

6.0 ASSESSMENTS OF OTHER LIKELY EFFECTS

This chapter provides an assessment of effects both from and on the Project that are different from those potential effects of the Project on the environment in Chapter 5.0. These include likely effects of the Project on the sustainable use of resources (Section 6.1), likely effects of the environment on the Project (Section 6.2), and climate change considerations (Section 6.3).

6.1 LIKELY EFFECTS OF THE PROJECT ON THE SUSTAINABLE USE OF RESOURCES

The *CEAA* and the EA Guidelines issued by CNSC require that the EA Study Report take into account whether the likely environmental effects from the Project would affect the sustainability of renewable and non-renewable resources. Sustainability is used in a manner consistent with the United Nation's definition of sustainable development i.e., "*economic development that meets the needs of the present without comprising the ability of future generations to meet their own needs*" (UN WCED 1987). Project "needs of the present" are defined as needs for the duration of the Project Refurbishment Phase and Continued Operation Phase (i.e., approximately 2010 – 2060). Project "needs of the future" are assumed to refer to the period after the Continued Operation Phase.

Potential interactions between project works and activities (during both Phases) and the environmental components identified in Chapter 5 were reviewed to determine the likelihood of interactions between the Project and renewable and non-renewable resources.

6.1.1 Renewable Resources

As identified in the EA Guidelines, the following environmental components associated with renewable resources may be affected by the Project:

- Surface Water Resources;
- Aquatic Environment;
- Terrestrial Environment, and
- Geology and Hydrogeology (subcomponent groundwater quality and groundwater recharge and flow).

6.1.1.1 Surface Water Resources

Project-environment interactions related to surface water resources are discussed in Section 5.5 (non-radiological) and Section 5.9.3 (radiological). Interactions were identified with all sub-

components (Lake Ontario circulation, water temperature, drainage water quality, and shoreline processes) during various project works and activities, as provided in Table 5.3-1. This discussion is different from that in Chapter 5.0 because it assesses potential likely effects on surface water as a renewable resource.

Surface water (i.e., Lake Ontario) serves as a natural source of drinking and service water for people and industry surrounding the PN site, and as a resource for both the aquatic and terrestrial environment (discussed in Sections 6.1.1.2 and 6.1.1.3, respectively).

As a renewable resource for drinking and service water, surface water is directed to the Water Supply Plants (WSPs) taking water from Lake Ontario. The WSPs nearest to PNGS are located in Ajax (Ajax WSP) and Toronto (Frank J. Horgan WSP). As indicated in Section 5.5, any adverse effects on water quality at WSPs associated with the Project are associated with the thermal plume. Under baseline conditions, the effects on water quality resulting from the influence of the increased temperatures due to the PNGS thermal plumes on the biological activity and chemical activity are small, with no significant effects on the ability to treat water for potable purposes. Three-dimensional model simulations of the thermal plumes from PNGS during the Refurbishment Phase predicted that the estimated maximum limits of the combined thermal plume do not extend as far as these WSPs, and there will be a decreased thermal input to Lake Ontario during this phase of the Project. The same minor effects as currently occur under baseline conditions are expected during the Continued Operation Phase.

Evaporation loss due to the warmer water is about 2-3 m³/s. The loss is approximately 268,000 m³/day or 95 x 10⁶ m³/year.

With respect to surface water quality (radiological), historical data demonstrates that all tritium concentrations measured in the Regional, Local and Site Study Areas are below Ontario's Drinking Water Quality Standard. Overall, the concentrations of gross beta, which does not include tritium, measured from the WSPs and the surface water samples within the Site Study Area are well below OPG's internal screening level. Gross beta concentrations are also within the range of expected gross beta concentrations that result from the presence of naturally occurring radionuclides, together with fallout from atmospheric nuclear weapons testing. As indicated in Section 5.9.3, no measurable change in radiological emissions to surface water are expected from either phase of the Project.

With respect to surface water quality (non-radiological), effects from the Project on surface water (i.e., boiler blowdown, surface water runoff, changes to discharge and intake flowrates) are not expected to cause a measurable change within Lake Ontario, as further discussed in Section 5.5.

Overall, no Project-related activities are expected to affect the sustainability of surface water as a renewable resource.

6.1.1.2 Aquatic Environment

Aquatic environment interactions as a result of the Project are discussed in Section 5.6 (non-radiological) and Section 5.9.3 (radiological). Interactions were identified with all sub-components (aquatic habitat and aquatic biota) during various project works and activities, as provided in Table 5.3-1. This discussion focuses on the potential likely effects of the Project on the aquatic environment as a renewable resource, including those resulting from likely effects to surface water as a resource for the aquatic environment.

Lake Ontario is the principal aquatic environment related to the PNGS B Project. Changes in this resource as a result of the Project may affect the aquatic biota, specifically the fish population and diversity which are identified as renewable resources.

The assessment of Project effects in Section 5.6 (non-radiological) evaluated the possibility of localized effects on aquatic habitat (i.e., its usage by fish) associated with thermal and current velocity changes resulting from activities during refurbishment (i.e. two out of four units operating when each unit is being refurbished). No adverse effect for habitat usage due to changes to velocities within the PNGS B intake and outflow channels and the decrease in the thermal plume emanating from the PNGS B discharge channel were identified. Fish will continue to be lost due to impingement and entrainment; however, no population level effects to fishes are predicted as a result of impingement and entrainment. Effects on the aquatic environment (non-radiological) during the Continued Operation Phase (i.e., after all units are refurbished) will likely be the same as the existing pre-Project effects.

The assessment of Project effects in Section 5.9.3 (radiological) indicated no measurable change to emissions to surface water and thus the aquatic environment during either phase of the Project.

Overall, it is unlikely that there will be any significant effect on the sustainability of fish populations and diversity as a result of the Project. Moreover, there is currently no commercial fishery or any likelihood of subsistence fishing in the vicinity of the PN site that would rely on this resource.

6.1.1.3 Terrestrial Environment

Terrestrial environment interactions as a result of the Project are discussed in Section 5.7 (non-radiological) and Section 5.9.2 (radiological). Interactions were identified with sub-components

(vegetation communities and species, wildlife habitat, and wildlife communities and species) during various project works and activities, as provided in Table 5.3-1. This discussion assesses the potential likely effects of the Project on the terrestrial environment as a renewable resource, including those resulting from likely effects to surface water as a resource for the terrestrial environment.

Lake Ontario serves as a resource for the terrestrial environment (i.e., waterbirds). In addition, the terrestrial sub-component of vegetation communities and species is a renewable resource for wildlife communities and species.

As previously discussed, no likely Project-related effects on Lake Ontario as a renewable resource are expected. Therefore, the sustainability of Lake Ontario as a renewable resource for waterbirds will not be affected by the Project.

As indicated in Section 5.5.7, no effect on vegetation communities, including wetlands, woodlands, shrubland, open grassland, parkland, shoreline and the built environment on the PN site is likely to occur as a result of this Project. As indicated in Section 5.9.2, gamma radiation (including contribution from nuclear waste) and atmospheric emissions (i.e., emissions to terrestrial vegetation) arising from both phases of the Project are not expected to be significantly different from baseline conditions. Therefore, no potentially significant incremental environmental effects within the Local Study Area are expected.

Overall, it is unlikely that there will be any effect on the sustainability of vegetation communities and species or surface water resources and, subsequently, wildlife communities and species.

6.1.1.4 Geology and Hydrogeology

The geology and hydrogeology sub-component of groundwater quality, recharge and flow is identified as a source of a renewable resource that may be affected by the Project. Interactions as a result of the Project are discussed in Section 5.8 and Section 5.9.4. Interactions identified with groundwater sub-components during various project works and activities are provided in Table 5.3-1.

Investigations on the PN site have identified tritium in groundwater beneath PNGS B where the inactive drainage system receives groundwater and discharges it to a settling basin prior to discharge to the station intake channel in Lake Ontario. Tritium in groundwater is not part of normal operations per se; rather it is a result of a maintenance and repair issue during operation of the auxiliary systems. All tritium activities are below the CNSC-approved tritium in non-potable groundwater criterion for PNGS B (Jacques Whitford Environmental 2000). The

analysis presented in the TSD for Radiation and Radioactivity demonstrated that there are no adverse effects from tritium emissions to surface water. Works and activities associated with both phases of the Project are not expected to change baseline conditions; hence, no potentially significant incremental environmental effects within the Regional, Local and Site Study Areas are expected.

Overall, it is unlikely that there will be any effect on the sustainability of groundwater as a result of the Project.

6.1.2 Non-Renewable Resources

PNGS B is an existing facility. The Refurbishment and Continued Operations Phases of the Project will not include any new construction or engineering works that would require large quantities of materials or non-renewable resources. Non-renewable resources which would be used for the Project are limited to the materials used to refurbish the four reactor units (Section 6.1.2.1), to operate the station (Section 6.1.2.2), and to construct additional storage structures at the PWF (Section 6.1.2.3).

