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Summary report Workshop 3: Refining hypotheses and identifying flow needs

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UNB

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Disclaimer

This report is intended to provide a brief summary of the third environmental flows workshop. The information presented in this report provides generic summary information, and is not in any way intended as an alternative to proactive consultation with regulatory authorities. The information contained herein does not necessarily represent the opinion of the Canadian Rivers Institute.

Acknowledgements

We would like to thank the participants at the third flow-ecology workshop held on the 3rd November 2016 for their significant contributions to the discussion.

We would also like to acknowledge the Nature Conservancy for their continued support of the project. The Nature Conservancy shared their experiences and background material from their previous environmental flow workshops.

List of acronyms

CRI	Canadian Rivers Institute
CRI SINLAB	Canadian Rivers Institute – Stable Isotopes in Nature Laboratory
ECCC	Environment and Climate Change Canada
ELOHA	Ecological Limits of Hydrologic Alteration
MAES	Mactaquac Aquatic Ecosystem Study
MGS	Mactaquac Generating Station
NBP	New Brunswick Power
SJR	Saint John River
UNB	University of New Brunswick

Workshop 3 background

The Mactaquac Generating Station (MGS), a 672 MW run-of-the-river hydroelectric facility, was constructed in 1968 on the mainstem of the Saint John River (SJR) and is owned and operated by New Brunswick Power (NBP). NBP initiated a process to explore three options for the future of MGS: (i) repowering the station with a new powerhouse and spillway; (ii) rebuilding the spillway only; or (iii) removing all parts of the station. A fourth option has recently been added to extend the life of the existing generation station beyond 2030 through removing and replacing concrete and equipment in the existing structure.

Integrating an understanding of the natural variability in the both intra- and inter-annual flow regimes into a management framework is critical for maintaining short- and long-term habitat complexity and connectivity, and can be directly and indirectly linked to ecosystem integrity and life history patterns, for example spawning and recruitment cues. Developing testable hypothesised associations between flow and thermal regimes, aquatic and riparian habitats, and ecosystem integrity is a key component in the development of sustainable holistic environmental flow approaches (e.g. Poff et al. 2010). The holistic approach proposed through the Ecological Limits of Hydrologic Alteration (ELOHA) allows for the development of testable hypotheses focused on specific flow components within identified major habitat types targeted at a local or sub-regional scale (Poff et al. 2010).

Workshop objectives

With the proposed options of either repowering or rebuilding the MGS or components of the MGS, there is a clear opportunity to develop a sustainable environmental flows strategy for the future of the Wolastoq / Saint John River / Fleuve Saint-Jean. Building on material developed during Workshop 1 (June 2015) and Workshop 2 (October 2015) paired with pre-workshop assignments, the third workshop will focus on:

1. Using expert knowledge and group discussion to refine flow-ecology and temperature-ecology hypotheses within target flow components;
2. Developing broad flow and temperature needs; and
3. Identifying potential variables for the long-term monitoring and assessment of the Saint John River.

Appendices 1, 2 and 3 provide a summary of the workshop outline, revised background materials in addition to a list of participants.

Workshop summary

Through four highly productive discussion breakout groups, the 35 participants of the second flow-ecology workshop identified more than 500 separate flow-ecology hypotheses across six target habitat types (large tributary and main channel, medium tributaries, small tributaries and headwaters, island habitats, floodplain forests and riparian wetland) and four flow types (low, high, seasonal and ice-affected flows). These hypotheses formed the basis for the third environmental flows workshop.

For the third workshop, the majority of the 12 participants were assigned a subset of the >500 hypotheses targeted at their area of study and research expertise. During the workshop, each participant led a detailed scientific discussion about their hypothesis subset resulting in a final

subset of refined or combined hypothesis statements. Additionally, cause-effect linkage statements were proposed and refined for the majority of the hypotheses, which will help in the assessment of the hypothesis statements. Finally, a number of broad flow and temperature needs were identified which will form the base for the identification of key variables for the long-term monitoring of the proposed environmental flows framework.

