# _Mactaquac Aquatic Ecosystem Study_

By 2017, NB Power will make a multi-billion dollar decision to rebuild or remove the Mactaquac Dam (MD) on the Saint John River (SJR), near Fredericton, NB, Canada. The Canadian Rivers Institute has been charged with providing the environmental science to support NB Power's decision. The **Mactaquac Aquatic Ecosystem Study** (MAES) is a planned, whole-river ecosystem study and manipulation. It begins with a minimum of eight years to study the structure and function of a large river ecosystem, followed by a manipulation of flow, sediment load, and thermal regime with consequential effects on the ecosystem, and then a multi-year period to monitor the recovery to a new river state. The manipulation will induce either an acute, major perturbation with long-term effects, i.e., removing the dam and restoring the river to a free-flowing form, or a minor, lesser stress event created by the multi-year, re-construction of the dam, but

Mactaquac Dam, Saint John River (Hatch Consulting)

chronic in that the dam and related issues persist. A comprehensive study and planned manipulation of an ecosystem of this scale is arguably the largest freshwater ecosystem study and experiment that has been attempted. We are seeking motivated, self-driven and talented post-doctoral candidates and graduate students in Biology, Civil Engineering, Geological Engineering, Hydrological and Hydrodynamic Modelling, and Fluvial Geomorphology.
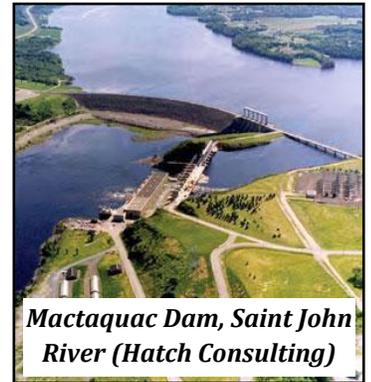
Beginning Summer 2014

1. MScEng (Geology) - **Accurate definition of sediment layering of a reservoir**. One of the primary concerns with dam remediation is estimating the volume of sediment accreted since emplacement (45 years in the case of Mactaquac Dam). While the total volume may be large, spread over a large area the local thickness of the sediments may be very thin (decimetres). Digital subbottom profiling records acquired using broadband acoustic sources (28 kHz and 3.5 kHz) will be analyzed to define this layer as well as gravity cores to understand impedance contrasts and advance our interpretation of sediment layers. The 3.5 kHz profiles are also expected to provide insights into the deeper stratigraphy (glacial and post-glacial) that will be controlling the groundwater flux during reservoir drawdown and potentially influencing engineering solutions for the future MD removal or renewal. We will complement the acoustic survey with a towed low power seismic system to obtain greater depths of penetration and/or improved resolution in areas of particular interest. Possible options include the IKB Seistec system previously proven for subbottom aquifer imaging at Fredericton or a sparker-based system capable of greater penetration in coarse sediments and tills. [Supervisor Dr. Karl Butler, UNB Fredericton]

2. MSc (Hydrological Modeling) - **Climate and future hydrological regimes for the Saint John River**. Working with the modeling team (hydrological/hydraulic/thermal models and paired with downscaled climate information), the MSc Candidate will model trends for the hydrological and thermal regimes predicted for the SJR for different climate scenarios. Different approaches to downscaling climate data will be explored, for example, Statistical Downscaling Model, using modelled climate data available through the Canadian Climate Change Scenarios Network (www.cccsn.ec.gc.ca). This work will set the hydrological foundation for developing appropriate environment flow regimes for the SJR. [Supervisors Dr. Wendy Monk, UNB Fredericton and Dr. Andre St-Hilaire, INRS Quebec City]

3. MSc (Hydrological Modeling) - **Modeling predicted thermal regimes downstream during reservoir drawdown**. The objective of the project is to predict reservoir temperatures and the water temperature downstream of the dam under various release scenarios to minimize the temperature impacts. Working closely with a PDF mainly responsible for downstream scenarios, the M.Sc. candidate will concentrate on establishing the reservoir temperature conditions. To account for vertical thermal variability in the reservoir, e.g., seasonal stratification, a CEQUEAU thermal model complemented by a 1D vertical water temperature model called MyLAKE(Multi-year Lake

simulation model) will be used. Thermal indices will be computed from synthetic temperature time series. These indices are descriptive statistics that quantify spatio-temporal variability in water temperature amplitude, frequency, timing and duration of warm events, and will be compared with habitat maps and biota distribution to examine implications for dam removal and longer term, environmental flow regimes. [Supervisor Dr. Andre St-Hilaire, INRS Quebec City – note that proficiency in French is required]