Many factors affect the supply capability and reserves of non-renewable resources, including supply and demand, accessibility, stockpiling and inventory practices, conservation and recycling practices. Should PNGS B undergo refurbishment-related construction and engineering activities, a potential effect of the Project on non-renewable resources exists.

6.1.2.1 Refurbishment

Refurbishment of the PNGS B reactors involves the replacement of steam generators, fuel channels (fuel channel assemblies, calandria tubes and endfitting assemblies), feeder piping, etc. As a consequence, various wastes will be generated.

Some of the waste is directly recyclable, such as metal filings, electrical cables, paper, glass, and metal cans. However, the largest quantities of waste are associated with the pressure tube/calandria tube replacement and steam generator replacement. Currently, the replaced components are not likely to be recycled and likely will require temporary storage at PWF before shipment off site.

The total quantity of metal waste associated with these activities is approximately 1000 tonnes per reactor unit. The annual Canadian consumption of ferrous scrap as an input in steel production has been near 10 million tonnes in recent years (Canadian Steel Producers 2005). Therefore, it is considered unlikely that the disposal of contaminated metal waste from PNGS B would measurably affect the availability of these materials in Canada or elsewhere.

The quantities of fuel and lubricants used by refurbishment and construction equipment during the Refurbishment Phase are unlikely to measurably affect the availability of these materials in Canada or elsewhere.

6.1.2.2 Continued Operation

Materials used to operate the station include the uranium dioxide fuel used in the reactors and oils, chemicals, and lubricants used to operate and maintain various station systems. As described in Chapter 2.0, PNGS B uses natural uranium dioxide pellets enclosed within metal tubes made of a zirconium alloy. The fuel is manufactured in Ontario using uranium mined in Canada or elsewhere. The metal tubes are also manufactured in Ontario.

The total quantity of fuel used per year at PNGS B is estimated to be up to 14,000 bundles, containing approximately 300 tonnes of uranium and less than 30 tonnes of zirconium. The world supply of uranium has exceeded the demand for many years. The World Nuclear Association currently estimates that known world reserves of low-cost uranium are adequate for at least the next 70 years of world demand, and that further exploration and higher prices will yield further resources as present ones are depleted (WNA 2006). It has recently been estimated that Canada's uranium reserves could support uranium mining production at current rates for another 40 years (NRC 2005). The annual production of uranium in Canada is approximately 10,000-12,500 tonnes per year (NRC 2005). Therefore, the use of uranium by PNGS B is unlikely to significantly affect the supply of uranium in Canada or elsewhere.

The minerals used to produce zirconium metal are very common in the earth's crust. The annual worldwide production of zirconium minerals is currently estimated at well over 800,000 tonnes and the worldwide reserves are estimated to exceed 50 million tonnes (Hedrick 2000). Therefore, the relatively small quantity of zirconium used by PNGS B is unlikely to significantly affect the supply of this metal.

Similarly, PNGS B uses various oils, chemicals and lubricants, including fuel for back-up generators. The quantities of these materials would be similar to those used by other industrial facilities. Although the volumes of these materials used have not been quantified, it is considered unlikely that PNGS B's consumption would measurably affect the availability of these materials in Canada or elsewhere.

The continued operation of PNGS B will displace the use of non-renewable fuels (coal, natural gas), resulting in a positive effect of the Project on sustainability.

6.1.2.3 Construction of Storage Structures at PWMF

The types of raw materials likely to be used in the PNGS B Project for the construction of storage structures at PWMF (OPG 2003a) are expected to be similar to those employed at the PWMF I for the existing used fuel dry storage structures:

- Standard materials for construction and maintenance of the storage structures, typical of the industrial structures within the PWMF;
- Asphalt and concrete to enclose and cover the surface areas surrounding the structures;
- Shielding materials (recycled material may be used if possible);
- Minor quantities of petroleum, oil and lubricants related to operation and maintenance of equipment; and
- Fencing and related materials.

The use of aggregate materials in the construction of the storage structures will be negligible in the context of the abundance of aggregate resources. The quantities of fuel and lubricants used during site preparation and construction of the proposed project will be similar to those used in the construction of any typical industrial facility (e.g., a small manufacturing plant). The use of these materials would not measurably affect their availability in Ontario or elsewhere.

The quantities of non-renewable resources required to sustain the construction of storage structures at PWMF would be minor compared to on-going normal construction activities in southern Ontario. In summary, it is unlikely that there will be any significant adverse effects of the Project on the sustainability of non-renewable resources.

6.2 LIKELY EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The EA Guidelines require that consideration be given to how the environment could adversely affect the PNGS B Project, assessing environmental events that are considered credible in the context of the Project. The approach to the assessment of the effects of the environment on the Project involves:

- Identifying and describing those environmental conditions (i.e., events) with a reasonable probability of occurring that are likely to result in a significant environmental effect or pose a hazard to workers or the public.

- Describing the features of Project design and operation that are intended to safely withstand the likely effects of natural hazards including any contingency measures currently in place.
- Describing and assessing the significance of the likely effects and hazards to workers and the public (if any).

Additional discussion of potential effects of the environment on the Project is provided in Chapter 7.0 and in the TSD for Credible Malfunction and Accident Scenarios.

6.2.1 Potential Environmental Conditions and Likely Effects on the Project

Table 6.2-1 identifies the potential conditions in the environment that may affect the Project and its principal component(s). Potential conditions arise from two major aspects of the environment: the physical environment (i.e., natural hazards) and the biophysical environment (i.e., natural conditions). The physical environment encompasses natural physical phenomena on land, in bodies of water and in the atmosphere. The biophysical environment encompasses living organisms that inhabit the physical environment.

**TABLE 6.2-1
POTENTIAL ENVIRONMENTAL CONDITIONS
AND INTERFERENCE WITH THE PROJECT**

Potential Environmental Condition	Principal Affected Component(s) of the Project
Physical Environment	
Flooding	<ul style="list-style-type: none"> • Integrity and function of external structures and systems, e.g., electric power systems
Lake Ice	<ul style="list-style-type: none"> • CCW system • Service water system
Severe Weather	<ul style="list-style-type: none"> • Integrity and function of external structures and systems, e.g., electric power systems
Seismic Events	<ul style="list-style-type: none"> • Systems critical to safe plant shutdown, e.g., nuclear safety systems, nuclear steam supply system
Climate Change	<ul style="list-style-type: none"> • Integrity and function of external structures and systems, e.g., electric power systems • Integrity and function of breakwater and cobble shoreline • Water systems (i.e., CCW system and service water system) • Stormwater management system • Auxiliary power system
Biophysical Environment	
Zebra and Quagga Mussels	<ul style="list-style-type: none"> • Service water system
Attached Algae	<ul style="list-style-type: none"> • CCW system • Service water system
Fish	<ul style="list-style-type: none"> • CCW system • Service water system

The conditions included in Table 6.2-1 are based on experience of past effects that have occurred at PNGS B, including the effects of lake ice, zebra and quagga mussels, attached algae, and fish. Environmental conditions that may adversely affect the Project, but which have not actually affected PNGS B in the past, such as flooding, lake water levels, severe weather, seismic events, and climate change were also considered.

Flooding and severe weather are assumed to primarily affect external structures, systems and buildings. The likely effects of seismic events are considered in relation to systems critical to safe station shutdown following a seismic event, for reasons discussed below. Each natural hazard and potential environmental condition, and likely project interference, is described in subsections 6.2.2 and 6.2.3. Relevant project design features and contingency measures are described in subsection 6.2.4. Climate Change has been forwarded for more thorough analysis in Section 6.3.

6.2.2 Conditions in the Physical Environment

6.2.2.1 Flooding

Flooding can occur when the Lake Ontario water level rises significantly, following a prolonged period of above-average precipitation in the Great Lakes basin. However, Lake Ontario water levels are managed for navigation purposes. Flooding can potentially affect the integrity and function of external structures and systems. The likelihood of coastal flooding at PNGS B was investigated through an assessment of the variation in lake levels and the wave run-up that may be observed at the site (see Sections 4.2.5.1 and 4.2.5.4). A detailed presentation of the assessment is included in the TSD for Surface Water Resources.

The long-term average Lake Ontario still water level is 74.7m IGLD (International Great Lakes Datum). Based on historic water levels in Lake Ontario from 1960 to 1998 (i.e., the period since the water levels have been regulated by the St. Lawrence Power Project), the 200 year return period flood is at elevation 76.1 m IGLD. The 200 year return period flood has a 1-in-200 or 0.5% chance of occurring in any year. This return period was chosen for the assessment of flooding potential because it represents a flood that is possible, but unlikely to occur, during the proposed period of PNGS B operations (i.e., until 2060).

Flooding can also occur through wave run-up, particularly during a severe storm with large waves. Wave run-up is defined as the uprush of water from waves acting or breaking on a shoreline or structure. Wave run-up was investigated using representative water levels of 74.5 m (average) and 76.1 (1 in 200 year) m IGLD (see TSD for Surface Water Resources for details).