Conclusions and next steps

The workshop discussion was highly productive and resulted in the refinement of flow-ecology hypotheses, the identification of cause-effect statements and the proposed broad flow needs statements for the SJR. This information will form the basis of tailored flow recommendations and flow statistics in the final strategy. The data acquired from the wider literature and discussions across the three workshops will be incorporated into the final environmental flows strategy for the Saint John River.

References

CRI. 2015. "Mactaquac Aquatic Ecosystem Study. http://canadianriversinstitute.com/research/mactaquac-aquatic-ecosystem-study/.

NB Power. 2015. "Mactaquac Project." http://www.mactaquac.ca/.

Poff, N. L., Richter, B. D., Arthington, A. H., Bunn, S. E., Naiman, R. J., Kendy, E., Acreman, M., et al. 2010. "The Ecological Limits of Hydrologic Alteration (ELOHA): A new framework for developing regional environmental flow standards." Freshwater Biology 55: 147–70.

Appendix 1. Workshop 3 agenda.

8.30am - 8.50am	Welcome and review of Workshop 2 outputs
8.50am - 10.30am	Group discussion: Flow-ecology and temperature-ecology hypotheses
10.30m - 10.45am	Health break
10.45am - 12pm	Group discussion: Flow-ecology and temperature-ecology hypotheses
12pm - 1pm	Lunch provided
1pm - 2.30pm	Group discussion: Developing broad flow and temperature needs
2.30pm - 2.45pm	Health break
2.45pm - 4.20pm	Group discussion: Identifying potential variables for the long-term monitoring and assessment
4.20pm - 4.30pm	Final workshop remarks

Appendix 2. List of Workshop 3 participants and their affiliation

Participant	Organisation
Donald Baird	ECCC, UNB, CRI, MAES
Anthony Bielecki	NB Power
Meghann Bruce	UNB, CRI, MAES
Zacchaeus Compson	UNB, CRI, MAES
Allen Curry	UNB, CRI, MAES
Colin Curry	ECCC, CRI
Mat Gorman	NB Power
Brian Hayden	CRI SINLAB, UNB, CRI
Tommi Linnansaari	UNB, CRI, MAES
Wendy Monk	UNB, CRI, MAES
Daniel Peters	ECCC
Gordon Yamazaki	UNB, CRI, MAES

Appendix 3. Workshop 3 background materials provided to workshop participants (developed by Wendy Monk)

Workshop background material

The following information can be used to support the refinement of the flow-ecology and temperature-ecology hypotheses. These materials are an updated subset of those provided for Workshop 2.

- Figure 1 provides a broad schematic of the latitudinal and longitudinal connectivity among the major draft habitat types identified for the Saint John River during Workshop 1.
- Tables 1 - 4 summarises the vegetation, benthic macroinvertebrates, fish and mussel taxa groups, their shared traits, and example taxa within each group. Note that not all of the taxa within the Saint John River demonstrate sensitivities to flow and temperature but can be discussed in the context of the wider ecological community.
- Figures 2 - 4 are example hydrographs for the major draft habitat types summarising key hydrological components including seasonal and long-term flow variability.
- Tables 5 - 8 summarise the trait groups of vegetation, benthic macroinvertebrates, fish and freshwater mussel groups and indicate which taxa occur within each major draft habitat type.

Major draft habitat types

The classification of aquatic and riparian habitats within the ELOHA framework helps to broaden the application of the developed flow-ecological and temperature-ecology response associations to streams and rivers across a wider geographical area (Poff et al. 2010). Extensive discussion during break-out group sessions during Workshop 1 identified six major draft habitat types within the Saint John River watershed (Figure 1):

