

2.0 DESCRIPTION OF THE PROPOSED PROJECT

As stated in the EA Guidelines, “an adequate description of the Project is necessary to permit a reasonable consideration in the screening of the environmental effects of the Project.” The Guidelines further state that “the main objective of the project description is to identify and characterize those specific components and activities of the project that have the potential to interact with, and thus result in a likely change or disruption to the surrounding environment, during normal operations and during malfunctions and accidents.” This chapter provides an overview of PNGS B, including physical structures, systems, components and activities during normal operations, and a description of the project works and activities associated with the Project. A description and analysis of credible malfunction and accident scenarios is in Chapter 7.0.

2.1 HISTORICAL BACKGROUND OF PICKERING NUCLEAR GENERATING STATION B

PNGS B has generated electricity continuously since May 1983 when the first unit came on line. In 2005, PNGS B produced electricity output of 13.7 terawatt hours (TWh). This is approximately 10% of the electricity requirements of the Province of Ontario.

Table 2.1-1 provides the in-service date for each unit at PNGS B.

**TABLE 2.1-1
IN-SERVICE DATES FOR PNGS B UNITS**

Unit #	Net Electrical Output (MW(e))	In-Service Date
5	516	May 1983
6	516	February 1984
7	516	January 1985
8	516	February 1986

PNGS B was designed for a nominal design life of 30 years of operation prior to replacement of certain major components. In general, the limiting factor to design life in a CANDU reactor such as PNGS B is the degradation of reactor components due to accumulated exposure to reactor operating conditions.

Since they were placed in service, PNGS B Units 5-8 have operated safely.

2.2 OVERVIEW OF PNGS B BUILDINGS AND STRUCTURES

PNGS B comprises four nuclear reactors, four turbine/generator sets and their associated equipment, services and facilities. The design net electrical output of each unit is 516 MW(e); this yields a total station net output of 2,064 MW(e). Power is produced at 24 kV and delivered at 230 kV and 60 Hz to the southern Ontario electrical grid. The station is used for base-load operation.

Each unit comprises a power source capable of operating independently of the other units, but using certain common services. Further, PNGS B shares the PN site and many services and facilities with PNGS A. These shared facilities may be situated at PNGS B, PNGS A or elsewhere on the PN site. The Project does not involve major modifications to PNGS A facilities or structures.

A general schematic of PNGS A and PNGS B as of 2006 is shown in Figure 2.2-1 and identifies the major facilities and structures that make up the stations. PNGS B occupies the lower right hand half of the figure. The common service wing (Item 5 on Figure 2.2-1) is located midway between the PNGS A and PNGS B reactor buildings, and provides a demarcation between the two stations.

The principal buildings and structures comprising PNGS B are briefly described in the following sections. These buildings and structures contain the systems and activities required to generate electricity and operate the station safely. Where buildings or structures are shared with PNGS A, this is noted.

- Four **reactor buildings**, identified as Units 5-8 (Item 2 on Figure 2.2-1), containing the reactor, control mechanisms, fuelling machines, heat transport system, steam generators and auxiliary equipment. Each reactor has its own unit emergency control centre located south of each reactor building under the pressure relief duct. Cross-sections of a reactor building are shown on Figure 2.2-2.
- **Reactor auxiliary bay** (Item 23 on Figure 2.2-1), running the full length of the four units (305 m) and covering the area between the turbine auxiliary bay and the reactor buildings. The reactor auxiliary bay houses auxiliary systems.
- **Powerhouse** (Item 4 on Figure 2.2-1), including a turbine hall and turbine auxiliary bay running the full length of the station. The turbine/generators are arranged in a line down the turbine hall. The powerhouse contains the steam and feedwater systems, and most of the electrical distribution system.

- **Screenhouse** (Item 11 on Figure 2.2-1). A single intake channel and common forebay serves both PNGS A and PNGS B. A pair of rock groynes extends out into the lake to reduce recirculation of effluent water and silting. A screenhouse and intake duct for condenser circulating water (CCW) and service water serve all four PNGS B units. The screenhouse consists of screens that remove algae, fish and other debris from lake water. After passing through the condensers, the CCW is discharged into covered ducts immediately north of the powerhouse and returned to the lake at the outfall and discharge channel at the eastern end of Unit 8 (Item 13 on Figure 2.2-1).
- **Standby and emergency electric generators.** Standby power is available from six independent gas turbine driven generators in the event that the station is disconnected from the grid (Item 15 on Figure 2.2-1). The standby generators are supplied with No. 2 fuel oil which is stored in two storage tanks (Item 19 on Figure 2.2-1). The tanks are located within a dyked area to contain oil in case of spillage or tank rupture.

Emergency electrical power can also be supplied by two seismically qualified emergency power generators which are completely independent and separate from the standby generators (Item 16 on Figure 2.2-1). Fuel oil for the emergency generators is stored in two storage tanks, which are contained within a dyked area (Item 20 on Figure 2.2-1).

- **Containment structures including a pressure relief duct.** An important safety feature of PNGS B is a negative pressure containment system to contain radioactive emissions in the event of low-probability accident scenarios. By maintaining the containment system at less than atmospheric pressure during and after a possible radioactive release, outside air will leak inwards and any immediate releases to the environment will be avoided or controlled. The negative pressure containment envelope consists of PNGS A and B reactor buildings, the pressure relief duct, an elevated concrete vacuum duct running the length of the station (Item 7 on Figure 2.2-1), and a vacuum building (Item 6 on Figure 2.2-1) that is common to both PNGS A and PNGS B.
- **East annex building** (Item 24 on Figure 2.2-1). Originally constructed to support the PNGS A retubing project, the east annex is a two-storey steel frame building used to store new fuel and to store and service equipment and tooling.
- **Electrical transmission facilities.** During normal operation, each unit generator supplies power to the 230 kV electrical grid through the switchyard (Item 14 on Figure 2.2-1). Each unit has one main output transformer. Two transformers supply each unit's station loads. The PNGS B switchyard is leased and maintained by Hydro One.
- **Emergency water supply pumphouse** (Item 26 on Figure 2.2-1). This facility houses the pumps and water supply equipment that can provide emergency makeup water to various PNGS B nuclear and non-nuclear systems in the event that normal water supply is not available.

- **Sediment suction system pumphouse** (Item 32 on Figure 2.2-1). The sediment suction system minimizes the accumulation of sediment in plant systems. Large pumps convey sediment-laden water from the intake to the PNGS B outfall, where the sediment is returned to the lake. This mixing of cold lake water with warm water discharged from the CCW also reduces the temperature difference between discharged water and lake water.
- **Oil and chemical storage building** (located between the PNGS B powerhouse and switchyard). This building provides storage and dispensing facilities for bulk oils and combustible, toxic, corrosive and reactive chemicals. It serves both PNGS B and PNGS A.
- **Auxiliary steam boiler** (Item 33 on Figure 2.2-1). This facility serves as backup for the supply of heating steam to the PN site.
- **Administration building, Engineering Services buildings, and Main and Auxiliary Security Building** (Items 27 28 and 34 on Figure 2.2-1). These buildings provide offices and support services for station staff.
- **High pressure emergency coolant injection (HPECI) facilities** (Items 8, 9 and 10 on Figure 2.2-1). The emergency coolant injection system is a special safety system that has no role during normal operations but is poised ready to inject light water into the heat transport system should an accident occur that requires additional cooling of the fuel. It consists of a 780 m³ elevated water tank, high-pressure pumps and an auxiliary services building. These facilities are common to PNGS A and PNGS B.
- **New water treatment plant** (Item 29 on Figure 2.2-1). This plant filters and demineralizes lake water for use in feedwater and other demineralized water systems at PNGS A and PNGS B, and has a design flow rate of 66 L/s. The treatment process comprises filters, ultra-violet sterilization, reverse osmosis, and ion-exchange columns. The new water treatment plant is located north of the PNGS B CCW discharge and outfall, outside the Security Protected Area, and is operated under a commercial supply contract.
- **Auxiliary irradiated fuel bay (AIFB)** (Item 30 on Figure 2.2-1). The AIFB provides underwater storage for used fuel from PNGS A and for cobalt-60 from PNGS B.
- **Heavy water upgrading plant and towers** (Items 18 and 25 on Figure 2.2-1). These facilities purify heavy water from the moderator and heat transport systems. All heavy water upgrading facilities are common to PNGS A and PNGS B.
- **Pickering Nuclear Information Centre** (Item 31 on Figure 2.2-1). This building, which is located outside the security fence, provides displays and exhibits relating to electricity

generation and use, with a focus on nuclear power and the environment. The Information Centre is open to the general public.

- **East Complex** (Figure 1.1-2). This area is an industrial area containing a mix of uses including: technical and field support offices; warehousing; maintenance garages; machine shops; chemical storage building; several parking areas; material storage; a combustion-turbine unit standby power system, access roads and drainage ditches. The extreme east end of the area contains the South East inert fill area, now closed, and a wetland.
- **Pickering Waste Management Facility (PWMF)** (Item 22 on Figure 2.2-1 and shown on Figure 1.1-2). The PWMF I is used for dry storage of used nuclear fuel and consists of a Dry Storage Container (DSC) processing building, two storage buildings to store DSCs, and an area for Dry Storage Modules (DSMs). The PWMF II consists of an area in the East Complex for two additional storage buildings which are not yet built but which have received EA and construction approval. The storage buildings at both PWMF I and PWMF II are designed to store DSCs which contain nuclear used fuel from PNGS A and PNGS B. The DSMs, which are large cylindrical casks made of reinforced concrete and thick carbon steel inner and outer liners, store the used reactor components removed during the retubing of the PNGS A reactors in the 1980s.

2.3 DESCRIPTION OF PNGS B SYSTEMS, COMPONENTS AND ACTIVITIES

The systems that make up PNGS B are housed within the buildings and facilities described in the preceding section. The following overview of the PNGS B is based on its current condition and operation. The Project entails carrying out all necessary refurbishment and upgrade on these systems to ensure that they can continue to operate safely and efficiently over their extended operating life, assumed for EA purposes to be 2060. Current station operations provide the basis for predicting and assessing future environmental effects. Each system is described in further detail in the following sections.

Figure 2.3-1 presents a simplified flow diagram of the major PNGS B systems including their general location in the vacuum building, reactor building or powerhouse.

2.3.1 Reactor

Within the reactor, fission occurs and heat is produced. Each PNGS B reactor unit consists of a horizontal, cylindrical tank (the calandria vessel) with integral end shields, fuel channel assemblies with integral end fittings, and reactivity control units. The reactor is submerged in light water within a carbon-steel-lined concrete vault (the calandria vault). In order to sustain a

nuclear chain reaction, the calandria is filled with a “moderator” consisting of heavy water - a substance that slows down the neutrons released in the fission process so that they can be absorbed more readily by uranium and transuranium atoms. A reactor is “critical” when a self-sustaining fission chain reaction is taking place, where the neutrons generated in the fission reactions go on to cause additional fission reactions at a constant rate within the reactor. These absorptions result in the splitting, or “fission” of uranium and transuranium atoms, which releases heat. The heat generated by the fission of uranium and transuranium atoms is transferred to the heat transport system, described further in Section 2.3.2.

2.3.1.1 Reactor Assembly

The reactor assembly is shown in Figure 2.3-2. The calandria vessel is axially penetrated by 380 calandria tubes. The calandria tubes provide access through the calandria vessel for the 380 fuel channel assemblies containing nuclear fuel. Fuel channel assemblies are described in more detail in Section 2.3.2.

The end-shields are located at each end of the calandria vessel, forming part of the vault enclosure. The end-shield is filled with carbon steel balls and demineralized light water to provide shielding for the fuelling machine vault.

2.3.1.2 Reactivity Control Devices

The reactor core has neutron absorbing devices, both liquid and solid, to control reactivity. During operation, reactivity is controlled by adjuster rods, control absorbers, zone controllers, and poison addition. Under emergency or accident conditions, shutoff rods or liquid poison injection into the moderator achieves fast reactor shutdown. Power measuring devices such as in-core flux detectors and out-of-core ion chambers are the sensing elements for these regulating and protective devices.

2.3.2 Reactor Process Systems

2.3.2.1 Heat Transport

The principal design objective for the heat transport system is to provide reliable cooling of the reactor fuel under all operating conditions for the life of the plant. Achieving minimum leakage, maximum reliability, and minimum radiation fields, providing good access for personnel, and making provision for maintenance were assigned high priorities in design.

The heat transport system circulates pressurized heavy water through the reactor fuel channels to remove heat produced by the fission of uranium fuel within the fuel bundles. The heat is transferred to light water in the steam generators located inside the reactor building. This system

is entirely separate from the moderator system (described in Section 2.3.2.3) and captures the vast majority of the reactor's heat output. The pressurized heavy water coolant in the heat transport system is re-circulated. The heat transport system includes 380 reactor fuel channels, 12 steam generators, 16 main circulating pumps, two pressurizing pumps, and shutdown cooling loops. Figure 2.3-1 illustrates this process. Chemistry of the reactor coolant is controlled by filtering, ion exchange, and chemical addition.

Feeders

There are 380 feeder pipes at each end of the reactor. They connect the individual fuel channels to the reactor inlet and outlet headers. Feeders range in length from 8 m to 20 m and are between 5 cm and 9 cm in diameter.

Fuel Channel Assemblies

Each reactor has 380 fuel channels and each channel holds 12 fuel bundles within a 6.3 m long pressure tube. Each assembly is supported horizontally by the end-shield. There is an end fitting on each end of each pressure tube. The end fitting provides a transition between the pressure tube and the heat transport system piping. The end fitting contains a shield plug and a channel closure plug, both of which are removed and reinserted by the fuelling machine during refuelling (as described in Section 2.3.6).

The annulus space between the pressure tube and the calandria tube is filled with dry carbon dioxide. This gas annulus provides thermal insulation between the hot primary coolant in the pressure tube and the relatively cool moderator in the calandria, and is used to monitor any leakage of heat transport coolant or moderator into the annulus. Annular spacers called garter springs prevent contact between the pressure tube and the calandria tube.

Shutdown Cooling Systems

The shutdown cooling system provides cooling to the fuel while the reactor is shut down. It is used to reduce and maintain the temperature of the heat transport system water during unit outages. There are four shutdown cooling loops per reactor, each consisting of a pump and a heat exchanger, and they are isolated from the heat transport system while the reactor is operating.

Purification System

The heat transport purification system limits the activity and corrosion product build-up in the reactor coolant by removing soluble and insoluble impurities and by controlling the pH of the heavy water. Purification system equipment consists of filters and ion exchange columns. The filters are disposed of when full and the ion exchange resin is slurried out of the columns when spent.

Pressure Relief Devices

The combined effects of liquid relief valves and the reactor shutdown systems provide protection against overpressure of the heat transport system.