At a lake level of 74.5m IGLD, adequate freeboard is provided for all of the modelled storm waves. There is no overtopping predicted for the sites depicted in Figure 4.1-3 with the modelled storm waves at a lake level of 74.5m IGLD. However, overtopping is predicted across the PN site for the 1 in 200 year water level with the modelled storm waves, although the rate of overtopping is predicted to be small.

Stormwater management systems on the PN site are sized to accommodate the Regional Storm Event (1 in 100 year storm). Therefore, it is unlikely that severe rainstorms would overwhelm the PN site.

6.2.2.2 Lake Ice

Lake ice accumulation in the intake channel can block the supply of water to the CCW and other service water systems. Large ice jams are rare and only two significant events have been reported since 1971 (OPG 2000a). In the past, ice jams have primarily affected PNGS B because of the configuration of the forebay and the presence of a skimmer wall at PNGS A. Ice can accumulate at the PNGS B intake because it is at the end of the forebay and the ice cannot flow any further.

Observations of Lake Ontario ice conditions near the PN site from 1969 to 1980 included airborne reconnaissance to map the extent of ice cover, and ground observations to determine ice conditions along the shore. It was found that during PNGS operations, the extent and duration of ice accumulation depends on meteorological conditions and the extent of the thermal plume (OPG 2006d). However, ice booms installed at the intake channel are expected to prevent any ice jams from occurring by preventing significant amounts of shore ice from being pulled into the intake channel.

6.2.2.3 Severe Weather

The following discussion reviews severe weather events that could affect PNGS B and PWF, including thunderstorms, tornadoes and ice storms. Severe weather can potentially affect the integrity and function of external structures and systems at PNGS B and at PWF.

Tornadoes

The distribution of tornadoes, particularly in Ontario, appears to be random and extremely localized. A tornado usually affects a limited area and only for a short period of time; however, serious property damage and injury, including fatalities, may occur along its path. A few tornadoes or funnel clouds (tornadoes that do not reach the ground) are confirmed each year in

southern Ontario. In the Regional Study Area, one tornado per 10,000 km² can be expected annually (Environment Canada 2003). The area of the Regional Study Area is approximately 850 km²; therefore, approximately one tornado every 12 years may be expected.

Although rare, a tornado would be the worst type of severe weather that might affect the PNGS B Project. In the event of a tornado, damage to the PNGS B reactor buildings is unlikely due to the robust construction. Damage to other buildings on the PN site and the storage structures at PWMF might occur as a result of strong winds, rapid pressure change, tornado-generated projectiles and/or the collapse of other structures or buildings. Various operational and safety systems could be compromised by building damage and/or power outages. Although on-site road systems might be damaged or obstructed, neither tornadoes nor missiles generated by them can cause significant damage to the used fuel storage containers or the used fuel within them.

Thunderstorms and Hail Storms

Thunderstorms and hail storms are more frequent occurrences than tornadoes; however, they are less damaging. Thunderstorms are more common during the warmer months of the year (May to September). They usually occur as a result of convective instability in a humid atmosphere or as a result of the passage of warm or cold fronts. Typically, thunderstorms are of short duration (e.g., 30 minutes), but during this time they can briefly produce very strong winds (50 km/hour or more) and torrential rain (5-10 cm/hour or more). Damaging hail can sometimes accompany severe thunderstorms. Lightning is a common characteristic of thunderstorms that can cause serious damage to structures.

The frequency of thunderstorms and hail storms in the Site Study Area is expected to be similar to that at the Frenchman's Bay meteorological station, the nearest meteorological station that records thunderstorms. For the period 1971-2000, the data from this station indicates that there are, on average, 27.9 thunderstorms per year and 1.3 hail storms per year in the PNGS area (Environment Canada 2003).

Thunderstorms and hail storms can damage external structures, buildings and systems directly through high winds, heavy rain and lightning. Operational and safety systems can be affected by power outages.

Ice Storms

Ice storms are caused when the atmosphere is layered, with a layer of warm air above the denser cold air near surface. As precipitation falls in the warm layer, rain forms. The rain then falls

into the shallow cold layer and freezes on contact with the surface. Ice storms can damage light structures such as power transmission lines because of the weight of accumulated ice.

Ice storms are known to occur in Eastern Ontario and Quebec, and may occur in Southern Ontario around PNGS B. On average, Ottawa and Montreal receive freezing precipitation 12 to 17 days a year. However, this type of precipitation generally lasts only a few hours. In January 1998, a severe ice storm occurred in Eastern Ontario and Quebec; over 90 millimetres of freezing drizzle fell during the five-day storm. This magnitude has an annual probability of occurrence of about 1 in 100 (Ontario Hydro 1998b). The January 1998 ice storm caused significant damage to transmission lines and sub-transmission systems. The PNGS (i.e. steam generators, APS, EPG, etc.) is able to withstand a storm-induced loss of grid.

6.2.2.4 Seismic Events

Seismicity at PNGS B is discussed in Section 4.5 and in the TSD for Geology, Hydrogeology, and Seismicity. In general, earthquakes in stable interior regions, such as the Lake Ontario region, occur at depths of 5 km to 20 km on faults formed hundreds of millions of years ago. Deformation features observed in the Rouge River Valley, within 10 km of the PNGS, have been analyzed to assess their seismic hazard. It was concluded that these features are unlikely to be seismogenic in origin (Godin *et al.* 2002). The seismic hazard for the Pickering area is thus considered to be low to moderate.

The Southern Ontario Seismic Network (SOSN) collects seismicity data and seismic hazard information for the Southern Ontario region. In 1996, the Pickering SOSN station was added and is located within 20 km of PNGS (OPG 2006d). Within a 50 km radius of Pickering, there have only been three earthquakes of greater than or equal to Magnitude (M) 3 in recorded history. The November 1999 (M 3.8) earthquake offshore of Pickering caused no damage to the station, and operation of the PNGS B reactors was not affected.

Data from all known earthquakes of greater than M 2.5 within 100 km of Pickering, within the period of historic record (since about 1850) indicate that local events have been small (i.e., less than M 4.5). Information on the older events (pre-1960s) is very uncertain, in terms of both earthquake magnitudes and locations. In the last 20 years, for which catalogue information is most complete and reliable, there have been four events of greater than M 2.5, as shown on Table 6.2-2.

**TABLE 6.2-2
EARTHQUAKES OF M > 2.5**

Date	Event	Distance from the PN Site
July 23, 1987	M 2.9	66 km
November 26, 1999	M 3.8	22 km
May 25, 2000	M 2.6	3 km
March 28, 2005	M 2.6	59 km

These events would produce ground motions that might be weakly felt at the PN site, but are far below the damage threshold. For example, as discussed in the TSD for Geology, Hydrogeology and Seismicity, the 2005 event was felt at the PN site, and produced recorded ground velocity there of about 0.02 mm/s. By comparison, the damage threshold occurs at a velocity of about 100 mm/s.

6.2.3 Conditions in the Biophysical Environment

6.2.3.1 Zebra Mussels

At many sites on the Great Lakes, nuisance mussels now include the zebra mussel, *Dreissena polymorpha*, and the quagga mussel, *Dreissena bugensis*. Both species are similar in size but differ primarily in how they attach to substrate, and the temperatures at which reproduction occurs (Claudi and Leach 2002). Most important with respect to effects on PNGS operation, the means of controlling both species of mussels, including present use of continuous and intermittent applications of sodium hypochlorite, are the same.

Without appropriate control in raw water systems, these mussels generally lead to fouling of virtually all solid substrates. Within a growing season, densities of adult mussels may reach a few thousand to several hundred thousand per square meter of surface area. If uncontrolled, mussels may lead to restricted flow or blockage in piping and strainers, reduced heat transfer, failure of critical equipment, and potential outages. Such problems are more likely to occur in areas of low water flow most common in service water systems. Experimental and casual field observations indicate that settlement of mussels is precluded only when continuous flow rates are in excess of about 1 to 2 m/s.

Zebra mussels are a non-native species that was inadvertently introduced to North America during the mid-1980s in the ballast water of ocean-going ships (Nelepa and Schloesser 1993). In 1989 (former) Ontario Hydro recognized that zebra mussels could interfere with operation of their generating stations located on the Great Lakes and began studies in 1990 (Wiancko 1999). Since then, zebra mussels have rapidly colonized Lake Ontario, their huge population profoundly

affecting some fish and invertebrate species and the nutrient distribution and food-web patterns of the lake. Unlike native freshwater mussels, adult zebra and quagga mussels are not free-moving, but live attached to rocks and other solid substrates, including built structures.

During their reproductive season, typically in the spring, summer and/or autumn, large numbers of zebra and quagga mussel larvae are present in Lake Ontario. The free-floating, planktonic larvae are drawn in with lake water and can attach themselves to water intake structures and the inside of pipes and other equipment through which lake water is circulated. Attachment is a function of several parameters which include flow rate, light levels, and food supply. Their establishment and growth within PNGS B systems could, if unchecked, eventually restrict or block water flow and may interfere with mechanical operation of equipment such as valves.