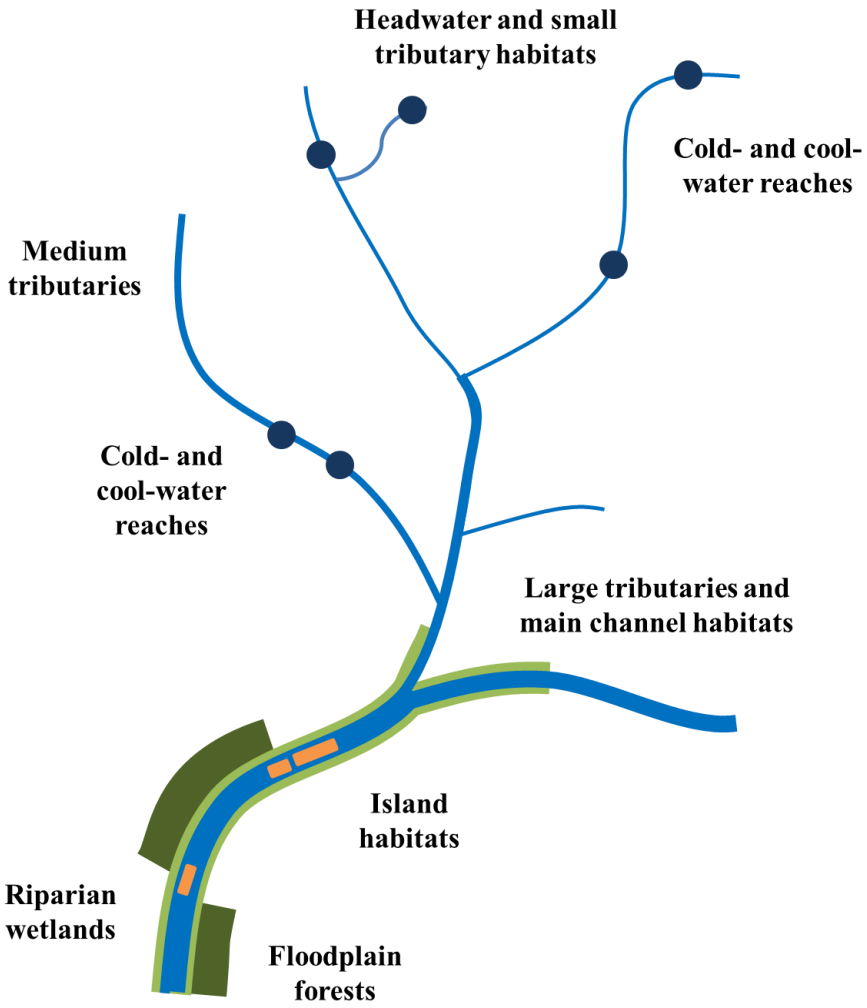

Figure 1: Schematic identifying the longitudinal and lateral connections among the major draft habitat types identified during Workshop 1

1. **Headwater (<20km²) and small tributary (<250km²) habitats [including cold- and cool-water reaches]**: Typically perennial conditions; few mussels; high macroinvertebrate diversity; withdrawals could lead to seasonal flow depletion in dry seasons/years; cold- and cool- water habitats are critical for spawning and rearing habitats for key taxa, and provide refuge during high temperature events.

2. **Medium tributaries (<1500km²) [including cold- and cool-water reaches]**: Perennial conditions; stream channels are well defined and have higher morphological complexity; high fish and mussel diversity; some floodplain development in lower reaches; cold- and cool- water habitats are critical for spawning and rearing habitats for key taxa, and provide refuge during high temperature events.

3. **Large tributaries (<2500km²) and main channel habitat**: Providing important habitat diversity for rare species; perennial conditions; high fish and mussel diversity; complex

stream channels including margins, islands and backwater habitats; expansive floodplains; often influenced by flood control and hydropower operations.

4. **Mainstem island habitats**: Unique habitats with direct linkages with flow regime variability; provide flow refugia for both aquatic and terrestrial taxa; important for rearing edge habitat for key taxa; hydrologically-complex habitat mosaic within channel; susceptible to loss of habitat with development of hydropower.

5. **Riparian wetlands**: Refugia during high water events; critical feeding, spawning and rearing habitat for key species; important lateral connection between riparian and aquatic habitats; relatively high biodiversity; can be sinks/sources for sediments, nutrients, etc. depending on connectivity; can help attenuate flood pulse.

6. **Floodplain forests**: Unique highly diverse ecosystem; offers stable habitat containing rare species; key linkage between terrestrial and aquatic habitats; periodically connected at higher flows to main channel; limited occurrence in Atlantic Canada; susceptible to invasions by non-native species due to high edge:interior ratio.