Pressure relief for the bleed condenser is provided by two relief valves. Sections of the heat transport system that can be isolated are protected against overpressure by lines connected to the reactor inlet or outlet headers.

Reactor Coolant Chemistry

Carbon steel is used for the feeders, headers and heat transport system piping. The steam generator tube material in the refurbished steam generators will likely be Inconel, rather than the current Monel material. This material change is a result of operating experience and more recent technology, and will not affect system operation or chemistry.

The reactor coolant chemistry parameters were chosen to minimize corrosion rates on all surfaces exposed to the coolant, and components are selected to have low cobalt content to minimize out-of-core radiation fields. These objectives are achieved by maintaining an alkaline environment, adding hydrogen to the coolant and through use of the purification system filters and ion exchange columns.

Reactor Coolant Leakage Detection

Due to the high cost of heavy water and the radiological effects associated with tritium¹, minimizing heat transport system leakage and detecting leakage are important. Where possible, piping is welded and joints minimized. Components susceptible to leakage, such as valve stems and mechanical joints, are covered and any leakage is directed to a collection system. Moisture-detecting elements are placed on the floor in low areas to detect leakage. Air dryers are used to extract and collect heavy water from the reactor building atmosphere.

Heat transport leakage from a pressure tube is detected through increases in the annulus gas system moisture content.

¹ Tritium is discussed in Section 4.6.3.3; the discussion includes the Ontario Drinking Water Quality Standard for tritium.

Steam Generators

Twelve steam generators (also referred to as boilers) per reactor transfer heat from the heavy water coolant, in the heat transport system, to light water on the secondary side. Heavy water in the heat transport system flows through tubes in the steam generators. The light water is on the outside of the steam generator tubes. Heat is transferred through the metal of the steam generator tubes. The steam created moves through the steam system, described in Section 2.3.2, to the turbines. Each steam generator is approximately 14 m in length and 2 m wide.

The steam generated on the secondary side of the steam generator normally contains a negligible amount of radioactivity. If a steam generator tube leaks, leakage from the heat transport system would be detected by monitoring the steam for tritium. Extensive inspection and maintenance programs minimize the likelihood of occurrence of a steam generator tube leak.

2.3.2.2 Steam and Feedwater Systems

For each reactor, steam from the 12 steam generators flows through main steam piping from the reactor building to the turbines in the powerhouse. Figure 2.3-1 includes a schematic of the steam and feedwater system, which is a closed loop system.

The feedwater system consisting of a low-pressure (condensate) circuit and a high-pressure (boiler feed) circuit, collects and condenses steam from the turbines and supplies it to the boilers.

Condensed steam from the condenser hotwells (described in Section 2.3.4) is pumped through a series of feedheaters, gradually increasing the feedwater temperature. Boiler feed pumps increase the water pressure to allow injection into the steam generators. Although the steam and feedwater system is a closed loop system, when make-up water is required, due to steam losses and boiler blow-down, it is supplied from the demineralized water storage tanks which are supplied by the new water treatment plant.

The feedwater chemistry is controlled to limit dissolved solids and minimize corrosion. The feedwater is treated with hydrazine and morpholine to reduce the oxygen concentration and to control pH. The chemical injection system consists of totes for storage of the hydrazine and morpholine, and metering pumps to inject the chemicals into the feedwater system. Demineralized water is mixed with the hydrazine to achieve the correct concentration. Blowdown of steam generator light water controls the concentration of dissolved solids in the water in the steam generator secondary side.

2.3.2.3 Moderator and Auxiliary Systems

At PNGS B, the calandria is filled with a heavy water (D₂O) moderator. The moderator slows down neutrons from fission reactions in the fuel, increasing the opportunity for these neutrons to trigger additional fissions. The heavy water moderator is circulated and cooled. This system is separate from the heat transport system. The moderator auxiliary systems include the moderator purification system, moderator cover gas system, moderator heavy water collection system, and liquid poison injection system.

During normal operations, tritium and activation products of moderator impurities may accumulate in the moderator. Chemistry control of the moderator water is maintained by filters and ion exchange columns in the moderator purification system. Helium is used as a cover gas over the moderator.

The moderator heavy water collection system collects heavy water from various points in the moderator system to prevent leakage to the reactor building atmosphere.

The moderator liquid poison injection system is used to control the rate of fission reactions in the core in certain circumstances, such as following a unit startup or during a unit shutdown. This is done by adding solutions of boron or gadolinium to the moderator water. These materials are called neutron “poisons” since they absorb neutrons very well, and thus remove those neutrons from the fission process and enable control of nuclear reactions occurring in the core.

2.3.3 Special Safety and Safety-Related Systems

Defence in Depth

A multiple barrier approach has been built into the design of PNGS B to control releases of radioactivity to the environment. There are five barriers:

- The uranium fuel is solid, molded into ceramic fuel pellets which have a high melting point and lock in most fission products;
- The fuel sheath is made of high integrity welded metal (Zircaloy) and contains the solid fuel pellets;
- The heat transport system is constructed of high strength pressure tubes, piping and vessels and contains the fuel bundles;
- The containment system provides a relatively leak-tight envelope that is maintained slightly below atmospheric pressure to encourage air to leak in instead of out, thereby

helping to prevent release of radioactivity that escapes from the heat transport system; and

- The 914 m exclusion zone around the station reduces the effect of any radioactive releases from PNGS B are well diluted by the time they reach the outer boundary.

Special Safety Systems

PNGS B has four independent special safety systems designed to ensure that a reactor may be safely shut down, the fuel remains cooled, and radioactivity is contained in the unlikely event of an accident. They are poised systems with no active process function. They are designed solely to mitigate the consequences of both a single failure in a process system, and a (much less frequent) dual failure consisting of a single failure in a process system combined with the coincident unavailability of one of the special safety systems. The four special safety systems are:

- Shutdown System No. 1 (SDS1);
- Shutdown System No. 2 (SDS2);
- Emergency Coolant Injection (ECI) system; and
- Containment system.

As noted above, these systems are independent of each other. They are also, as much as possible, independent of any of the process systems, including the reactor regulating system. These systems have no process function in the production of electricity.

2.3.3.1 Shutdown Systems 1 and 2 (SDS1 and SDS2)

The primary method of quickly terminating reactor operation, or “tripping” the reactor, Shutdown System 1 (SDS1), is the release of 28 gravity-drop, spring-assisted shutoff rods into the reactor. SDS1 employs an independent triplicated logic system, which senses the requirement for reactor trip and de-energizes the direct current clutches to release the shutoff rods. Shutdown System 2 (SDS2) provides a second diverse and independent method of quickly terminating reactor operation. SDS2 utilizes rapid injection of concentrated gadolinium nitrate solution into the moderator through six horizontally distributed nozzles. SDS2 has an independent triplicated logic system, which senses the requirement for shutdown and opens fast-acting valves that cause high pressure helium to inject the gadolinium into the moderator.

2.3.3.2 Emergency Coolant Injection (ECI)

The emergency coolant injection (ECI) system provides cooling to the fuel should an accident occur that requires coolant makeup beyond the capability of the heat transport pressure and inventory control system. The ECI system refills the primary heat transport system and keeps it filled after a loss of coolant accident (LOCA).

The ECI system has a water storage tank and high-pressure injection pumps. Following the high pressure injection phase, a low pressure recovery system recirculates water from the reactor building sump, through a heat exchanger to cool the water, and back into the heat transport system to maintain fuel cooling. By maintaining fuel cooling, the release of radionuclides into containment following a LOCA is limited so that the public dose limits are not exceeded.

2.3.3.3 Containment System

The containment system forms an envelope around the nuclear components of the reactor and the reactor coolant system. The system's overall purpose is to prevent or limit any significant release of radioactivity, which may be present in the containment atmosphere following certain postulated accident conditions, to the outside environment. To do this, the containment system limits the pressure following a LOCA to within the design pressure and reduces the pressure to sub-atmospheric for the long term. PNGS A and PNGS B share a common containment envelope consisting of the vacuum building and pressure relief duct. In addition, the nuclear systems of each reactor are contained in a reactor building which is also part of the containment system.

2.3.3.4 Other Safety-Related Systems

There are many plant systems that have a safety-related role in controlling reactor power, cooling the fuel, and containing radioactivity. Some of these systems are active (e.g. process systems used in the electricity generation process) and some are poised for use in emergency situations (e.g. emergency power and water systems for use in the event of a seismic event or fire). Inspection, testing and maintenance of plant systems is carried out commensurate with the safety-related importance of each system.

2.3.4 Turbine/Generator and Auxiliaries

Each PNGS B unit has a dedicated turbine/generator set. The turbines, generator and associated auxiliary systems are described below.

Figure 2.3-1 shows schematically how the steam generators use heat from the reactor to supply steam to the turbine/generators and how that steam is condensed in condensers and returned to the steam generators via the feedwater heating system. This process is also discussed in Section 2.3.2.

2.3.4.1 Turbine

The turbine is a tandem compound unit, directly coupled to the generator. There are three low pressure cylinders and one high pressure cylinder. Moisture separators and reheaters are used to improve the efficiency of the turbine. The rated speed of the turbine is 1,800 rpm for 60 Hz operation. The turbine includes an electro-hydraulic governor system to control speed.

2.3.4.2 Generator

The generator is a three-phase, 60 Hz machine, producing electricity at 24,000 volts. The rotor and stator core are hydrogen cooled. The stator windings are cooled with water. A seal oil system prevents hydrogen from escaping from the generator.

2.3.4.3 Steam Supply

Four pipes transport the steam from the steam generators to the turbine. Sixteen safety valves and 12 steam reject valves are installed on the steam piping in the reactor auxiliary bay as the piping emerges from the reactor building wall.

The steam reject valves are used to discharge steam to the atmosphere at times when the turbine is unavailable to accept steam (e.g. during unit warmup following an outage), or at times when there is a power mis-match between the reactor and the turbine (e.g. tripped turbine or inadvertent turbine steam valve closure).

2.3.4.4 Main Condenser

Steam from the low pressure turbine cylinders exhausts into the condenser shells where it is condensed using lake water and collected in the hotwells. External makeup water to the closed loop steam and feedwater system is fed into the hotwells by the demineralized water makeup system, from the demineralized water storage tank.

Condenser Circulating Water System

The condenser circulating water (CCW) system is an open loop system designed to supply cooling water to the condensers to condense the turbine exhaust steam.

CCW flow, which passes through the condenser tubes, is drawn from Lake Ontario at a rate of approximately 29,000 L/s per reactor through the PNGS B screenhouse. Two CCW pumps per reactor unit pump water to the condensers. An in-line debris filter installed in each of the CCW inlet pipes prevents debris from entering the condenser waterboxes. As well, a condenser tube cleaning system is installed for on-line cleaning of the condenser tubes using sponge balls.

After cycling through the condenser, cooling water is discharged to the CCW duct. CCW discharges from all four units flow into Lake Ontario via the PNGS B discharge channel.

2.3.5 Electrical Power Systems

The electrical power system includes electrical distribution (buses and switchgear), transformers, and generation of emergency power. These systems deliver power to the grid and supply electrical power throughout the station.

2.3.5.1 Generation of Emergency Power

Standby power is available from six independent gas turbine driven generators in the event that there is a loss of electrical power from the Ontario electrical grid and from a reactor unit. (Item 15 on Figure 2.2-1). The standby generators are supplied with No. 2 fuel oil which is stored in two storage tanks (Item 19 on Figure 2.2-1). The tanks are located within a dyked area to contain oil in case of spillage or tank rupture.

Emergency electrical power can also be supplied by two seismically qualified emergency power generators which are completely independent and separate from the standby generators (Item 16 on Figure 2.2-1). Fuel oil for the emergency generators is stored in two storage tanks which are contained within a dyked area (Item 20 on Figure 2.2-1).

2.3.5.2 Auxiliary Power System

The Auxiliary Power System (APS) is an emergency standby power source, located in the East Complex, consisting of combustion turbine units. The system is currently being installed and will be available in 2007. This system will supply electrical power to the PN site in the event of a loss of power supply from the Ontario electrical grid. The APS uses fuel oil, which is stored on site in storage tanks. These tanks are within dyked areas to contain oil in case of spillage or tank rupture.

2.3.6 Fuel and Fuel Handling

2.3.6.1 Fuel

The reactor is fuelled with natural uranium in the form of pellets of uranium dioxide. Twenty-one pellets are stacked end-to-end and sealed in a zirconium alloy tube to form a fuel element. Twenty-eight of these elements are assembled between two end plates to form a cylindrical fuel bundle, as shown in Figure 2.3-3. Each fuel bundle has an outside diameter of 100 mm and weighs approximately 21 kg. Each of the reactor's 380 fuel channels contains 12 bundles to provide 4,560 bundles per reactor.

2.3.6.2 Fuel Storage and Handling

The fuel handling system comprises equipment required for refuelling the reactor, for the storage of new fuel, and for the temporary on-site storage of irradiated fuel. There are also facilities for shipping small amounts (one or two bundles) of irradiated fuel off site, although this is done infrequently.

Irradiated or non-irradiated ("fresh") PNGS B natural uranium fuel bundles cannot form a critical assembly in air or in light water. This means that there is no criticality concern regarding the material volume or layout of this fuel during storage and handling, as the fission reactions cannot self-sustain in air or light water, regardless of the fuel geometry.

Fresh Fuel Storage and Handling

There are facilities for bulk storage of fresh fuel, safe transfer of fuel to the reactor building, inspection of the fuel in the fresh fuel loading areas, and manual loading of fresh fuel bundles into the motorized fresh fuel magazines. The fresh fuel storage room is in the east annex adjacent to Unit 8.

Since only natural uranium is used, criticality is not a concern during storage or fuel handling either in air or in light water. The handling facilities are designed to avoid damaging the fuel bundles.

Fuelling Machine and Transfer of Irradiated Fuel

The on-power refuelling equipment is located in the reactor building and consists of two identical fuelling machine heads which are operated remotely and automatically from the control room. Each machine is supported from a carriage structure, which in turn is carried on a bridge

structure. The bridge moves vertically and the carriage moves horizontally along the bridge allowing access to all fuel channels.

Fresh fuel bundles from the fuelling machine are pushed into one end of the fuel channel by a remotely operated ram in one fuelling machine. Irradiated fuel bundles are simultaneously discharged at the other end of the channel into another fuelling machine. The irradiated fuel is discharged to a transfer mechanism, then to a fuel transfer elevator and onto a conveyor cart. The cart travels through a light water filled duct to the irradiated fuel bay.

Irradiated Fuel Storage

The irradiated fuel bay (IFB) is in the reactor auxiliary bay between Units 6 and 7. The fuel handling system is similar to that used at PNGS A, except that the irradiated fuel is transferred from storage baskets to storage modules. This transfer results in more efficient bay storage. Modules hold 48 pairs of bundles. Modules provide much greater storage density than baskets. There are two receiving bays in the IFB. In the receiving bay, the fuel is transferred from the conveyor cart to storage baskets, and later to modules. Used fuel that has been cooled for at least ten years in the IFBs is transferred into Dry Storage Containers (DSCs) for processing and dry storage at PWWF.