Zebra and quagga mussels can also cause screenhouse operational and maintenance problems. Large numbers of dislodged mussels and/or their empty shells have been periodically observed in the PNGS A and PNGS B screenhouses. The shells and/or mussels can collect on the travelling screens and, after being washed from the screens, accumulate in sumps along with small fish and aquatic plants. There they interfere with operation of the rakes that empty the sumps into dumpster bins for disposal. The rakes are adequate to pick up floating fish and vegetation, but they cannot remove the piles of shells and mussels at the bottom of the sumps.

6.2.3.2 Attached Algae

Filamentous attached algae grow in great abundance on rocks and other hard surfaces along the Lake Ontario shoreline and on rocky substrates on the bottom of the lake. The most important species to PNGS B is *Cladophora* which is filamentous green algae that grows attached to hard surfaces within the littoral zone.

The Lake Ontario shoreline in the vicinity of the City of Pickering provides an excellent growth environment for *Cladophora*, and earlier studies indicated that over 99% of the algae growing in an area 10 km east and west of the station was *Cladophora* (Aquatic Sciences 1997). The thermal discharges of both PNGS A and PNGS B create a local environment that is thermally enriched compared to other areas farther from the station, thus potentially enhancing algae growth locally. An adjacent sewage treatment plant adds nutrients to the water which also contributes to algae growth. This treatment plant is expected to double in size and could result in further phosphorus loading; phosphorus availability is a limiting factor for *Cladophora*. Local watercourses and storm drains are also sources of nutrients. The anticipated urban growth will result in increased runoff in the local watersheds over the next 30 years. This in turn will increase the relative contribution of runoff nutrients and warm water to the effluent pathways to Lake Ontario.

Information on the distribution of *Cladophora* in the vicinity of PNGS was obtained using an electromagnetic radiation imaging ground-truthed by divers (Aquatic Sciences 1997). Results indicated that within 4.4 km of PNGS there was an estimated 101.7 metric tonnes dry weight of *Cladophora* in August of 1995. Assuming fresh weight is approximately 20 times dry weight, an estimate of *Cladophora* within 4.4 km of PNGS is 2000 tonnes.

During mid-summer and fall, *Cladophora* senesces, sloughs off their substrate and drifts with waves and currents before washing ashore (Harris 2004). When detached, these algae form “balls” which can travel long distances, and if moving east of the station can become entrained at the PNGS B. Entrainment of the attached algae, either as mats or diffuse in the water, can cause water supply problems at water intakes by plugging screening equipment and strainers.

Since the late 1970's, a number of changes have taken place in Lake Ontario which have affected the abundance and structure of the algae community. Many studies were conducted to determine the causes of excessive growth. The key factor appeared to be phosphorus loading. The removal of phosphorus from detergents, improved phosphorus removal by sewage treatment plants and changes in agricultural practices resulted in a decline of *Cladophora* in the littoral zone of the Great Lakes (Bootsma 2004). In the latter part of the 1990's, excessive *Cladophora* growth re-emerged as a management problem in the Great Lakes. The main factor appears to be the introduction of the zebra and quagga mussels. Zebra and quagga mussels filter the water of zooplankton and other particulates resulting in an improved light penetration, thus providing a more favourable environment for *Cladophora* growth (Claudi and Leach 2002). Feces and pseudofeces produced by the mussels contain nutrients. They are deposited on the substrate and fertilize growth of attached algae (Hecky et al. 2004).

A research initiative related to attached algae in Lake Ontario began in 2002. This research was aimed at a better understanding of the factors that influence the growth of *Cladophora* in Lake Ontario with the ultimate goal of providing advice on possible control methods (Ontario Water Works Research Consortium (OWWRC) 2007). This research was carried out at the University of Waterloo with a grant from the OWWRC and support from the National Water Research Institute and the Ontario Ministry of the Environment. Additional research by the University of Waterloo is currently being funded by OPG and the Regional Municipalities of Durham and York.

Since 1972, eighteen incidents have been identified in station documents where acute influxes of algae have had an impact on PNGS operations (OPG 2006d). An earlier inspection of the data indicated that lake currents at the time of these incidents has predominantly been to the west to southwest with maximum current speeds usually at or above 20 cm/s (OPG 2006d). The lake currents that carry the algae to the PNGS A and PNGS B cooling water intake are driven by

winds. There is a lag between a change in wind direction and a corresponding change in the direction of the lake current. Winds at the time of the acute influx of algae incidents have predominantly been from the east (NE to SE) and most commonly associated with velocities exceeding 20 km/h. However, this analysis is preliminary and a more robust statistical and risk assessment tool would be required to better predict algae events at PNGS B.

OPG initiated a program in 2006 to address potential short-term and long-term solutions to the algae problem at PNGS B. Focus was directed at options within the greenhouse, and at the intake. One initiative was the installation of a seasonal (May to December) algae mesh barrier off the end of the east groyne. This represents a relatively short-term solution to prevent algae entry into the station. The net, which is approximately 60 m in length, is angled 45 degrees off the east groyne, and is expected to be operational in 2007. A more long-term option could draw deeper, cooler water rather than water from the littoral zone where the highest densities of *Cladophora* occur. This long-term option offers additional advantages including reduced silt, less fish impingement and a reduction in the temperature of intake water.

6.2.3.3 Fish

Invasive species such as zebra and quagga mussels, and alewife create change in the Great Lakes, including Lake Ontario. There are two recent invader fish species, Asian carp and in particular, round goby, which may also affect the station by altering the nearby fish community and zebra and quagga mussel populations over the next decade.

Alewife

During the early 1970s, there were instances when a single fish species, alewife (*Alosa pseudoharengus*), interfered with the intake of CCW and service water from Lake Ontario to PNGS A. At that time, Lake Ontario nutrient levels were high and predator populations were low compared to present conditions. As a result, Lake Ontario supported a huge population of alewife, a type of herring native to the Atlantic Ocean that had invaded the lake. Each year alewives migrate inshore in large numbers to spawn along beaches. Unlike other Lake Ontario fish species, they also die in the nearshore areas during the spawning run. These massive die-offs in the 1970s fouled beaches and marinas and, at PNGS A, contributed to the impingement of large amounts of alewife over very short time periods. The alewife fouled the PNGS A trash racks and travelling screens and, because the alewife could not be removed quickly enough, temporarily reduced water supply to PNGS A. This reduction in water availability also resulted in a reduction in power production. Since the early 1970s, fish impingement has not caused similar operational problems at either PNGS A or PNGS B. Although the majority of

impingement at PNGS B in 2006 was comprised of alewife, the abundance of alewife has declined since the 1990's (Shaner and Lantry 2005).

Round Goby

The round goby (*Neogobius melanostomus*), is a recent invader thought to have been accidentally released into the Great Lakes from the ballast water of ships traveling from Europe. The round goby was first reported in Lake St. Clair in 1990 (Jude *et al.* 1992), and is now reported in all five Great Lakes. Round gobies have been extremely abundant in many locations, and densities of more than 100 fish/m³ of water are not uncommon in Lake Erie and Lake St. Clair. Round goby have recently been observed impinged at PNGS B.

As round goby populations have expanded, there have been corresponding reductions of bottom dwelling species such as sculpins, darters and sticklebacks, which have been observed in PNGS B impingement studies (see the TSD for the Aquatic Environment). Round goby have been reported to feed on the eggs and fry of various sportfish. However, many larger fish such as walleye, a VEC species, have been reported to actively feed on goby.

Goby prefer rocky and sandy bottoms similar to the bottom substrate observed near PNGS (Golder 2006a). They have also been observed to feed on zebra mussels within the littoral zone, although they seem to prefer the smaller mussels to the adult form. Studies have reported that individual fish can eat nearly 80 zebra mussels per day.

Asian Carp

Asian carp generally refers to four species of non-indigenous fish that are native to Asia and escaped from aquaculture facilities in the US where they were introduced to control vegetation. They are presently noted in large numbers in Ohio and especially the Illinois River which is hydrologically linked to the Great Lakes. Asian carp are now being reported in Lake Erie but their numbers are low. Due to their large size (35 kg; 1.5 m in length), voracious appetite for plankton, and rapid rate of reproduction, these fish could pose a significant risk to the Great Lakes ecosystem.

6.2.4 Design and Contingency Measures and Likely Effects

The preceding sub-sections described the potential environmental conditions in the physical and biophysical environment that may affect PNGS B. The following sub-sections describe and evaluate the project design features and contingency measures that will either mitigate or prevent the effects of these potential environmental conditions. Considering these, the likely effect on

the Project of such conditions, and the need for further mitigation and the significance of residual effects (if any) are assessed.