Table 1: Examples of shared traits and example taxa for benthic macroinvertebrate groups in the Saint John River watershed

Taxa (traits)	Groups and examples
Benthic macroinvertebrates (energy environment, substrate, habitat association, velocity and thermal niche)	**Benthic macroinvertebrate taxa associated with high energy, flowing waters**: occurring in high energy, dynamic substrates consisting of cobbles and boulders of streams and rivers e.g. Sallflies (Chloroperlidae), Net-spinning caddisfly (Hydropsychidae), Golden stonefly (Perlidae), Winter stoneflies (Taeniopterygidae), Blue-winged Olives (Baetidae), Apple caddisfly (Brachycentridae)
	Benthic macroinvertebrate taxa associated with moderate to low energy, stable substrate, flowing waters: occurring in moderate to low energy, stable substrates consisting of gravels and cobbles in flowing waters. Found in the downstream reaches of small rivers and the stable back channel, low gradient areas of large rivers e.g. Spiketails (Cordulegastridae), Tube-making caddisfly (Polycentropodidae), Clubtail (Gomphidae), Fingernet caddisfly (Philopotamidae)
	Benthic macroinvertebrate taxa associated with slow flow areas, vegetated backwaters: low gradient backwater, backchannel, sloughs of medium to large rivers as well as lakes and ponds. Usually confined to slow-moving portions of riverine environments in sandy or muddy substrates with a tolerance for heavy detritus, aquatic vegetation, and warmer water e.g. Angler's Curse (Caenidae), Long-horned caddisfly (Leptoceridae), Ramshorn snail (Planorbidae), Northern caddisfly (Limnephilidae)

Table 2: Examples of shared traits and example taxa for mussel groups in the Saint John River watershed

Taxa (traits)	Groups and examples
Mussels (energy environment, substrate, habitat association, velocity and thermal niche, silt tolerance)	**Freshwater mussel associated with very high energy, cold, clear, flowing waters**: mussel habitat specialist, occurring in very high energy, stable boulder substrates of cold water streams and rivers. Often co-occurs with trout habitat e.g. Eastern Pearlshell (*Margaritifera margaritifera*)
	Freshwater mussels associated with high energy, dynamic substrate, flowing waters: mussel species occurring in high energy, dynamic cobbles and boulders substrates of streams and rivers e.g. Alewife Floater (*Anodonta implicata*), Eastern Elliptio (*Elliptio complanata*)
	Freshwater mussels associated with moderate to low energy, stable substrate, flowing waters: Freshwater mussels occurring in moderate to low energy, stable substrates consisting of gravels and cobbles, in flowing waters. Found in the downstream reaches of small rivers and the stable back channel, low gradient areas of large rivers e.g. Brook Floater (*Alasmidonta varicose*), Triangle Floater (*Alasmidonta undulata*)
	Freshwater mussel associated with stagnant, vegetated backwaters: mussel preferring low gradient backwater, backchannel, sloughs of medium to large rivers as well as lakes, ponds, and marshes. Usually confined to slow-moving portions of riverine environments, in sandy or muddy substrates, with a tolerance for heavy detritus, aquatic vegetation, and warmer water e.g. Eastern Floater (*Pyganodon cataracta*)

Table 3: Examples of shared traits and example taxa for vegetation groups in the Saint John River watershed

