s) are changed. Science should state how the method should be used and how it should be validated.
- There is a need to identify the questions “what is needed for the questions of the river (e.g. hydrology, morphology…). Then there are a number of methods that could provide some of the answers, and therefore not project driven but river driven questions.
- Instead of re-inventing the wheel, maybe publish material(s) should be referenced.
- Complete validation may not be possible until project(s) are complete. For example dams.
- Collection of baseline measurement should be encouraged to later assess the projects. To establish if the amount of data is sufficient for assumed solution(s) a power analysis on those data should be done. This will tell you how much data is needed.
- A question was raised, “Can data that was used to develop a model be used as validation data to modify the model?” Modeling experts confirmed that validation data is just used for validating and it has to be a separate data set from the data used for modeling.
- Science should provide what is scientifically sound for the various methods.

Discussions also identified that most systems are already altered. This guideline should provide identification of the steps that will lead people to go where you want them to go. It could also provide some qualifiers when you don’t need mitigation. It can also refer to the removal of water or change in geomorphology in order to determine something to compensate and not just a number. Science cannot say that these numbers are correct but at least provide detailed qualifiers for them. In the end the guideline will help point proponents to what data/information is required.

Dams and Hydro projects fall into a different category of its own because they are large projects and will be required to go through an Environmental Assessment process of their own.

HOLISTIC ASSESSMENT METHODOLOGIES

Presenter: T. Linnansaari
Rapporteur: Boumy Sayavong

Holistic methods are a group of methods contributing to environmental flow frameworks that attempts to maintain a natural hydrological regime to sustain healthy river and riparian ecosystems. Holistic methods merge human and ecosystem flow requirements into a seamless assessment framework. Holistic methods involve workshop settings with stakeholders and multi-disciplinary teams of experts on the basis of consensus, recommendations, develop an environmental flow standard. Whether bottom-up or top-down, all holistic approaches share some common properties regarding achievement, or maintenance, of ecological sustainability.

The common properties include:

1) Some components of the natural flow regime cannot be scaled down, and must be retained in their entirety;
2) Other components of the natural flow regime can be scaled down;

3) Other components of the natural flow regime can be omitted altogether; and,

4) The variability of the regulated flow regime should mimic that of the natural flow regime.

The author discusses four commonly used frameworks of the holistic method which include: Building Block Methodology (BBM); Downstream Response to Imposed Flow Transformation (DRIFT); Benchmarking and the derived frameworks; and, The Ecological Limits of Hydrologic Alteration (ELOHA) Approach.

The BBM uses an expert panel method. It does not consider scenarios, builds up “one and only” flow regime to keep a river in a predetermined condition. It has three main parts to it; data gathering, workshop and conflict resolution. It is time and resource consuming but a simplified BBM can also be used to simplify situations, identify important flow components where limited resources are available.

DRIFT builds upon BBM but is a top-down, interactive, scenario-based approach, designed for use in environmental flow negotiations. The DRIFT framework is comprehensive and includes major abiotic and biotic components that constitute the ecosystem. The DRIFT framework consists of four modules: Biophysical module; Sociological module; Scenario development; and, Economics. DRIFT methodology makes extensive use of expert knowledge, the guidelines for selecting scientific panel members for DRIFT projects are based upon the well-established protocols of the BBM. Considerable uncertainty in the decision-making is inevitable when the ecological consequences are predicted for the different species within each biotic component The DRIFT framework accounts for this uncertainty by using "severity ratings" and the predicted direction in change while the confidence level in all these decisions is also reported. When the different flow scenarios are contrasted, patterns in the direction of change and severity emerge, and can be used for making a decision between the scenarios despite the uncertainty.

Benchmarking evaluates the condition of a range of rivers (or river reaches) that have been subjected to various degrees of flow regulation and water resource development and their associated percentage of change in each flow from its natural value and link that to the observed ecological impact. These relationships (% change in flow statistic versus ecological impact) can be used for making probability statements about the ecological implications of altering a river’s flow regime by specified amounts compared to the natural regime.