6.2.4.1 Conditions in the Physical Environment

Flooding

The possible flooding conditions at PNGS B are discussed in Section 6.2.2.1. PNGS B has shoreline protection works and site drainage to protect against flooding. Based on the existing topographic data and base plan, the crest of the existing shoreline protection at PNGS B typically ranges in elevation from 78 to 80 m IGLD, with the lowest point at 76.7 m at the SW corner of the East Complex. When compared to the estimated 1-in-200 year water level of 76.1 m IGLD and the observed historic fluctuations, these elevations along the foreshore suggest that there is a low probability of flooding at the site due to high lake levels. A minimum of 0.6 m of freeboard is available at the lowest portions of the shoreline protection, ranging to over 2.0 m for most of the site (discussed further in the TSD for Surface Water Resources).

As the crest of the protection works exceeds 77.5 m IGLD for much of their length, the probability of flooding due to wave run-up and overtopping is considered low. Periodic wetting during extreme events due to wave spray and splash will occur. However, it is considered unlikely that waves will break directly over the shoreline protection. The surficial drainage system is expected to have adequate capacity to deal with any spray that may occur.

No further contingency measures are required to supplement the existing design and mitigation features in place to resist flooding. The potential for flooding at PNGS requires no further consideration, as no effect on the Project is likely.

Lake Ice

The possible lake ice blockages at PNGS B are discussed in Section 6.2.2.2. PNGS has adopted procedures for clearing ice blockages; these include lowering flow rates in the CCW (if necessary, the reactor power can be reduced to lessen the need for cooling water), directing warm water from the outfall into the intake to melt the ice, and installation of ice booms. In the event that the CCW intake is completely blocked by ice, the reactors would be safely shut down and maintained in a safe shutdown state.

No further contingency measures are required to supplement the existing design and mitigation features in place at PNGS. The current design and contingency measures are sufficiently robust to mitigate any potential effects associated with lake ice on the Project.

Severe Weather

The possible severe weather conditions at PNGS B, including thunderstorms, hail storms, tornadoes and ice storms, are discussed in Section 6.2.2.3. Structures at PNGS B have been exposed to various weather conditions for 23 years (those at PNGS A have been exposed for over 35 years), and are built in such a way that no significant damage to the station structures has occurred. It is particularly noted that the January 1998 ice storm did not damage any of the components necessary for generating power. The design of PNGS B external structures is similarly robust. In addition, equipment redundancy and diversity would reduce any potential effects. Therefore, if severe weather occurred at PNGS B, no significant damage would be anticipated.

No further contingency measures are required to supplement the existing design and mitigation features in place to withstand severe weather. The potential for severe weather requires no further consideration, as no effect on the Project is likely.

Seismic Events

PNGS B was designed, in accordance with the then draft CSA Standard N289.3-M81 requirements, to be seismically qualified to the best engineering standards at the time of construction (late 1970's). A Design Basis Earthquake (DBE) was chosen for seismic qualification, and represents the combined effects at the site of a set of possible earthquakes, resulting in ground motions having a low (less than 1:1000) probability of exceedence during the life of the plant (OPG 2006d). A set of systems, structures and components were seismically qualified to ensure that the following functions are maintained in the event of an earthquake:

1. The reactor can be shut down.
2. The reactor remains shut down.
3. The decay heat can be removed.
4. The radioactivity released from containment is minimized.
5. The status of the nuclear steam supply system can be monitored.
6. Systems, other than the reactor proper, containing significant amounts of radioactivity must not be damaged to such an extent as to lead to radioactive releases above allowable limits.
7. An earthquake does not cause a loss-of-coolant accident.

PNGS B seismic qualification is predominantly analytical. It includes stress analysis reports for nuclear structures, generally using finite element analysis models and dynamic analysis. For pressure boundary piping systems the stress analysis was conducted as per the ASME Boiler and

Pressure Vessel Code, Section III for nuclear piping including seismic loads. Electrical components were qualified generally by shake table testing. Testing was conducted in accordance with draft CSA Standard N289.4-M86, IEEE Standard 344, or Technical Specifications developed for particular types of components.

PNGS B was designed to be as similar to PNGS A as possible to make use of the design and construction experience obtained on PNGS A. The basic station design of PNGS B, including the reactor building and primary heat transport system, was the same as PNGS A; however, structures, systems and components required to perform the seven safety functions listed above were seismically qualified.

The PNGS A containment structures (Reactor Building, Pressure Relief Duct and Vacuum Building) were designed to exceed the National Building Code 1965 seismic design provisions. At the time of PNGS B licensing, the common containment structures were confirmed to be seismically qualified to meet the PNGS B DBE seismic design requirements.

In the late 1990's, a seismic assessment of PNGS A was conducted using the Electric Power Research Institute/Seismic Qualification Utility Group (EPRI/SQUG) Seismic Margin Assessment (SMA) methodology (OPG 1998). SMA is a method in which a Review Level Earthquake (RLE) is used to challenge the plant design and to identify low seismic capacity structures, systems and components. This approach is standard practice for seismic assessment of existing "as built" nuclear power plant facilities.

The RLE used to analyze the seismic capacity of PNGS A and for safety systems common to PNGS A and PNGS B, was established by OPG based on a uniform hazard spectrum, at the 84th percentile level (median plus one standard deviation of the family of derived hazard curves), for ground motions having a probability of 10^{-4} per annum of being exceeded (Asmis and Alexander 1996). The RLE was based on results of a probabilistic seismic hazard evaluation (Atkinson 1994). The RLE represents ground motions which are stronger than any recorded motions in eastern Canada to date, and is sufficient to accommodate the effects of moderate nearby earthquakes as well as larger more distant events.

The SMA methodology is based on documented performance of power and heavy industrial plant structures and components in major earthquakes, on seismic fragility analysis and on generic seismic testing of components (PNGS A Safety Report). The PNGS A Seismic Assessment was performed by experienced earthquake engineering consultants and by OPG staff trained as EPRI/SQUG seismic capability engineers. The PNGS A Pressure Relief Duct (PRD) was analysed because of its unique structural configuration and the requirement to maintain its containment integrity. It was determined that the seismic qualification of the PRD was sufficient

to resist the RLE ground motion and no seismic upgrades to the PRD were required (OPG 2000f).

PNGS B is judged to be more seismically robust than the original design of PNGS A as its safety-related structures, systems and components are seismically qualified by design and testing. This is illustrated by the experience of the evaluation of the PRD, which was designed to exceed the original PNGS A design code requirements, and determined to be qualified for both a DBE and RLE. Earthquake experience data and known conservatisms in the PNGS B seismic design parameters indicates that the existing PNGS B seismically qualified structures, systems and components have considerable margin beyond the DBE. In addition, the SMA of components used in both PNGS A and B generally indicates that components seismically qualified to the PNGS B DBE have sufficient capacity to perform their required seismic functionality at RLE levels (OPG 2006d).

No further measures are required to supplement the existing design and mitigation features in place to resist seismic events. The potential for seismic events requires no further consideration.

6.2.4.2 Conditions in the Biophysical Environment

Zebra and Quagga Mussels

The zebra and quagga mussel conditions at PNGS B are discussed in Section 6.2.3.1. To prevent attachment of larval mussels within pipes and other equipment through which lake water is circulated, service water systems at PNGS B are protected by the injection of a biocide (sodium hypochlorite). Unlike the service water system, high water velocity in the CCW system prevents establishment of zebra and quagga mussels without the need for biocides in that system.

The mussel control system is located at the PNGS B greenhouse. Injection usually takes place from June to November. The solution is injected continuously in the pumpwells of the service water pumps. The total chlorine residual in the station outfall at the property limit is maintained at or below 0.01 ppm, as required by the MOE. In the greenhouse, the problem of zebra and quagga mussels and/or empty shells accumulating in sumps has been adequately addressed by monitoring and periodic removal using vacuum trucks. No further contingency measures are required to supplement the existing design and mitigation features in place to resist fouling, as no effects on the Project are expected from zebra or quagga mussel.

Attached Algae

The occurrence of attached algae (*Cladophora*) at PNGS B is discussed in Section 6.2.3.2. Aquatic plant material, attached algae, and other debris such as wood, fallen leaves and plastic refuse collects on the greenhouse bar racks and travelling screens at PNGS B. To prevent blockage of water flow, the bar racks are cleaned by automatic mechanical rakes either set on a regular timed scheduled cycle or triggered by pressure sensors that measure flow resistance by detecting water level differences between the upstream and downstream side of the racks. High-pressure water is used to wash the travelling screens of accumulated plant and other material.

CCW pumps are shut down and reactor power levels are reduced if there is a perceived threat of an algae run. It is possible that if the standing crop of *Cladophora* close to PNGS and elsewhere along the north shore of Lake Ontario continues to increase, the motors that operate the travelling screens may not have sufficient power to deal with future loadings (OPG 2000a). In the event that intake water flow is considerably restricted by aquatic plants, and the mechanical rakes and travelling screens cannot re-establish or maintain sufficient flow, reactor power would be reduced due to reduced cooling water availability.