4. PDF (Civil/Hydrodynamic Modeling) - **Sediment resuspension, movement, and fate post-dam removal -** The PDF will develop, calibrate and validate a hydrodynamic model that includes the entire study area of the reservoir and river reach. The project will then integrate the bathymetric surveys and reservoir sediment volume, grain size, and spatial distribution analyses into "Delft3d" model that simulates the interaction of water and sediment (both suspended and bed total load) in time and space (http://oss.deltares.nl/web/delft3d). Long- and short-term morphological changes and sediment distributions will be predicted to best understand how disturbed materials will move in the water column and their ultimate fate. This dynamic-bed model will simulate seasonal streamflows to investigate the optimal timetable for the dam removal to mitigate downstream effects of suspended sediment concentration and spatial patterns of sediment deposition.[Supervisor Dr. Katy Haralampides, UNB Fredericton]

5. PhD (Limnology) - **Chemical and biotic source materials from the reservoir drawdown**. In a dam removal scenario, ~350km3 of water must be displaced downstream. The PhD Candidate will conduct a complete, spatio-temporal analyses of the reservoir's limnological conditions to understand the physical-biological characteristics of water released in a dam removal scenario. The survey will produce data to build and assess a model of downstream dispersal for various biological components (e.g., nutrients, alga, contaminants, dissolved oxygen) using a DELWAQ model, D-Water Quality and D-Ecology modules. We plan to develop and test a rapid phytoplankton assessment tool using an 'bbe AlgaeTorch' (www.bbe-moldaenke.de) as a rapid vertical profiling sampling protocol to increase our data for modeling and also provide guidance data during the drawdown regime when reservoir limnological responses will be intensified by declining water volumes and effects on temperature, concentrations of nutrients, and biota. [Supervisor Dr. Allen Curry, UNB Fredericton]

6. M.Sc. (Aquatic ecology) -**River metabolism.** Led by the M.Sc. Candidate, the project will first determine the metabolism of the planktonic and benthic communities using the light/dark bottle incubation and benthic chamber techniques. The objective is then to determine an appropriate reaeration coefficient for an open water metabolism method applicable for regulated rivers such as the SJR.[Supervisor Dr. Joseph Culp, UNB Fredericton]

7. PhD (Fish Ecology/Biotelemetry) - **Reservoir transit and downstream approaches to a large dam by Atlantic Salmon**. Downstream movements of Atlantic salmon present challenges at two spatial scales. The capability of smolts (downstream) and adults (upstream and downstream) to negotiate the ~100km reservoir is not understood. The PhD Candidate will use acoustic tracking with multiple fixed receivers (www.vemco.com) and manual tracking, to track smolts, kelts and upstream migrating adults during a multi-year field campaign. Pathways will be mapped and synthesized with limnological data to best understand reservoir bottlenecks. The finer scale 3D movement by downstream migrants during the approach to the dam will use a 16 antenna, high performance hydro-acoustic array (HTI) at the upstream face of the existing dam to understand mechanisms dictating dam passage. Position will start fall 2014, with field activity planned in spring 2015. [Supervisors Dr. Tommi Linnansaari and Dr. Steve Peake, UNB Fredericton]

8. PhD (Fish Ecology/Biotelemetry) - **Restoration potential for reproduction by Striped Bass**. Because Striped Bass still migrate and are distributed throughout the SJR up to MD during its spawning period, it is a candidate for population recovery using engineered reproductive habitats downstream of MD, e.g., by manipulating flows. The PhD Candidate will locate the preferred seasonal habitats of striped bass using a combination of radio and acoustic telemetry and will link movement behavior to physical habitat variables (e.g. depth, velocity, substrate, temperature, and flow) and

biological understanding (e.g. prey abundance) to generate an understanding of the basic ecology of the species in the river. Verification of habitat use and presence of associated fish species will be carried out by using SeaViewer underwater camera system operated on a georeferenced transect grid. Potential spawning areas will be further refined by capturing fish using traps and electrofishing during the spawning period. Using observations from tracking and river environment maps created in the other projects, we will build a model of potential spawning habitat as a function of discharge using River2D for the current and future river scenarios. In-stream and in-hatchery experiments (Mactaquac Biodiversity Facility, Fisheries and Oceans Canada) with SJR Striped Bass gametes will be used to test the viability of fertilization and survival of larvae in the SJR. The cumulative knowledge will be used to determine and model engineered spawning habitats for striped bass. [Supervisors Dr. Allen Curry and Dr. Tommi Linnansaari, UNB Fredericton]

9. MSc (Fish Ecology/Biotelemetry) – **Atlantic and Shortnose Sturgeon: Habitats and relationships to a new environmental flow regime**. The MSc Candidate will use acoustic telemetry (Vemco) to track Shortnose and Atlantic sturgeon to determine the location of spawning grounds of both species and to extend the understanding of seasonal habitats of adults in the SJR. The work builds on existing and ongoing effort and infrastructure by Ocean Tracking Network partners. DIDSON technology and 3D tracking using HTI acoustic technology will focus on studying the fine-scale effects of flow and velocity fields on spawning and recruitment success. Habitat characteristics including depth, velocity, substrate, and temperature will be measured as a function of flow.   The output from hydrodynamic models will be combined with field data and re-analysed using River2D to build a model of potential spawning habitats as a function of discharge. Future spawning sites for flow regimes predicted for either the dam renewal or removal scenarios will then be predicted. [Supervisors Dr. Steve Peake and Dr. Tommi Linnansaari, UNB Fredericton].