The Ecological Limits of Hydrologic Alteration (ELOHA) Approach does not reveal any new flow assessment but is an approach that provides a consistent approach for analysis and synthesis of information to achieve a desired environmental flow. It consists of five steps that take into consideration scientific and social processes. These steps involves: hydrologic modelling; classification of rivers; the extent of alteration; establishing flow-ecological relationships; and, establishing environmental flow standards with subsequent monitoring and adaptive management.

Discussions

The problem with ELOHA is that there are very few examples with no examples from Canada. Costs and time requirement for an ELOHA will vary and will depend on availability of data and regions. An example was mentioned of a fast track system done on a 3000 km^2 example in Colorado cost approximately $200k. Most people are afraid of using the ELOHA because it is comparable to a large scale environmental assessment.

Participants asked how ELOHA can be used for project assessment because it is a true EA process. It is a comprehensive framework (a whole ecosystems approach) for assessment of a variety of environmental factors and these factors are determined by an expert panel, who will determine the process of the EA.

Participants mentioned that the ELOHA makes you think about the whole picture (holistic approach) but it is not always best to use it depending on the rivers and needs and is not well suited to un-developed systems. ELOHA could be useful in small rivers by focuses on establishing flow-ecology relationships recognizing that within the ELOHA framework, the flow requirements for fisheries would only serve as one input component for the assessment of fisheries flow requirements. The methodologies for the assessment of fisheries flow requirements should be consistent with broader-scale approached for the potentials inclusion in such holistic methods.

Table 3: Strengths, weaknesses and data requirements for holistic methods.

Strengths	Weaknesses
All-encompassing	Can be laborous, time-consuming, expensive
Flow alteration based on ecological considerations	Reliance on “experts”
Can use multiple inputs…all methods	

Criteria for the determination of potential impact (of flow alteration to fisheries)

There was agreement amongst participants based on current knowledge, flow discharge alteration less than 10% (instantaneous flow) relative to its “natural” flow regime have high probability of low or undetectable impact to ecosystems that support fisheries unless the application produces rigorous ecosystem-based studies which show otherwise. Instantaneous flow regime does need to be used (for example weekly, semi-weekly). For the purposes of this SAR, a “natural flow regime” is defined as observed “natural” flow data or “naturalized” (reconstructed hydrograph based on at least 20 years of continuous hydrological data) data. Technical guidelines for the creation of “naturalize” flow data should be recommended in the SAR and if possible the participants want the SAR to be a stand-alone document.

There was acknowledgement that winter flow data has more uncertainty due to ice, however it will be better than no data. Habitat Managers want daily flow or what is best available. There was agreement that risk to the ecosystems which support fisheries increases with increase alteration of flow (increases with cumulative levels of flow regime alteration). The group implied that if instantaneous flow regime is between 10% and 20% there is some risk. This framework focuses exclusive on flow modification and not potential associated impacts e.g. entrainment, fish kill, temperature etc. The SAR should include Canadian case references and reference Richter`s work.

In preparing for the Science Advisory Report (SAR) participants agreed that following types of systems below be exempted from the workshop’s discussion and approaches:

- Hydro diversion channels;
- Very small systems;
- Intermittent streams;
- Controlled systems; and,
- Non-fish bearing systems (unless downstream fishery).

In the suite of approaches the SAR in principle should:

- Give consideration to a “no go flow” for example in exceptional droughts, periods of historic low flow at which these rules do apply;
- Include qualifiers of mitigation (and compensation) in its recommendations;

- Have a table of Science recommendation(s) with exceptions if a project or projects fall outside of the exception to provide for some allowance and room for flexibility; and,
- Ensure tools that are being developed capture 80% of projects and not the 10% of small projects.
  - Maybe build on the cases of cut-off flow that provinces have who have to deal with the fisheries and not the water resource (for example cut-off in flow that affect the fisheries);
  - Classification is a policy decision. The Science should be the same and should not depend of the classifications of the system;
  - Two potential uses of river classification (their hydrology –Pristine vs altered);
  - Risk management assessments will take care of most large projects; and
  - Conditions of directing the use of detailed methods:
    a) Hydro-electric,
    b) Consideration of non-fish bearing system (unless there is downstream fisheries).