Personnel are protected from radiation exposure by remote handling of irradiated fuel and by underwater transport and handling of the irradiated fuel on the conveyor, and in the receiving and storage bays. Ventilation and filtration remove fission products should fuel be inadvertently damaged during handling.

There is provision for underwater handling of shipping flasks for irradiated fuel, as well as for inspection of irradiated fuel.

The storage of irradiated natural uranium fuel in light water is not a criticality concern.

Irradiated Fuel Bay Cooling and Purification

The IFB cooling and purification system is designed to maintain the temperature and level of the storage bay water and conveyor ducts, maintain optical clarity of the water to permit observation of irradiated fuel handling operations, and remove radionuclides from the water. Filters, ion exchange columns and heat exchangers are used.

Makeup water is supplied by the demineralized water system. Leakage from the IFB is collected and discharged to the radioactive liquid waste management system.

2.3.6.3 Irradiated Cobalt Storage and Handling

Cobalt-60 is produced in Units 6, 7 and 8 for use in off-site medical and commercial irradiation facilities. New cobalt rods are loaded onto adjuster rod assemblies and placed in the reactor core during a unit outage. Following an irradiation period in the reactor of generally two years, the irradiated cobalt-60 is removed during a unit outage and transferred to the Auxiliary Irradiated Fuel Bay (AIFB). Fresh cobalt rods are then reloaded into the core to produce more cobalt-60.

Cobalt-60 is stored underwater in the AIFB and subsequently processed for shipment off site.

As cobalt-60 is highly radioactive, transfer flasks and transportation containers are well shielded to protect workers and the public. The water in the AIFB provides radiation shielding for workers.

2.3.6.4 Fuel Defect Detection

Fuel defects in the PNGS reactors are detected by two means. The presence of fuel defects in the reactor is detected through increased levels of fission products in heat transport system water samples. The presence of fuel defects in fuel discharged from the reactor (following channel refuelling) is detected through increases in gamma activity levels during transfer of fuel to the irradiated fuel bay.

2.3.7 Instrumentation and Control

There is a variety of equipment at PNGS B for a large number of diverse monitoring, control, and display functions. Instrumentation provides signals for control and display of plant variables. A dual computer control system is central to the instrumentation and control systems. The plant is highly automated and requires minimal operator action during operation. Each unit has two independent computers, each capable of complete unit control. This dual computer system assures the very high reliability needed for plant control. Several major control loops use the two computers as direct controllers and result in a redundant and highly reliable system, which is powerful and flexible. Other control loops use conventional analog instrumentation.

The major control loops in the plant are:

- Overall plant control;
- Reactor power control;
- Boiler pressure control;

- Boiler level control; and
- Heat transport pressure control.

The control systems are completely independent of the special safety systems. The shutdown systems can cope with failures of any of these systems. In addition to these systems, there are numerous smaller control loops around the plant. There are also many controls associated with the fuelling machines.

2.3.7.1 Reactor Regulating System

One of the most important control systems is the reactor regulating system. The reactor regulating system is an integrated system comprising reactor neutron flux and thermal power measurements, reactivity control devices, and a set of computer programs, which are all coordinated to perform three main functions:

- Monitor and control total reactor power;
- Monitor and control power distribution within the reactor core; and
- Monitor important plant parameters and reduce reactor power automatically if any parameter is outside its limits.

2.3.8 Auxiliary Systems

Production of power requires an extensive set of auxiliary systems, some of which are described briefly in the following sections.

2.3.8.1 Water Systems

Water is drawn from Lake Ontario into the powerhouse. Pumps supply water to the CCW system and the service water systems. The station has the following water systems:

- CCW system (previously described in Section 2.3.4.4);
- Low-pressure service water system;
- High-pressure service water system;
- Recirculated cooling water system;
- Emergency water system;

- Sediment suction system;
- Demineralized water system;
- Domestic water system; and
- Screenwash water system.

The presence of zebra mussels in Lake Ontario poses a potential concern to the PNGS B water systems. The mussels attach themselves to water intakes and associated piping and could, if unchecked, reduce the flows. As a result, the low-pressure service water system, and systems that draw water from it, which draw raw water from the lake are protected against zebra mussel infestation by chlorination. Sodium hypochlorite is injected into these systems generally during the months from June to November. The total chlorine residual in the station outfall is maintained, as required by a condition of the MOE Certificate of Approval, at or below 0.01 ppm through dechlorination using sodium bisulphite injection.

In recent years, increasing algal impingement, specifically involving *Cladophora*, has clogged screenhouse equipment and reduced cooling water flow to the plant. A seasonal (generally May to December use) algae mesh barrier has recently been installed off the end of the east groyne of the intake water structure, as the problem is associated primarily with lake currents flowing east to west. The barrier extends approximately 60 m into Lake Ontario. The effectiveness of the barrier will be assessed to determine whether continued use is beneficial.

Each unit has a **low-pressure service water (LPSW) system** supplied by three pumps located in the powerhouse. These pumps supply a common header. From this header, water is supplied to a variety of nuclear and conventional equipment. The typical flow rate during unit operation is approximately 4,400 L/s. Emergency low pressure service water pumps can supply reduced unit water demands in the event of a partial loss of electrical power.

High-pressure service water (HPSW) is taken from the unit low-pressure service water header in the powerhouse and the pressure is increased by the HPSW pumps. This system supplies cooling water to a variety of nuclear and conventional equipment for loads at an elevation too high to be supplied by the LPSW system, and to the fire protection system. Under certain winter conditions, a portion of the reactor building service water discharge is rerouted back to the screenhouse to prevent the formation of frazil ice on the intake screens.

The **recirculated cooling water system** is a closed loop system that provides clean demineralized water at 29°C to equipment which might become fouled or plugged by impurities from raw lake water.

The **emergency water system** can supply raw lake water directly to critical plant systems to provide cooling in the event of loss of normal cooling supplies. The system is designed to remain functional following a seismic event.

The accumulation of sediment at the PNGS B water intake is an ongoing problem causing condenser tube erosion, silt accumulation in heat exchangers, service water strainer plugging, and unit derating. The **sediment suction system** minimizes the accumulation by sucking up the sediment at the point of maximum deposition and pumping this silt-laden water into the station discharge channel. The system also reduces the temperature of the station discharge, helping to ensure that station differential temperature (11°C, or 14°C during an algae impingement event) and effluent temperature limits (between 32°C and 37°C, depending on time of year and algae conditions) are maintained.

The sediment suction system has two submersible pumps, a suction funnel located in front of Unit 5 at the bottom of the intake, a suction pipe 122 m long located under the intake, sluice gates, bar screens, and trash handling equipment.

The new water treatment plant supplies demineralized light water to both PNGS A and PNGS B stations. It treats lake water taken from the CCW duct at PNGS B and supplies the demand of demineralized water at flow rates up to 66 L/s. The water treatment plant comprises filters, ultra-violet sterilization, reverse osmosis, and ion-exchange columns.

The **demineralized water system** stores demineralized water in large storage tanks at each unit. The tanks are interconnected. The water is used primarily for makeup to the feedwater system, but also supplies other systems such as the recirculated cooling water system.

Domestic water is supplied from the City of Pickering water mains. The supply pressure is controlled uniformly by a regulating valve. An emergency supply of domestic water is taken from a new water supply on Brock Road through a meter house.

2.3.8.2 Drainage Systems

The on-site drainage system is subdivided into inactive drainage, active drainage, sewage system and stormwater drainage.

Inactive Drainage

The inactive drainage system collects drainage from floor drains and utility drains from the turbine hall and turbine auxiliary bay as well as foundation drains. The water collects in a sump

on each unit, and is pumped via a header common to all units to a holding pond, where it is sampled as it is discharged to the lake. Dechlorination, through the use of sodium bisulphite injection, takes place if necessary.

Active Drainage

The active drainage system segregates liquid waste by the degree of contamination and directs it to the receiving tanks of the radioactive liquid waste management system.

Sources of active liquid waste include reactor building floor drains, reactor auxiliary bay floor drains, irradiated fuel bay drainage, and spent ion exchange resin slurring water.

Prior to discharge, the waste can be treated in a purification system (filters, ion exchange columns). The waste is then sampled and analyzed to ensure the discharge will not be toxic, as required by provincial MISA regulations, and to ensure that radioactivity levels are sufficiently low. As a final safeguard, there are radioactivity monitors on the discharge piping and they will automatically stop the discharge flow if the detected activity is high.

Sewage System

The sewage system collects waste throughout the PNGS A and PNGS B complex and discharges it into the Regional Municipality of Durham sewage mains. All sewage is either directed by gravity or pumped to a final sewage lift station on site.

Station Stormwater Drainage

Stormwater is discharged directly to Lake Ontario at various locations. Measures such as good housekeeping, drain covers in areas of potential oil contamination and use of swales and ditches all contribute to minimizing contamination of stormwater.

2.3.8.3 Compressed Air Systems

The compressed air systems consist of instrument air, service air and breathing air. Instrument air is provided by compressors at each unit. Air receiver tanks store instrument air for use during a temporary loss of power. The service air for all four units of the station is supplied by one system. The breathing air for PNGS B is also supplied by one system.

2.3.8.4 Heating and Ventilation

The heating systems are required to provide comfort to people working inside the plant and to prevent equipment and fluid freezing should the plant be shutdown in the winter. Steam,

electricity, and hot water are used for heating. Hot water from the domestic water system is used for humidification.

Ventilation and air conditioning systems are provided to control temperature, moisture and atmospheric conditions as needed for employees and plant equipment. Ventilation exhaust from areas that may contain airborne radioactive materials (such as reactor buildings and the irradiated fuel bay) is filtered and monitored prior to discharge. The reactor buildings are maintained at a slight negative pressure by adjusting the inlet and outlet air flows; air flows within the reactor buildings are adjusted so that air flow is from areas of potentially less contamination to areas of potentially more contamination. This minimizes dose to workers. Air flows within the plant (but outside the reactor building) are also adjusted so that air flow is from areas of less or no contamination to areas of potentially more contamination.

2.3.8.5 Other Auxiliary Systems

Other auxiliary systems at PNGS B include:

- **Communication Systems.** The key communication systems used at PNGS B include the public address system, which is designed to transmit paging, general communication messages and emergency signals to the personnel in PNGS A and B and in the immediate outer areas of the plant; telephone system; maintenance communication system, which provides a permanent means of communication between various locations within PNGS A and B; suit communication system, which provides an effective means of voice communication for personnel working in areas where radiation protective clothing is necessary; emergency communication system, which provides seismically qualified two-way voice communication between personnel involved in reactor emergency activities; and a closed-circuit television system, which is used for viewing operations in areas not accessible because of high radiation levels.
- **Lighting Systems.** The lighting arrangement provides adequate levels of illumination with due regard to the special nature and function of each particular area.
- **Site Security Facilities.** The provision of security at PNGS B has, in addition to normal industrial security functions, a requirement to provide security against illegal acts designed to damage the plant or release radioactivity to the public.

2.3.8.6 On-site Transportation

There is an extensive existing road network at the PN site including the roadways and parking lots necessary to service PNGS B. The roads are used by employees, contractors and visitors to drive to and from the site, as well as for the transfer of materials.

2.3.9 Maintenance Programs

There are three general areas of maintenance performed at PNGS B: preventative maintenance, corrective maintenance and improvement or upgrade activities. Each plays an important role to ensure that PNGS B operates safely and in accordance with its licensing requirements.

Maintenance work is managed through a computerized work management system known as PASSPORT. PASSPORT maintains a record of maintenance tasks performed and those which require completion. Tasks are scheduled in a way that minimizes the impact of maintenance work on plant safety. As appropriate to the nature of the task, technical content is established by the Engineering Division. PASSPORT is updated with the completion of corrective and preventative maintenance tasks performed. Consequently, this system provides a record of past work done, as well as work to be done in the future.

2.3.10 Aging Management

OPG's Integrated Aging Management (IAM) program provides for timely detection and mitigation of significant aging effects in systems, structures and components important to plant safety, reliability, and economics. The IAM program provides a sound technical basis for achievement of design life and possible life extension. Specific aging management actions are designated to detect, minimize, and mitigate aging degradation before safety margins and reliability of systems, structures and components are compromised.

IAM is an integrated part, along with System Health Reporting, for station condition assessment required for Operational Business Planning.

As part of the planning for the PNGS B Project, a station condition assessment is being undertaken as a component of the IAM program.

2.3.11 Administration and Support Systems

Administration Systems requiring consideration in the EA study include purchasing, payroll, and station administration. Purchasing and payroll are discussed in Chapter 4.0 (Existing Environment) under socio-economic conditions.

Administration functions at the PN site either support PNGS A and B operations separately, or support both organizations. The PWMF is supported by a separate organization within the Nuclear Waste Management Division (NWMD). Reorganization of administrative functions occasionally takes place to enhance the effectiveness of the support in response to changing conditions.

OPG, as the property owner, is a source of revenue for local government through taxes and permits.

2.4 MATERIALS MANAGEMENT

2.4.1 Heavy Water Management

Systems for storing, transferring, cleanup and upgrading of heavy water (D₂O) are common to all units at PNGS A and B. The general principles involved in heavy water management are:

- Ensure an adequate supply of heavy water is available and can be moved between systems as required;
- Ensure the concentration of light water in the heavy water is controlled to meet the needs of the heat transport and moderator systems. This is referred to as the “isotopic” of the heavy water and is a measure of the purity of the heavy water. Moderator systems require heavy water of higher purity, or higher isotopic. Increasing the isotopic of heavy water is referred to as “upgrading”;
- Ensure the heavy water meets the chemistry specifications of the upgrading systems through ion exchange, filtering and oil/water separation;
- Provide separation of heavy water containing low concentrations of tritium (for heat transport system use) from heavy water containing higher concentrations of tritium (for moderator system use);
- Provide the ability to remove tritium from heavy water. This is done at the Darlington Tritium Removal Facility (TRF);
- Minimize the loss of heavy water by collecting the water from liquid leakage, vapour recovery or spills, and recycling the water for reuse through cleanup and upgrading activities.

Every effort is made to minimize the loss of heavy water from heat transport and moderator systems due to both the high cost of heavy water and the radiological effects associated with the release of tritium. Measures to achieve this include the following:

- Heavy water is transferred throughout the station by pumps and piping systems wherever practical, minimizing the use of drums for storage and transfer;
- The number of mechanical joints in heavy water systems is minimized and piping is welded where practical;
- Heavy water leakage is diverted to collection systems; and
- Air dryers are used to extract and collect heavy water from the reactor building atmosphere.

