4.0 ATMOSPHERIC ENVIRONMENT

The atmospheric environment is the layer of air near the earth's surface; it is a valued component (VC) because a healthy atmosphere helps sustain life and maintain the health and well-being of the biophysical environment and its inhabitants. If not properly managed, releases of air contaminants (including greenhouse gases (GHGs)) to the atmosphere may cause adverse interactions with the air, the land and the waterways near each of the Options.

Did you know?

The Earth's **atmosphere** makes water on Earth possible and allows life to flourish. The thin layer of gases, tiny water droplets and dust particles making up the earth's atmosphere provides us with oxygen to breathe, precipitation to nourish our ecosystems and an ozone shield to protect living things from harmful ultraviolet rays from the sun. The atmosphere also acts as an insulating blanket, reducing heat loss from earth to space, keeping temperatures on earth warm enough for life to exist. This natural phenomenon has been called the greenhouse effect (Environment Canada 2005).

4.1 SCOPE OF THE REVIEW

This CER Report considers the potential environmental interactions of each Option with the atmospheric environment and mitigation measures likely to be required.

The potential environmental interactions are associated with releases of air contaminants and GHGs to the atmosphere, as well as potential changes in microclimate, by each of the Options.

In this CER Report, the approach is to select the environmental interactions, establish boundaries for the review, characterize the environmental interactions, and provide a review for each Option, with particular emphasis on the identified issues of concern.

4.1.1 Why Atmospheric Environment is a Valued Component

The atmospheric environment is a component of the environment that comprises the layer of air near the earth's surface up to a height of approximately 10 km. The atmospheric environment is a VC for the following reasons.

- The atmosphere and its constituents are needed to sustain life and maintain the health and well-being of humans, wildlife, vegetation, and other biota.
- The atmosphere is a pathway for transporting air contaminants to the freshwater, marine, terrestrial and human environments. These air contaminants are in the form of gases and particles that can be deposited on land and water.
- If not properly managed, releases of air contaminants may cause adverse environmental interactions with the air, the land, and the waterways near the Options.
- GHG emissions accumulate in the atmosphere and are thought to be a major factor in producing climate change (an enhanced greenhouse effect).

- Changes in microclimate (*e.g.*, local air temperature, local winds, visibility) can result from land use changes arising from the Options, such as the change in the size of a lake or waterbody.

The atmospheric environment is, therefore, a VC because there is a potential for its interaction with the Options.

The Greenhouse Effect

A greenhouse is used to create a warmer growing environment for plants that would not survive in the colder conditions outdoors. In a greenhouse, energy from the sun enters through the glass as rays of light. This energy is absorbed by the plants, soil and other objects in the greenhouse. Much of this absorbed energy is converted to heat, which warms the greenhouse. The glass helps keep the greenhouse warm, by preventing the warmed air from escaping (Environment Canada 2005).


Image courtesy of NASA/JPL-Caltechpasses

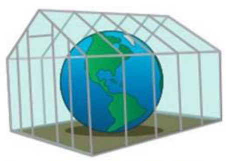
Image courtesy of NASA/JPL-Caltech

The earth's atmosphere does the same thing as a greenhouse, by creating warmer conditions on earth than would not exist without the atmosphere. Greenhouse gases (such as carbon dioxide) in the atmosphere do what the glass of a greenhouse does. Some of the heat energy bounces back into space, but some of it is kept in by our atmosphere. During the day, the sun shines through the atmosphere, and the surface warms up in the sunlight. At night, the earth's surface cools, releasing heat back into space (Environment Canada 2005, NASA 2015).

The **natural greenhouse effect** of earth's atmosphere keeps some of the sun's energy from escaping back into space at night, and warms the earth up to just the right temperature. As industrial activity, and the burning of fossil fuels (*e.g.*, oil and coal), increased over the last 150 years, so did the release of greenhouse gases to the atmosphere. As GHGs in the atmosphere increase, so does the amount of heat being held in by the atmosphere. Too much carbon dioxide and other greenhouse gases in the air are making the greenhouse effect stronger. If this **enhanced greenhouse effect** is too strong, the earth gets warmer and warmer. This is what is refered to as global warming (NASA 2015). The consequences of global warming, including the changes in long-term weather patterns that result from it, are commonly referred to as **climate change**.

4.1.2 Regulations and Policies Relevant to the Atmospheric Environment

Air quality in New Brunswick is regulated by the *Air Quality Regulation* under the New Brunswick *Clean Air Act*. Federally, the main instruments for managing air quality are the *Canadian Environmental Protection Act* (*CEPA*) and the Canada-Wide Standards (CWS) developed by the Canadian Council of Ministers of the Environment (CCME). The CWS include objectives, standards or guidelines for protecting the environment and human health. A number of these exist to protect air quality, including those for ambient air quality objectives for dust (also known as particulate matter less than 2.5 microns, or $PM_{2.5}$).

Although emissions of GHG are not regulated in New Brunswick, the New Brunswick Climate Change Action Plan (NBENV 2007) provides policy approaches to reduce overall GHG emission from existing facilities. The existing national guidance with respect to addressing climate change in environmental assessments is provided by the Canadian Environmental Assessment Agency (CEA Agency) (CEA Agency 2003). If GHG emissions from the Options are predicted to be medium or high, the CEA Agency guidance requires development of a GHG management plan.

There are no applicable provincial regulations or policies related specifically to climate or microclimate. The necessity for a review of microclimate is driven by considerable interest from stakeholders, such as the public and nearby communities and activities (*e.g.,* farming).

Did you know?

Microclimate is defined as the collection of attributes arising from long-term weather conditions over a relatively small area where conditions of shelter, landscape, wind, temperature, pressure, precipitation, clouds, soil, vegetation, and/or drainage are different from their general surroundings, with spatial scales ranging from 1 m^2 to 1,000 m^2. Examples include a hillside near a body of water, or a downtown core.

4.1.3 Area of Review

For considering a potential change in air quality and a potential change in microclimate due to the Options, the area of review for the atmospheric environment VC generally extends from the Station upriver to Hartland and downriver to Coytown (a small community on the south side of the Saint John River between Oromocto and the Village of Gagetown), within a linear distance of 5 km from the current headpond footprint (Figure 4.1). This area of review includes the area of physical disturbance that may result from each of the Options.

For a potential change in GHG emissions, since the interaction of the Options with GHG emissions is expected to be a provincial, national and ultimately global concern, the area of review is global in extent. However, the GHG emissions from the Options are estimated based on the surface area encompassed by the physical disturbance.

Did you know?

Climate is the long-term weather for a given region. Canada has 11 climate regions that include Arctic tundra, Pacific Coast, Northeastern Forest (large parts of Ontario, Quebec), and Atlantic Canada.

Climate normals are averages of specific measurements (such as temperature, wind direction or rainfall) extending over a few decades (Environment Canada (2015b) specifies a 30 year period as standard). This is also referred to as a period of record. Data are available for 1961-1990, 1971-2000, and 1981-2010.

4.1.4 Key Issues

The key issues for the atmospheric environment are listed in Table 4.1.

Table 4.1 Description of Key Issues for the Atmospheric Environment

Key Issue	Description
Potential change in air quality	Emissions of dust and criteria air contaminants; emissions of volatile organic compounds, reduced sulphur compounds, or methane (odour). • Equipment and activities for all Options may produce air contaminant emissions and dust that could change air quality. • Dewatering of the headpond in Option 3 may create odour and dust from the newly exposed sediments that were previously submerged in the headpond.
Potential change in GHG emissions	• The GHGs discussed in this CER Report are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (in units of CO_2 equivalents or CO_2e[b]). • Equipment may produce GHGs through the burning of fossil fuels. • Dewatering may cause a change to GHGs because of the loss of the headpond, which may be a carbon sink; and dewatering may result in the generation of GHGs including methane from biological processes in exposed sediments.
Potential change in microclimate	The headpond likely creates microclimates in this area (*e.g.*, local air temperature, local winds, and circulation patterns). Dewatering the headpond for Option 3 may cause a change to the microclimate in the specific area of the headpond by changing the radiative and convective energy exchange of the landscape.

Notes:

[a] Criteria air contaminants are a group of nine common air contaminants released into the air from various processes including industrial production and fuel combustion. They include total particulate matter (PM), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen oxides (NO_X, expressed as NO_2), hydrogen sulphide (H_2S), carbon monoxide (CO), ammonia (NH_3) and ozone (O_3).