To preserve ravine ecosystem structure and function that support fisheries the group felt text is needed in the SAR to define the cut-off limit to protect fisheries during extreme low flow events. Some provinces currently have methodology to determine this cut-off limit. Should the use of provincial cut-off limits be used if they have them and will the SAR limit supersede it? The SAR should mention that "cut-offs" do exist within the provinces. Currently Science does not have a cut-off number, provinces have it. For provinces that do not, the SAR should mention that this is important and a standard should be developed.

The group agrees that there is science to support natural flow regimes to sustain fisheries and the ecosystem structure and functions which support them. The group supports in addition to screening criteria if a proposed water obstruction exceeds cumulative water use >10% of instantaneous and < 30% of the Mean Annual Discharge (MAD) a rigorous level of assessment should be required to evaluate potential impacts on ecosystem functions that sustain fisheries, including identification of mitigation measures as it heightens the risk of impacts to ecosystems that support fisheries.

There is science to support that rivers do need low level times. If projects require water at extreme low conditions, the proponents are required to provide justification and science needs to support this.

In the absence of such a discrete cut-off, water extraction beyond hydrologic "base flow" is discouraged as this would subject ecosystems that support fisheries to a high level of risk. There was some debate as whether to use 10% instantaneous flow or some other number. There was agreement that if another instantaneous flow great then 10% were to be used the burden should be on the proponents to provide the scientific evidence that states the suggested flow rate does not impact the ecosystems that supports fishery of the system of interest.

SUMMARY OF IFN APPROACHES IN VARIOUS PROVINCIAL AND INTERNATIONAL JURISDICTIONS

Environmental Flow Needs (EFN) Assessment in support of water licensing decisions in British Columbia

Presenter: S. Babakaiff
Rapporteur: Boumy Sayavong

Hatfield et al. (2003) and Lewis et al (2004) served as primary guidance for in-stream flow studies in British Columbia but the consistent guideline application was challenging to many users due to the document's length and its implementation was least to a few agency personnel with sufficient expertise.

The province distilled the guidelines further to only a few pages which consisted on check list style processes and procedures. In general five main steps are required. They are:

- Description of methods & results for all info needs relevant to determining the effects of flow alterations on fish & fish habitat (e.g. hydrology, geomorphology);
- Presentation and analysis of microhabitat data including:
    a) Tables of transect-specific data such as geo-referenced transect location, channel width (m), wetted width (m), mean depth (m), mean velocity (m sec-1), and useable weighted width (m). Discuss transect sites selection, and the 'representative-ness' of these habitats within the diversion reach.
    b) Plots of wetted width, mean depth, mean velocity, and useable weighted width as a function of flow for each transect.
- Application of the ten general steps for detailed assessment (per Section 4.1.10.1 of Lewis et al. 2004), and provide all requisite tables & graphics;
- Calculation of statistical confidence for each component of the analysis, including the empirical relationship between habitat & flow, and a comparison of impact magnitude and statistical confidence intervals; and
- Discussion of the biological significance of changes in comparison to the results of similar studies in the grey or scientific literature.

The proposed Water Sustainability Act & associated policy will obligate SDMs to consider EFN consistently in allocation decisions. Water Licence Application submitted to FrontCounter B.C. will be requested for their water uses within *Quick Licensing* thresholds & within Groundwater exemption threshold. If it is within the exemption it will be up to the SDM's discretion to consider EFNs. However if is above the exemption limit the SDM will review application using Risk Management Framework to resolve if risk factors to stream health. If the factors to stream health are low to moderate, SDM applies a desk-top analysis using the EFN Desk-Top Tool for most applications. If the application is high risk, applicants will be required to complete a detailed information checklist for EFN assessment. B.C.'s quick licensing thresholds, risk management framework and detailed information checklist are still being finalized as of March 2012.

A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams

Presenter: A. Locke
Rapporteur: Boumy Sayavong

Standardize methods and site specific studies provincial wide can be costly. To be efficient, economical and scientifically defensible Alberta uses the Desk-top Method

to establish environmental flows in Alberta's rivers and streams. The level of environmental flow recommended by the Alberta Desktop Method is the greater of either:

- A 15% instantaneous reduction from natural flow; or,
- The lesser of either the natural flow or the 80% exceedance natural flow based on a weekly or monthly (depending on the availability of hydrology data) time step.