Supply and Transfer Systems

A central heavy water supply facility, located between PNGS A and PNGS B, consists of five tanks, pumps and a heavy water addition station. Incoming external shipments of heavy water are accepted here from tanker trucks or drums. Additional tanks are used to transfer heavy water with a high tritium concentration into approved transportation containers for shipment to the Darlington TRF for tritium removal. Heavy water returned from the TRF is transferred to the heavy water supply system or directly to the heavy water transfer system.

The heavy water in the supply system storage tanks can be pumped directly to the heat transport or moderator system of any reactor via the heavy water transfer system. The heavy water transfer system consists of piping connecting each reactor to the heavy water supply system, and to the other reactors, for efficient heavy water transfer with a minimum of drum usage. The heavy water transfer system has seven separate piping systems to maintain segregation of heavy water by its tritium concentration and isotopic.

Cleanup and Upgrading Systems

There are separate heavy water cleanup systems for heat transport and moderator water to maintain segregation of heavy water by its tritium concentration. These cleanup systems remove impurities, other than light water, from the heavy water through ion exchange, filtering and oil/water separation. This cleanup is done prior to sending the heavy water to the upgrading systems.

There are separate upgrading systems for heat transport and moderator water to maintain segregation of heavy water by its tritium concentration and to achieve the target range of isotopics for each of these systems. The upgrading process removes light water from the heavy water.

Vapour Recovery Systems

There are four separate vapour recovery circuits in each reactor building to dry the atmosphere in areas that are subject to heavy water leakage during operation or servicing of equipment. This has the dual benefit of reducing heavy water losses and reducing tritium concentrations in the reactor building atmosphere. Water collected by these vapour recovery circuits is sent via the heavy water transfer system for cleanup and upgrading prior to reuse.

2.4.2 Non-Radioactive Materials Management

Chemicals, gases, lubricants and oils are received for use at PNGS B. Other materials include conventional industrial and office supplies that are shipped to the site by truck, and generally stored in warehouses or where they are used. Materials are managed in accordance with applicable regulations, such as the Fuel Handling Code and the *Environmental Protection Act, Regulation 347* (Government of Ontario 2005).

Table 2.4-1 represents the list of chemicals, gases, lubricants and oils used at PNGS B considered in the EA study. Table 2.4-1 identifies the system in which each substance is used and its purpose, along with the storage location and the ultimate fate of the substance (disposal or consumption).

**TABLE 2.4-1
CHEMICAL USAGE AT PNGS B**

Chemical	Where Used (System)	Purpose	Storage	Disposal
Boric acid	Moderator system	Reactivity control	Mixed with D ₂ O in the liquid poison tanks	Removed by ion exchange (IX) resin in the moderator purification system
Gadolinium nitrate	Moderator system	Reactivity control	Mixed with D ₂ O in the liquid poison tanks	Removed by IX resin in the moderator purification system
Helium gas	Cover gas for moderator; liquid zone control; D ₂ O storage tank	Cover gas to prevent air ingress	Gas cylinders	Periodically purged to reactor building exhaust for chemistry control
Oxygen gas	Moderator cover gas; annulus gas	Added to recombine with D ₂ gas; to maintain pressure integrity	Gas cylinders	Consumed; emitted to reactor building exhaust
Hydrogen gas	Heat transport system; main generators	Remove O ₂ from the heat transport system; cooling for the generators	Mobile trailer and gas cylinders	Consumed in the heat transport system and vented to reactor building exhaust; periodically vented to atmosphere from the main generators
Hydrazine (35% solution)	Emergency coolant injection system; steam generator feedwater; condensate feedwater; recirculating cooling water system; end shield cooling water	Removal of O ₂ and pH control	Oil and Chemical Storage Building – Totes and drums – Totes in chemical addition station in turbine hall	Consumed but residual may be discharged to lake or atmosphere. A breakdown product in feedwater is ammonia.
Lithium hydroxide	Heat transport system; end shield cooling system; recirculating cooling water system	pH control	Station –chemical addition systems	Consumed (used when pH must be rapidly corrected; usually the pH is controlled by lithiated IX columns)
IX resin H ⁺ HO ⁻	Moderator system; irradiated fuel bay; auxiliary fuel bay; liquid zone control	pH control and removal of impurities	Purification IX columns	Temporary storage – spent resin tank; interim storage – WWMF

TABLE 2.4-1 (Cont'd)
CHEMICAL USAGE AT PNGS B

Chemical	Where Used (System)	Purpose	Storage	Disposal
IX resin Li^+ HO^-	Heat transport system; end shield cooling; recirculating cooling water system	pH control and removal of impurities	Purification IX columns	Temporary storage – spent resin tank; interim storage – WWMF
IX resin SO_3^{2-}	Stator cooling water system	Removal of O_2	IX column	Industrial waste disposal
Sulphuric acid; sodium hydroxide; sodium metabisulphite; polyaluminum chloride; anti-scalant; sodium hypochlorite	On-site water treatment plant	Production of demineralized water	Tanks within water treatment plant	Consumed
Carbon dioxide gas	Annulus gas system; generator	Annulus gas system – carrier gas; generator – purging gas	Outdoor tank (gas cylinder)	Annulus gas system – to reactor building exhaust; generator – vented to atmosphere
Morpholine	Steam generator feedwater; condensate feedwater	pH control and corrosion control	Totes in Oil and Chemical Storage Building and chemical addition station in turbine hall	Partly consumed; atmospheric discharge; and steam generator blowdown
Sodium hypochlorite	Low pressure service water	Zebra mussel control	Four tanks in chlorination house	Consumed and residual to Lake Ontario
Sodium metabisulphite	Inactive drainage; reactor building service water	Dechlorination	Outdoor tanks with secondary containment	Consumed
Sulphur hexafluoride	Condenser circulating water system	Leak detection	Gas cylinders	To lake (small volumes only)
Grade B#2 oil	Standby generator; emergency power generators, auxiliary power system	Fuel	Outdoor tanks with secondary containment	Consumed resulting in waste gases CO_2 , NO_x , SO_2 , etc.

TABLE 2.4-1 (Cont'd)
CHEMICAL USAGE AT PNGS B

Chemical	Where Used (System)	Purpose	Storage	Disposal
Lubricating oil and seal oil	Turbine lubricating oil system; generator seal oil system	Lubrication and sealing	Three tanks on the north side of the turbine hall	Reused or removed by contractor
Insulating oil	Main output and service transformers	Cooling for the transformers	Brought in by truck	Removed by contractor
Ethylene glycol	Battery rooms	Air conditioners	Small head tanks in powerhouse	Removed by licensed contractor if necessary
Reolube Turbo fluid 46 (Fire Resistant Fluid (FRF))	Turbine governor	Hydraulic fluid for turbine governor valves	Tanks in powerhouse	Reused or drummed for disposal

It is anticipated that no additional types of chemicals, lubricants or oils will be required or consumed as a result of the Project. Occasionally, plant systems such as the generator, heat transport system or boilers may require internal cleaning with solutions such as mild acids to remove foreign material build up. No system cleans are planned at this time, although a heat transport system clean may be included in the refurbishment work; should they be required, any necessary regulatory approvals would be obtained and all regulatory requirements would be met for emissions and for waste disposal.

2.5 WASTE MANAGEMENT

Waste Management includes the management of operations wastes produced at PNGS B. Wastes produced include used fuel, radioactive solid wastes (ILW & LLW), radioactive liquid wastes, radioactive gaseous wastes, and non-radioactive wastes (solid and liquid non-hazardous wastes and hazardous wastes). Each of these waste streams is discussed below.

There are facilities for safe temporary storage and safe handling of all radioactive liquid and solid wastes. All equipment, tanks, and facilities for handling liquid and solid wastes are flexible enough to cope with the anticipated increase in waste volume and activity during periods of major maintenance work.

There are several basic treatment processes for the management of the radioactive wastes depending upon the type and level of radioactivity. These processes include:

- Holding the waste to allow time for natural isotope decay;
- Controlling the rate of release of some liquid and gaseous radioactive wastes in the respective plant effluent streams;
- Ion exchange and filtration to remove the radioactive materials from liquid wastes;
- Mechanical or chemical processes to remove the radioactive materials from solid wastes;
- Filtration to remove radioactive materials from gaseous wastes;
- Use of shielding flasks when transferring ILW to the WWMF for storage; and
- Interim storage of solids in solid radioactive waste storage facilities with shielding prior to off-site shipment.

2.5.1 Radioactive Waste Management

2.5.1.1 Irradiated (Used) Fuel

Irradiated fuel is stored in the station IFB and the PWWF.

Used fuel bundles (also called “irradiated fuel bundles”) are discharged from the reactor at the same time that fresh fuel is loaded (see Section 2.3.6). These used fuel bundles are highly radioactive. Within each (sealed) element are fission and activation products, including strontium-90, cesium-137, iodine-131 and plutonium-239. Over time, these isotopes decay, gradually reducing heat output and decreasing the radioactivity of the bundle. Typically, the radioactivity in used fuel decays to approximately 0.1% of its initial activity within ten years of being removed from the reactor.

Used fuel management consists of keeping the used bundles cool and shielded while the radioactivity naturally decays. PNGS B uses a water-filled bay to manage used fuel for approximately ten years prior to transfer to dry storage containers (DSCs). Used fuel transfer to the IFB is discussed in Section 2.3.6.

PNGS B produces approximately 3,480 used fuel bundles per unit per year. If all four units were to operate for an average of 30-35 years post refurbishment, a total of 452,400 used fuel bundles (that is, 32.5 years average \times 3,480 bundles \times 4 units) would be produced over this period. It is estimated that prior to the start of refurbishment, PNGS B will have produced approximately 390,000 fuel bundles (including the reactor core inventory required prior to refurbishment) for a lifetime total of approximately 842,400 bundles. The PNGS B irradiated fuel bay has storage capacity for approximately 150,000 bundles. Therefore, additional storage is required for some 692,400 bundles from PNGS B over its anticipated lifetime. This additional storage requirement will be provided at PWWF.

Dry storage of used fuel was initiated at the PN site in 1995 as a common facility to serve both PNGS A and B. Used fuel is stored in DSCs at PWF as an interim stage in the management of used fuel. A DSC is constructed of two steel shells filled with high density concrete. The DSC has been designed for above-ground storage and transportability. Each DSC has a storage capacity of 384 used fuel bundles. The used fuel in the seal-welded DSCs is stored in an inert helium atmosphere.

To the end of 2006, 165,500 bundles of fuel were in dry storage at the PN site in two storage buildings (SB1 and SB2 at PWF I) which have a combined capacity of 251,000 bundles. The activity of transferring used fuel from the IFBs at PNGS B to the PWF I for processing is currently included under the PWF I licence. Therefore, this activity is not part of the Project. Activities associated with the transfer and storage of used fuel during continued operation after refurbishment are considered part of the Project.

In 2004, the PWF Phase II EA was approved for the construction of two additional storage buildings (SB3 and SB4) each with a capacity of 192,000 bundles (OPG 2003a). The PWF II EA evaluated a Siting Area, containing three alternative site areas in the East Complex (Figure 2.5-1). A Preferred Site Area was identified; however, the PWF II EA concluded that there were only minor differences among the three Site Areas and all areas would be acceptable to accommodate the two PWF II storage buildings.

The PWF operating licence was amended to permit the construction of two new buildings (SB3 and SB4 at PWF II). SB3 will house used fuel, and is planned for operation in 2008 with a capacity of 192,000 bundles. Initially, it was expected that SB4 would be constructed about 2016. At that time it was anticipated that there would be six units in operation at the PN site (two units at PNGS A and four units at PNGS B) producing a total of approximately 20,000 bundles per year. At this fuelling rate, the fourth storage building (SB4) would supply approximately nine years of storage for the six units. However, the exact timing of future storage buildings at PNGS will depend on operational plans for both PNGS A and B, and on the availability of a long-term storage facility off site.

Used fuel will ultimately be managed in a long-term facility to be sited, constructed and operated by the federally mandated Nuclear Waste Management Organization (NWMO) (NWMO 2005). It is assumed that used fuel will start to be transported to a long-term management facility operated by the NWMO around the year 2035.

2.5.1.2 Radioactive Solid Waste Management – Intermediate and Low Level Waste

Intermediate Level Waste (ILW)

In Canada, low-level radioactive wastes (LLW) comprise all forms of radioactive wastes except for spent fuel waste and for those wastes derived from uranium or thorium mining and milling. Canada does not have an intermediate level waste (ILW) category. For operational purposes, OPG defines ILW as wastes with dose rates greater than 10 mSv/h.

Spent ion exchange resins, classified as ILW, are slurried from the purification systems to the spent resin storage tanks at each unit for temporary on-site storage and decay. One tank in each unit holds the spent resin from the moderator, liquid zone control, and end-shield cooling systems and another tank holds the spent resin from the heat transport purification system. The Unit 6 heat transport resin tank also receives spent resin from the IFB purification system.

Spent resins are subsequently slurried from the storage tanks to a 3 m³ disposable liner and then transported in the bulk de-watered form inside the Trillium Transportation Package (TTP) to the WWMF at the Bruce Site for storage.

After removal, radioactive disposable filters (classified as ILW) are placed in shielding flasks, transferred to the in-station flask lay-down area, loaded into the Radioactive Filter Transportation Package (RFTP) and transported to the WWMF for storage.

Non-processible radioactive waste (classified as ILW) is collected and packed in appropriate sized containers in the solid radioactive waste management area for subsequent off-site shipment to the WWMF for processing or storage.

Low Level Waste (LLW)

For operational purposes, OPG defines solid LLW as waste with contact radiation fields less than 10 mSv/h at 30 cm.

LLW is composed of maintenance wastes originating from day-to-day reactor operations. They consist of cleaning materials, personal protective equipment, contaminated metal parts and miscellaneous items, including floor sweepings. Dry solid wastes are collected throughout the station on a daily basis. LLW is categorized as incinerable, compactable, and non-processible wastes as described below.

The majority of the incinerable LLW is low activity items that include paper, plastic booties and bottles, wood, plastic suits, cardboards, mop heads, cloth, ventilation filters (non-metallic) and rubbers. They are collected in plastic bags, packed into 0.6 m³ shipping containers, which are then loaded onto Industrial Package Type 2 (Type IP-2) transportation packages and moved out of the station for subsequent incineration at the WWMF. LLW is sometimes stored temporarily at the Waste Handling Facility in the Service Wing before it is shipped off site for processing and storage.

Compactable radioactive waste (classified as LLW) is collected in plastic bags and stored temporarily in the solid radioactive waste management area before being shipped to the WWMF, where it is compacted and stored. Compactable LLW includes miscellaneous wastes such as respirator filters, light gauge metals, welding rods, metal cans, insulation, metallic air filters, air hose and small cables.