Taxa (traits)		Groups and examples
Vegetation (inundation tolerance, frequency and severity of flood scour, seed dispersal, disturbance regime)	**Submerged aquatic vegetation**	**Submerged aquatic vegetation associated with riffles**: submerged aquatic vegetation occurring in the relatively shallow, fast moving waters of medium to large rivers e.g. Fountain moss *(Fontinalis sp.)*
		Submerged aquatic vegetation associated with runs: submerged aquatic vegetation occurring in moderately deep, moderate currents of medium to large rivers. Diverse vegetation community e.g. Water stargrass (*Heteranthera dubia*)
		Submerged aquatic vegetation associated with pools: submerged aquatic vegetation occurring in the relatively deep slow moving water of medium to large rivers. Diversity may be low, while abundance can be high e.g. Waterweed (*Elodea nuttallii*, *Elodea canadensis*), Eel grass (*Vallisneria americana*), some water milfoils (e.g. *Myriophyllum farwellii*)
	Emergent aquatic vegetation	**Emergent vegetation**: emergent vegetation occurring in slow moving areas of medium to large rivers. These areas include shorelines, side and back channels areas, and the confluence areas of major tributaries. Water levels may fluctuate seasonally, but the substrate is seldom dry. Typically a mixture of submerged and free-floating aquatic species e.g. Spatterdock (*Nuphar variegata*), Common bladderwort (*Utricularia macrorhiza*), some water milfoils (eg. *Myriophyllum alterniflorum* and *M. sibericum*)
	Floodplain and riparian vegetation	**Shoreline and scour vegetation**: periodically exposed shorelines and stream margins maintained by severe flooding and scour e.g. Furbish's lousewort (*Pedicularis furbishiae*)
		Floodplain vegetation: annual spring flooding and prolonged inundation by flood waters, highly fertile floodplain soils which host characteristic plant assemblages of flood-tolerant trees and shrubs and emergent and submerged plants e.g. Speckled alder (*Alnus incana*), Black willow (*Salix nigra*), Silver maple (*Acer saccharinum*), Butternut (*Juglans cinerea*)
		Wetland vegetation: occurring within the riparian corridor along the stream networks, unique array of wetland habitats including swamps, marshes, fens, flooded meadows, shallow lakes and marsh islands, high number of priority taxa associated with wetland habitat e.g. Arrowhead (*Sagittaria latifolia*) Willow spp. (*Salix spp.*), Meadowsweet (*Spiraea alba*)

Table 4: Examples of shared traits and example taxa for fish groups in the Saint John River watershed

Taxa (traits)	Groups and examples
Fish (body size, home range, habitat association, feeding habit, velocity and thermal niche)	**Cold- and cool-water fish**: Presence limited by low temperature thresholds e.g. Brook trout (*Salvelinus fontinalis*), Brown trout (*Salmo trutta*), Slimy sculpin (*Cottus cognatus*)
	Riffle obligate fish: Small bodied, flow velocity specialists, riffle/run habitat e.g. juvenile Atlantic salmon (*Salmo salar*) and Blacknose dace (*Rhinichthys atratulus*)
	Nest building fish: Sensitivity to flow conditions (esp. stranding) during nest building, spawning and egg and larval development; diverse nesting strategies e.g. Creek chub (*Semotilus atromaculatus*), Redbreast sunfish (*Lepomis auritus*), Smallmouth bass (*Micropterus dolomieui*)
	Resident fish with defined spawning migrations: : large home range species, requiring connectivity between mainstem and small river habitats during spawning migrations e.g. White sucker (*Catostomus commersonii*)
	Pool associate species: Large bodied fish that occupy deep, slow moving bodies of water e.g. adult Atlantic salmon (*S. salar*), adult White sucker (*C. commersonii*)
	Diadromous fish: large-bodied fish that require connectivity between mainstem and tributary habitats for spawning and nursery habitat e.g. American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), or require specific flow conditions to ensure successful egg development e.g. Shortnose sturgeon (*Acipenser brevirostrum*), Striped bass (*Morone saxatilis*)
	River margin or backchannel species: Juvenile life stages of various species requiring shallow, slow moving habitats with adequate macrophyte cover for refugia e.g. cyprinid family (shiner spp., dace spp.) and pike family.
	Vegetation spawners: Fish that rely on either spring flows to flood emergent vegetation for spawning e.g. Yellow perch (*Perca flavescens*), Chain pickerel (*Esox niger*), Muskellunge (*Esox masquinongy*) or require inundated macrophytes or filamentous algae for spawning in summer months e.g. Golden shiner (*Notemigonus crysoleucas*)
	Cold- and cool-water fish: Presence limited by low temperature thresholds e.g. Brook trout (*Salvelinus fontinalis*), Brown trout (*Salmo trutta*), Slimy sculpin (*Cottus cognatus*)

