1.0 INTRODUCTION

This document is the final Comparative Environmental Review (CER) Report of three options being considered for the anticipated end of service life of the Mactaquac Generating Station (the Station) in Mactaquac, New Brunswick. The Mactaquac Project (the Project) currently consists of an evaluation of potential options to address the future of the Station at the end of its service life in 2030. The Station is owned and operated by the New Brunswick Power Corporation (NB Power), and is located on the Saint John River approximately 19 km west of the city of Fredericton (Figure 1.1).

What is the environment?

In the Comparative Environmental Review, the term "environment" includes the social and economic environment as well as the natural environment. This includes air, land, water, plants, animals, people, and the interactions between all of these things.

To address the anticipated end of service life of the Station, NB Power is

considering three "end-of-life" options for the Station (the Options). To assist in the understanding of environmental, social, and socio-economic issues potentially associated with each of the Options, NB Power conducted a Comparative Environmental Review (CER). The information collected as part of the CER will be considered by NB Power, along with other information (e.g., business case, engineering, other considerations), in its decision-making regarding the Station later in 2016. The CER will also support the scoping and conduct of any future environmental impact assessment and/or environmental assessment (EIA/EA) that may be required through a formal regulatory process for the option that will ultimately be selected by NB Power (the Preferred Option).

In addition to the three end-of-life options discussed in this CER Report, NB Power is also considering a fourth "Life Achievement" Option, described in Appendix A of this document to accompany the main analysis for the three end-of-life options. The Life Achievement Option was not initially included in the CER process because development of this option was not as advanced as the three end-of-life options, and had yet been determined to be technically feasible at the time of writing the draft CER Report. An Addendum to the CER Report (Appendix A) was later developed to provide further information to NB Power on the possible environmental issues associated with the Life Achievement Option as it is currently conceived, and how it could be made acceptable, following a similar approach to that followed for the three end-of-life options in the CER Report. This Addendum is provided in Appendix A to this CER Report.

1.1 ABOUT NB POWER

As outlined in "NB Power's 10-Year Plan, Fiscal Years 2016 to 2025" (NB Power 2014a), NB Power is a Crown corporation owned by the Province of New Brunswick and is the largest electric utility in Atlantic Canada.

NB Power has one of the most diverse generating systems in North America, consisting of 13 power generating stations including: nuclear, hydro, coal, oil, and diesel. NB Power also has power purchase agreements with various privately-owned renewable and natural gas-powered facilities in New Brunswick. NB Power maintains more than 6,800 km of transmission lines and over 20,000 km of distribution lines in the province (NB Power 2014a).





NB Power's mission is to "Proudly Serve Our Customers by Being Top Quartile" (NB Power 2014a). NB Power's more than 2,300 employees, working in generating stations, offices and in operations around the province, are committed to providing safe, reliable and efficient power to its more than 397,000 customers in New Brunswick.

1.2 ABOUT THE MACTAQUAC GENERATING STATION

The Mactaquac Generating Station, located on the Saint John River approximately 19 km west of the city of Fredericton, New Brunswick, is a hydroelectric generating station with a capacity of approximately 670 megawatts (MW) that provides renewable electricity and reliability services (commonly referred to as ancillary services) to New Brunswickers. It was commissioned in 1968.

What is a headpond?

The term "headpond" is often used in hydro-electricity projects to describe the artificial reservoir of water created upstream of a dam, which is regulated for the production of electricity. The term is made up of the words "head", which refers to the potential energy created by the weight of a water column, and is used to drive hydro-turbines (see section 2 for more information), and "pond", which means to hold back water. The Station, shown in Photo 1.1, consists of an earthen dam constructed of rock-fill and sealed by clay; a headpond between the Station and the town of Woodstock (approximately 96 km upstream); a concrete spillway; a concrete diversion sluiceway; a concrete intake structure; a concrete powerhouse that houses six hydroelectric turbines; and associated equipment.

What are reliability services?

The Mactaquac Generating Station provides much more than just a renewable power source to NB Power and its customers. It also serves many other important functions that ensure customers have a reliable source of power. These reliability services include things like balancing, reserves, and system black start.

Balancing means that the Station is able increase or decrease generation to respond to variations in consumption of energy by customers or variations in production of energy by other generating sources. Reserves are required in order to recover in minutes from the sudden unexpected loss of other generation. New Brunswick's system black start plan requires the Mactaquac Station to start generating electricity on its own and then start other generating facilities in the case of a province wide black-out.