Non-processible LLW includes lathe turnings and metal filings, heavy gauge metal and components, floor sweepings, glass, and larger electrical cables. This waste is packaged and transported to the WWMF.

PNGS B currently produces approximately 325 m³ per unit per year of routine operational LLW and ILW, resulting in a stored volume of approximately 150 m³ per unit per year after processing of the low level waste portion at the WWMF. OPG is in the process of implementing their Solid Waste Minimization Plan. It is expected that current and future LLW minimization efforts will be applied to reduce the amount of operational waste. Initiatives to reduce solid waste include using washable cotton liners, rubber gloves and slip-on booties, reducing packaging at the warehouses before being delivered to the station.

Shipments of active material conform to the CNSC's *Packaging and Transport of Nuclear Substances Regulations* (CNSC 2000) and the *Transport of Dangerous Goods Regulation* issued by Transport Canada (Transport Canada 2005). Other regulations specific to the mode of transport are applied as required.

2.5.1.3 Radioactive Liquid Waste Management

The radioactive liquid waste management system (RLWMS) is common to PNGS A and B. This system receives and treats the waste streams directed to it by the active drainage systems. The system discharges treated wastes at a controlled rate to Lake Ontario through the CCW discharge ducts and the PNGS A and PNGS B discharge channels.

The active drainage system is designed to segregate the wastes, according to type and projected radioactivity level, and divert them to specific receiving tanks. Potentially radioactive effluents

and chemical contaminants from all applicable areas of PNGS during normal operations are directed to receiving tanks. All receiving tanks are pumped directly through a purification system to a dedicated discharge tank. The purification system treats water contaminated with chemicals such as hydrazine and other elements such as copper, zinc or iron that could cause the water to be toxic. The discharge tanks are sampled for various radiological and chemical parameters and discharged only if they meet required specifications. All discharges from the RLWMS must be non-toxic as directed by Provincial Municipal Industrial Strategy for Abatement (MISA) regulations. The purification system also removes some of the gross beta-gamma activity from the water caused by activated suspended solids or dissolved radionuclides before being released.

Before any treated waste is discharged to the lake, the radioactivity is checked to ensure that the degree of dilution, which varies with the number of operating CCW pumps, is sufficient for release. As a final safeguard against the discharge of high activity waste, the waste discharge lines are provided with activity monitors. On detection of higher than expected radioactivity, these monitors will initiate closure of isolating valves preventing further discharge.

Certain types of non-aqueous radioactive liquids, such as lubricating oils and liquid scintillation cocktails that meet the waste acceptance criteria for the WWMF, are collected, packaged and transported to the WWMF for incineration. Other types of non-aqueous radioactive liquids are collected and transported to licensed third party facilities for treatment. Secondary wastes from the third party treatment, such as incinerator ash, is returned to OPG for storage at the WWMF.

2.5.1.4 Radioactive Gaseous Waste Management

Gaseous wastes from potentially active areas, such as reactor buildings, are monitored for radioactivity before release to the atmosphere. Where radioactive particulate and radioiodine may be present, the gases from active ventilation stacks are filtered through absolute filters (for particulate) and charcoal filters (for radioiodine) before being released to minimize the release of radioactivity to the environment. At times, gases may be contained before release to allow time for radioactive isotopes to decay, reducing emissions to the environment.

Gaseous wastes are generated, and minimized in the following ways:

- Radioiodine is a product of fission reactions, and is usually contained within the sealed fuel bundle elements. Gaseous radioiodine may escape into the heat transport system if a small defect occurs in a fuel element seal. Releases to the reactor building atmosphere are minimized by purification of the heat transport system heavy water to remove radioiodine, and by removal of defective fuel from the reactor. Charcoal filters in the ventilation exhaust stacks also remove radioiodine;

- Radioactive noble gases are a product of fission reactions and, similar to radioiodine, can be released to the heat transport system if a small defect occurs in a fuel element seal. Noble gases cannot be effectively filtered, but strict quality control in the manufacturing and testing of fuel elements has resulted in very low noble gas emissions;
- Gaseous tritium waste takes the form of tritiated water vapour. Tritium is produced in heavy water systems that are exposed to the neutron-rich environment of the reactor core, when a deuterium atom (heavy hydrogen isotope) in a heavy water molecule absorbs a neutron. Means of minimizing tritium releases to the reactor building atmosphere and the environment are discussed in Section 2.4.1;
- Radioactive particulates are formed as products of fission reactions or by neutron absorption in various materials (called “activation products”). The release of these particulates to the reactor building or IFB atmosphere is minimized by purification of the coolant water. Release to the environment is further minimized by the use of absolute filters in the ventilation exhaust stacks;
- Carbon-14 is created in the reactor through neutron activation, primarily in the moderator and moderator cover gas systems. Carbon-14 release is minimized through purification systems. Ventilation exhaust stacks are monitored for gaseous carbon-14 activity.

2.5.2 Non-Radioactive Waste Management

Non-radioactive wastes are re-used or recycled where feasible. Hazardous wastes are handled in accordance with regulations and are shipped off site to licensed disposal facilities. Non-hazardous solid wastes meeting landfill requirements are disposed of accordingly in an off-site landfill. Non-radioactive gaseous and liquid emissions are controlled in accordance with provincial Certificate of Approval (C of A) requirements.

The following methods are used to minimize and manage waste generation:

- Reusable equipment and materials are used as much as possible;
- Waste and recyclable material are separated at the designated collection points;
- As little material as possible is taken into the station, particularly packaging, to minimize the chance of radioactive contamination and thus the creation of additional radioactive waste; and
- The work planning process requires that no materials be brought onto the site unless there is an acceptable method of disposal of the waste to be generated.

Table 2.5-1 summarizes the management of non-radioactive solid, liquid and gaseous wastes.

**TABLE 2.5-1
OVERVIEW OF MANAGEMENT OF NON-RADIOACTIVE WASTE AND EMISSIONS**

Type	Sub-Type	Source/Examples	Management	Frequency of Operation
Solid Wastes	Domestic garbage	Administration building, cafeteria and other plant buildings	Sent to off-site landfill	Weekly/daily
	Recyclables	Paper, wood, glass, ferrous and non-ferrous metals, batteries	Sent to contractors for recycling	Weekly/daily
	IX column resin	Stator cooling water purification system	Sent to off-site landfill	As required
	Clean and chemically-contaminated soil	Soil removed and not needed Soil contaminated following a spill	Depending on degree of contamination, soil may be disposed of by disposal contractor, or as landfill or industrial fill	As required
	Asphalt, concrete	Road areas, concrete structures	Sent for recycling	As required
Liquid Wastes	Water	CCW discharge	Discharged to Lake Ontario	Continuous
		Steam generator blowdown	Discharged to Lake Ontario	Continuous
		Service water discharge	Discharged to Lake Ontario	Continuous
		Inactive drainage systems (yard, foundation and utility)	Discharged to PNGS B forebay	Continuous
		Domestic sewage	Domestic sewage sent to Region of Durham sewage collection system	Batch basis (daily)
		Switchyard drainage system	Collected in catchbasins and discharged to Lake Ontario	As required
Liquid Wastes	Oils	Bulk oils from standby generators, emergency power generators, auxiliary power system	Collected in storage tank until removal by contractor for disposal or recycling	As required
		Lubricating oil steam/generator seal oil	Stored in a waste tank on the north side of the turbine hall until removal by contractor for disposal or recycling	As required
	Chemicals and oils (including PCBs)	Chemical, oily waste and Reolube collection and disposal system	Sent to contractor for disposal or recycling	As required
	Water Treatment plant process wastes	Water treatment plant	pH and chlorine adjustment by waste neutralization system and discharge to Lake Ontario or sanitary sewer	As required

TABLE 2.5-1 (Cont'd)
OVERVIEW OF MANAGEMENT OF NON-RADIOACTIVE WASTE AND EMISSIONS

Type	Sub-Type	Source/Examples	Management	Frequency of Operation
Gaseous Wastes	Steam (may contain impurities such as ammonia and hydrazine)	Large steam discharge valves	Discharged to the atmosphere	Periodic
		Small steam discharge valves	Discharged to PNGS B forebay	Periodic
		Safety relief valves	Discharged to the atmosphere	Periodic
	Exhaust and odours	Diesel generators, oil storage tanks, non-nuclear oil systems, non-nuclear gas systems	Vented directly to the atmosphere	Periodic

All hazardous wastes are handled and stored according to the appropriate federal and provincial regulations, and the services of licensed contractors are frequently used. These wastes include expired chemicals, cleaners, paint, aerosol cans and electrical components. Non-radioactive oil and chemical wastes are removed from the site within 90 days of waste generation. Devices that contain liquid mercury (electrical switches, instrumentation) are carefully packaged to avoid breakage and leaks, and are sent to facilities that can recycle the mercury.

OPG has increased the types and amounts of materials that are recycled on the site in recent years. In 2005, the following materials were sent for recycling: soil, concrete, brick, asphalt, electronics, glass, wood, beverage cans, paper, metals, cardboard, paper towels, plastic, newspaper, Styrofoam, and batteries. The total amount of solid waste disposed of in 2005 from the PN site (PNGS A and B together) was approximately 1,600 metric tons, while the amount of recycled materials was approximately 2,120 metric tons. It is anticipated that the amount of wastes generated on the site from ongoing operations will remain at similar levels in future, although continuous improvement efforts in reusing and recycling may reduce the amounts sent to landfill.

2.5.2.1 Management of PCBs

PNGS B has limited equipment that contains polychlorinated biphenyl (PCB) material, and no PCB-containing transformers. Two locked and secured areas have been designated exclusively for PCB waste storage at PNGS B. These waste materials typically consist of PCB-containing capacitors and lighting ballasts. There is a second PCB secured storage site located within the Pickering East Complex. This site is used as a staging area only for PCB-containing equipment

such as drained transformers, PCB liquids from the drained transformers, debris such as the plastic sheets used for spill protection during transformer draining, personal protection equipment such as gloves, coveralls and Tyvek™, lighting ballasts and miscellaneous electrical electronic circuits and capacitors. These PCB-containing equipment are disposed of off site in compliance with MOE and Environment Canada regulations. No treatment occurs at this site. PNGS follows specific procedures for the handling and storage of PCB-containing equipment.

2.5.2.2 Management of Asbestos

An asbestos management program exists at PNGS B to ensure that all work that may involve asbestos-containing materials is properly identified and controlled. Procedures, training and equipment are in place to ensure that exposure to asbestos will be minimized and asbestos-containing wastes will be disposed of in accordance with regulatory requirements.

A database of known asbestos-containing materials is maintained; inspections of these materials are carried out to ensure the asbestos is appropriately sealed and identified. Any work that has the potential to disturb asbestos-containing materials is controlled using established procedures to safely control and manage the asbestos hazard.

2.6 PROJECT PHASES AND SCHEDULE

The Project consists of four principle stages: preparation for refurbishment; refurbishment; refuelling and restarting; and operations and maintenance. Each of these phases is briefly described below, along with any associated waste management activities. For the purposes of the EA Study, the first three activities are grouped together as the “Refurbishment Phase” and the fourth comprises the “Continued Operation Phase”.

2.6.1 Refurbishment Phase

2.6.1.1 Preparation for Refurbishment

Preparation for Refurbishment includes the activities that would be undertaken in advance of the major refurbishment activities. These include:

- Preparation of contractor procedures and plans;
- Mobilization of contractor workforce;
- Procurement of equipment and components;
- Construction of construction facilities such as change rooms, meeting rooms, shop facilities;

- Relocation of buildings or structures;
- Possible construction of building and tank facilities for storage of heavy water;
- Possible construction of laydown areas;
- Construction of waste storage structures or buildings;
- Defuelling and dewatering of the reactor in preparation for refurbishment, including managing the removed heavy water and used fuel; and
- Creation of an “islanded” configuration for the unit to be refurbished to ensure that the refurbishment work does not interfere with safe operation of the running units.

Section 2.7 describes the specific project works and activities that make up the Preparation for Refurbishment activities of the Refurbishment Phase.

2.6.1.2 Refurbishment

Refurbishment comprises a number of works and activities. For each reactor unit, these include:

- Replacement of the fuel channels (i.e., pressure tubes and end fitting assemblies) and calandria tubes;
- Replacement of the inlet and outlet feeders from the end fittings to the reactor inlet/outlet headers;
- Replacement of the steam generators; and
- Normal upgrade and maintenance activities of the type that are undertaken during a unit outage.

Section 2.7 describes the specific project works and activities that make up the Refurbishment activities of the Refurbishment Phase. These activities apply to all four of the PNGS B units.

2.6.1.3 Refuelling and Restarting

Refuelling refers to the initial loading of the reactor fuel channels with new fuel following the major refurbishment activities. Restarting comprises the activities associated with starting up plant systems and raising reactor power to generate electricity.

The activities associated with refuelling and restarting each unit includes:

- Loading new fuel into each of the fuel channels;
- Refilling the moderator with heavy water;
- Refilling the heat transport system with heavy water;
- Startup and testing of plant systems;
- Achieving criticality in the reactor core;
- Raising reactor power;
- Admitting steam to the turbine; and
- Reconnecting the unit to the electrical grid to generate electricity.

It is expected that CNSC approval will be required to progress beyond certain key points in the refuelling and restarting activities. OPG would ensure that any conditions specified in the operating licence are met.

Section 2.7 describes the specific project works and activities that make up the Refuelling and Restarting activities of the Refurbishment Phase. These activities apply to all four of the PNGS B units.

2.6.2 Continued Operation Phase

2.6.2.1 Operations and Maintenance

For EA purposes it is conservatively assumed that all units at PNGS B will operate at a reactor power of 100% throughout their extended operational life, using natural uranium fuel. Environmental effects resulting from this assumption provide an upper bound scenario, as units may be run at less than full power periodically, or undergo regular maintenance outages.

2.6.3 Project Schedule

As noted earlier, to develop the bounding scenarios for EA purposes, the earliest start date for the construction of buildings to store refurbishment waste and steam generators and to support construction-related activities is estimated to be approximately 2010. Refurbishment of the first unit is likely to begin between 2012 and 2014. Refurbishment of each unit could take approximately 2 ½ to 3 years to complete. It is expected that refurbishment phase activities would be completed between 2024 and 2026 at the latest. Scheduling of each unit's refurbishment outage will depend on several factors such as contracting strategy, resource availability, generation planning, and unit performance. Refurbishment and replacement of the life-limiting components of the PNGS B units will extend the expected service of the units. Refurbishment outages may proceed on two units at a time, or the outages may proceed

sequentially. The bounding environmental effects of all of these possibilities are addressed in the EA Study Report.