The intent is full protection of the aquatic environment in the absence of having site-specific information that could otherwise be used to establish an environment flow. The Alberta Desktop Method was developed with the intent that by staying within recommended limits, there is a very low probability of ecological effects to the aquatic environment (full aquatic ecosystem protection). It achieves this by preserving not only water quantity within the stream, but also the natural fluctuations that occur day to day, including peak events. The Environmental Flow recommendation specifies for the lowest flows that occur up to 20% of the time, no abstractions of water should be permitted – providing an ecosystem baseflow. For the remaining 80% of the time when flows are higher, up to 15% of the natural flow can be taken (leaving 85% of water in-stream).

Assessing the alteration of rivers in Ontario

Presenter: R. Metcalfe
Rapporteur: Boumy Sayavong

The presenter provided relevant Legislation regarding flowing waters. They included:

- Lakes and Rivers Improvement Act (MNR);
- Ontario Water Resources Act (MOE);
- Clean Water Act (MOE);
- Endangered Species Act (MNR); and,
- Lake Simcoe Protection Act (MOE).

In Ontario the following principles are followed to ensure the framework informs application review, construction, redevelopment, and operation of dams:

- Develop a practical science-based approach to assess the potential effects of dam construction and operation on aquatic ecosystems;
- Develop technical advice that is flexible to varying spatial and temporal scales and development structures and operations; and
- Develop a framework that is consistent and transparent in its application.

There is a need to know the ecological condition that will be associated with a specific degree of alteration and describe it in a way that management and the public understand. Their main framework tries to answer key questions about current and future conditions:

- What does the system look like now (physical, chemical, biological characteristics)? <u>*current condition*</u>
- If already altered, what did the system look like before it was altered? <u>*reference condition*</u>
- What is the planned development (including its operation)?
- How will those characteristics change with the planned development? <u>*future condition*</u>
- Can the expected changes be mitigated? If yes, re-evaluate expected changes.
- What does the system look like after the alteration?

Review of select international best practices – Examples from the United Sates

Presenter: T. Annear
Rapporteur: Boumy Sayavong

The presenter provided a brief review of instream flow methods and approaches from the United States realizing that there are several levels of protection each of which can be viewed as success or failure depending on a person or group's perspective.

In many cases throughout the U.S. streams are afforded only the most basic instream flow protection while allowing depletion of higher flows that may be essential to maintaining historic ecosystem function. He stated that it is often too late to correct these oversights by the time the public realizes what's happened and one should always seek the highest level of instream flow protection whenever possible. The models used in the state of Wyoming include the use of the following:

- Hydraulic model (habitat retention);
- Hydrologic model (20% Exceedence);
- Multiple correlation habitat model (HQI);
- PHABSIM (1-Dimensional model); and,
- River 2-D (2- Dimensional model).

These strategies are used for securing instream flow water rights according to standards acceptable to the Wyoming State Engineer's Office. The recommendation for the winter period is structured to essentially ensure no extraction of water during ice-prone times of year.

Table 4: Example of Life Stages and Fishery Function

Life stage and Fishery Function	Over-Winter Oct 1 – Mar 31	Early Spring Apr 1 – May 14	Spring May 15 – Jun 30	Summer Jul 1 – Sep 30
Survival of all life stages	1	2	2	2
Connectivity between habitats for adult & juvenile CRC	2	2	2	2
Spawning & incubation			3	
Adult & juvenile growth				4
All life stages habitat*		5	5	
1=Natural 20% exceedance flow or Habitat Retention, whichever is greater	2=Habitat Retention	3=Physical Habitat Simulation	4=Habitat Quality Index	5=Channel Maintenance

RESIZING A RIVER: USING ADAPTIVE MANAGEMENT TO DEVELOP A DOWNSCALED FLOW REGIME IN A REGULATED RIVER

Presenter: Mike Bradford
Rapporteur: Boumy Sayavong

The presenter states that setting environmental flow regimes is a significant challenge for water managers due. The challenge is due to two main things:

a) Differences in the value of water to different people;

b) There is significant scientific uncertainty about the response of the ecosystem to flow regimes.