Sources: Contours, First Nations Reserve, and Roads are from SNB, Waterbodies and Watercourses from NBDNR, All data downloaded from GeoNB.



Project Location





Photo 1.1 Mactaquac Generating Station

The dam also serves as an important highway link across the Saint John River (known locally as "Mactaquac Road"), linking Routes 102 and 105 of the provincial highway system.

The Station was originally intended to have an approximate 100-year service life (*i.e.*, end of service life in 2068), as is normally the case with hydroelectric generating stations around the world.

A conceptual rendering of the existing Mactaquac Generating Station and its major components is provided in Figure 1.2.



Source: NB Power

Figure 1.2 Conceptual Rendering of the Existing Mactaquac Generating Station



1.3 WHY IS THE MACTAQUAC PROJECT REQUIRED?

Current modelling indicates that the Station is experiencing a premature end of service life as a result of an alkali-aggregate reaction (AAR) within the existing concrete structures at the Station AAR is a chemical reaction that occurs between the cement and the aggregate rocks that are used to make concrete. The aggregate that was used for the construction of the Station is believed to be at least partially responsible for the AAR.

As a result of the AAR reaction, the concrete in the concrete structures at the Station (including the intake structure, the spillway, the powerhouse, and the diversion sluiceway) is expanding. The occurrence of AAR is relatively common, with hundreds of hydro stations and other concrete structures around the world being similarly affected.

A schematic that briefly explains how an alkali-aggregate reaction occurs is provided in Figure 1.3.

What is an Alkali-Aggregate Reaction (AAR)?

An alkali-aggregate reaction (AAR) in an internal reaction that occurs when alkalis in cement react with reactive aggregate particles.

- In most concrete, aggregates are more or less chemically inert. However, over time, some aggregates react with the alkalis in concrete, causing expansion and cracking of the concrete.
- For large concrete structures, the result of this expansion is normally unsightly cracking.
- Although structural integrity of the concrete structure may not be impaired, major operation and maintenance problems may occur, such as binding of gates, cracking of piers, and misalignment of equipment such as generators.
- Since the 1980s, NB Power has performed various maintenance activities at Mactaquac to address AAR:
 - Modifications to equipment
 - Grouting of structures to control leakage
 - Slot cuts
 - Reconstruction of expansion joints





Source: PCA (2015)



Figure 1.3 How an Alkali-Aggregate Reaction (AAR) Occurs



Since the mid-1980s, NB Power has been monitoring the AAR issue and carrying out maintenance work on the concrete portions of the structures, including cutting slots into the concrete to allow the concrete expansion to occur and maintain the functionality of equipment at the Station, along with other measures.

Though NB Power continues to maintain the Station-related structures so as to assure their continued structural integrity and dam safety, current modelling is indicating that the AAR has reduced the life expectancy of the Station to approximately the year 2030, instead of its original 100-year design life. Studies to verify the 2030 end of service date have been conducted and are ongoing, and these studies may also identify any other potential solutions that have not yet been considered. Recent indications are that the concrete at the Station may continue to be structurally sound until approximately 2060, but it is likely that some mechanical equipment within the Station would not be operable for that entire duration; the Options (including the Life Achievement Option, Appendix A) are therefore being explored as a conservative measure in the event that the Station becomes inoperable prior to that time.

The earthen dam will remain suitable for continued use beyond 2030 if needed.

1.4 HOW IS NB POWER ADDRESSING THE ISSUE?

To address the early end of service life of the Station, NB Power is considering three end-of-life options as part of the Mactaquac Project as to the potential fate of the Station at its end of service life. These options were chosen for consideration in the CER because they are considered to be technically achievable, and they provide a long-term solution to problems facing the current Station.

The end-of-life Options are:

- Option 1, Repowering;
- Option 2, Retain the Headpond (No Power Generation); and
- Option 3, River Restoration.

Additionally, a fourth option, "Life Achievement", is described in Appendix A.

The three end-of-life Options are shown in Figures 1.4 to 1.6, and are briefly described as follows.



Option 1, Repowering (Figure 1.4): Refurbish the Station by constructing a new powerhouse, spillway, and other components, followed by the removal of the existing concrete structures at the Station. (Source: NB Power)



Figure 1.6

Conceptual Rendering of Option 1, Repowering

Option 2, Retain the Headpond (No Power Generation) (Figure 1.5): Build a new concrete spillway and maintain the dam as a water control structure without power generation, followed by the removal of the existing concrete structures at the Station. (<u>Source:</u> NB Power)



Figure 1.