As noted, refurbishment of the first unit is likely to begin between 2012 and 2014. However, depending on the many factors noted above, OPG may delay the beginning of the refurbishment outages by up to several years. In this case, systems and components on the units (including individual life-limiting components such as certain pressure tubes or feeder pipes) will be maintained (maintenance, modification or replacement) on an as-needed basis until the refurbishment outages begin. This is a normal maintenance activity at PNGS.

Operation of all four refurbished reactors is anticipated to continue to the new end of life, which has been conservatively assessed to be 2060 for the last of the four units.

2.7 PROJECT WORKS AND ACTIVITIES – REFURBISHMENT PHASE

Sections 2.7.1 through 2.7.3 present information on project works and activities related to the Refurbishment Phase with an emphasis on the systems, components and activities that may be expected to change as a result of the Project.

2.7.1 Site and Facility Preparation for Refurbishment

Preparation for refurbishment includes on-site preparations for refurbishment, and defuelling and dewatering the reactors. These activities are described below.

2.7.1.1 Site and Contractor Preparation for Refurbishment

Contractor Preparation for Refurbishment

A large portion of the refurbishment work will be done by contractors. Prior to working at the PN site, contractors will be required to prepare an Environmental Management Plan (EMP) consistent with the current OPG operating policies and procedures. This EMP must satisfy OPG that strict quality, environmental and safety standards will be met. OPG will provide oversight of work done by contractors, to a degree that depends on the abilities and experience of the chosen contractors, and on the contracting strategy. Contractors will prepare procedures and plans for the work, and OPG will review and accept the documents.

Contractors will mobilize their workforce, equipment and field offices at site just prior to beginning work. Contractors working at the PN site must be qualified and trained. It is anticipated that all critical aspects of the refurbishment work will undergo rehearsal using mock-ups of the equipment.

Contractor parking will be provided within the existing on-site parking facilities south of Montgomery Road and the parking area north of Montgomery Road noted on Figure 2.7-1.

Procurement and Mobilization of Equipment and Components

The major system components to be procured for refurbishment include steam generators, feeder piping, fuel channel assemblies and calandria tubes.

As this is essentially a large construction project, a large amount of heavy machinery will be mobilized. This includes diesel-powered transportation equipment, including a large multi-wheeled ground transporter, forklifts, tractor trailers, and other construction equipment such as cranes, earthmovers, electrical generators, etc. A large crane will be required for hoisting of the steam generators into and out of the reactor buildings, through specially prepared and approved openings in the reactor building domes. This crane will be situated on the south side of the reactor buildings.

Relocation/Removal/Construction of Buildings, Structures, and Equipment

Some structures and equipment within the PNGS Protected Area will have to be temporarily relocated or removed to make room for the large crane that will be used to lift the steam generators into and out of the reactor buildings. Items identified as obstructing the crane locations include fire hydrants, an equipment storage building, the gas bottle storage enclosure and the chlorine building. These structures and equipment, all located south of the reactor buildings, will be removed, relocated or modified to accommodate the crane. Measures will be put in place to mitigate the impact of removing these items temporarily. Figure 2.7-1 illustrates the proposed location for the Protected Area Construction Crane & Laydown Area.

Similarly, some structures and equipment may have to be temporarily relocated or removed to facilitate the movement of refurbishment equipment, components and wastes through the station. Appropriate measures will be put in place to mitigate the impact of this work. Some service structures, such as the East Annex, may require modification to accommodate the refurbishment services work.

Although some construction equipment and temporary facilities will be located within the PNGS Protected Area boundary, the majority of the temporary construction facilities and laydown areas will be located in the East Complex area (Figure 2.7-1). This figure shows preferred locations; however, other locations on site could be used. Construction-related facilities, such as change rooms, shop facilities, construction offices, and laydown areas for equipment and machinery will be required. These land uses are similar to the existing land use in the East Complex area. Depending on the exact timing, some existing buildings and structures within the East Complex will be converted to these uses or replaced as required. It is anticipated that some current office facilities, storage buildings and workshops may be affected. These structures will no longer be

required for PNGS B operation and are slated for demolition by the time refurbishment commences. Areas that are currently being used for outdoor storage of materials will also be affected, and will continue to serve that purpose for refurbishment material storage.

Some additional service buildings or structures may be required within the PNGS Protected Area Boundary. A new building with storage tanks may be required to accommodate the transfer and storage of heavy water drained from the heat transport and moderator systems during the refurbishment outages. There may be a need for service buildings to accommodate additional personnel or additional equipment storage. The preferred location for additional service buildings or structures will be within the area identified on Figure 2.7-1 as Protected Area Construction Crane Laydown Area and Services; however, other locations on site could be used. Any new building will be designed and constructed following OPG's structured engineered change control process. This process ensures that the building will comply with the current PNGS operating licence as well as all applicable design and construction regulations and codes, such as the National Building Code of Canada or any applicable Canadian Standards Association (CSA) standards. Any necessary building permits or regulatory approvals will be obtained.

Construction of Radioactive Waste and Used Fuel Storage Buildings

As part of the refurbishment activities, various refurbishment wastes (such as steam generators and fuel channel assemblies) will be generated. For these wastes, one or more refurbishment waste storage building(s) of various sizes will be built in about 2010, to store the retube waste containers (RWCs), and steam generators prior to transport off-site. The refurbishment waste storage building(s) will be constructed in the East Complex area for the interim storage of these wastes in Storage Area 6 (SA6) (see Figure 2.7-1). Building design would be subject to licensing and operational optimization studies, and could envelope the requirements for refurbishment waste and used fuel dry storage applications. This would allow for the storage of additional used fuel should the refurbishment waste building(s) be empty by the mid to late 2020's.

The building(s) constructed in SA6 will be constructed to process and house the 48 steam generators and possibly other large system components and RWCs. The building(s) will comprise:

- a processing area or building which could include segmentation, volume reduction, dismantling, re-welding, and packaging of the steam generators and their components;
- an area or building to store the unprocessed and processed steam generators and other large system components; and

- an area or building to store RWCs.

The management of refurbishment waste is further discussed in Section 2.7.4.

Should the refurbishment waste building(s) not be empty by the mid to late 2020's, an additional used fuel dry storage building will be required and constructed in a storage area (SA5) located to the east of SB3 (as illustrated in Figure 2.7-1).

SB4 and the used fuel dry storage building in SA5 will be similar to the storage buildings already used at the PWF, modified as required to address heat dissipation and radiation shielding considerations associated with the waste packages. These buildings will be single storey, commercial-type concrete structures with a concrete slab-on-grade floor, passive ventilation and inactive drainage. The modular nature of the dry storage concept allows storage buildings to be constructed on an as-required basis. The exact timing of future storage buildings at PNGS will depend on operational plans for both PNGS A and B, and on the availability of a long-term storage or disposal facility off site.

All structures will be designed to meet the requirements of the National Building Code of Canada in effect at the time of construction approval. Stormwater management for the new buildings will be compatible with the Stormwater Management Plan developed for the PWF II.

2.7.1.2 Defuelling and Dewatering the Reactor

Defuelling the Reactor

Each reactor will be defuelled using its fuelling machines. The used fuel will be removed from the fuel channels and transferred, using the existing irradiated fuel transfer and conveyor systems, to the IFB for wet storage. Consistent with current practice, the used fuel will remain in the IFB for at least ten years of cooling prior to being transferred to dry storage at PWF.

Dewatering the Reactor

Initial dewatering may result in some increase in radiological emissions from the RLWMS and from reactor building ventilation exhaust. Heavy water will be drained from the moderator and heat transport systems and their auxiliaries. The systems will be dried and may be rinsed to remove the remaining heavy water. This will minimize the tritium emissions later in the refurbishment outage. Dewatering the moderator and heat transport systems on one reactor unit involves the removal of approximately 242 m³ and 139 m³ of heavy water, respectively (OPG 2006d).

A chemical clean of the heat transport system may take place to reduce the radionuclide loading on the insides of the piping, to reduce radiation fields and thus to reduce worker dose during refurbishment. A description of this process is provided in Section 2.7.2.1. Additional waste generated during this clean (e.g. ion exchange columns) has been accounted for in this study.

Adjuster Rod Removal

The adjuster rods will be removed from the reactor core prior to refurbishment work. This will reduce the radiation fields during refurbishment, and thus reduce the worker dose. On Units 6, 7 and 8, the adjuster rods are used to produce cobalt-60, for use in off-site medical and commercial irradiation facilities, as described in Section 2.3.6.3. The cobalt-60 bundles from these units will be removed from the adjuster assemblies, per current practice, and transferred to the AIFB for processing. On Unit 5, the adjuster rods are currently made from stainless steel, but may be converted to cobalt-60 production.

Islanding the Unit

After defuelling, the unit to be refurbished will be isolated, to a certain extent, from the operating units at the PN site, to facilitate the refurbishment work while not affecting the safe operation of the running units. This is called “islanding the unit”. Islanding will involve physical separation of the unit to be refurbished from the common negative pressure containment system by sealing the transition duct between the boiler room and the containment pressure relief duct. It will also involve isolation of the unit’s portion of some shared systems and potentially involve equipment logic or operational changes to support the needs of the remainder of the station. Operationally, the islanded unit will be supported separately from the remainder of the station and in a manner that benefits safe and efficient access for construction staff.

2.7.1.3 Management of Heavy Water

The removed heavy water will be collected, upgraded and stored in a manner similar to current operating practice (see Section 2.4.1). Additional capacity for storage of removed heavy water will likely be required during the Refurbishment Phase. This could potentially include a new storage building which would meet all regulatory requirements, or use of an existing on-site facility. The nature and location of this storage facility will be further developed in the detailed engineering phase. Storage plans for each unit’s inventory will vary depending on available storage space at the time of the refurbishment outage. The heavy water will be reused once refurbishment is complete. If the heavy water is to be detritiated prior to reuse, it will be shipped to the Darlington Tritium Removal Facility in specially designed containers called Tritiated Heavy Water Transportation Packages (THWTPs) (OPG 2005h), as per current practice. OPG

has heavy water storage facilities on the PN site, and storage of heavy water is within PNGS B's current operating licence.

Heavy water is reusable and interchangeable between units. However, heavy water used for moderator and heat transport systems is kept separated as the isotopic composition and chemical characteristics of the heavy water in the two systems are slightly different.

2.7.2 Refurbishment

The refurbishment works will be undertaken following a strict work sequence and appropriate technical and safety procedures such that the health of on-site workers and the general public, as well as the environment, are not compromised beyond conditions that prevail during normal operation of the station. Shielding will be used to reduce worker dose at workface locations, as well as in the RWCs and other refurbishment waste containers.

2.7.2.1 Replacement of Reactor Components

The following components will be replaced during refurbishment: pressure tubes; calandria tubes; endfittings, shield plugs, closure plugs; spacers; feeder coupling hardware; feeder tubes (up to the headers); feeder tube supports; feeder cabinet insulation; and positioning assemblies.

The work will be carried out in several stages, although they will not be fully sequential:

- **Vault Preparations:** Main tasks include vault decontamination, removal of feeder cabinet and reactor face insulation, installation of shielding, installation of additional services to support the work (e.g., communications).
- **Removal of Fuel Channels, Calandria Tubes and Feeders:** The feeder pipes will be removed first. Shielding and automated tooling will be used where feasible to reduce worker dose. All of the components of the fuel channel assemblies (including pressure tubes) and the calandria tubes will be removed.
- **Heat Transport System Chemical Decontamination:** A decontamination process may be used to reduce the radiation fields on the feeders, reactor headers, pressure tubes and end fittings before component replacement. A variety of chemical decontamination processes are available, and no decision has been made at the present time about which, if any, would be employed. However, the process would likely consist of the addition of a reagent (e.g., citric acid, EDTA and ascorbic acid) into the water in the system to release contaminants and oxides. The contaminants will then be removed from the liquid using an ion exchange resin and physical filtration. A pre-treatment with Alkaline Permanganate may be used to condition the grown-on layer of oxide on the stainless steel

surfaces for ease of removal during the chemical decontamination. This activity will take place within the reactor building.

- **Installation of New Fuel Channels, Calandria Tubes and Feeders:** New fuel channel assemblies and calandria tubes will be installed in the reactor core. New feeder piping will be installed. The reactor vaults will be returned to operational status through removal of all the temporary services, removal of temporary shielding and tooling, and reinstallation of feeder cabinet and reactor face insulation.
- **Waste Handling:** Refurbishment of fuel channel assemblies, calandria tubes and feeder piping is expected to generate ILW & LLW. It is expected that volume reduction techniques such as cutting and crushing will be used for pressure tubes and calandria tubes. These materials will be placed into specially shielded RWCs, and transferred to the PVMF II for storage. Feeder pipes will be cut into lengths that will fit into standardized waste containers, and transported off site as per routine LLW generated at PNGS B. The management of refurbishment waste is further discussed in Section 2.7.4.

It should be noted that pressure tube replacement, as well as limited calandria tube and feeder replacement, has successfully taken place in several CANDU reactors.

2.7.2.2 Removal and Replacement of Steam Generators

All of the steam generators will be replaced during the refurbishment outages. Each PNGS B unit has 12 steam generators, which are approximately 14 m in length and 2m wide. The existing steam generators weigh approximately 90,000 kg each. The replacement steam generators may differ in size and weight as a result of material and dimensional changes.

Replacement of the steam generators will be carried out in four stages as follows:

- **Building and Equipment Preparation:** Specially prepared and approved openings in the concrete reactor building dome to provide crane access for lifting the steam generators into and out of the reactor building. A wet-cutting technique will be used to minimize the spread of dust. These holes will be temporarily covered to prevent precipitation from entering the reactor building, and will be permanently sealed when the work is complete, to restore the containment barrier. A large heavy lift crane will be positioned on the south side of the reactor building. The crane to be used will have to meet stringent safety requirements, such as being single-failure-proof and having a significant safety factor in terms of lifting capacity. Temporary lifting rigs may be required within the reactor building to position each existing steam generator for the lift,

and to position the new steam generators in their final locations. Structures and components in the paths of the lifts would be temporarily removed or relocated.

- **Removal of Steam Generators:** This includes removal of insulation, cutting or disconnection of all piping and equipment attached to the steam generators, and capping of all openings to prevent release of loose radioactive contamination. The exterior surface of the steam generators will be cleaned prior to removal from the reactor building to avoid the spread of contamination. Although the boom of the crane will cross over the pressure relief duct, it is expected that the steam generators themselves will not be lifted over the pressure relief duct. They will be lowered to the ground in the space between the reactor buildings and the pressure relief duct and then moved under the pressure relief duct.
- **Installation of Steam Generators:** The new steam generators will be shipped to site by truck under strict safety conditions. The materials used for the boiler tubes may change slightly as a result of operating experience and more recent technology, but the changes are minor and will not affect system operation or chemistry. Steam generator installation will be carried out by reversing the procedure for removal. Connections to process piping and instrumentation will be made and insulation installed. When all of the new steam generators have been installed, equipment and structures will be returned to operational status by removing temporary services and lifting rigs, and reinstalling any equipment that was temporarily removed. The holes in the reactor building dome will be repaired to restore the containment structure. Appropriate testing will be done to confirm containment system integrity.
- **Waste Handling:** Steam generator replacement will generate liquid waste, LLW and ILW, including the steam generators themselves, insulation materials and miscellaneous components. The liquid waste (i.e., light water) from the secondary heat transport system will be drained from the steam generators. The water will be monitored to ensure it is within C of A limits for Industrial Sewage Works before being discharged to the lake. If contamination is detected during the monitoring, the water will be drained to the RLWMS for processing.