[b] Carbon dioxide equivalents, or CO_2e, is a unit of measurement that allows the effect of different greenhouse gases to be compared using carbon dioxide as a standard unit for reference. Carbon dioxide equivalents refer to the amount of carbon dioxide that would give the same warming effect as the effect of the greenhouse gases being emitted (McGrath 2010). In this review, the CO_2e quantities of GHGs are calculated using the 100-year global warming potential (GWP; the relative measure of how much heat a greenhouse gas traps in the atmosphere) as follows (IPCC 2014): CO_2 GWP = 1; CH_4 GWP = 28; and N_2O GWP = 265.

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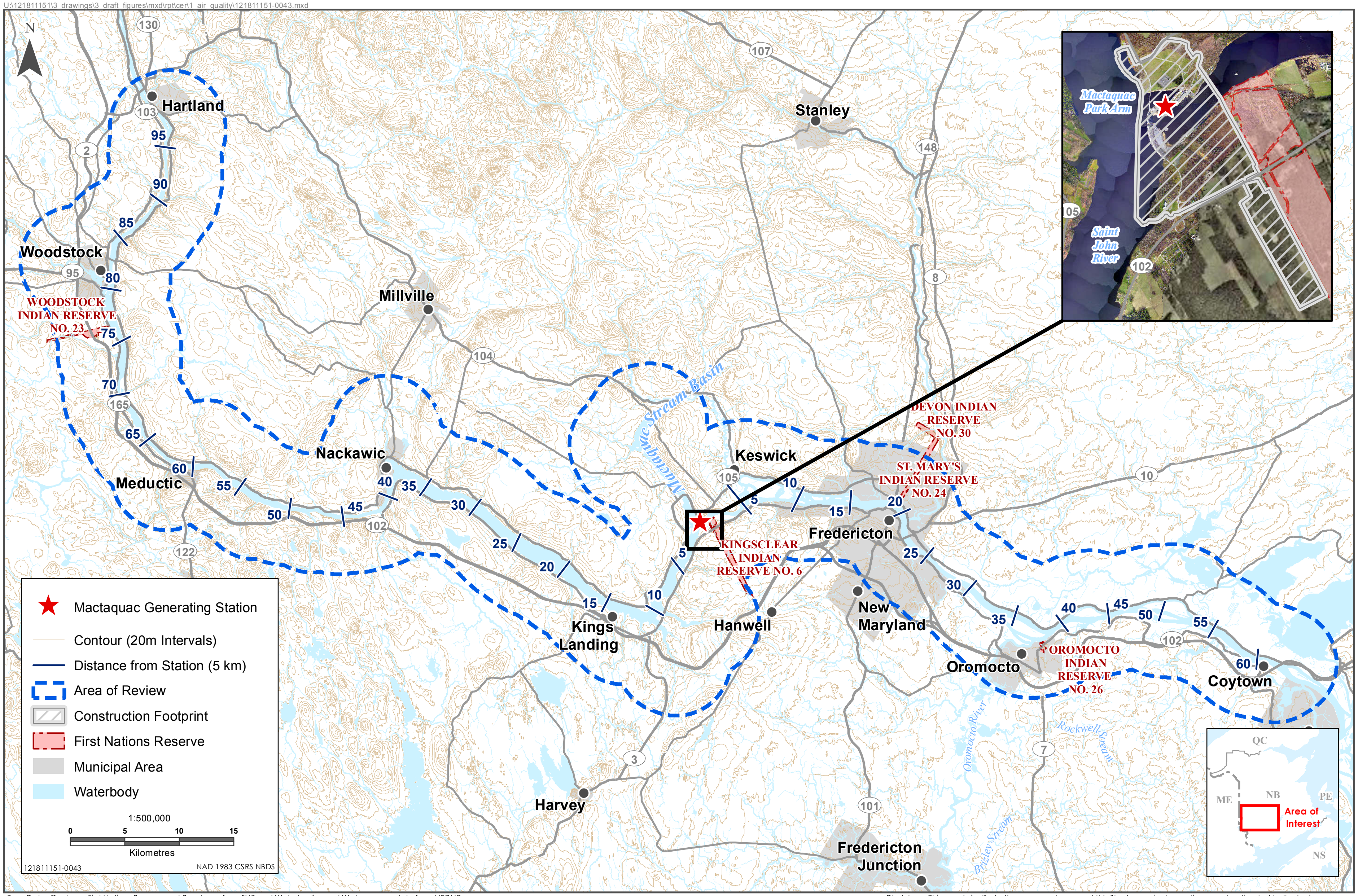

Base Data: Contours, First Nations Reserve and Roads are from SNB and Waterbodies and Watercourses data from NBDNR. All data downloaded from GeoNB. Basemap Aerial imagery from GeoNB. Detailed imagery from Leading Edge (2014).

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

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121812215 - Mactaquac Project - NB Power

Area of Review for the Atmospheric Environment

Figure 4.1

Table 4.2 describes the emissions considered for describing a potential change in air quality.

Table 4.2 Air Contaminant Descriptions

Air Contaminant	Description	Sources	Interactions
Dust (also known as total particulate matter, or PM)	• Airborne, specks of solid or liquid matter, including dust, ash, soot, smoke, or tiny particles of pollutants.	• Industrial fuel use, construction activity, motor vehicles, road dust, agricultural operations.	• Can be a major form of air pollution.
Particulate matter less than 10 microns (PM_{10}) (also known as fine particulate matter)	• Describes particles that are 10 microns (millionths of a metre and not visible) or less in diameter, and sometimes referred to as fine particulate matter.	• Same as for dust.	• Same as for dust.
Particulate matter less than 2.5 microns ($PM_{2.5}$) (also known as respirable particulate matter)	• Particles that are 2.5 microns in diameter or less, and sometimes referred to as inhalable or respirable particulate matter.	• Created by combustion processes such as the burning of fossil fuel. • Same as for dust.	• Reduces visibility. • $PM_{2.5}$ may be more of a carrier of contaminants, such as sulphates, nitrates, carbon, and heavy metals than PM_{10}.
Sulphur dioxide (SO_2)	• Colourless gas. • Has a sharp odour, like that of a struck match. • May notice an acid taste in air at higher concentrations.	• A by-product of the burning of sulphur-bearing fuels such as oil and coal.	• High concentrations can damage trees and agricultural crops, and corrode metals. • Combines with water vapour in air to form acid aerosols and acid rain.
Nitrogen oxides (NOx)	• A group of gases produced when nitrogen and oxygen combine, typically when fuels are burning at high temperature.	• Combustion of fossil fuels by motor vehicles and power generating stations.	• Can irritate the lungs and lower our resistance to respiratory infections. • Can damage vegetation, including food crops. • A major factor in the formation of acid rain.
Volatile organic compounds (VOCs)	• A group of carbon containing substances. • Some of these compounds take the form of gases. • Liquid VOCs, such as gasoline, will readily evaporate, hence the term "volatile".	• Handling of fossil fuels may be a source. • Evaporation of liquid solvents and fuels such as gasoline.	• React with other substances such as NOx in the presence of heat and strong sunshine to create ground-level ozone and smog. • Some VOCs, such as benzene, are toxic.
Total reduced sulphur (TRS) compounds	• Produce offensive odour similar to rotten eggs or cabbage. • TRS includes hydrogen sulphide (H_2S), which has a characteristic "rotten egg" odour and is formed from the decomposition of organic matter.	• Natural sources include swamps, bogs and marshes.	• TRS compounds are not normally considered a health hazard; however, they are a primary cause of odours. • Some TRS compounds, like H_2S, are toxic at high concentrations.

Sources: NBDELG N.D., OMECC (2010)

4.2 EXISTING CONDITIONS

4.2.1 Sources of Information

This information is drawn from the following sources:

- existing air quality information (*e.g.*, regional ambient air quality monitoring data);
- regional climatic information (*e.g.*, temperature, winds, precipitation);
- known information about emissions; and
- the experience and judgment of the study team.

4.2.1.1 Air Quality

Key information for determining existing air quality included data provided by the New Brunswick Air Quality Monitoring Results Report (NBDELG 2013a). That report summarizes data obtained from the air quality monitoring network that has been operated by the government and industry in New Brunswick to monitor ambient concentrations of various air contaminants in selected New Brunswick communities. The monitoring network was designed by NBDELG primarily to monitor compliance with ambient air quality standards and objectives.

Provincial and national emission totals, as submitted to the National Pollutant Release Inventory (NPRI), are summarized from the Environment Canada website (Environment Canada 2015c).

4.2.1.2 GHG Emissions

Information for estimating GHG emissions from existing facilities include data provided by Environment Canada (2015d) (for provincial and national GHG emissions) and data provided by the World Resources Institute (CAIT 2015) for estimating global GHG emissions.

The quantities of GHGs released at water reservoir surfaces are largely from biological processes that occur as part of the natural carbon cycle. Biological processes occurring in the headpond, that involve the decomposition of vegetation or near-surface soil carbon, and emit GHG emissions from the surface of the water, the turbines and spillway. These GHG emissions from the headpond are estimated by using calculation methods from the Intergovernmental Panel on Climate Change (IPCC 2003).