10. MSc (Fish Ecology) - **Near dam, spatio-temporal distribution of migrating American Eel elvers**. Since 1980, eel elvers are no longer reported arriving at the MD fish trap, which corresponds to the start-up of the last two turbine units at MD and thus suggests a velocity barrier for migration. The MSc Candidate will study the spatio-temporal distributions of elvers on their final approach to MD to ascertain the success of passage upstream to this presumed barrier. Clusters of habitat traps will be distributed within 20km downstream of MD and the presence of elvers monitored to establish spatio-temporal patterns of upstream movement. Based on abundance patterns and measures of flow and temperature at traps and using the hydrodynamic model output, predicted migration paths will be created and the potential migration bottlenecks will be identified. Additionally, the hydrodynamic models will be applied to describe predicted habitats for elvers to further evaluate how future flows may impact the habitats of migrating elvers. [Supervisors Dr. Tommi Linnansaari and Dr. Allen Curry, UNB Fredericton]

11. MSc (Aquatic Insect Ecology) - **Environmental and future flows with habitat implications for riparian insect species at risk.** The SJR watershed provides the critical habitat necessary for the conservation of three insect species at risk within the province of New Brunswick: Skillet Clubtail, Pygmy Snaketail, and Cobblestone Tiger Beetle (www.sararegistry.gc.ca). Because a future change in flow regime has the potential to impact the flooding patterns for riparian trees and island habitats, the MSc Candidate will conduct surveys of the species in the downstream riparian areas (river banks and islands) to locate and map occurrences. The geospatial distributions will be evaluated against the detailed riparian maps and the future flow scenarios to assess the potential loss of emergence habitats for these species. [Supervisor Dr. Wendy Monk, UNB Fredericton].

Beginning Summer 2015
12. MScEng (Civil/Geomatics) - **Analysis of resolution, accuracy and information content of airborne laser ultra-shallow water surveys.** The project is a development and test of LiDAR as an effective tool in river management. Until recently, LiDAR was inefficient in inland, shallow waters as the depth limitation was <1m (separating the pulse waveform reflection from the water surface and its bed). New shorter pulse systems are narrowing that gap, but at the expense of penetration (dependent on

water clarity). In addition, these systems can provide a measure of optical water clarity and river bed reflectance. Previous work on the underlying laser waveforms has demonstrated detection of vegetation. The MSc Candidate will assess the accuracy, and minimum and maximum depth limits achieved by such a system. [Supervisor Dr. J. Hughes Clarke, UNB Fredericton]

13. PhD (River Ecology) - **Trophic structure and biomonitoring metrics for a large river**. The trophic structure of large rivers is spatio-temporally complex yet essential to understand for informative, effective decisions regarding multi-use rivers. Trophic structure can be affected by manipulations of flow and thus, metrics of trophic structure and organic matter pathways) may be informative when assessing the impacts of dam removals . The PhD Candidate will compile a multi-parameter and scale bio-physical assessment of the Saint John River using stable isotopes of C and N from which trophic metrics of river ecosystem status will be created (Stable Isotopes in Nature Laboratory, CRI/UNB) based on > 5000 samples that are to be collected. [Supervisors Dr. Allen Curry, UNB Fredericton and Dr. Karen Kidd, UNB Saint John]

14. MSc (Ecology/Ecohydraulics) - **A quantitative model of fish habitats in a large river**: The project will take a mesohabitat approach to assess the changes in habitat conditions if the current dam would be removed. The suitability of existing hydromorphological unit (HMU-mesohabitat) classification schemes designed for smaller rivers and/or single species situations will be further developed for the SJR. Fish assemblage associated with mesohabitats will be established. A species-seasonal habitat use matrix will be populated by observed and literature data. Final habitat associations based on "habitat suitability" and associated uncertainty will be created using a novel approach of fuzzy-logic rules created via a multi-expert consultation exercise with the goal to establish probability of fish presence in different HMU parcels. The MSc Candidate will derive HMU's from the output from the "Delft3D" hydrodynamic model, use the depth/velocity simulation output, combined with substrate data transformed into HMU parcels in Arc-GIS based meso-CASiMiR model that can utilize the fuzzy logic based rules alongside with standard preference functions. [Supervisor Dr. Tommi Linnansaari, UNB Fredericton]