However, OPG has been proactive in dealing with future algae events by developing short-term and long-term solutions both within the greenhouse as well as potential modifications to the intake structure. This has included improving greenhouse performance through modifications to the existing screens as well as investigating newer screening technology including barrier nets. As described in Section 6.2.3.2, a seasonal algae mesh barrier has been installed 60 m off the end of the east groyne of the intake as a short-term solution to algae influx. It is anticipated that this barrier will help to alleviate the severity of algae entrainment events at PNGS B. Other options are currently being considered by station staff to address the effects on PNGS from attached algae. Further, OPG and the Regions of York and Durham have commissioned a study at the University of Waterloo ("*Hydrodynamic and Ecological Modeling of Algae in Lake Ontario*") to assess the sources of the algae affecting the lake in the vicinity of the PN site. The study will propose preventative or ameliorative measures as appropriate.

Considering the contingency measures, the potential for effects from attached algae on the Project requires no further consideration.

Fish

The occurrence of fish at PNGS B is discussed in Section 6.2.3.3. Along with the fish currently found in Lake Ontario, (e.g., alewife) the introduction of invasive species such as round goby and Asian carp may affect the station during either phase of the Project.

Since the 1970s, the Lake Ontario alewife population has been greatly reduced by management of nutrient inputs to the lake and stocking of predatory salmon and trout. Furthermore, Lake Ontario's pattern of nutrient distribution has been greatly altered by the zebra and quagga mussels such that the lake cannot support nearly as many alewife or other open-water fish as it once did. The 1991 estimate, made just as the zebra mussels were becoming established in Lake Ontario, was 15 billion fish (OPG 2000a). As of the last published estimate, the 1998 Lake Ontario alewife population included 2.9 billion adult fish.

Given the decline of the alewife population, the continued presence of zebra and quagga mussels, and the current and foreseeable management of Lake Ontario nutrient levels and fish community composition, it is highly unlikely that alewife will become so numerous that they will affect the continued operation of PNGS B. Furthermore, currently no other Lake Ontario fish species matches the alewife's pattern of mass inshore migration and mortality that caused the problems in the 1970s.

PNGS B could, however, be affected by other recent invaders, notably the round goby and Asian carp. Round goby have been observed as impinged fish at PNGS B and Asian carp may be impinged in the future. However, it is unlikely that any fish species will become numerous enough to represent a threat to water intakes at PNGS B. As such, no further consideration of effects on the Project from fish is required.

Climate Change

This subject is discussed in Section 6.3.

6.2.5 Summary of Likely Effects of the Environment on the Project

Section 6.2.4 assessed the potential conditions in the environment that could reasonably be anticipated to interfere with the Project. The assessment considered potential physical and biophysical environmental conditions; the Project design and contingency features that are in place to withstand such conditions; the need for any additional mitigation measures; and the effects on the Project that are considered likely to result from such conditions. This assessment

concluded that no significant effects of the environment on the Project are anticipated once design and contingency features are considered.

PNGS B is designed such that systems important to nuclear safety would continue to operate if any of the environmental conditions discussed in Section 6.2.1 to 6.2.4 were to occur. On the basis of the existing design and contingency features in place to withstand the potential environmental conditions, no additional mitigation measures are required. It is determined that adverse effects on the Project as a result of the environment are unlikely, given that OPG will develop an adaptive management strategy to manage any variability in the environment that could adversely affect PNGS B.

6.3 CLIMATE CHANGE CONSIDERATIONS

In November 2003, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) released a document entitled *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners*. This Guidance Document outlines a procedure within the EA process for assessing whether:

- a proposed project may contribute to Greenhouse Gas (GHG) emissions; and,
- climate change may have an impact on a project.

The Guidance Document was used to assess the potential effect of climate change on the proposed PNGS B Project.

Greenhouse Gas Emissions

The production and use of fossil fuels is the main source of GHG emissions (methane (CH₄), carbon dioxide (CO₂) or nitrous oxide (N₂O)).

GHGs are emitted at the PN site primarily from auxiliary backup equipment and from on-site vehicular traffic. During the Refurbishment Phase, the operation of construction equipment will release small quantities of GHGs (less than 2500 tonnes CO₂.eq/year) in excess of existing and Continued Operations at the site. Therefore, the GHGs emitted during the Refurbishment Phase represent a maximum scenario for the Project and have been used to assess the impact of the Project's GHG emissions.

Climate Change

As outlined in the Guidance Document (FPTCCCEA 2003), to determine whether the effects of climate and climate change on the Project need to be evaluated in detail in an EA study, a

determination is required of whether a particular project has any sensitivity to potential changes in climate. The proposed PNGS B Project may extend past 2060, and, therefore, may be subject to changes in climate. As such, an evaluation of the effects of climate and climate change on the Project is presented in Sections 6.3.1 and 6.3.2.

6.3.1 Overview of Effects of Greenhouse Gas Emissions

The potential impact of greenhouse gas (GHG) emissions from the Project was assessed through estimation of the GHG emissions during the Refurbishment Phase. These emissions were estimated using U.S. EPA AP-42 emission factors (U.S. EPA 1995a), and source information detailed in the TSD for the Atmospheric Environment. It should be noted that the estimates are conservative because they assume conservative operating hours for all equipment.

The estimated GHG emissions emitted from the PN site during the Refurbishment Phase are detailed in Table 6.3-1. GHG emissions expected during the Continued Operation Phase are inclusive only of the combustion equipment emissions detailed in Table 6.3-1.

**TABLE 6.3-1
ANNUAL GREENHOUSE GAS EMISSIONS – REFURBISHMENT PHASE**

Source	CO ₂ -equivalent Emissions (tonnes/year)
Refurbishment Construction Equipment	
Generator	772
Forklifts	176
300 Tonne Crane	345
90 Tonne Crane	212
Multiwheeled Transporter	496
Gantry	345
Total Construction Equipment	2345
Combustion Equipment	
6 Standby Gas Turbine Generating Sets – B side	5090
2 Emergency Power Generators	326
Auxiliary Steam Boiler	558
Two APS 57 MW Combustion Turbine Unit (CTU)	1942
Two APS 1 MW Auxiliary Diesel Generator	51
Total Combustion Equipment	7967
Total Refurbishment Phase Emissions	10,312

As presented in Section 5.4 and in the TSD for the Atmospheric Environment, Environment Canada (2006b) reported over 200,000,000 tonnes CO₂-eq from Ontario sources in 2004. The

Project's GHG emissions in comparison to Ontario's total GHG emissions are negligible (less than 0.01%) and thus no further consideration is required.

6.3.2 Overview of Potential Climate Change Impacts

Studies reported by Environment Canada (1990) and the International Panel on Climate Change (2001), based on the results of the Global Circulation Models (GCMs), indicate that predicted increases in global mean temperatures could result in the following impacts in Ontario over the next 100 years:

- Shifts in climatic zones several hundred kilometres northward;
- Decreases in the total amount of precipitation in Southern Ontario, but an increase in Northern Ontario;
- A greater frequency of higher intensity precipitation events;
- Higher maximum temperatures and a greater frequency of hot days and heat waves;
- Increasing minimum temperatures resulting in fewer cold days, frost days and cold waves;
- Intensified drought and flood due to El-Nino events;
- Northward shifts of forest ecosystems, but with narrower boundaries for some species;
- Net basin runoff decreases of 25 to 50% in the Great Lakes – St. Lawrence system (water level reduction of 30 to 80 cm);
- Alteration of current distribution and abundance of Great Lake coastal wetland communities due to decreases in water levels (Mortsch *et. al.* 2006);
- Disappearance of some resident fish species from the Great Lakes, but an estimated 30 new species as replacements;
- Increased potential for forest fires due to drier conditions;
- Increases in Great Lake water temperatures (Kling *et al.* 2003);
- Increases in the ice-free shipping season in the Great Lakes; and
- Positive effects on summer recreation and tourism, but negative effects for winter activities.

The International Lake Ontario – St. Lawrence River Study Board is studying four options of regulating Lake Ontario water levels. Their March 2006 report to the IJC identified that the four

options could change the range of water levels throughout the year. None of the scenarios result in water levels that exceed the current maximum water level or drop below the currently reported minimum water level.

6.3.2.1 Preliminary Scoping for Consideration of Impacts

The Guidance Document (FPTCCCEA 2003) specifies that the first step in determining whether or not changes to climate need to be evaluated in more detail in an EA study is to determine whether the Project has any sensitivity to potential changes in climate.

Activities related to the Refurbishment Phase of the Project are relatively short in duration (2010 to approximately 2024), particularly considering site preparation activities will take place over a two-year period. Therefore, climate change impacts related to this phase have not been considered. However, the Continued Operation Phase of the Project extends to 2060 and, therefore, may be subject to changes in climate.