Did you know?

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. In the 25 years since it was formed, it has become a key place for the exchange of scientific information on climate change within the scientific community as well as across governments around the world (Edenhofer and Seyboth 2013).

Three greenhouse gases are released from reservoirs at hydro dams. These are carbon dioxide (CO_2,), methane (CH_4), and nitrous oxide (N_2O). Emissions of N_2O from flooded lands are generally very low, especially in colder climates that prevail at Mactaquac (UNESCO 2006; IPCC 2006; IPCC 2011). For this reason, the IPCC calculations do not consider N_2O. For the purposes of this review, where there is a low level of agricultural activity being conducted within the area of review for GHGs, the release of N_2O is not considered.

Did you know?

Biological processes are necessary for all living organisms to survive and contribute to the carbon balance on earth. The carbon balance is related to GHGs since capture and release of carbon dioxide contributes to concentrations of GHGs in the atmosphere, which contributes to climate change. In turn, carbon fixing from the atmosphere into vegetation, soils and other media return this essential element to the earth so that it becomes available for biological and life processes.

Carbon is one of the essential elements needed by plants and animals to survive. Since the existence of life on earth, there has been a dynamic balance between the nutrient needs of vegetation and animals and the ability of the soil to supply it. At the heart of this nutrient balance is a carbon cycle.

The carbon cycle involves the movement of carbon between four major zones:

1) The atmosphere; 2) living organisms; 3) the soil; and 4) the water on the earth's surface (oceans, rivers and lakes) (Soil-Net.com n.d).

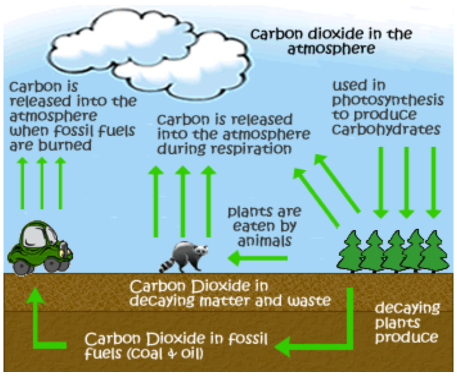


Image Courtesy of www.realtrees4kids.org

During photosynthesis, plants combine carbon dioxide from the air and hydrogen from water to make carbohydrates. Some of these carbohydrates are stored in the tissues of the plant and others are used by the plant for energy. Oxygen is released as a by-product.

When that plant is eaten by an animal, the cells of the animal break down the plant during digestion. This releases the stored carbon and other nutrients into the animal's system.

As animals breathe out, carbon dioxide is released into the air (atmosphere) and the cycle can begin again.

Breathing is not the only way carbon makes it into the air. Carbon and carbon dioxide are also released when dead plants and animals are decomposed and when fossil fuels are burned (for example, gas burned in a car engine).

The IPCC (2003; 2006) describes how to estimate GHG emissions from reservoirs at three levels of detail (called Tiers), with the level of detail increasing as one proceeds from Tier 1 to Tier 3. For this review, Tier 1 and Tier 2 estimates, are relatively simple and included for comparison.

4.2.1.3 Microclimate

The establishment of existing conditions for a microclimate relies on the following:

- baseline climatic data, from Environment Canada;
- climate trends and variations, from Environment Canada;
- information from the Intergovernmental Panel on Climate Change (IPCC); and
- experience with microclimate from other similar projects.

4.2.2 Description of Existing Conditions

4.2.2.1 Air Quality

4.2.2.1.1 Ambient Air Quality

According to the NBDELG report entitled "New Brunswick Air Quality Monitoring Results: 2011" (NBDELG 2013a) and previous annual reports, the existing and historical ambient air quality at Fredericton (the nearest air quality monitoring location to the Station) is generally considered to be good.

The province has two systems for describing the air quality in New Brunswick: the Index of the Quality of the Air (IQUA) and the Air Quality Heath Index (AQHI). In 2011, air quality was in the good to poor IQUA and AQHI categories at all stations across the province greater than 97% of the time.

Index of the Quality of the Air (IQUA)

The IQUA has been used in New Brunswick since 1979. Data for key air contaminants are converted into a value that ranges from 1-100+ based on regulatory objectives for each contaminant.

IQUA Rating	% of regulatory objective
good	0-25
fair	26-50
poor	51-100
very poor	over 100

Air Quality Health Index (AQHI)

This was first introduced in New Brunswick in 2008. The index is based on three key health-related pollutants: nitrogen dioxide (NO_2), ozone (O_3), and respirable particulate matter ($PM_{2.5}$). It uses a scale of 1-10+, with higher values representing greater health risks.

Given the rural nature of the area of review and the Station itself, ambient air quality is expected to be good most of the time and similar to, or better than, that reported for Fredericton.

4.2.2.1.2 Existing Air Contaminant Emissions

Table 4.3 compares New Brunswick's emissions of selected criteria air contaminants to the national totals.

Table 4.3 2013 Emissions Totals for Selected Criteria Air Contaminants, New Brunswick and Canada

Criteria Air Contaminant	Total New Brunswick Emissions, 2013 (kilotonnes, kt)[1]	% of National Emissions	Total 2013 National Emissions (kilotonnes, kt)[1]
PM	388	1.61%	24,057
VOCs	35.7	1.67%	2,135
NO_x	39.3	1.91%	2,061
CO	147	2.33%	6,301
SO_2	29.6	2.40%	1,231

Notes:
[1] Environment Canada (2015c)
CO - carbon monoxide
VOCs – volatile organic compounds
NOx - nitrogen oxides
PM – total particulate matter
SO_2 - sulphur dioxide

New Brunswick's contribution to the national total releases of air contaminants is relatively low, on average at approximately 2% of the national totals.

4.2.2.2 GHG Emissions

4.2.2.2.1 Emission of GHGs from Existing Facilities

Provincial GHG emissions in 2011 (including industrial facilities, agriculture, vehicles, and natural sources) were 18,500 kilotonnes of CO_2e (NBDELG 2015a). Thirteen industrial facilities in New Brunswick reported GHG emissions to Environment Canada (2015d) for 2011, for a total of 7,854 kilotonnes CO_2e (NBDELG 2015b). Major GHG emitters in New Brunswick include the Saint John Oil Refinery (39.5%), the Belledune Generating Station (34.7%), Bayside Power in Saint John (9.6%), and the Coleson Cove Generating Station (4.6%).

Canada's GHG emissions in 2011 were 701,000 kilotonnes CO_2e (Environment Canada 2015c). New Brunswick's contribution to national GHG emissions is approximately 2.6%.

Greenhouse gas emissions globally are estimated to be 43,000,000 kilotonnes CO_2e per year (CAIT 2015). Canada's contribution to global GHG emissions is approximately 1.7%.

4.2.2.2.2 Emission of GHGs from Biological Activity

Greenhouse gases of concern are CO_2, CH_4, and N_2O. N_2O emissions from reservoirs are typically very low, relative to CO_2 and CH_4 (IPCC 2006). Therefore, this review does not include N_2O from biological sources or from the surface of the water, and the biological GHG emission estimates from the headpond include only CO_2 and CH_4.

Many factors may influence the emissions of CO_2, CH_4 and N_2O from flooded land. Examples include the age of the reservoir, land-use prior to inundation, climate, and management practices as well as pH, salinity, depth, altitude, and available carbon (IPCC 2006). It is widely understood, for example, that temperature is an important control on the overall magnitude of CH_4 and CO_2 emissions. This is demonstrated by higher GHG emissions from reservoirs situated in tropical climates than in boreal and temperate climates (Duchemin *et al.* 2002; St. Louis *et al.* 2000). Emissions from reservoirs also tend to be highest early after flooding of the land when the rate of decomposition of organic matter is highest (typically within the first two to three years after flooding (UNESCO 2006)), and tend to decrease over time (Soumis *et al.* 2005; Tremblay *et al.* 2004a).

Using the IPCC methods, GHG emissions from the existing operation of the Station are estimated to range from 70 to 86 kilotonnes CO_2e per year calculated according to IPCC Tier 2 and Tier 1, respectively. Each of these GHG emission estimates account for a small percentage of provincial (0.50%), national (0.01%), and global (0.0002%) GHG emissions reported in 2011.