15. MSc (Biogeochemistry) - **Reservoir sediment composition, chemistry, and potential for downstream displacement**. The Candiate will determine spatial distribution of sediment composition and chemistry in the reservoir by collecting grab and core samples. Shallow (5 cm) sediment layers will be sampled to examine spatial variability in and magnitude of contaminants and nutrients. From the gravity cores, slices will be used to assess differences among deposition layers for erosion mapping and sediment transport consequences and to inform ongoing collection of sediments. Analyses will include grain size, %N, %P, total organic and inorganic carbon and contaminants (PCBs, chlorinated pesticides, metals, PAHs). The MSc Candidate will assess nutrients and contaminants and their implications for the dam removal scenario, and the project potentially includes numerical modelling of transport and deposition of nutrients and contaminants using DELWAQ models.[Supervisor Dr. Karen Kidd, UNB Saint John]

16. MSc (Fluvial Geomorphology/Ecohydrology) - **Final river setting following a dam removal**. Predicting the final setting of the river in the dam removal scenario informs the ecosystem studies because the new river includes habitats that can be defined by predicted flows and depths, sediment transport and deposition, and barriers. The MSc Candidate will predict these physical characteristics of the new river using a channel evolution model approach based on existing dam removal projects (Elwha River -) and modeling experiments . Once channel placement and forms are predicted, the Candidate will use knowledge from the whole ecosystem study and literature to predict the habitats and barriers for fishes in a new river.[Supervisors Dr. Wendy Monk and Dr. Allen Curry, UNB Fredericton]

17. MSc (Fish Ecology/Biotelemetry) – **The ecology of muskellunge, an introduced predator, in the vicinity of a large dam**. Muskellunge originated upstream of MD from an introduction and now occur up- and downstream of MD, but spawning sites remain unknown. Their impact on the SJR ecosystem is similarly unknown, but management of the species either with or without a dam will have significantly different objectives if muskellunge are reproducing downstream. The MSc Candidate will

locate habitats downstream of MD using both radio- (Lotek) and acoustic telemetry (Vemco). Successful spawning will be confirmed by collecting eggs and/or fry from vegetation in the area, and/or by collection of young-of-the-year (YOY) in trap or seine nets later in the season. Quality of nursery habitat will be assessed by monitoring growth rate and abundance of YOY. [Supervisors Dr. Steve Peake and Dr. Allen Curry, UNB Fredericton].

18. PhD (Aquatic Ecology) - **Historical, current and future lateral connectivity within the floodplain**. The SJR ecosystem boasts substantial wetland habitats sustained by the lateral connectivity with its largely intact floodplain, which is rare in a temperate zone river of this size flowing into either side of the Atlantic Ocean. The Grand Lake Meadows is a 116,000 hectare wetland and a Provincial Protected Area with several species of concern. The PhD Candidate will examine historical records using aerial photographs paired with historical water level records to quantify the connectivity among wetland habitats and the main channel and then structure sampling of the current wetland biodiversity (measured through DNA-based biodiversity analysis) along a wetland habitat connectivity gradient. Using these temporal-spatial patterns, the goal will be to predict future wetland connectivity modification under environmental flow scenarios derived from the ongoing hydrological modeling.[Supervisor Dr. Donald Baird, UNB Fredericton].

To apply:
Prospective candidates should email a cover letter, CV, unofficial university transcripts and contact information for three people who can serve as references. The cover letter must clearly indicate the project being applied for, and outline how the candidate's previous experience has prepared him/her to function as a leader of the respective MAES study component, and what specific qualifications the candidate will bring to the large, multidisciplinary MAES Team.

Review of applicants for the projects starting in summer 2014 will begin 21 February 2014 and continue until the positions are filled. Ideal start date for 2014 projects is in March/April. For positions starting 2015, applications can be provided until fall of 2014. Send complete application packages to Project Manager Gordon Yamazaki by email (Gordon.yamazaki@unb.ca).

[Please note that full-time faculty members of the University of New Brunswick are currently on strike, and regular email communications have been disabled for the (unknown) duration of the labour dispute. Therefore, all MAES related enquiries during the labour dispute should be directed to the email address provided above].

The *Canadian Rivers Institute* (CRI) was founded in 2000 as a collaboration of researchers at the University of New Brunswick. The mandate of the CRI is to develop the aquatic science needed to understand, protect, and sustain water resources for the region, nation, and the planet. Currently, the research network is led by a team of 20 Science Directors, all of which are leading experts in Aquatic Research Sciences and includes 7 Canada Research Chairs. A large network of associates, students, and a team of more than 20 technical and management staff comprises the support network of CRI. For more information about CRI, please visit www.canadianriversinstitute.ca