The removed steam generators will be sealed and loose contamination on the exterior surfaces will be removed or fixed prior to removal from the reactor building. This will ensure that neither loose contamination nor radioactivity releases will be present during loading onto and unloading from the transfer vehicle. The steam generators will be transferred to the new refurbishment waste building(s) in the East Complex for interim storage and/or processing. Management of refurbishment waste is further discussed in Section 2.7.4.

The concrete and dry solids from the cutting slurry used to cut the reactor dome would be checked to confirm that they are not radioactive and then disposed of as landfill or sent

for recycling. If radioactive, the concrete and dry solids would be handled as LLW in a similar manner to other LLW.

The temporary coverings of the openings in the reactor building dome will not allow maintenance of the same type of negative pressure containment that is normally in place during unit operation. For this reason, the openings will not be cut until all fuel has been removed from the reactor core and the reactor building has been physically separated from the common negative pressure containment system, as described in Section 2.7.1.2. Steps will be taken to ensure that radioactivity emissions from the reactor building are controlled. These steps could include decontamination of work areas, continued operation of the filtered and monitored ventilation systems, air barriers maintained between the boiler room and the reactor vaults, monitoring of airborne contaminants, and procedures to respond with mitigation measures to any indication of elevated airborne contaminant levels.

It should be noted that replacement of larger steam generators has been successfully carried out at a number of U.S., Asian, and European nuclear plants, including St. Lucie station, FL; Oconee station in Seneca, S.C.; Altbach, Germany; and Doel Belgium, Belgium; among others (Mammoet World 2005). Steam generator replacement is currently underway at Bruce A Units 1 and 2 in Ontario.

2.7.2.3 Refurbishment of Reactor Auxiliary Systems and Feedwater Systems

Refurbishment/upgrades of the reactor auxiliary systems includes normal maintenance and repair to be undertaken during each refurbishment outage, and maintenance activities normally required for the refuelling and restart of any reactor unit.

2.7.2.4 Upgrades to and Maintenance of Other Systems

Throughout the nuclear and non-nuclear plant systems of PNGS B, there may be opportunities during the refurbishment outages to undertake normal repair, maintenance and upgrades of components. While these activities are undertaken as part of normal operations and maintenance during typical unit outages, they are noted here to indicate the likelihood that ongoing repair and maintenance may also occur during the major refurbishment outages. This work may generate small volumes of LLW and non-radioactive waste. The wastes will be managed in a manner similar to current practice.

One possible upgrade is the replacement of the low pressure turbines with new higher efficiency turbines. This could potentially improve efficiency by up to 25 MW per unit with a corresponding reduction in the heat input to Lake Ontario.

2.7.2.5 Workforce, Payroll and Purchasing

The number of OPG employees is not anticipated to change significantly during refurbishment. Any redirection in “routine” work (while a unit is being refurbished) will be made up in other types of work, either supporting that unit or on other units.

In addition to the full-time OPG employee complement, refurbishment would require, as a maximum for the refurbishment of each unit, an incremental labour force of approximately 2000 workers. These individuals would likely be contractors. They will live off-site and commute to the PN site, thereby increasing the vehicular traffic during the Refurbishment Phase of the Project. In addition to labour force transportation, this activity also captures the transport of materials and replacement components to the site for refurbishment activities.

Payroll and purchasing is discussed in Section 5.12.1.

2.7.3 Refuelling and Restarting Reactors

Refuelling involves loading the reactor fuel channels with new fuel bundles; it will take place following the major component refurbishment activities. The moderator and heat transport systems will be filled with heavy water. Following the start up and testing of unit systems, power will be raised and the unit will be connected to the electrical grid. The reactor will be brought up to full power in a series of steps, meeting certain condition and performance criteria at each step.

No new construction or engineering works requiring large quantities of materials or non-renewable resources are expected for this phase. Refuelling and restarting activities are expected to generate LLW and ILW typical of maintenance outages.

2.7.3.1 Refuelling

When the major component refurbishment is complete and the conditions of the plant operating licence are met, OPG will begin the refuelling process in preparation for return to service of the refurbished unit. Natural uranium fuel bundles will be used to load the core, except that some bundles of depleted uranium (uranium with a lower concentration of the uranium-235 isotope) may be placed in certain positions in the core to properly shape the neutron flux distribution of the fresh core.

Each reactor will require 4,560 bundles, or approximately 385 tonnes of fuel for all four units. PNGS B fuel is in the form of compacted and sintered cylindrical pellets of uranium dioxide, stacked and sealed within zirconium alloy tubes. These tubes, or fuel elements, are assembled

into 28-element cylindrical fuel bundles, held together by two end plates. Each bundle weighs approximately 21 kg. Since only natural (or depleted) uranium is used, criticality is not a concern during storage or handling of the fuel, either in air or in light water.

New fuel will be brought into the reactor building to a fuel receiving area. Fresh fuel will likely be loaded into the new fuel channels manually, as per past practice for initial fuel load into a new reactor core.

Refilling the moderator and primary heat transport systems involves the transfer from storage of 242 m³ and 139 m³, respectively, of heavy water into the reactor systems.

2.7.3.2 Restarting

Restarting reactors consists of system start up and testing, raising power and generating electricity for the electrical grid. At each regulatory hold point, specified requirements will be met and regulatory approvals will be obtained prior to proceeding. Following the extended planned outages, reactor systems will be systematically started up, configured for reactor operation, and tested as needed. Newly installed equipment and components will be tested. Nuclear fission reactions in the reactor core will be increased in a controlled manner until criticality is achieved. Reactor power will then be increased in a controlled manner. Steam will be admitted into the turbine and the steam and feedwater system will be placed into service. The unit's electrical generator will be connected, or synchronized, to the electrical grid and will begin to supply power to the Ontario electrical system. The reactor will be brought up to full power in a series of steps, meeting certain conditions and performance criteria at each step.

Once the reactor core reaches equilibrium conditions, several months following restart, routine on-power refuelling will begin. Returning the reactor to full power will produce used nuclear fuel and purification wastes, such as filters and ion exchange (IX) resins, as well as other LLW.

At the end of the Refurbishment Phase, all four reactors will be operational.

2.7.4 Management of Refurbishment Waste

As part of the refurbishment activities, various refurbishment wastes, including fuel channel assembly wastes and the large steam generators (as discussed in Sections 2.7.1.2 and 2.7.2.2 respectively), miscellaneous wastes, and non-radioactive wastes will be generated and will need to be managed. Ancillary to the primary refurbishment activities will be the construction of waste management structures to accommodate refurbishment waste (Section 2.7.1.1).

2.7.4.1 Transportation of Wastes to WWMF

OPG has been safely transporting LLW and ILW and other radioactive materials from the PN site to the WWMF and other destinations for over 35 years. On-going transportation of radioactive materials to the WWMF is in accordance with all applicable requirements including the NSCA and regulations, and Transport Canada regulations. All wastes requiring off-site transportation would be managed using OPG's existing, approved transportation processes. Any additional transportation packages required for specific wastes would be designed, licensed and procured according to OPG's existing processes and applicable CNSC and Transport Canada regulations.

The L&ILW transportation routes associated with refurbishment waste shipment would be similar to those currently used, along with the associated transportation procedures. Roads used between the WWMF and the other nuclear generating stations are generally operating at a Level C or higher level of service. A Level C means manoeuvrability is restricted and speed is near free flow. Total daily traffic volume on these roadways is high enough that the addition of approximately two additional shipments per day during the period of refurbishment would not be measurable against the variation in the total daily volume of traffic.

For transportation from PNGS to WWMF, the packages will meet or exceed CNSC *Packaging and Transport of Nuclear Substances Regulations* and by reference the International Atomic Energy Agency (IAEA) requirements for routine, normal and accident conditions. Type B transportation packages will be required to transport the retube components. Type B transportation packages are designed to survive certain tests including the ability to survive a 9 m free drop, water spray, penetration, stacking, thermal and water immersion tests. The maximum radiation level at any point on any external surface shall not exceed 2 mSv/h. The maximum radiation level at 1 m from the package surface shall not exceed 0.1 mSv/h.

2.7.4.2 Steam Generators

A steam generator may be placed temporarily in a laydown area (Protected Area Construction Crane and Laydown Area – see Figure 2.7-1) adjacent to the reactor building in preparation for transfer to the refurbishment waste storage building(s) (located within SA6) at the PWWMF II, or transport to the WWMF for centralized storage. As noted previously, these old steam generators will be monitored to confirm that there is no external contamination and all openings will be sealed. Loose contamination on exterior surfaces will be removed or fixed prior to removal from the reactor building. Should external contamination be discovered, it will be cleaned up and any resulting waste will be managed as appropriate.

Once at the refurbishment waste storage building(s), the steam generators may be processed by segmentation, volume reduction, dismantling, re-welding, and/or packaging. These activities would be conducted in a designated processing area or building with appropriate ventilation and dust control, including at a minimum, HEPA filters. Cutting and crushing activities would occur remotely to ensure worker protection.

Processed steam generators and their components will be transported off site to the WWMF for long-term management. Alternatively, steam generators could be transported off site to a third party for processing.

The estimated volume of the 48 steam generators is 2,500 m³.

2.7.4.3 Fuel Channel Assembly Wastes

Fuel channel assembly wastes will be placed into retube waste containers (RWCs), transported from the reactor face, through the station, and out to the proposed refurbishment waste storage building(s) for temporary storage, before transportation off site to the WWMF. Alternately, they may be transported directly to the WWMF. The total estimated stored volume of fuel channel assembly waste from all four units will depend on the final storage concept selected. For preliminary planning purposes, a total as-stored volume of 3,000 m³ (OPG 2006c) is assumed, based on a storage concept similar to that employed in the refurbishment of Bruce A Units 1 and 2 (Bruce Power 2005).

2.7.4.4 Miscellaneous Refurbishment Waste

In addition to fuel channel assembly wastes and the steam generators, the Project is expected to generate LLW as a result of the refurbishment activities.

Feeder pipes and similar wastes would be cut into suitably-sized pieces and packaged into standardized waste containers for transportation to the WWMF for long-term storage, or to a third party for processing. Alternatively, these waste streams may be selectively decontaminated at the PN site and released as scrap metal. Standard waste processing practices will be followed.

All routine LLW produced as a result of refurbishment activities (e.g., personal protective clothing and other miscellaneous wastes) would be collected and managed using the existing normal process for routine operational wastes (segregated into various waste streams, packaged and transported to the WWMF for volume reduction and storage).

The total estimated volume of miscellaneous routine LLW generated as a result of refurbishment is estimated to be 1,000 m³ per unit for a total of approximately 4,000 m³ (OPG 2006c).

2.7.4.5 Management of Non-Nuclear Waste

As mentioned in Section 2.7.2.4, some components of the existing low-pressure turbines, including the cylinder covers (top and bottom) and the turbine spindles, may be replaced. The weight of these is 2,500 tonnes for all four units.

The normal repair and maintenance activities that will take place during the refurbishment outages will generate small amounts of non-radioactive wastes. In addition, the large augmented refurbishment workforce will contribute to non-radioactive waste generation by virtue of their presence, such as residuals from use of consumables (e.g., paper), foodstuff wastes, etc.

Non-radioactive wastes will be managed in a manner similar to current practice. Non-radioactive wastes will be re-used or recycled where feasible. The PN site already recycles over 50% of all non-radioactive wastes generated. Hazardous wastes are handled in accordance with regulations and are shipped to licensed disposal facilities. Non-hazardous solid wastes meeting landfill requirements are disposed of accordingly in an off-site landfill. The approximate increase in combined non-radioactive waste to be generated during the Refurbishment Phase is estimated to be 15,300 tonnes.

2.7.4.6 Total Refurbishment Waste

An estimate of the total amount of refurbishment waste and the activity of LLW wastes is provided in Table 2.7-1. It is likely that the fuel channel components and steam generator waste will be temporarily stored at PWWF; these wastes have an activity of 1.59×10^6 TBq. Miscellaneous LLW and feeder pipes will be transported to the WWMF; these wastes have a combined activity of 2.1×10^1 TBq.

TABLE 2.7-1
ESTIMATED AMOUNT OF WASTES EXPECTED FROM PNGS B
REFURBISHMENT ACTIVITIES

Class	Description (per unit)	Amount	Activity (TBq)*
Low- and Intermediate-Level Radioactive Wastes	Nuclear System Refurbishment	3,000 m³ (as shipped, all four units)	1.59x 10 ⁶
	Miscellaneous LLW (1,000 m ³ /unit)	4,000 m³ (as shipped, all four units)	7.2 x 10 ¹
	Steam Generator Replacement	2,500 m³ (as shipped, all four units)	1.3 x 10 ³
Non-Radioactive Wastes / Reused Recycled Material	<ul style="list-style-type: none"> • Generator/Turbine components • Miscellaneous electrical used equipment and components • Miscellaneous from site preparation, construction, construction/equipment decommissioning • Additional materials and wastes by virtue of augmented refurbishment workforce. 	15,300 tonnes (all four units)	-

Source: OPG 2006c.

* Retube waste based on nine months after shutdown.

TBq = terabequerel.

2.8 PROJECT WORKS AND ACTIVITIES – CONTINUED OPERATION PHASE

The list of project works and activities provided below comprises all the systems, components and activities of existing PNGS B operations, based on the system groups identified in Section 2.3. One system group (“Instrumentation and Control”) has no direct interaction with the environment and is included in the effects assessment of other systems. Accordingly, this system is not included in project works and activities.

The project works and activities identified for the Continued Operation Phase are as follows:

- Reactor Core;
- Reactor Process Systems and Safety Systems;
- Turbine/Generator and Auxiliaries;
- Electrical Power Systems;
- Fuel and Fuel Handling;
- Auxiliary Systems;

- Maintenance and Repair;
- Interim Storage of Refurbishment Waste at PWF;
- Management of Operational Low and Intermediate Level Waste;
- Transport of Operational Low and Intermediate Level Waste to the WWMF
- Interim Storage of Used Fuel at PWF;
- Construction of Additional Storage Structures at PWF for Additional Used Nuclear Fuel;
- Management of Non-Nuclear Waste;
- Administration, Purchasing and Payroll; and
- Security, Safeguards and Emergency Response.