4.2.2.3 Climate and Microclimate

4.2.2.3.1 Climate

The climate of New Brunswick is generally characterized as continental in the central and northern regions of the province, with more of a moderated climate in the southern and eastern regions of the province due to influence from the Atlantic Ocean (*e.g.*, Gulf of St. Lawrence, Northumberland Strait, Bay of Fundy). In the winter months, cold Arctic air frequently flows across New Brunswick. The winters are generally characterized as cold with major snow falls. However, short, mild spells often occur throughout the winter when the flow of Arctic air breaks down, often resulting in several freeze-and-thaw cycles which are generally more prevalent in southern areas. In summer, the air mass is generally warm with occasions of hot, humid air from the Gulf of Mexico, specifically in areas away from the influence of the ocean (Environment Canada 2000).

Topography (land elevation) has a limited influence on the climate in New Brunswick, except for localized effects in some locations due to areas of terrain relief or air flow along river valleys.

The most recent climate normals available (1981-2010, referred to below as the period of record) are taken from data measured at the Fredericton Airport weather station, which is located near the Saint John River and approximately 30 km from Mactaquac. Fredericton and Mactaquac are about the same distance to the ocean and exhibit similar (although not identical) topography. Therefore, climate data from Fredericton are expected to be reasonably representative of average weather conditions at Mactaquac.

At the Fredericton Airport, during the winter, the air mass is cold with a January daily mean temperature of -9.4°C. In the summer, the air mass is predominantly warm continental with a July daily mean temperature of 19.3°C. The extreme maximum and minimum temperatures recorded are 37.2°C and -37.2°C, recorded during August and February, respectively. The change in mean annual temperature was an increase of 1.1°C over the period of record (Environment Canada 2015b).

The average annual precipitation for the Fredericton Airport weather station is 1,077.7 mm, of which 79.7% is rain. Extremes in daily precipitation occurred in August and September and are 124.0 mm to 148.6 mm. When comparing the mean annual precipitation from 1981 versus 2010, there was a 62 mm increase in rain and snow over that period (Environment Canada 2015b).

The average relative humidity (annual) values for the same period of record are 83.3% and 58.7% for the morning and afternoon, respectively.

The average number of days per year with visibility less than 1 km is 108.4, over the same period of record.

The average annual wind speed reported at the Fredericton Airport weather station is approximately 12.0 km/h. The maximum wind speeds occur in April with average speeds of 14.2 km/h and the minimum speeds occur in August at an average of 9.6 km/h. The average monthly wind speeds are higher in the winter than in the summer. The prevailing winds are from the south or southwest in summer and from the west or northwest in winter.

Maximum hourly wind speeds, averaged from 1981 to 2010 for each month, range from 48 km/h and 80 km/h. Maximum gusts for the same period range from 93 km/h to 132 km/h. Extreme winds are uncommon at Fredericton: over the last three decades there has been an average of 1.7 and 0.2 days per year with winds greater than or equal to 52 km/h and 63 km/h, respectively (Environment Canada 2015b).

4.2.2.3.2 Climate and Microclimate

A comparison with regional information for New Brunswick for 2014 indicates the following:

- annual temperatures in the 11 climate regions of Canada exhibit positive trends over the 67 years, with the trend being the weakest in Atlantic Canada (0.7°C);
- temperatures (as an average) across the country warmed by 1.6°C over the past 67 years, while temperatures in New Brunswick in 2014 were near the baseline; and
- precipitation across the country in 2014 was slightly below the reference values. Atlantic Canada in 2014 was among the 10 wettest since 1948 (Environment Canada 2015a).

The Mactaquac headpond is located in the Atlantic Maritime Ecozone, which is characterized by rough upland terrain and coastal lowlands, also including mixed wood Acadian forests, coastal islands, sand dunes and numerous lakes. The climate of this ecozone is described in the Ecological Framework of Canada (2015) as follows.

> *"The proximity of the Atlantic Ocean creates a moderate, cool, and moist maritime climate. Most of the ecozone experiences long, mild winters (averaging about -4°C in January) and cool summers (the mean daily July temperature is 18°C). Coastal communities are generally several degrees warmer in winter and slightly cooler in summer.*
>
> *During late spring and early summer, the mixing of the cold Labrador Current and the warm Gulf Stream produces frequent banks of sea fog over coastal areas. Average precipitation varies from 1,000 mm inland to 1,425 mm along the coast. The average annual growing season ranges from 1,500 to over 1,750 growing degree-days above 5°C. Frost-free days, on average, fluctuate from 80 in the New Brunswick highlands to 180 along the coast. With a storm frequency higher than anywhere else in Canada, sunshine can be a rare commodity."* (Ecological Framework of Canada 2015).

This description is more applicable to the coastal part of the zone. Fredericton has a more continental climate (warmer in summer, colder in winter), and it is 200 km from the Gulf of St. Lawrence so the moderating effect of that body of water would be more limited inland. It is more likely that the Mactaquac area and areas upstream of it would experience conditions similar to Fredericton because of the short distance between the two (Fredericton is about 19 km from the headpond) and they are both either located on, or adjacent to, the Saint John River.

4.3 SUMMARY OF STANDARD MITIGATION FOR ATMOSPHERIC ENVIRONMENT

Standard mitigation and best management practices that are relevant to the atmospheric environment will be implemented for construction and operation. These are based on normal operating procedures and regulatory requirements, which are detailed in Section 2.6, and it includes mitigation specific to the atmospheric environment.

4.3.1 Air Quality

The following are standard mitigation measures that will be used to manage Project-related changes in air quality:

- developing a detailed plan for dust control, including the implementation of mitigation and follow up monitoring. This plan will include items such as:
  - applying water or other approved dust control compounds on the site and access roads, as required, to reduce dust generation during dry periods; and
  - seeding and re-vegetation of the exposed banks of the Saint John River, as well as topsoil and overburden storage piles as soon as possible after disturbance;
- implementing an idling policy to reduce the consumption of fuel when equipment and vehicles are stationary for extended periods of time;
- adhering to a comprehensive equipment preventative maintenance program for maintaining vehicle condition. This will help enhance fuel efficiency and vehicle performance;
- where possible, reduce haul routes to and at the site and revise routing to avoid residential areas; and
- covering trucks that contain material that could generate dust during transit; cleaning mud from vehicles leaving unpaved site areas onto public roads.

4.3.2 GHG Emissions

Mitigation that improves fuel efficiency will also reduce GHG emissions from equipment.

4.3.3 Microclimate

There are no standard mitigation measures recommended for changes to microclimate, mainly because the changes to microclimate are expected to be small. This is especially true for Option 1 or Option 2. Small microclimate changes may occur for Option 3 because of changes to topography and changes in the area's heat balance due to removal of the headpond; however, no mitigation is expected to be necessary.

4.4 POTENTIAL INTERACTIONS BETWEEN ATMOSPHERIC ENVIRONMENT AND THE OPTIONS

Table 4.4 provides an overview of how the options might interact with atmospheric environment.

Table 4.4 Potential Interactions between Atmospheric Environment and the Options

Phase	Option 1			Option 2			Option 3		
	Potential Change in Air Quality	Potential Change in GHG Emissions	Potential Change in Microclimate	Potential Change in Air Quality	Potential Change in GHG Emissions	Potential Change in Microclimate	Potential Change in Air Quality	Potential Change in GHG Emissions	Potential Change in Microclimate
Construction (New Facilities, Options 1 or Option 2)	✓	✓	NI	✓	✓	NI			
Demolition (Existing Structures, Options 1 or Option 2)	✓	✓	NI	✓	✓	NI			
Operation (Options 1 or Option 2)	NI	NI	NI	NI	NI	NI			
Decommissioning (Option 3)							✓	✓	✓

Notes:
✓ = Potential interactions.
NI = No interaction.
Shaded cells are not applicable to the particular option and phase.

Construction and demolition of Option 1 or Option 2 are not expected to result in a dramatic change in the surface area of water, and they are not expected to produce perceivable changes in microclimate.

The emission of air contaminants during operation of Option 1 or Option 2 are expected to originate only from vehicle traffic associated with worker commutes and from specific supplier and maintenance activities. These emissions are expected to be similar to emissions from operation and maintenance of the existing Station. Therefore, no change in air quality associated with the operation of Option 1 or Option 2 is expected.

Releases of GHGs during operation of Option 1 or Option 2 will occur from continued biological activity associated with flooded lands that form the headpond immediately upstream of the dam, degassing through the turbines and over spillways and smaller amounts associated with the burning of fuel for travel, vegetation control and other maintenance activities. It is expected that biological GHG emissions from operation of Option 1 or Option 2 will continue at rates that are similar to current rates because the size of the headpond, and water flows from turbine and spillways, would not change appreciably compared to current conditions. Similarly, the vehicle travel and maintenance activities for Option 1 or Option 2 are assumed to be unchanged from existing conditions. Therefore, GHG emissions from combustion of fuel during operation of Option 1 or Option 2 are expected to be similar to existing conditions and there is no interaction.