The PNGS site and the PNGS B Project are described in Chapter 2.0. The key elements of the Project are described in detail in Sections 2.7 and 2.8. The key physical structures and systems of the PNGS that have a potential sensitivity to climate change are:

- Reactor Buildings – buildings, structures and systems have been constructed based on design weather data (harsh environmental conditions), a design basis earthquake and a site design earthquake. They were designed to meet the requirements of the National Building Code of Canada (OPG 2006d);
- Other Buildings on PN Site – buildings and structures have been constructed to meet the National Building Code of Canada;
- PVMF Storage Structures – structures have been and will be designed to comply with the National Building Code 1995 edition and National Fire Code 1995 edition (or latest editions at the commencement of the construction licence); they will conform to design and construction protocols specifically developed to minimize the potential for structural failure;
- Breakwater – a reinforced wall that provides a barrier between Lake Ontario and the reactor buildings. The breakwater is located between the discharge and intake channel;

-
- Cobbled Shoreline – the shoreline east of the discharge channel, where the proposed PWMF II structures and additional refurbishment waste storage structures for this Project will be located;
 - Screenhouse and Water Systems – water is drawn from Lake Ontario through the screenhouse to be used in the CCW and service water systems;
 - Stormwater Management System – consisting of a series of ditches and drains that are designed for the current Regional Storm Event;
 - Auxiliary Power Systems – including such equipment as electrical standby generators, emergency power generators, auxiliary steam boiler, and Auxiliary Power System (APS).

The climate change parameters that are considered to have a potential interaction with the PNGS physical structures and systems are:

- Precipitation – overall, average precipitation is expected to decrease, but precipitation occurs in a more intense manner.
 - Total Annual Rainfall – expected to decrease;
 - Total Annual Snowfall – expected to decrease;
 - Frequency and/or Severity of Extremes – precipitation events are expected to be more severe and occur more frequently. In the next 100 years, the frequency of extreme precipitation events will increase and possibly double; therefore, the 1-in-100 year storm may become a 1-in-50 year storm.
- Frequency and Severity of Extreme Weather Events – storms not exclusively precipitation events (e.g., lightning, tornadoes, hurricanes), are expected to be more severe and occur more frequently. The GCMs estimate that within the next 100 years, storm intensity may increase by 40-50%, and the frequency of extreme weather events in the next 100 years may double.
- Lake Ontario Effects:
 - Lake Ontario Water Temperature – surface mixed layers expected to increase by approximately 3-5°C by 2050 due to warmer air temperatures (Lehman 2002).
 - Lake Ontario Water Level – expected to decrease by as much as a metre. However, it must be noted that the level of Lake Ontario is controlled for navigation purposes.

Other climate parameters were considered to have insignificant interactions with the physical structures and systems associated with the Project, and thus were not included in the assessment. These parameters include the following:

- Wind Velocity – not defined separately because extremes are encompassed within frequency and severity of weather extremes.
- Evaporation – potential changes will not affect PNGS operations.
- Soil moisture – potential changes will not affect PNGS operations.
- Groundwater – potential changes will not affect PNGS operations.

6.3.2.2 Identification of Impact Considerations

To further assess the potential interaction of climate change parameters with the Project physical structures and systems, a screening exercise was undertaken to evaluate and rank each potential interaction. The Guidance Document (FPTCCCEA 2003) provides a methodology to assist in identifying project sensitivity to changes in climate parameters.

Each of the Project's physical structures and systems has been evaluated against each climate parameter and assessed for potential sensitivity. Table 6.3-2 provides the results of the screening exercise and identifies the sensitivity ranking assigned for each physical structure or system related to the Project.

A "Nil" rank was assigned if it was determined that the physical structure or system was not sensitive to a change in the climate parameter.

A "Low" rank was assigned if it was determined that the physical structure or system was unlikely to be sensitive to a change in the climate parameter.

A "Medium" rank was assigned if it was possible that the physical structure or system would be sensitive to a change in the climate parameter.

A "High" rank was assigned if it was likely the project physical structure or system would be sensitive to a change in the climate parameter.

**TABLE 6.3-2
POTENTIAL INTERACTIONS BETWEEN THE PNGS PROJECT AND CLIMATE CHANGE PARAMETERS**

Project Physical Work or Activity	Climate Parameter					
	Precipitation			Weather other than Temperature or Precipitation	Lake Ontario Effects	
	Total Annual Rainfall	Total Annual Snowfall	Frequency and/or Severity of Extremes (return period)	Frequency and Severity of Extreme Weather Events	Lake Ontario Water Temperature	Lake Ontario Water Level
Reactor Buildings	No likely effects since reactor buildings, structures and systems have been constructed based on design weather data (harsh environmental conditions) and were designed to meet the National Building Code of Canada. Nil			No likely effect since reactor buildings, structures and systems have been constructed based on design weather data (harsh environmental conditions), a design basis earthquake and a site design earthquake, as well as being designed to meet the National Building Code of Canada. Nil	No effect on reactor buildings is anticipated. Nil	No effect on reactor buildings is anticipated. Nil
Other Buildings on PN Site	No likely effects since buildings, structures and systems have been constructed based on design weather data (harsh environmental conditions) and were designed to meet the National Building Code of Canada. Nil				No effect on buildings is expected. Nil	No effect on buildings is expected. Nil
PWMF Storage Structures	No likely effect since structures have been and will be designed to comply with the National Building and Fire Code and will conform to design and construction protocols specifically developed to minimize the potential for structural failure. Nil		Extreme precipitation could cause erosion along shoreline which could affect the integrity of the land on which the structures are built. Low	Potential for increased shore erosion due to greater intensity of waves, which could affect integrity of land structures are built on. Low	No effect on PWMF storage structures is anticipated. Nil	No effect on PWMF storage structures is anticipated. Nil
Breakwater	No effect on the breakwater is anticipated. Nil	No effect on the breakwater is anticipated. Nil	No effect on the breakwater is anticipated. Nil	An increase in the severity of storm levels could potentially result in increased wave levels although this may be mitigated by the expected decrease in lake levels. Low	No effect on the breakwater is anticipated. Nil	No effect on the breakwater is anticipated. Nil
Cobbled Shoreline	No effect on the cobbled shoreline is anticipated. Nil	No effect on the cobbled shoreline is anticipated. Nil	Extreme precipitation could cause increased erosion along shoreline. Low	Potential for increased shore erosion due to greater intensity of waves, which could affect stability of the shoreline. Medium	No effect on the cobbled shoreline is anticipated. Nil	No effect on the cobbled shoreline is anticipated. Nil
Water Systems	No effect on water systems is anticipated. Nil	No effect on water systems is anticipated. Nil	No effect on water systems is anticipated. Nil	Could result in greater disturbance of algae leading to greater quantities of algae becoming detached. Detached algae could potentially affect the intake water flow. Medium	Increase in water temperature in Lake Ontario could lead to warmer intake water temperature, increased algal and zebra mussel growth and alteration of fish communities in Lake Ontario. Results could include more frequent derating of station generation due to temperature restrictions and more frequent algal entrainment and zebra mussel incidents. Medium	Potential for impact on quantity of process cooling water and service water available. Lake Ontario water levels are controlled for navigation. An estimated drop in water levels of less than 1 m is unlikely to affect PNGS B given the range of conditions PNGS B was designed to accommodate. Low
Stormwater Management System	No effect on the stormwater management system is anticipated. Nil		Possible overflow of the stormwater management system, causing localized erosion. Medium	No effect on the stormwater management system is anticipated. Nil	No effect on the stormwater management system is anticipated. Nil	No effect on the stormwater management system is anticipated because it is located well above lake level. Nil
Auxiliary Power Systems	No effect on the auxiliary power systems is anticipated. Nil	No effect on the auxiliary power systems is anticipated. Nil	No effect on the auxiliary power systems is anticipated. Nil	Could cause the facility to lose all power including its auxiliary backup power, which could be an issue if the facility did not have enough power to allow a proper shutdown. Due to the many levels of backup at the facility, it is unlikely that all systems would be non-operational. Low	No effect on the auxiliary power systems is anticipated. Nil	No effect on the auxiliary power systems is anticipated. Nil

6.3.2.3 Assess Impact Considerations

Table 6.3-2 contains the results of a screening exercise conducted to identify the potential interactions between climate change and the Project. No high risk interactions were identified. Several interactions were identified as having medium rank, indicating a possible effect.

The Guidance Document (FPTCCCEA 2003) specifies that climate parameter-project component interactions evaluated as being of Medium or High risk should be assessed in more detail. The components ranked Medium in the screening exercise presented in Section 6.3.2.2 are as follows:

- Cobbled shoreline and extreme weather event;
- Water systems and extreme weather event and increase in lake temperature; and
- Stormwater management system and extreme precipitation event.

The Guidance Document (FPTCCCEA 2003) specifies that the confidence level associated with data indicating changes to a climate parameter should be determined. The results of the GCMs indicate the potential for more extreme weather events in the future. Studies on the effect of climate change on the Great Lakes indicate the potential for an increase in lake temperature due to expected increases in surface temperatures (Kling *et al.* 2003). Therefore, it seems likely that extreme weather events, precipitation and otherwise, as well as an increase in Great Lakes temperatures over the next 60 years is likely.