He provided a case study from the Lower Bridge River in British Columbia which has high stakes in environmental value, financial value from hydro power and social interests. The author was able to do some monitoring as to whether flow affects habitat quality because the system can be manipulated in a controllable scale to study the flow issue without interference of the operation of the hydro system.

They found from the results of monitoring that habitat quality is constant and fish production is a direct function of the relationship between wetted area and flow. When the channel is rewetted it quickly became functional. They also found that habitat quality change with flow, and after some threshold point this causes a net reduction in fish production.

Rigorous adaptive management is frequently recommended and but less frequently implemented as an approach to establish flows because long trials are difficult to sustain but is good learning benefit for stakeholders and participants.

COMPARISON OF HYDRODYNAMIC AND HABITAT ESTIMATES

Presenter: H. Ghamry
Rapporteur: Boumy Sayavong

The relationship between aquatic habitat and river discharge frequently relies on hydrodynamic modeling. The presenter conducted two hydrometric surveys in the Northlands reach of the Athabasca River during the winter with ice-covered conditions five-years apart (2004 and 2009). These surveys were used as calibration for the River2D model and then the model was used to predict the measured flow conditions from other surveys to assess or validate the accuracy of the model's predictions over time.

River2D is a two-dimensional finite element depth averaged model. It is based on De St. Venant equations. River2D assumes a uniform flow over the depth and hydrostatic pressure distribution. River2D has modules to predict hydrodynamic for ice-free and ice covered cases, and to simulate habitat (WUA calculation using HSI from the three separate suitability indices (for depth, velocity, and channel index). An applied range of flows varied from 50-250 m^3/s (daily discharge ranges from 75 to 250 m^3/s from 1957-2009 at Northlands according to Water Survey of Canada) was investigated. Based on the model, the ratio of wetted/total area based on contours of depth (0.2-3.4 m) or velocity (0.1-1.0 m/s) had estimated errors within 5.6% and 15.7%, respectively.

Comparisons of the predictions of total river reach wetted areas and the life stage and species specific WUAs for adult walleye, longnose sucker, and Northern pike distributions were carried out as well for the two 2004 and 2009 observations. For adult walleye, error estimates for the ratio of WUA/total wetted area were within 3.4% and 7.6%. Similarly, the corresponding error estimates for the same ratio were 4.5% and 14.1% for adult longnose sucker and 3.1% and 6.8% for Northern pike.

The presenter suggests his results support the validity of the River2D predictions as the error estimates were still within reasonable values or limits.

APPENDIX 1: TERMS OF REFERENCE

Standardized Framework for the Assessment of Instream Flow Needs in Canada

National Peer Review – National Capital Region

March 6-8, 2012
Montréal, QC

Chairpersons: Keith Clarke and Roger Wysocki

Context

Fisheries and Oceans Canada (DFO) Habitat Managers seek scientific guidance and advice regarding a standardized approach to assessing instream flow needs (IFN) for fish and fish habitat in Canada. This standardized framework for the assessment of instream flow needs must consider the diversity of aquatic (riverine) ecosystems in Canada.

DFO Habitat Policy and Habitat Management would like to move towards a more standardized approach to delivery of their program, from both the perspectives of (i) technical standards, and (ii) process standards (including methodologies and information requirements). In order to provide for more consistent review of instream flow requirements, a review of the science regarding instream flow needs is sought, along with technical guidance towards a more standardized assessment and evaluation for the protection and conservation of fish and fish habitat.

Research Document: The Canadian Rivers Institute of the University of New Brunswick has produced a Working Paper "Review of approaches and methods to assess Environmental Flows across Canada and internationally" which will serve as scientific input for this CSAS process.

Objectives

1) Peer review the Research Document indicated above.
2) Review and clarify the various definitions and terminologies commonly used in IFN methods/assessments.
3) Review and compare the various IFN methodologies, including the benefits and assumptions of each, and situations under which they are most appropriate and for which management purposes they were designed.
4) Provide technical recommendations towards the standard(ized) assessment of IFN for the management of fish and fish habitat in the Canada, including:
    - Pan-Canadian Framework with regionalization based on river (hydrological/flow regime/ecological) regions/types (suggested flow-chart/infographic);
    - IFN monitoring considerations and adaptive management;
    - Addressing data gaps in Canada and knowledge gaps in general; and
    - Addressing uncertainty in IFN assessment.