Conceptual Rendering of Option 2, Retain the Headpond (No Power Generation)

Option 3, River Restoration (Figure 1.6): Remove the Station and enable the river to return to a free-flowing state. (Source: NB Power)



**Note: These are artist's renderings and are intended to explain the basic concept of each option and foster discussion. Actual designs will include additional elements (e.g., roadway, fish passage, powerhouse, and spillways) and are subject to updates as more studies are completed and feedback is received from First Nations, the public, and stakeholders.



NB Power is continuing to review the projected 2030 end of service life for the Station. That work includes exploring ways to continue operations within the current footprint beyond 2030. NB Power did not initially include these potential approaches for continuing operations within the current footprint (collectively referred to as the Life Achievement Option" in the CER process because they had not yet been determined to be technically or economically feasible. Since that time, recent modelling and engineering have shown that, despite an ongoing growth of the concrete due to AAR, known issues may be able to be mitigated with extensive ongoing maintenance, repair, or refurbishment, and as such it may be possible to maintain or partially refurbish the existing Station components to extend their life beyond 2030).

An Addendum to the CER Report was developed to provide further information to NB Power on the possible environmental issues associated with the Life Achievement Option, and how it could be made acceptable, following a similar approach to that followed for the three end-of-life options in the CER Report. The discussion of the Life Achievement Option is provided in Appendix A; that option is not discussed further in the main body of this Final CER Report.

One of the Options will be selected as the Preferred Option by NB Power based on a review of engineering, constructability, environmental, Aboriginal, social, and economic considerations.

NB Power plans to recommend a Preferred Option by the end of 2016 and begin to prepare for the environmental regulatory approval processes for the Preferred Option, in order to allow sufficient time to secure approvals, and finalize design decisions. Completion of the environmental regulatory processes by approximately the end of 2019 would enable construction of the option with the longest lead time (*i.e.*, Option 1, Repowering) and allow for existing facilities to be out of service by approximately 2030. The process for the Project, including key decisions points, is summarized in Figure 1.7.





Figure 1.7 Process for the Project, Including Key Decision Points

1.5 WHAT IS THE COMPARATIVE ENVIRONMENTAL REVIEW (CER)?

As outlined in the Terms of Reference for the CER (NB Power 2014b), the purpose of the CER was to:

- evaluate, at a high-level, the likely potential environmental effects of each Option;
- identify the key mitigation measures to make each Option environmentally acceptable, if it was selected;
- support NB Power's selection of a Preferred Option later in 2016; this decision will be based on the environmental, economic, engineering, energy policy, and social considerations that are identified through the CER process and other parallel studies being carried out by NB Power;
- provide a mechanism by which Aboriginal, public, and stakeholder input regarding environmental issues related to the Options can be considered by NB Power in its decision-making; and
- aid in the scoping and conduct of any required future EIA/EA of the selected Preferred Option.



The CER also supported informed discussions on the Options for the Project during NB Power's broader public engagement efforts.

The CER process is not part of a formal environmental regulatory process, but rather informs a future EIA/EA process that may be required of the Preferred Option, once selected. About the Comparative Environmental Review (CER) Process

The CER process is not part of a formal or legal environmental regulatory process. This unique process, developed by NB Power for the Mactaquac Project, is intended to contribute to NB Power's choice of a Preferred Option by offering a means of comparison between Project Options, based on how they might affect the environment. The CER also informs and prepares for a focused, formal environmental assessment of the Preferred Option, once it is selected by NB Power.

1.6 HOW DOES THE CER WORK?

The CER process was outlined in the "Terms of Reference for the Comparative Environmental Review (CER) of Options for the Mactaquac Project, Mactaquac, New Brunswick", dated November 2014 (NB Power 2014b). The Terms of Reference:

- defined the requirements of, and process for, carrying out the CER;
- defined the desired outcomes, timeframes, and deliverables of the CER; and
- identified the composition and mandate of the CER Advisory Committee (see box in Section 3.1.1) that was formed to assist in the completion of the CER.

The CER process is shown in Figure 1.8, and is described further in Chapter 3 of this CER Report.