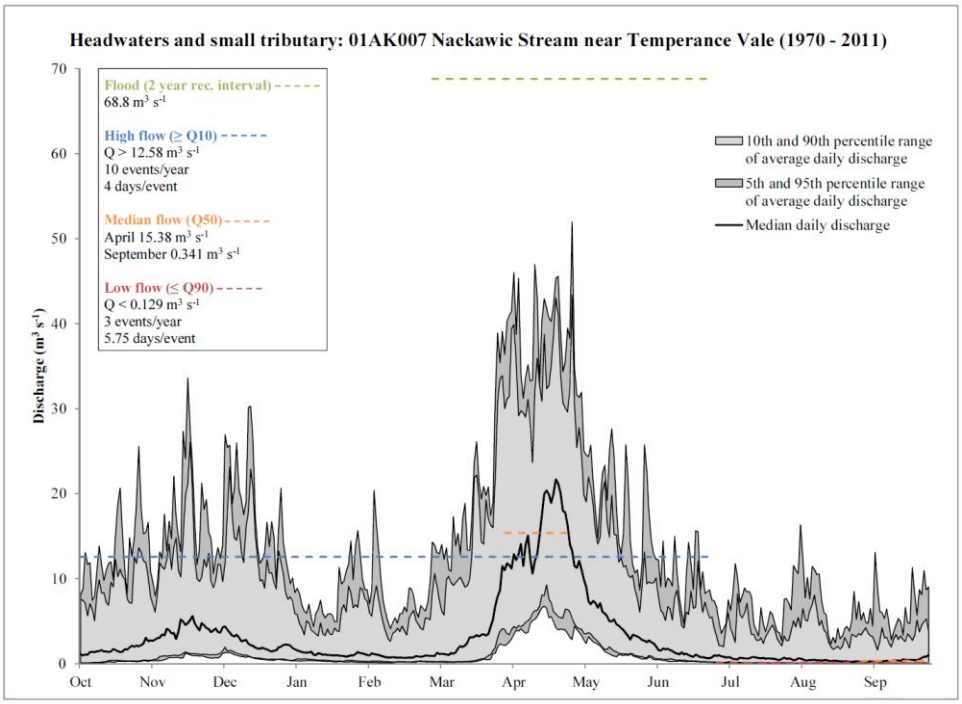

Figure 2: Example of hydrograph for headwaters and small tributary habitat (01AK007 Nackawic Stream near Temperance Vale, 1970 - 2011)

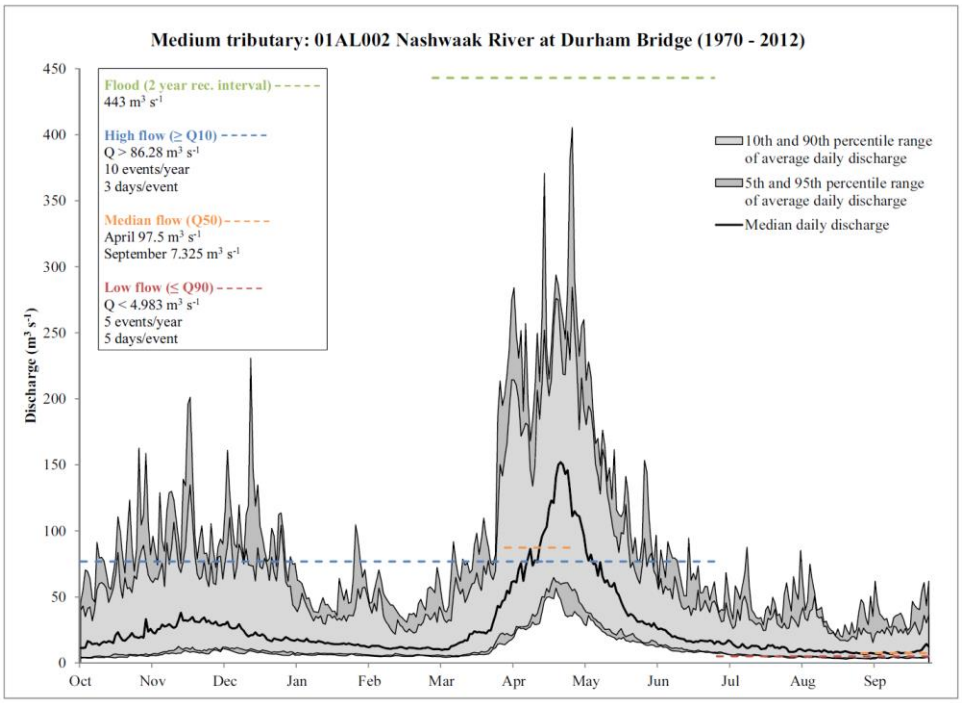

Figure 3: Example of hydrograph for medium tributary habitat (01AL002 Nashwaak River at Durham Bridge, 1970 - 2012)