The size of the headpond for the operation of Option 1 or Option 2 will be largely the same as existing conditions. Therefore, no change in microclimate is expected because a change in the size of the water surface would be the main cause of a change in microclimate.

4.4.1 Potential Change in Air Quality

The air contaminants considered in this review, based on their expected emissions during the Project phases, are:

- dust (in the form of PM, PM_{10} and $PM_{2.5}$);
- criteria air contaminants (CACs), which for this review are sulphur dioxide (SO_2), nitrogen oxides (NO_X), and carbon monoxide (CO);
- volatile organic compounds (VOCs); and
- total reduced sulphur (TRS) compounds as a potential cause of odour (Option 3 only).

4.4.1.1 Option 1 or 2

Because the activities associated with Option 1 or Option 2 will be similar, the review of the potential changes in air quality for these options is combined. The main differences between the two options will be the duration of construction and demolition activities (approximately 11 years for Option 1 and 10 years for Option 2), and the area of disturbance associated with each (a lesser area of disturbance with Option 2 compared to Option 1). The activities expected to be sources of air contaminant emissions during construction are site preparation, construction of facilities (*e.g.*, powerhouse, spillway, switchyard, fish passage and ancillary facilities), on-site quarrying (if required), excavation of rock and construction materials, and road access. Demolition of the existing diversion sluiceway, main spillway, powerhouse, and switchyard will also result in emissions.

Heavy mobile equipment and transport vehicle operation during construction and demolition will be sources of combustion gases (sulphur dioxide, nitrogen oxides, and carbon monoxide) and fugitive dust emissions from movement around the site and movement of overburden and from transportation of materials to and from the site.

The construction of Option 1 or Option 2 will require the excavation and movement of large quantities of earth materials. However, the amount and type of equipment used will vary depending on the construction contractor, the origin of the materials, and each of the construction activities.

Typically, during construction and demolition projects, emissions of combustion gases from equipment and transportation sources are not normally released in quantities that would cause large-scale air quality issues (with implementation of standard mitigation such as listed in Section 2.6); though some localized and infrequent episodes of poor air quality may occur on occasion. Dust has a larger potential concern during construction and demolition. It is discussed in further detail in the subsection on dust emissions.

4.4.1.1.1 Air Contaminant Emissions

Emissions estimates from construction of the Lower Churchill project (on the Churchill River in Labrador) have been used to estimate the anticipated air contaminant emissions from Option 1 or Option 2. Air emissions from the 10-year construction of the Lower Churchill project are expected to result mostly from combustion of fossil fuels and fugitive emissions (*i.e.*, dust) from construction activities; the same is expected for Options 1 and 2 at Mactaquac.

Conservative annual emissions from construction equipment from the Lower Churchill project, as an indicator of potential emissions from Options 1 and 2 at Mactaquac, are presented in Table 4.5, along with a comparison to the total New Brunswick emissions for 2013.

Table 4.5 Estimated Construction Air Contaminant Emissions – Options 1 and 2

Air Contaminant	Estimated Annual Emissions from the Lower Churchill Project (as a Surrogate for Option 1 or 2 Emissions) (kilotonnes, kt)[1]	Total New Brunswick Emissions, 2013 (kilotonnes, kt)[2]
PM	0.133	388
VOCs	0.125	357
NO_X	1.897	39.3
CO	0.409	147
SO_2	0.155	29.6

Notes:
[1] Average yearly emissions, Nalcor (2009)
[2] Environment Canada (2015c)
CO – carbon monoxide
NO_X – nitrogen oxides
PM – total particulate matter
SO_2 – sulphur dioxide
VOCs – volatile organic compounds

It is expected that emissions from Option 1 will be higher than from Option 2 because the duration is longer and amount of work is larger compared with Option 2.

Overall, under the assumption that emissions from Option 1 or Option 2 at Mactaquac are comparable in terms of order of magnitude to those expected from the Lower Churchill project, the total emissions to the atmosphere on an annual basis during construction of Options 1 or 2 are small compared to the annual emissions from other sources in New Brunswick (*i.e.*, less than 0.5 percent of total New Brunswick emissions in 2013). Further, the current air quality of the surrounding area is considered to be good, most of the time. Based on data from the construction of similar facilities and with implementation of mitigation, combustion gases are not expected to be an issue for air quality.

4.4.1.1.2 Dust Emissions

The greatest potential change in air quality due to the construction of Options 1 or 2 is anticipated to be dust generated from construction near the Station.

Dust generation depends on many factors such as the moisture in the soil, the level of activity at a particular location, and meteorological conditions at the time (mainly wind speed and direction). Potential for dust concerns will be higher during periods of high winds or extreme dry periods.

Sources of dust may include activities associated with:

- construction equipment on dirt roads;
- aggregate transport;
- aggregate piles, deposit and take away;
- aggregate crushing;
- blasting;
- concrete mixing; and
- brownfield spaces required for the work (*e.g.,* temporary laydown areas).

That stated, however, controlling dust emissions from construction sites is a fairly well understood practice and mitigation measures aimed at reducing dust levels are, for the most part, generally effective at achieving those objective. With implementation of the mitigation methods listed in Section 4.3, the potential change in air quality with respect to dust emissions is expected to be small. The key standard mitigation required during dry periods or high wind events is to apply water or other approved dust suppressants on roads or construction areas to reduce dust. With consistent application of dust suppressants, dust levels should be able to be controlled to a point where ambient concentrations are below provincial air quality objectives.

4.4.1.2 Option 3

The potential change in air quality from the operation of heavy equipment during decommissioning of Option 3 is expected to be less than for Option 1 or Option 2. The duration of decommissioning and scope of work overall is less than in Option 1 or Option 2. Given the lesser duration and lesser level of construction activity associated with Option 3 compared to Option 1 or Option 2, except for dust (discussed below), the emissions associated with Option 3 would be less than those two options. Therefore, these emissions are not discussed further in this review.

Dewatering of the headpond may result in dust emissions and potential odour from exposed sediment. The potential emissions from dewatering are described further below.

4.4.1.2.1 Dust Emissions Following Dewatering of the Headpond

Dust emissions from the construction activities associated with the removal of structures for Option 3 are expected to be less than those for Option 1 or Option 2. The construction footprint will be smaller, and the duration of Option 3 is also shorter than for the other options.

Once the headpond has been dewatered, underlying soils and sediment will be exposed as water is removed. They will dry out and may release dust into the atmosphere during dry and windy conditions, which could interact with nearby residents. The duration of these emissions is expected to be short/medium because, over time, the surface of the exposed sediments will weather and harden (creating less potential to be picked up by winds). Further, it is assumed that the exposed banks of the

Saint John River will begin to re-vegetate themselves through natural processes within one to two growing seasons, as has been demonstrated with other dam removal projects. However, there could be areas where the vegetation does not re-establish quickly or is sparse. If dust becomes an issue, active re-seeding could be increased to speed up re-vegetation of the exposed banks and sediments. Once the exposed banks of the Saint John River are re-vegetated, dust should no longer be a concern. Therefore, with mitigation (*i.e.*, active hydroseeding in sensitive areas), activities are expected to result in a minimal change in the air quality, most of the time. A shoreline dust control study has been conducted which identified areas where dust may be more likely to be released under Option 3, and includes site-specific mitigation for these areas.

4.4.1.2.2 Odour Following Dewatering of the Headpond

Following dewatering of the headpond, there is the possibility that odour emissions could result from the sediment that is exposed during dewatering. The amount of organic carbon or reduced sulphur compounds that could be released from the sediment is unknown. These compounds are the result of decomposition of organic matter in the sediments, and can be detected by humans at very low concentrations in ambient air. However, based on experience from other dam removal projects (*e.g.*, Petitcodiac River Causeway Removal, Eel River Dam Decommissioning), activities are not expected release odours in quantities that would cause a large change in the air quality. There may be noticeable odours for short time periods when an area is first exposed, but as with dust from dewatered areas, once the exposed banks of the Saint John River begin to re-vegetate, any odours that may be perceptible from time to time would be expected to decrease over time.

4.4.2 Potential Change in GHG Emissions

There is potential for releases of GHGs to contribute to the global concentration of GHGs in the atmosphere due to:

- GHG emissions from the burning of fuel in equipment and vehicles during construction, demolition, and decommissioning (for Options 1, 2 or 3); and
- GHG emissions from biological activities during decommissioning (*e.g.*, GHGs from the surface of the river and from exposed sediment) (for Option 3 only).