Figure 1.8 Comparative Environmental Review (CER) Process

Final Guidelines (Stantec 2015a) for the CER were developed by Stantec on behalf of NB Power. These were developed in consultation with NB Power and the CER Advisory Committee, and were released for public review from November 25, 2014 to January 8, 2015. The Final Guidelines provided "how-to" directions for carrying out the CER. The Final Guidelines outlined the different methods and issues that needed to be considered and addressed as part of the CER to produce a final document that will be useful to the public and to NB Power. The Final Guidelines:

- described the key environmental issues of concern (known as Valued Components, or VCs) that were evaluated in the CER;
- identified how the Options are expected to interact with VCs, at a high level; and
- provided work plans for carrying out the CER for each VC.

What is a Valued Component?

A Valued Component (VC) is a term that refers to aspects of the environment that have scientific, social, cultural, economic, historical, archaeological, or aesthetic values to society. This term is common in environmental assessment and related processes, and is used throughout this report to refer to the aspects of the environment receiving a more focused review.



Further details on the CER process, scope and methods are provided in Chapter 3 of this CER Report.

In addition to the Final Guidelines, the CER was informed by various other sources of information including published literature, interviews, other studies that were carried out in parallel with the CER, and the results of Aboriginal, public and stakeholder engagement, among other sources of information.

1.7 WHAT WILL HAPPEN AFTER THE CER IS COMPLETED?

NB Power has indicated that it will make a decision on which option it will recommend as the Preferred Option at Mactaquac by the end of 2016, to allow sufficient time to complete the required approval processes, engineering design, and procurement processes to be able to implement the Preferred Option prior to the projected end of service life of the existing facilities in 2030. Option 1 (Repowering) is the end-of-life Option that requires the longest amount of time to complete (*i.e.*,, approximately six years to construct the new facilities associated with that option and a further five years to demolish the concrete structures associated with the existing Station, for a total of eleven years for Option 1).

Therefore, NB Power undertook various studies and analyses to identify the Preferred Option, some of which are ongoing at the time of finalizing this CER Report. The planning process includes consideration of engineering, constructability, financial, social, and environmental factors. These studies included, but are not limited to, the following:

- engineering design, cost estimates, and schedule;
- development of business case and analysis of financial considerations, including an evaluation of the cost of replacement power (including greenhouse gas (GHG) emissions) and reliability services under each of the Options;
- consideration of how each Option aligns with NB Power policies and obligations (for example, NB Power's obligation to meet the provincial Renewable Power Portfolio standard);
- the results of the Mactaquac Aquatic Ecosystem Study (MAES), a whole ecosystem study of the aquatic environment upstream and downstream of the dam;
- a comparative environmental review (CER) of the Options, including potential environmental interactions and required mitigation;
- a social impact comparative review (SICR) of the Options;
- Aboriginal engagement; and
- public and stakeholder engagement.

These and other inputs will be considered by NB Power in the course of selecting its Preferred Option for the Project, as summarized in Figure 1.9. Many of these studies have been completed or are nearing completion; however, some studies and programs (e.g., MAES, engineering design, Aboriginal engagement) will continue up to and following the selection of a Preferred Option. Aboriginal, public and stakeholder engagement activities are described further in Section 3.4.



More Information on Public and Stakeholder Engagement Completed for the Project

The results of the CER were intended to support a broader public engagement process which ended on May 31, 2016. This public engagement process consisted of several open houses, facilitated workshops, surveys, and feedback through various written forms and online tools. These activities provided further information on the engineering, scientific, environmental, social, and economic research for the Project Options and provided opportunities for New Brunswickers to give their thoughts and comments on these issues so that they can be considered by NB Power in its decision.



Figure 1.9 Key Inputs to the Decision-Making Process for a Preferred Option

NB Power assembled a team of engineers, scientists, planners, and subject-matter experts to carry out the above-noted studies to provide information to inform its selection of the Preferred Option. The key members of the Project Team assembled to assist in the planning and preliminary design of the Project is shown in Table 1.1.



Name of Firm	Role
Stantec Consulting Ltd.	 Comparative Environmental Review (CER) and related environmental studies Baseline data collection (recreation, property values, economy and business, ice regime, intakes and outfalls, infrastructure, groundwater, archaeology)
Canadian Rivers Institute (CRI)	Mactaquac Aquatic Ecosystem Study (MAES)
NATECH Environmental Services Ltd.	Hydrodynamic modellingSediment transport modellingRegulated outfalls
Dillon Consulting Limited and Kingsclear First Nation Economic Development Corporation	Aboriginal engagement program
Dillon Consulting Limited and Rayworth Consulting Inc.	Social Impact Comparative Review
 Hatch Ltd., with the following subcontractors: Amec Foster Wheeler PLC exp Services Inc. Stantec Consulting Ltd. 	Preliminary engineering designConstructability reviewCost estimation
NATIONAL Public Relations	Public engagement program
exp Services Inc.	Transportation Study
GHD Limited	Erodible slopes inventorySubmerged structures inventoryAquifer study
THRIVE Consulting Ltd.	 Social Ecological History of the Saint John River and its Watershed
Kleinschmidt Inc. and Riverside Technology, inc.	Multi-Criteria Decision Analysis (MCDA) for the Options