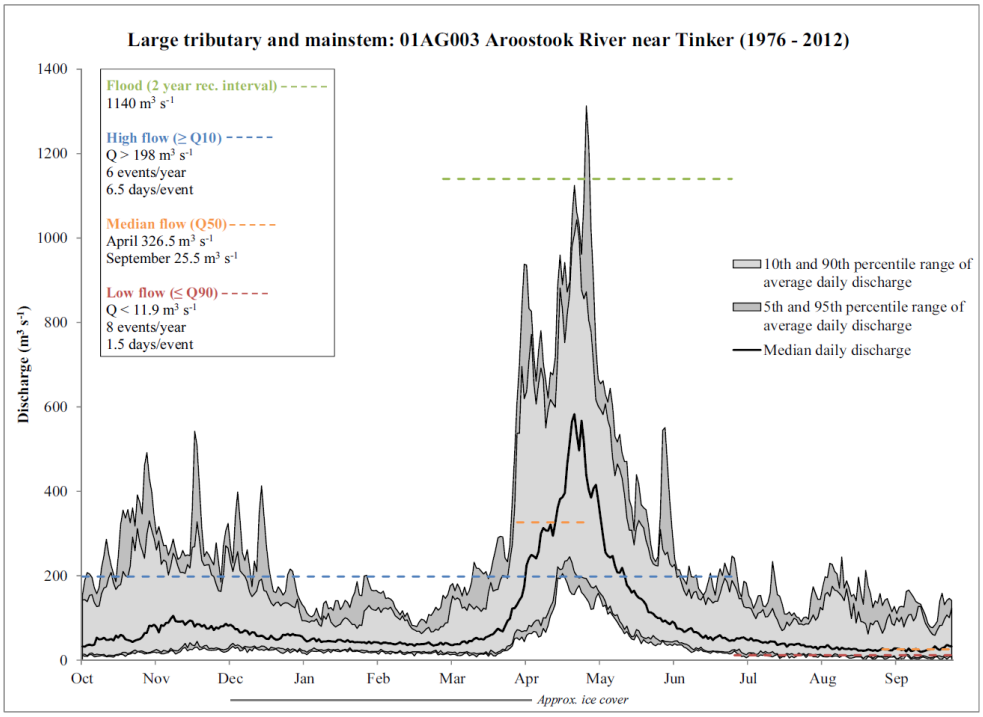

Figure 4: Example of hydrograph for large tributary and mainstem habitat (01AG003 Aroostook River near Tinker, 1976 - 2012)

Table 5: Draft vegetation groups, example species, and associated habitat types for the SJR

	Taxa group	Headwater and small tributaries	Medium tributaries		Large tributaries and main channel	Island habitats	Riparian wetlands	Floodplain forests
		Cold-and cool-water reaches	*Cold-and cool-water reaches*	*Typical reach*				
Submerged aquatic vegetation	**Submerged aquatic vegetation associated with riffles**: e.g. Fountain moss *(Fontinalis sp.)*	•	•	•	•	•		
	Submerged aquatic vegetation associated with runs: e.g. Water stargrass (*Heteranthera dubia*)		•	•	•	•		
	Submerged aquatic vegetation associated with pools: e.g. Waterweed (*Elodea nuttallii*, *Elodea canadensis*), Eel grass (*Vallisneria americana*), some water milfoils (e.g. *Myriophyllum farwellii*)			•	•	•	•	
Emergent aquatic vegetation	**Emergent vegetation**: e.g. Spatterdock (*Nuphar variegata*), Common bladderwort (*Utricularia macrorhiza*), some water milfoils (eg. *Myriophyllum alterniflorum* and *Myriophyllum sibericum*)	•	•	•	•	•		
Floodplain and riparian vegetation	**Shoreline and scour vegetation**: e.g. Furbish's lousewort (*Pedicularis furbishiae*)				•	•		
	Floodplain vegetation: e.g. Speckled alder (*Alnus incana*), Black willow (*Salix nigra*), Silver maple (*Acer saccharinum*), Butternut (*Juglans cinerea*)			•	•		•	•
	Wetland vegetation: e.g. Arrowhead (*Sagittaria latifolia*) Willow spp. (*Salix spp.*), Meadowsweet (*Spiraea alba*)			•	•	•	•	