4.4.2.1 Option 1 or 2

The main sources of GHG emissions for Options 1 or 2 would be from the combustion of fossil fuel in the heavy equipment used in transportation, site preparation and construction of new power generating infrastructure. Since this no appreciable change to water levels expected following the implementation of Options 1 or 2, GHG emissions from biological activities during operation of Options 1 or 2 would be expected to be similar to, or less than those associated with the existing operation of the Station. Therefore, this latter aspect is not discussed further in the context of Option 1 or Option 2.

To estimate GHG emissions, GHG emissions from similar hydroelectric projects were prorated on a tonnes CO_2e/MW basis to determine the total GHGs from construction activities (BC Hydro 2012, Nalcor 2009). On this basis, the GHG emissions are estimated to be approximately 152 kilotonnes of CO_2e for Option 1 over the approximately 11-year construction and demolition period, with Option 2 emitting a lesser amount. The average annual total from Option 1 (13.8 kilotonnes of CO_2e per year) will be approximately 0.074% percent of the annual provincial total GHG emissions. This amount is relatively small in comparison to other ongoing sources of emissions in the province. GHG emissions from Option 2 would be expected to be less than for Option 1 due to the shorter construction period (10 years) and reduced amount of construction activities.

4.4.2.2 Option 3

4.4.2.2.1 Release of GHGs from Combustion of Fossil Fuel

During decommissioning, GHGs will be released from the combustion of fossil fuel in the heavy equipment used to dismantle and demolish the existing structures at the Station, including the removal of the earthen dam structure.

The GHG emissions from decommissioning vehicles and related equipment are expected to be much lower than the emissions estimated for Option 1 or Option 2 because the construction period is shorter (seven years) and there are fewer construction activities associated with this Option as compared to Options 1 or 2.

4.4.2.2.2 Release of GHGs from Biological Activity

All rivers and lakes, whether they are natural or manmade, emit GHGs due to decomposing organic material. As part of the natural cycle, organic matter is flushed into these waterbodies from the surrounding land. As a result, these freshwater systems also sequester some carbon in the sediments (IPCC 2011, Cole *et al.* 2007).

Under Option 3, the major pathways for GHG emissions are:

- emissions from the surface of the water due to biological activity; and
- breakdown of stored carbon in sediments, which will become exposed during the dewatering process.

<u>GHG Emissions from the Surface of the Water due to Biological Activity</u>

The GHG emissions from the surface of the water will continue at the same emission rate as for existing conditions, but these Option 3 GHG emissions will occur from a smaller surface area of water after the river is restored to near natural-flow conditions. Using the IPCC Tier 1 methods, GHG emissions from the surface of the river restored to near natural-flow conditions are estimated to be 45.4 kilotonnes CO_2e per year. This is 0.25% of provincial emissions, 0.006% of national emissions, and 0.0001% of global GHG emissions reported in 2011. These emissions would be expected to decrease over time as carbon is consumed.

GHG Emissions from Exposed Sediments

It is assumed that under Option 3, the river would be expected to return to near its original path and pre-flood surface area, which was estimated using GIS, based on aerial photos of the river from 1967. GHG emissions will occur from the exposed sediment when the headpond is drained. The carbon stored in the accumulated sediment at the bottom of the headpond will decompose and will be released to the atmosphere in the form of GHGs (*i.e.,* CO_2 and CH_4). The amount of GHG emissions from the sediment depends on the amount of organic carbon stored in the sediment.

While some sediments are known to contain 20% to 25% of carbon, by weight (Carignan and Lean 1991), based on available sediment samples, the Mactaquac sediment contains about 2.7% carbon by weight (Kidd *et al.* 2015). Sediment carbon is influenced by many factors including biological content (such as leaf litter inputs), biological processes by phytoplankton and zooplankton, as well as erosion rates. The Mactaquac headpond is a widening and deepening of a river, which transports solid, mineral based materials as well as water. The catchment of the Saint John River is subject to a great deal of human disturbance from, for example, forestry, agriculture, and urban development. Therefore, there is a relatively large supply of mineral sediment derived from watershed soils. As a result, the Mactaquac headpond sediment is mainly silt from upstream soils along with the small amount of carbon. In general, these upstream soils have already undergone decomposition processes before being washed into the water and deposited as sediment in the headpond.

Some carbon will be produced by biological processes in the headpond, but much of this will be washed downstream due to hydraulic flushing of the headpond, which occurs quite rapidly.

It is recommended that, should Option 3 proceed, an analysis of the carbon stable isotopes in sediment be undertaken, to determine the origin of the carbon. Such an analysis would likely demonstrate that the carbon is mostly of terrestrial origin (*i.e.*, silt from upstream soils), not aquatic origin (*e.g.*, from phytoplankton and zooplankton). If this is the case, this would suggest that the carbon has been "pre-digested" in the soil and that the residual carbon should be quite resistant to further rapid degradation.

Carignan and Lean (1991) demonstrate that even in a Canadian Shield lake (where most of the carbon is relatively fresh and more of it is produced via biological processes in the lake), the freshest carbon produced in water decomposes very rapidly with much of the decomposition happening before reaching the sediment. It is estimated that 99% of the remaining carbon in the Mactaquac headpond sediment would take as long as 75 years to lose half its mass as GHG releases.

The amount of carbon stored in the headpond sediment is estimated to be 561 kilotonnes, based on the average annual sedimentation load from 1967 (434 kilotonnes; Environment Canada 2015e), the average percent organic carbon in preliminary sampling results [2.7% (Kidd *et al.* 2015)] and age of the headpond (48 years). This is likely an overestimate because:

- the amount of sediment is calculated assuming that all the sediment deposited over the last 48 years stayed above the dam, and none of it was carried and deposited downriver, which is likely not the case (see Section 6); and

- the sedimentation rate post-1967, is likely to be lower than the 1967 rate, due to improvements in erosion mitigation (since the mid-1960s).

In addition to GHGs released from decomposition of sediment carbon, there is potential for CO_2 and CH_4 gas to exist as gas bubbles trapped in the sediment. This gas could also be released during the dewatering process. However, no estimate is available for the amount of gas in the sediment. Recent sediment sampling does not indicate the presence of a large amount of gas bubbles (Yamazaki, G., pers. comm., 2015). Additional sediment sampling would be needed to confirm the presence of gas in the sediments.

Based on previous research (Pacca 2007) and the estimated amount of carbon stored in the sediment of the Mactaquac headpond (561 kilotonnes of carbon), GHG emissions can be estimated for Option 3 by assuming that:

- the carbon within a 1 m deep slab of sediments in a reservoir being drained is subject to decomposition; and
- for every 10 CO_2 molecules emitted, one CH_4 molecule is emitted.

With these assumptions, the estimated GHG emissions are 3,900 kilotonnes CO_2e.

This GHG emission estimate is likely an overestimate because it assumes all of the carbon will decompose immediately upon dewatering. In consideration that the type of carbon present in the sediment is likely fairly resistant to decay, it may take 75 years for half its mass to breakdown (Carignan and Lean 1991). Therefore, the emissions are expected to be 52.6 kilotonnes CO_2e per year for 75 years. This is a low percentage (0.28%) of the total annual provincial GHG emissions reported for 2011.

Following dewatering, the exposed banks of the Saint John River are expected to begin to naturally re-vegetate within one or two growing seasons, and may be actively seeded in some areas to stimulate grass growth and prevent erosion. Within one or two years of being exposed, it would be expected that the sediment would be vegetated. Once vegetated, plant roots, and plant leaf litter will start adding carbon back to the dewatered area.

According to Conant *et al.* (2001), soil organic carbon content in temperate grasslands averages 4.6%. Permanent grassland, without cultivation, is known to increase soil carbon content (Acharya *et al.* 2012). Therefore, over a period of 5 to 10 years after dewatering, and assuming no other human intervention, the initial small loss of carbon during dewatering would be compensated for by carbon accumulation as the soil carbon content tends towards the 4.6% value typical of temperate grassland soils.

In conclusion, dewatering of sediments in the Mactaquac headpond is not likely to result in emission of GHGs that will not be compensated for through natural processes within a few years as the former sediment is transformed into vegetated soil.

4.4.2.3 Summary of GHG Emissions

A summary of GHG releases estimated for each Option is provided in Table 4.6.

Table 4.6 Summary of GHG Emissions

Option and Project Phase	Average annual GHG Emissions (kilotonnes CO_2e/y)	% Annual Provincial GHG Emissions (2011)	% Annual National GHG Emissions (2011)	% Annual Global GHG Emissions (2011)
Construction and demolition (Option 1) - fossil fuel combustion	13.8	0.074	0.002	0.00003
Construction and demolition (Option 2) - fossil fuel combustion	<13.8	<0.074	<0.002	<0.00003
Operation (Option 1 or Option 2) - biological emissions	NI	NI	NI	NI
Decommissioning (Option 3) - fossil fuel combustion	<<13.8	<<0.074	<<0.002	<<0.00003
Decommissioning (Option 3) - biological emissions from surface of water plus decomposition of carbon in exposed sediment due to dewatering[1]	98[A]	0.53	0.014	0.00023

Notes:
NI = No interaction.
[1] Biological Emissions from Surface of Water (Tier 1 =45.4 kilotonnes CO_2e/y)+ Decomposition of Carbon in Exposed Sediment due to Dewatering (52.6 kilotonnes CO_2e/y) = 98.0 kilotonnes CO_2e/y.