Expected Publications

- Science Advisory Report (SAR)
- Proceedings
- Research Document(s).

Participants

- DFO Science
- External experts
- Academia
- DFO Habitat Managers

APPENDIX 2: AGENDA

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat (CSAS)
National Science Advisory Workshop

Standardized Framework for the Assessment of Instream Flow Needs (IFN) in Canada

Marriott Château Champlain, Maisonneuve D
1 Place du Canada, Montréal, QC Canada H3B 4C9
Ph : 1-514-878- 9000
March 6-8, 2012

Time	**Tuesday March 6, 2012**
8:30 – 10:00	o Introduction to CSAS advisory process o Introduction of participants o Review Terms of Reference o Overview of goals and objectives of meeting o Review objectives of Habitat Policy (Director, Habitat Policy)
10:30	Break
10:30 – 12:00	o Presentation of main working paper (Dr. Tommi Linnansaari) o Section 1 – Introduction and Terminology o Section 2 – Broad categories of IFN methodologies
12:00 – 1:00	Lunch Break
1:00 – 2:30	o Section 3 – Hydrologic methods o Section 4 – Hydraulic / channel morphology o Discussion, Questions and Summary Points
2:30 – 3:00	Break
3:00 – 4:30	o Section 5 – Habitat Simulation models o Discuss scientific advice and guidance

Time	**Wednesday March 7th**
8:30 – 10:00	o Re-cap of day 1 (progress) o Section 6 – “Holistic” assessment methodologies
10:00 – 10:30	Break
10:30 – 12:00	o Summary of IFN methods in various Fed-Prov. jurisdictions o Review of select international best practices o Discuss scientific advice and guidance.
12:00 – 1:00	Lunch Break

Time	Wednesday March 7th
1:00 – 2:30	o Presentations #2-3 o Dr. Mike Bradford (Bradford 2011) o Dr. Haitham Ghamry o Discussion, Questions and Summary Points
2:30 – 3:00	Break
3:00 – 4:30	o Recommendations for IFN assessment in Canada o Discussion, Questions and Summary Points (advice)

Time	Thursday March 8th
8:30 – 10:00	o Re-cap of days 1 and 2 o Drafting of Science Advisory Report (SAR)
10:30	Break
11:00 – 12:00	o Drafting of Science Advisory Report (SAR) o Review of summary bullets of SAR
12:00 – 2:30	End of Workshop

APPENDIX 3: LIST OF PARTICIPANTS

Name	Affiliation
External academics or experts	
Tommi Linansaari (key presenter)	UNB
Donald Baird	UNB/EC
Wendy Monk	UNB
Tom Gleeson	McGill, geomorph
Daniel Boisclair	U de M; HydroNet
André St. Hilaire (first day only)	INRS; CWRI
Mathieu Lebel	WWF
Jack Imhof	Univ. of Guelph; TU
Allen Curry	UNB, CRI
Gilles Olivier	Risk expert
International experts	
Tom Annear	Wyoming Fish and Game
Provinces	
Allan Locke	Province of Alberta
Bob Metcalfe	Ontario
Scott Babakaiff	BC
DFO Science Participants	
Keith Clarke	NF&L
Karen Smokorowski	C&A
Mike Bradford	Pacific
Robert Randall	C&A
Daniel Caissie	Gulf
Haitham Ghamry	C&A
Neil Mochnacz	C&A
Mike Stoneman	NHQ
Doug Watkinson	C&A
Boumy Sayavong	NHQ, rapporteur
Roger Wysocki	NHQ, Co-Chair
DFO Habitat Management	
Simon Trepanier	QC
Dean Watts	Pac
Brian Makowecki	C&A
Jim Elliott or Stuart Dean	NHQ Operations
Neil Fisher	HQ Policy
Lonnie King	HQ Policy
Nick Winfield	HQ Policy