Table 1.1	Project Team -	Mactaquac	Project
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1.8 WHAT HAPPENS AFTER THE NB POWER DECISION IS MADE?

NB Power will identify the Preferred Option later in 2016, and will make a recommendation to the Government of New Brunswick for it to make a decision on Mactaquac.

Depending on the Option chosen, there is expected to be a requirement for a provincial environmental impact assessment (EIA), and possibly the need for a federal environmental assessment (EA). It is early in the Project planning process, however, and further clarity will be sought through discussions with federal and provincial regulators as planning proceeds.

NB Power will also require the review and approval of the New Brunswick Energy and Utilities Board (Table 1.2)) for the capital expenditure of the Preferred Option.

Various other approvals will also be required under federal and/or provincial legislation. These could include for example, permits for affecting fish habitat under the federal *Fisheries Act*; for impacts to species at risk under the *Species at Risk Act* or the New Brunswick *Species at Risk Act*; for emissions and releases of contaminants under the New Brunswick *Clean Environment Act*, *Clean Air Act*, or *Clean Water Act*; and possibly others.

A more detailed list of activities that will be undertaken by NB Power over the next few years is provided in Table 1.2. This table includes activities required to select a Preferred Option, as well as some of the next steps required for the approval of that Option once selected.



Approximate Timing	Activity
To be determined	 Procedural hearing scheduled by the Energy and Utilities Board (EUB). The purpose of this hearing is to allow all interested parties to comment on: the filing of this Application (for approval of the capital project expenditure), minimum filing requirements, the scheduling of hearing dates, and any other relevant issues.
September- December 2016	 Completion of a Multi-Criteria Decision Analysis (MCDA) using findings of various studies, expert opinions, and feedback received to date. NB Power selection of a Preferred Option, with the help of the MCDA. NB Power informs the shareholder (Province of New Brunswick) of its Preferred Option. Stakeholder briefings and announcement of the Preferred Option.
2017	 Public and stakeholder consultation on the 2017 Integrated Resource Plan (IRP) and the Preferred Option for Mactaquac, including demonstrating the rationale for the selected option (e.g., costs, MCDA model and narrative). Filing for required environmental approvals (depending on the option selected). 2017 IRP filed with the Province of New Brunswick (Executive Council) for approval. Mactaquac Project application filed with the Energy and Utilities Board (EUB), along with the approved 2017 IRP.
Source: NB Power	 option (e.g., costs, MCDA model and narrative). Filing for required environmental approvals (depending on the option selected). 2017 IRP filed with the Province of New Brunswick (Executive Council) for approval. Mactaquac Project application filed with the Energy and Utilities Board (EUB), along approved 2017 IRP.

Table 1.2 Activities to be Undertaken by NB Power Following the CER Process

1.9 PURPOSE AND ORGANIZATION OF THIS DOCUMENT

This document is intended to summarize the results of the Comparative Environmental Review (CER) carried out on the Options for the Mactaquac Project. It is organized in 18 sections, as follows.

- Section 1 (this Introduction) provides a brief overview and context for the Project, and outlines the structure of the CER Report.
- Section 2 provides a description of the Options as currently conceived, including a brief discussion of the existing Mactaquac Generating Station, a description of the phases and activities that could be carried out, and a discussion of mitigation measures that will be employed.
- Section 3 provides a discussion of scope and methods that are used to carry out the CER, as well as a summary of Aboriginal engagement and public and stakeholder engagement carried out for the Project.
- Sections 4 to 16 provide the results of the Comparative Environmental Review for each Valued Component for the CER, including a discussion of existing conditions, evaluation of Project-environment interactions, and mitigation.
- Section 17 provides a summary and conclusions of the CER.
- Section 18 provides the references cited or consulted in the preparation of the CER Report.

An Addendum to the CER Report relating to the Life Achievement Option is provided in Appendix A.

Additional supporting figures are provided in the mapbook.