Releases of GHGs related to combustion gases are considered low for each of the Options and can be partially mitigated through efficient equipment use and proactive maintenance.

Biological activities associated with the operation of Options 1 or 2 are expected to be similar to those of existing conditions. Therefore, no estimate is provided above in relation to Option 1 or Option 2. The quantity of GHG emissions from biological activity in the headpond under existing conditions is estimated to be approximately 86 to 89 kilotonnes CO_2e/year. These emissions are similar to that occurring from lakes naturally, and account for a small percentage of provincial (0.48%), national (0.012%), and global (0.0002%) GHG emissions reported in 2011.

The GHGs released as a result of biological processes are only considered for Option 3, and they are estimated at 98 kilotonnes CO_2e per year, which is a small percentage of the provincial (0.53%), national (0.014%), and global (0.00023%) GHG emissions reported in 2011. This low emission of GHG is due to 1) the low level of carbon content in the Mactaquac sediments relative to surrounding soils, 2) the expectation that sediments will re-vegetate quickly, and 3) the expectation that sediments will begin storing carbon, as soils supporting plant growth, within one or two growing seasons following dewatering of the Mactaquac headpond.

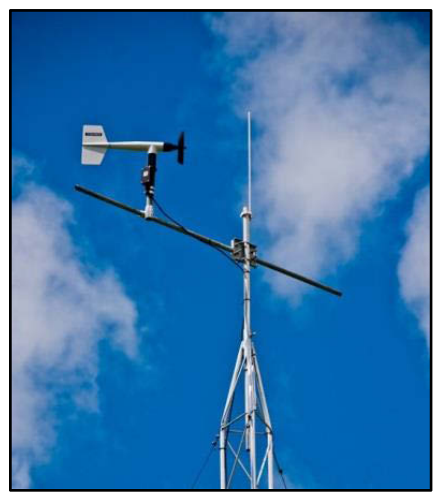
4.4.3 Potential Change in Microclimate

4.4.3.1 Option 3

The potential ways that a change in microclimate that might occur with Option 3 include:

- change in local temperature;
- change in local precipitation;
- change in local wind speeds or directions;
- change in local humidity;
- change in heavy fog days; and
- change in visibility.

Under Option 3, the air temperatures and precipitation in the region may change somewhat on a localized basis in terms of the ability of the land and water to be heated and retain, reflect or disperse that heat. This is associated with the drop in the quantity of stored water in the headpond as the dam is being removed, changing the landscape from lake-like to terrestrial conditions following dewatering. This change may also affect the convective and radiative heat balances on a localized basis, with for example the ground storing more heat in the summertime as compared to water, and thereby resulting in localized changes to air temperatures and circulation patterns as a result of the changed landscape. However, it would not be expected to result in large-scale changes to the microclimate of the headpond area as a whole.



The local wind speeds may change because of the change in landscape and, specifically, from the change in roughness at ground level. An increase in roughness (*e.g.*, more shrubs and trees, compared to the smooth surface of the water currently) will increase the frictional element and the mechanical turbulence near ground level. This in turn would affect local wind speeds and potentially wind directions. Local winds typically follow the geographical direction of the river valley, and wind direction may change if there is a substantive change in local topography.

Similar to the conditions for a change in precipitation, the local relative humidity, fogging and visibility may also change due to:

- the absence of the waterbody;
- a change in local air temperatures; or
- an increase in vegetation growth.

The IPCC (2014) provides detailed information on climate data (globally and regionally) to date and on forecasts for the future. Some of the highlights for the Atlantic Region are the following.

- The observed annual temperature increase over the 1901-2012 period for the Atlantic Canada region is reported to be about 0.5 to 1°C.
- The observed annual precipitation increase from 1951-2010 is reported to be about 5 to 10 mm per year per decade for Atlantic Canada.
- The mean projections based on climate modelling show an increase in temperature of 1 to 3°C by mid-21st Century and 2 to 6°C by late 21st Century.
- The mean projections show an increase in precipitation of 0 to10% by mid-21st Century and 0 to 20% by late 21st Century, where these are compared to the mean values for 1986-2005.

In summary, there is an expected increase in temperature of up to about 5°C and about 15% increase in precipitation for the Atlantic Region in the next 50 to 100 years.

Large lakes and reservoirs are known to interact with microclimate. The observed interaction at the Robert Bourassa Reservoir (Bégin *et al.* 1998) included a small change in spring thermal conditions, cooler temperatures in the early summer months and slightly warmer fall temperatures (Hydro-Québec 2006). However, it was concluded that these thermal interactions were limited to the immediate periphery of the reservoir (Hydro-Québec 2006). Given that the surface area of the Robert Bourassa Reservoir is 2,835 km^2 (Hydro-Québec n.d.), which is approximately 22 times larger than the Mactaquac Headpond (Hartland to Coytown), it is anticipated that the potential microclimatic changes for Option 3 will be less than at the Robert Bourassa Reservoir. Even if the interactions are measurable, the zone of influence rarely encompasses more than 20 km for a 1,000 km^2 body of water (Hydro-Québec 2001).

BC Hydro (2012) suggests that the presence of reservoirs will cause:

- at most, light breezes on normally calm days, but would not alter the frequency, direction or force of those winds; and
- changes associated with the microclimate of a reservoir less than those changes expected from global climate change; and a few additional hours per year of heavy fog and poor visibility.

In considering Option 3 with the removal of the headpond, the findings are likely to be similar in magnitude, but with an opposite effect. There may be some local increase in temperature due to the absence of the headpond but this is expected to be small and not likely detectable. This change may also cause a minor change in wind circulation patterns (speed and direction) as they flow down the valley; however, the change is not expected to be noticeable beyond about 100 m to 200 m from the former banks of the headpond. There may be a small decrease in the incidence of heavy fog and in the number of days with poor visibility but this is not likely to be detectable.

In summary, the changes to local temperature, precipitation, winds, fog and visibility are likely to be small, and if they occur, are likely to be confined to a small distance from the headpond. These changes may be indistinguishable from current values. Therefore, the changes in microclimate for

Option 3 are likely to be low. The nature of these changes may be positive (less fog) or negative (higher temperature), but these are expected to be small changes, never the less.

4.5 SUMMARY OF INTERACTIONS BETWEEN ATMOSPHERIC ENVIRONMENT AND THE OPTIONS

The interactions of the atmospheric environment with the Options are characterized in Table 4.7.

Table 4.7 Summary of Interactions between Atmospheric Environment and the Options[1]

Key Issue	Is the interaction negative or positive?	What is the amount of change?	What is the geographic extent?	How long does it last?	How often does it occur?	Has additional mitigation been recommended?
Potential Change in Air Quality						
Option 1 (Construction and Demolition only)	Negative	Medium	Area	Medium	Multiple	No
Option 2 (Construction and Demolition only)	Negative	Medium	Area	Medium	Multiple	No
Option 3 (Decommissioning)	Negative	Medium	Area	Medium	Multiple	Yes
Potential Change in GHG Emissions						
Option 1 (Construction and Demolition only)	Negative	Medium	Global	Medium	Multiple	No
Option 2 (Construction and Demolition only)	Negative	Medium	Global	Medium	Multiple	No
Option 3 (Decommissioning)	Negative	Medium	Global	Long	Continuous	Yes
Potential Change in Microclimate						
Option 3 (Decommissioning)	Positive/ Negative	Low	Area	Permanent	Single	No

KEY

Is the interaction negative or positive?
- Positive.
- Negative.

What is the amount of change?
- Low – a change that remains near existing conditions, or occurs within the natural variability for the atmospheric environment.
- Medium – a change that occurs outside the natural variability for atmospheric environment but does not change the overall status of the atmospheric environment.
- High – a change that occurs outside the natural range of change for the atmospheric environment that will change the status of the atmospheric environment locally or regionally.

What is the geographic extent?
- Site – the interaction is limited to the immediate area where Project-related activities occur.
- Area – the interaction is limited to the general area surrounding the Station.
- Region – the interaction occurs throughout the area of review and may extend to other regions.
- Province – the interaction affects the entire province.

How long does it last?
- Short – the interaction occurs for less than 3 months.
- Medium – the interaction occurs for 3 months – 1 year
- Long – greater than a year.
- Permanent – there is no foreseeable end-date for the interaction.