Table 6: Draft benthic macroinvertebrate groups, example species, and associated habitat types for the SJR

Taxa group	Headwater and small tributaries	Medium tributaries		Large tributaries and main channel	Island habitats	Riparian wetlands	Floodplain forests
	Cold-and cool-water reaches	*Cold-and cool-water reaches*	*Typical reach*				
Benthic macroinvertebrate taxa associated with high energy, flowing waters e.g. Sallflies (Chloroperlidae), Net-spinning caddisfly (Hydropsychidae), Golden stonefly (Perlidae), Winter stoneflies (Taeniopterygidae), Blue-winged Olives (Baetidae), Apple caddisfly (Brachycentridae)	•	•	•	•	•		
Benthic macroinvertebrate taxa associated with moderate to low energy, stable substrate, flowing waters e.g. Spiketails (Cordulegastridae), Tube-making caddisfly (Polycentropodidae), Clubtail (Gomphidae), Fingernet caddisfly (Philopotamidae)		•	•	•	•		
Benthic macroinvertebrate taxa associated with slow flow areas, vegetated backwaters e.g. Angler's Curse (Caenidae), Long-horned caddisfly (Leptoceridae), Ramshorn snail (Planorbidae), Northern caddisfly (Limnephilidae)			•	•	•	•	•

Table 7: Draft fish groups, example species, and associated habitat types for the SJR

Taxa group	Headwater and small tributaries	Medium tributaries		Large tributaries and main channel	Island habitats	Riparian wetlands	Floodplain forests
	Cold-and cool-water reaches	*Cold-and cool-water reaches*	*Typical reach*				
Cold- and cool-water fish e.g. Brook trout (*Salvelinus fontinalis*), Brown trout (*Salmo trutta*), Slimy sculpin (*Cottus cognatus*)	•	•					
Riffle obligate fish e.g. juvenile Atlantic salmon (*Salmo salar*) and Blacknose dace (*Rhinichthys atratulus*)	•	•	•	•	•		
Nest building fish e.g. Creek chub (*Semotilus atromaculatus*), Redbreast sunfish (*Lepomis auritus*), Smallmouth bass (*Micropterus dolomieui*)		•	•	•	•		
Resident fish with defined spawning migrations e.g. White sucker (*Catostomus commersonii*)		•	•	•			
Pool associate species e.g. adult Atlantic salmon (*Salmo salar*), White sucker (*Catostomus commersonii*)		•		•			
Diadromous fish e.g. American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), Shortnose sturgeon (*Acipenser brevirostrum*), Striped bass (*Morone saxatilis*)		•	•	•	•		
River margin or backchannel species e.g. juvenile Cyprinidae spp.		•		•	•	•	
Vegetation spawners e.g. Yellow perch (*Perca flavescens*), Chain pickerel (*Esox niger*), Muskellunge (*Esox masquinongy*)				•	•	•	•

Table 8: Draft mussel groups, example species, and associated habitat types for the SJR

Taxa group	Headwater and small tributaries	Medium tributaries		Large tributaries and main channel	Island habitats	Riparian wetlands	Floodplain forests
	Cold-and cool-water reaches	*Cold-and cool-water reaches*	*Typical reach*				
Freshwater mussel associated with very high energy, cold, clear, flowing waters e.g. Eastern Pearlshell (*Margaritifera margaritifera*)	●	●	●	●	●		
Freshwater mussels associated with high energy, dynamic substrate, flowing waters e.g. Alewife Floater (*Anodonta implicata*), Eastern Elliptio (*Elliptio complanata*)		●	●	●	●		
Freshwater mussels associated with moderate to low energy, stable substrate, flowing waters e.g. Brook Floater (*Alasmidonta varicose*), Triangle Floater (*Alasmidonta undulata*)			●	●	●		
Freshwater mussel associated with stagnant, vegetated backwaters e.g. Eastern Floater (*Pyganodon cataracta*)			●	●	●	●	