6.3.2.4 Methodology to Assess Risks Related to Climate Change

Each of the above interactions was further assessed to determine:

- The sensitivity of the project physical structures or systems to the meteorological parameters; and
- The risk level of any impact to the public or the environment.

This was done following the outline in the Guidance Document which specifies:

...the analysis should consider the range of possible outcomes under which the climate parameter may adversely affect the project or one of its components. The practitioner should then determine if there are potential risks to the public or the environment if one or more project components are affected by identified changes to climate parameters.

The Guidance Document methodology describes four possible cases to be considered:

- **Case One:** occurs when there is a high confidence level associated with project physical works or activities sensitivity to a climate parameter and a high risk to the public or the environment as a result of the effect of these changes on a project. In this case, the practitioner should proceed with the next steps in the risk assessment and indicate the probable range of changes to the appropriate climate parameters. Appropriate monitoring, follow-up and adaptive management procedures should be implemented.
- **Case Two:** occurs when there is a high level of confidence associated with project physical works or activities sensitivity to a climate parameter, but a low risk to the public or the environment as a result of these changes on the project. Except to document these findings in the EA, no further action need be taken by the practitioner.
- **Case Three:** occurs when there is a low confidence level associated with project physical works or activities sensitivity, but a high probability that the public or the environment will be placed at risk due to the effects of these changes on the project. All available climate change information (including the range of possible changes to the climate parameter) should be provided to the practitioner and public interest decision makers. Also, the next steps in the risk assessment should be conducted. Emphasis should be placed on the probable range of changes to the appropriate climate parameters, and the uncertainty associated with this information should be stressed in the EA. Appropriate monitoring, follow-up and adaptive management procedures should be implemented.
- **Case Four:** occurs when there is a low confidence level associated with project physical works or activities sensitivity, and a low risk to the public or the environment if the project is affected by these changes. In this case, no further action need be taken by the practitioner, other than documenting the findings in the EA.

The methodology in the Guidance Document then relates the relationship between risk and confidence level according to the four cases as described in Table 6.3-3.

TABLE 6.3-3
POSSIBLE CASES FOR ASSESSING RISKS TO THE PUBLIC OR ENVIRONMENT

	High Risk Of Impacts To The Public Or The Environment	Low Risk Of Impacts To The Public Or The Environment
High Confidence Level Of the project's sensitivity to a climate change parameter	Case One <ul style="list-style-type: none"> • Proceed with risk assessment outlined in Guidance Document • Implement appropriate monitoring, follow-up and adaptive management measures 	Case Two <ul style="list-style-type: none"> • Practitioner should provide all relevant climate change information • Report in EA • No further action required
Low Confidence Level Of the project's sensitivity to a climate change parameter	Case Three <ul style="list-style-type: none"> • Proceed with risk assessment outlined in Guidance document • Emphasize the uncertainty inherent in climate change data • Implement appropriate monitoring, follow-up and adaptive management measures 	Case Four <ul style="list-style-type: none"> • Report in EA • No further action required

Each of the project structures or systems identified as having a Medium sensitivity from the screening exercise (Section 6.3.2.2 and Table 6.3-2), was further assessed according to the above guidance. Table 6.3-4 provides the results of this assessment for the Project.

**TABLE 6.3-4
ASSESSMENT OF INTERACTIONS RELATED TO CLIMATE CHANGE – PNGS B PROJECT**

Project Physical Work or Activity	Climate Parameter	Project's Sensitivity to Climate Change Parameter	Risk Level of Impacts to the Public or Environment	Case	Action
Cobbled Shoreline	Extreme weather events	Potential for increased shore erosion due to greater intensity of waves, which could affect stability of the shoreline. Medium	Erosion of the shoreline into Lake Ontario could affect the water quality and habitat for aquatic biota. However, erosion along this shoreline is already occurring and no effect has been observed. OPG is monitoring the situation and will ensure preventative measures are undertaken such that no effect on the environment will occur. No effect on the public is expected. Low	Two	No further action
Water Systems	Extreme weather events	Could result in greater disturbance of algae leading to greater quantities of algae becoming detached. Detached algae could potentially affect the intake water flow. Medium	The continued use of the automated mechanical systems to clean the screenhouse bar racks and travelling screens will aid in mitigating the effects of increased algae events and avoiding risk to the public and the environment. Further, OPG is developing and implementing short and long term solutions for potential algae events. Low	Two	No further action
	Lake Ontario Water Temperature	Increase in water temperature in Lake Ontario could lead to warmer intake water temperature and increased algal and zebra mussel growth in Lake Ontario. Results could include more frequent derating of station generation due to temperature restrictions and more frequent algal entrainment and zebra mussel incidents. Medium	The effect will likely be a lengthening of the warm season rather than a significant increase in water temperature. The PNGS currently manages its operations around the fluctuations in water temperature without adverse effects to the public or the environment. Low	Two	No further action
Stormwater Management System	Extreme precipitation events	Possible overflow of the stormwater management system, causing localized erosion. Medium	In the event of rainfall greater than that used for the engineering design, there may be some localized erosion of ditches and possibly soil cover layer. However, the integrity of the structures and equipment on site would not be affected, thus avoiding risk to the public and the environment. Should the current Regional Storm Event be redefined, the adequacy of the stormwater management system will have to be re-evaluated as part of OPG's adaptive management plan. Low	Two	No further action

6.3.2.5 Results from Assessment of Risks Related to Climate Change

The assessment of risks related to climate change for the Project using the Guidance Document (FPTCCCEA 2003) methodology and the final results are shown in Table 6.3-4. These results show that, in spite of possible changes to the climate in the future, there were no climate parameters that would have an effect on a project physical structure or system resulting in a risk to either the public or the environment.

Cobbled Shoreline

The eastern portion of the PN property does not currently have shoreline protection. Erosion of the cobbled shoreline is already occurring, resulting in some potential to affect the integrity of the land on which the PWMF structures are proposed to be built, as well as the water quality. As indicated in the assessment tables, the current rate of erosion could increase as a result of an increase in the frequency and/or severity of extreme weather events.

However, a large amount of erosion of the cobbled shoreline would have to occur to adversely affect the integrity of the land on which the PWMF structures are built or the water quality. As a commitment in the PWMF II EA (OPG 2003a), OPG monitors shoreline stability and will undertake shoreline stabilization as necessary, thus alleviating any effect on the public or the environment. As such, no further action is warranted.

Water Systems

The current water systems are designed to provide adequate flow of water to service PNGS. The system is designed with specific measures, such as automated mechanical systems to clean the screenhouse bar racks and travelling screens, and the trial installation of a mesh barrier at the end of the east groyne of the intake water structure, to allow adequate intake water flow irrespective of algal growth (zebra mussel attachment is addressed by injection of sodium hypochlorite). Additionally, the PN processes are designed to allow for the fluctuation in CCW temperature that occurs seasonally and annually.

The analysis presented in Table 6.3-4 indicates that the effect of the frequency and/or severity of extreme weather events and increasing Lake Ontario water temperatures may result in more entrained algae events or zebra mussel growth, potentially affecting the intake water flow to the CCW and/or service water system. Any effects of algae entrainment events and zebra mussel attachment are currently being managed and any potential increase in these factors will be dealt with through the development of an

adaptive management strategy for the PN site. This has been identified as a follow-up activity (Section 11.3).

It is possible that an increase in lake water temperatures may result in discharge water exceeding the permitted maximum temperature limits more frequently. However, the discharge temperatures are monitored and if maximum temperature limits are exceeded, they will be dealt with through OPG's future adaptive management strategy.

Considering the contingency measures, the potential for effects on the water system from increases in the frequency and/or severity of extreme weather events, or from increases in Lake Ontario water temperatures requires no consideration because effects will likely be mitigated.

Stormwater Management System

Stormwater management systems are typically sized for the 100-year design storm or the prevailing Regional Storm Event. The analysis documented in Table 6.3-4 shows that the effect of exceeding the design capacity of the stormwater system because of an increase in the frequency and/or severity of extreme precipitation events may include overflow of the system and some localized soil erosion. However, there will be no adverse effects to any structures or equipment at the PNGS nor any risk to the public or the environment as a result of a stormwater system overflow. Further, any localized soil erosion from the stormwater system is easily repairable as part of the ongoing maintenance program. If the Regional Storm Event is redefined, OPG will re-evaluate the stormwater management system and make appropriate modifications. Given these considerations, no effects from increased frequency and/or severity of extreme precipitation events are expected on the PNGS stormwater management system.

Although this analysis has indicated there is no risk to the public or environment, as part of an adaptive management strategy to be developed for the PN site, the project physical structures and systems that could be affected by a change in climate parameters will be monitored and modifications implemented, if required.