How often does it occur?
- Single – the interaction occurs once.
- Multiple – the interaction occurs several times, either sporadically or at regular intervals.
- Continuous – the interaction occurs continuously.

Has additional mitigation been recommended?
- Yes.
- No.

Note:

[1] Some of the ratings for the environmental interactions in the table above have been updated from those provided in the Draft CER Report dated September 2015 (Stantec 2015b), to more accurately reflect the nature and extent of the anticipated interactions with the Options and to reflect feedback received during the public comment period.

4.5.1 Summary of Additional Potential Mitigation and Information Requirements

As described in Section 4.4, this review has identified the requirement for some additional potential mitigation and requirements for further study in some areas. These potential requirements are summarized in Table 4.8.

Table 4.8 Summary of Additional Potential Mitigation and Information Requirements

Option	Additional Potential Mitigation	Additional Information Requirements
Potential Change in Air Quality		
Options 1, 2, and 3	• None.	• Develop emissions inventory for the Preferred Option. • Conduct dispersion and deposition modelling of emissions from the Preferred Option.
Option 3	• Exposed banks of the Saint John River will be re-vegetated as quickly as possible, and hydroseeding will be considered, especially in areas that are not re-vegetating naturally or in high sensitivity areas.	• As above.
Potential Change in GHG Emissions		
Options 1, 2, and 3	• None.	• Develop GHG emissions inventory for the Preferred Option.
Option 3	• Re-vegetate exposed land as quickly as possible, and hydroseeding will be considered, especially in areas that are not re-vegetating naturally or in high sensitivity areas.	• When information is available on actively farmed land in the watershed, this should be considered in light of the assumption made that nitrogen cycling and N_2O emissions are expected to be negligible and not considered in the review. The assumption that nitrogen cycling and N_2O emissions from farming in the watershed area is negligible, can be verified through further study once the Preferred Option is chosen and additional information on land use becomes available. • Assumptions related to sediment accumulation to be verified for GHG estimate: ◦ emission estimates from biological activity calculated based on assumptions for 1967 sediment load accumulation in the headpond; this estimate could be refined using data from the MAES on the actual amount of accumulated sediment. • An analysis of the carbon stable isotopes in sediment would determine if the carbon is mostly of terrestrial origin, not aquatic origin. This would confirm that the carbon has been "pre-digested" and that the residual carbon in the sediment should be quite resistant to further rapid degradation. • How much GHG is trapped in the sediment in the form of bubbles? Sediment sampling from the MAES, as well as sonar and acoustic monitoring, will be used to confirm

Table 4.8 Summary of Additional Potential Mitigation and Information Requirements

Option	Additional Potential Mitigation	Additional Information Requirements
		the amount of bubbles formed in the sediment. Up to this point, and preliminary sampling conducted, there have not been indications of large amounts of bubbles, or GHGs trapped in the sediment.
Potential Change in Microclimate		
Option 3	• None	• May need to do Weather Research and Forecasting (WRF) (or equivalent) modeling to show the difference without and with the headpond in place.

4.5.2 Discussion

4.5.2.1 Potential Change in Air Quality

Currently, the air quality around the Station is good, most of the time, based on a review of the New Brunswick Air Quality Monitoring Results reports for the Fredericton area. The expected releases of combustion gas emissions for Options 1 or 2, including construction, demolition and operation, are not expected to cause a large change in air quality. Dust generation during construction and demolition has a greater potential to interact with ambient air quality. Mitigation of dust will be important in maintaining good air quality during construction and demolition. With standard mitigation procedures including dust suppressant use and timely re-vegetation of disturbed areas, the change in air quality is expected to be small. Once, construction and demolition are completed, there will be little interaction with air quality, similar to existing operation of the Station. Regardless of Option selected, an emissions inventory and dispersion model would be developed to further assess the potential change in air quality for the EIA of the Preferred Option.

For Option 3, emissions of air contaminants are not expected to cause a large change in air quality. During decommissioning the dewatered headpond will create a large area of exposed sediment that could be a source of dust and odourous compounds. This area should begin to re-vegetate within one or two growing seasons, which will help reduce these emissions. Additional mitigation measures, including hydroseeding of large open areas of exposed sediment, could also be used to mitigate these emissions further if needed.

4.5.2.2 Potential Change in GHG Emissions

Based on the preliminary estimates completed, releases of GHG emissions from combustion of fossil fuels during construction, demolition and decommissioning activities are not expected to contribute a large portion to existing provincial GHG emissions totals. Nonetheless, best practices should be used where feasible to reduce fuel consumption during the Project activities to manage GHG releases. The GHGs released as a result of biological processes for Option 3, are small and estimated at 98 kilotonnes CO_2e per year, which would contribute a small percentage of the provincial annual emissions (0.5%) The re-vegetation of dewatered areas will help mitigate GHG releases from the sediment during Option 3. Emissions estimates would be confirmed for any EIA required for the Preferred Option.

4.5.2.3 Potential Change in Microclimate

Only Option 3 is expected to interact with a change in microclimate. The main interactions are as follows.

- With the removal of the headpond, there may be some local increase in temperature but this is expected to be small and not likely detectable.
- The change in local topography, due to the absence of the headpond, may cause a slight change in wind speed and direction. This change, however, is not expected to be noticeable greater than 200 m from the former shoreline of the headpond.
- There may also be a small decrease in heavy fog and in the number of days with poor visibility, but this is expected to be a slight change and is not expected to be detectable.

Overall, the changes to local temperature, precipitation, winds, fog and visibility are likely to be confined to a small distance from the headpond and the interactions are likely to be small, to the point where changes would not likely be distinguishable from current values.

4.5.3 Assumptions and Limitations

4.5.3.1 Air Quality

The following assumptions are used in the discussion of air quality interactions with the Options.

- Overall construction activities would be similar to other hydroelectric projects of a similar size and scale.
- Construction activities during Option 1 or Option 2 will be similar, with the major difference being the total duration of the construction period.
- Construction activity for Option 3 will be less than for the other options, both in terms of duration as well as level of activity.
- Exposed sediment from dewatering of headpond would be expected to re-vegetate within one to two growing seasons.

The observations presented are based on preliminary details available during the CER and would need to be revisited for the selected Option, and refined based on more detailed information once that becomes available in the planning process.

4.5.3.2 GHG Emissions

It is assumed there is not a large amount of active farming or high inputs from fertilizer, thus nitrogen cycling and N_2O emissions are not considered in this review. If agricultural activity and fertilizer input is much higher than assumed, the GHG emissions could be underestimated.

Water flows and surface area of water in the headpond are likely to be relatively similar for Option 1 or Option 2 as compared to existing conditions. This implies that there is no anticipated change in GHG emissions during operation compared to existing conditions. If this is not the case, GHG emissions from the operation of Option 1 or Option 2 might change GHG emissions and thus, there may be an interaction.

Sediment loading in the headpond is assumed to be similar to that of 1967, pre-dam conditions; and all sediment is assumed to accumulate over the 48 years and remain upstream of the dam; therefore, the estimate of sediment carbon is likely to be conservatively high. This, in turn, means a conservatively high estimate of the GHG emissions from the decomposition of that carbon under Option 3.

It is also assumed that under Option 3, the river will return to near its original path and pre-flood surface area, which was estimated using GIS, based on aerial photos of the river from 1967. If the surface area of the river under Option 3 is smaller than that of 1967 river conditions, than the emission estimate for GHG emissions from the surface of the water would be conservatively high (given that the IPCC estimate is based on surface area of the water). If the river ends up having a larger surface area under Option 3 than that of 1967 river conditions, than the emission estimate for GHG emissions from the surface of the water would be lower than expected.

The average annual sedimentation load from 1967 was applied over the 48 years since the headpond was created, and it is assumed that all the sediment was deposited above the dam, and none of it was carried down river and deposited elsewhere. This could mean an overestimation of sediment accumulation, carbon content, and GHG emissions.

The amount of GHG emissions from sediment carbon decomposition is estimated assuming that carbon within a 1 m deep slab of sediments in a reservoir being drained is subject to decomposition. This could be an underestimate because decomposition could reach depths greater than the 1 m deep zone (Pacca *et al.* 2007).

4.5.3.3 Microclimate

There is no meteorological station at the site and it is, therefore, not possible to describe the microclimate of the headpond exactly; however, the weather station at Fredericton is assumed to be sufficiently close, so that data measured at Fredericton are likely to provide a reasonable estimate of the weather at the Mactaquac site.

Weather modeling was not done, but based on previous experience with similar types of hydroelectric projects, any change in microclimate that might occur with Option 3 is expected to be small.