A summary description of each of the project works and activities is provided in Section 2.12 as the Basis for Environmental Assessment (Table 2.12-1). More detail on these project works and activities is provided in Section 2.3.

2.8.1 Continued Operation

Operation of the refurbished reactors will be similar to current operation. The refurbished units will require ongoing maintenance. During operation, it is expected that three general areas of maintenance will be performed; namely, preventative maintenance, corrective maintenance, and improvement or upgrade activities. These maintenance activities will continue to the end of life of the reactors.

Shutdown of one or more of the reactors may occur prior to 2060. The preparation of the reactors for safe storage involves defuelling and dewatering and other isolation activities, as described in Section 2.7.1.2. These activities are assessed as part of this EA study.

2.8.2 Waste Management

As discussed in Section 2.7.1.1, should the refurbishment waste storage building(s) not be empty by 2024, additional used fuel dry storage will be required to accommodate the additional fuel produced due to the life extension of PNGS B. This building would be constructed in a storage area (SA5) located to the east of SB4 (as illustrated in Figure 2.7-1).

2.9 PRELIMINARY DECOMMISSIONING PLAN

Section 9.2.2 of the EA Guidelines for this Project requires that *“a preliminary decommissioning plan for the facility will be included in the assessment. The preliminary plan will document the*

preferred decommissioning strategy, including a justification of why this is the preferred strategy. It will also include end-state objectives, the major decontamination, disassembly and remediation steps; the approximate quantities and types of waste generated; and an overview of the principal hazards and protection strategies envisioned for decommissioning” (CNSC 2007).

2.9.1 Regulatory Requirements for Decommissioning

The CNSC regulates nuclear activities through a multi-stage licensing process, which includes application for construction, operating, decommissioning and abandonment licences. As early as possible, a Preliminary Decommissioning Plan must be prepared and submitted to the CNSC in accordance with the CNSC’s Regulatory Guide G-219 for Decommissioning Planning for Licensed Activities (CNSC 2000b). Preliminary Decommissioning Plans (PDPs) have been developed for both PNGS B (OPG 2007a) and PWSMF (OPG 2007b). The PDPs for both PNGS B and PWSMF describe the activities that will be required to decommission these facilities and to restore the sites for other OPG uses. The PDPs are not detailed plans for the future decommissioning of either of these facilities. However, they demonstrate that the planned decommissioning is feasible with existing technology. The decommissioning activities described here focus on the decommissioning of the PNGS B. The decommissioning activities for PWSMF have been addressed in the PWSMF Phase II Final EA Study Report (OPG 2003a).

Consistent with the definition in regulations under the *CEAA*, decommissioning does not include the cessation of operation of the physical work. From a regulatory perspective, decommissioning is not within the scope of this Project. Decommissioning will be subjected to requirements of the *NSCA* and a determination regarding the application of *CEAA* will be made at that time.

2.9.1.1 Forecast of Decommissioning Dates

Decommissioning of PNGS B will begin after a decision is made to cease operating the station. The current planned date for commencement of decommissioning of PNGS B is January 2023, which coincides with the shutdown of the first unit (Unit 5). Assuming that the refurbishment of PNGS B is approved and implemented, then decommissioning of PNGS B will occur after approximately 2060, after the last of the four reactors is shut down. Similarly, decommissioning of PWSMF will occur after all the used fuel and intermediate level waste have been removed to a long-term waste management facility and a decision is made to shut down the facility. Although PWSMF is located on the same site as PNGS B, the life cycle management plans of these facilities are separate from each other, and as such decommissioning of each facility will occur as required.

2.9.2 Decommissioning Strategy

The preferred decommissioning strategy for PNGS B is one of deferred dismantling. Deferred dismantling occurs when the reactors and stations are safely stored for several decades after shut down to allow radiation levels to decay prior to dismantling and site restoration. The preferred decommissioning strategy of deferred dismantling minimizes both the occupational radiation dose to workers, and the potential exposure of the public and the environment.

The decommissioning strategy of deferred dismantling involves three main phases as follows:

- Phase I – Preparation for Safe Storage;
- Phase II – Safe Storage and Monitoring; and
- Phase III – Dismantling, Disposal and Site Restoration.

2.9.3 Steps in Decommissioning

2.9.3.1 Preparation for Decommissioning

Prior to beginning the decommissioning, OPG will complete those actions necessary to comply with the requirements of the *NSCA* and Regulations of the CNSC, the *CEAA* and Regulations (if determined to be applicable), and the other applicable federal and provincial statutes and regulations. Some of the actions that will be required include:

- Submission of a notification of the intent to decommission the facility to the CNSC and ensure that the project is registered with *CEAA* (if determined to be applicable);
- Informing the public, key stakeholders and the host community of the decommissioning and obtain their input for the development of the Detailed Decommissioning Plan (DDP);
- Completion of an EA study of potential environmental effects for the decommissioning project (if required);
- Preparation and submission of the DDP and other documents for each station to the CNSC; and
- Obtaining the licences and permits required for the decommissioning work.

2.9.3.2 Phase I – Preparation for Safe Storage

During Phase I, the reactors will be defuelled and dewatered. However, shutdown of one or more of the reactors may occur prior to 2060 (the assumed start date of decommissioning when the last of the four operating reactors is shut down), when a reactor reaches its end-of-life during the Continued Operation Phase. Most of the external non-fixed surface contamination will be removed from accessible areas of the station. Internal chemical decontamination will remove the majority of radioactive material contained within contaminated systems. The largest source of remaining radioactivity will be used fuel remaining in the IFB and the neutron activated calandria and internals. Most of the other hazardous, non-nuclear materials will also be removed.

Radiation and contamination surveys of the station and its systems will be performed. Physical barriers will be installed to allow other units to function as the preparation continues and to control access to all radiation areas. Plant systems will be drained, de-energized and secured except for those required during the next phase. Non-essential equipment from offices, workshops and storerooms will also be removed.

2.9.3.3 Phase II – Safe Storage

The **Safe Storage Phase** will allow time for the decay of the short-lived fission and activation products that remain in plant components. The duration of the Safe Storage Phase was determined by balancing the reduced decommissioning cost and occupational dose achieved by allowing the residual activity to decay against the increased social and economic costs of a longer storage period. OPG has determined that a Safe Storage Phase of 30 years offers a reasonable balance of safety and cost. This decision will be reassessed periodically in light of experience, cost, changing technology, and the possible requirement of the site for other purposes.

Throughout the Safe Storage Phase, resident maintenance personnel will perform routine inspections, preventive maintenance and corrective maintenance. This work force will maintain the structures in a safe condition, provide adequate lighting, and perform periodic preventive maintenance on essential services. The existing site security arrangements for the facility will continue unless they are modified by agreement with the CNSC.

An environmental surveillance program will be carried out during the storage period to ensure that potential releases of radioactive material to the environment are detected and controlled if they occur. It is anticipated that the environmental surveillance program will be an abbreviated version of the program that has been used during normal station operations. Routine radiological monitoring of contaminated structures and systems will also be performed. Procedures for

responding to unanticipated changes in the radiological environment of the site and potential releases to the environment will be prepared and implemented if required.

2.9.3.4 Phase III – Dismantling, Disposal, and Site Restoration

The third and final phase, **Dismantling, Disposal, and Site Restoration** is scheduled to last approximately ten years. It begins with the removal of any remaining radioactive material. The resulting radioactive waste will be transported to an approved off-site disposal facility. After this, systems and equipment will be physically dismantled and removed. Surveys will be conducted to verify the site meets the necessary clearance levels before the remaining buildings and structures are demolished. The site will be restored to a condition suitable for other uses. As part of this work, OPG will apply to the CNSC for a Licence to Abandon the site.

Dismantling work would begin after the detailed planning has been completed and the necessary licences, permits, and approvals have been obtained. The work in this phase can be divided into a series of conceptual steps:

- Prepare the buildings and site;
- Dismantle systems;
- Dismantle structures;
- Manage the waste; and
- Restore the site.

Work in the different steps may occur in parallel. Surveys for radioactive and other hazardous materials will be performed throughout the dismantling work, culminating in a final survey.

All material removed during the decontamination and dismantling of the nuclear units will be routed to the central waste processing area, which will characterize, process, and prepare the material for release or shipment to an appropriate storage or recycling facility.

A series of surveys for radioactive and other hazardous materials will be performed throughout the course of the dismantling work. The surveys will be based on guidelines available at the time the work is to be done. Several different types of surveys are likely to be performed at different stages of the decommissioning.

- Scoping Survey to locate the contamination remaining in the facility at the end of the Safe Storage period;

- Characterization Surveys to identify the nature and form of the remaining contamination in order to assist in the planning of the decontamination work;
- Remediation Control Surveys to guide and monitor the decontamination work. They are also used to help to control the exposure of decontamination workers to radiation and hazardous materials; and
- Final Surveys to verify that the facility has been decontaminated to the extent that all remaining buildings, components and the site itself have residual activity levels below the established clearance levels. The final surveys will be performed when the remediation control surveys indicate that all the residual levels of radioactive and hazardous material in a work area are below the established clearance levels.

Dismantling work may proceed once the final surveys have confirmed that the residual contamination levels in a work area or unit are below the established clearance levels, and the results of these surveys have been accepted by the CNSC and other regulatory agencies to support an application for a Licence to Abandon.

By the end of the Dismantling, Disposal, and Site Restoration Phase, the site will be free of industrial hazards. All radioactive contamination in excess of the established clearance levels and all other hazardous materials will have been removed from the site. All of the station systems will have been dismantled and all of the buildings demolished. Subsurface structures will have been drained, de-energized, decontaminated, removed to a nominal removal depth (generally about 1 m) and capped. The site will have been restored to a state suitable for other OPG uses. The site will meet the criteria established by the CNSC for a Licence to Abandon.

2.9.4 Waste Management During Decommissioning

2.9.4.1 Radioactive Waste Management

Management of Used Nuclear Fuel

The Government of Canada passed the *Nuclear Fuel Waste Act (NFWA)* in 2002. The legislation required nuclear energy corporations to establish the Nuclear Waste Management Organization (NWMO) to study the options available to recommend a long-term management approach for used fuel. The NWMO has issued a study report “Choosing a Way Forward - The Future of Canada’s Used Nuclear Fuel”, in November 2005 (NWMO 2005). This report was intended to assist the federal government in choosing the approach for the long-term management of Canada’s nuclear fuel waste.

When the station is shut down, all of the used fuel resident in the four reactor units will be transferred to the IFBs for an initial cooling period of at least ten years. If the federal government's decision results in the availability of a long-term used fuel management facility by the time of shutdown of the PNGSs, the used fuel remaining in the IFBs will be transferred directly to this facility. In the event a long-term used fuel management facility is not available by this time, used fuel remaining in the IFBs will be transferred to dry storage in the PWSMF.

Management of Low- and Intermediate-Level Waste

Radioactive wastes will be treated and packaged on site in order to reduce worker exposure, to meet the regulatory requirements for waste transport and disposal, and to reduce the volume of low-density materials such as paper and plastic.

The decommissioning of the PNGS B will produce a relatively large number of components such as pumps, vessels, motors, etc., that will need to be packaged for disposal as LLW. Other smaller components and equipment will be cut to fit and placed in standard waste containers. Contaminated concrete (for example: surface contaminated concrete from the IFBs) will be broken up and loaded into disposal containers.

Wastes will be packaged for transport and disposed of according to the requirements of the applicable federal and provincial regulations. The necessary packages will be identified, designed, tested, and procured prior to the decommissioning project. The required licences, approvals, and certifications will also be obtained before the packages are put into service. LLW & ILW will be shipped off site to a long-term waste management facility that will have sufficient capacity to accept all of the wastes generated during the decommissioning of the PNGSs.

The projected volume of LLW & ILW that will be generated during the decommissioning of the PNGS B is shown in Table 2.9.1.

TABLE 2.9.1
PROJECTED VOLUMES OF LOW - AND INTERMEDIATE -
LEVEL RADIOACTIVE WASTE GENERATED
DURING THE DECOMMISSIONING OF THE PNGS B

PNGS B Unit	Low-level Radioactive Waste (m ³)	Intermediate-Level Radioactive Waste (m ³)
Unit 5	3,641	524
Unit 6	3,636	523
Unit 7	3,633	523
Unit 8	3,631	523
Unit 0 (common services)	5,183	50
TOTAL*	19,724	2,142

* May not add due to rounding.

2.9.4.2 Hazardous Waste Management

PNGS is already registered with the MOE as a generator of hazardous wastes. The waste generator registrations will be reviewed prior to beginning the decommissioning project to ensure that all of the wastes that will be generated are registered. Appropriate disposal facilities for hazardous wastes will be identified prior to the beginning of the decommissioning project. Hazardous wastes will be packaged for transport and disposal according to the requirements of the applicable provincial regulations. All hazardous wastes will be transferred to an appropriate, licensed waste management facility for storage or disposal. Waste manifests will be prepared and submitted as required by provincial regulations.

Designated Substances are defined in the Regulations made pursuant to the Ontario *Occupational Health and Safety Act*. An assessment of the Designated Substances used at PNGS B has been completed as required. The results of the assessments indicate that three Designated Substances are likely to be found in the stations at the time of shutdown:

Asbestos – Some asbestos – containing materials are in use at PNGS B. A database of known asbestos – containing materials is maintained and inspections are carried out to ensure the asbestos is appropriately sealed and identified.

Lead – Lead blocks, plate, and blankets are used for radiation shielding around PNGS A and B. Some contamination may remain on surfaces from previous lead melting operations. Lead paints are no longer used at PNGS B.

Mercury – Mercury was not used as a construction material. However, it is used in thermometers, manometers, hygrometers, mercury-wetted relays, magnetol and mercoild switches, vacuum pump temperature switches, transformer deluge systems, sealed batteries and various types of lamps (fluorescent, mercury vapour, metal halide, etc.). Free mercury is not stored or used at PNGS B.

Small quantities of some other Designated Substances, such as benzene and isocyanates, are occasionally used during projects but they are not routinely stored at either station. Silica containing materials are not used as decontamination (sandblasting) agents within the Protected Area of the stations; however, they may be used in workshops outside of the Protected Area.

Most of the hazardous materials stored on the site (flammable, cryogenic gases, oxidizers, corrosives, etc.) will be consumed during routine plant operations. It is anticipated that the inventories will be reduced as the units are successively shut down so that only small quantities will remain after the last unit is shut down. Some of the remaining materials (e.g., welding

gases) will be consumed during the Preparation for Safe Storage Phase. Others, such as the fuel oil for the standby generators, can be removed for use at other sites.

A number of other materials used during routine station operations are potentially harmful to workers or the environment. The inventories of these materials will be reduced as the plant approaches shutdown so only small quantities should remain at the start of the decommissioning.

2.9.4.3 Other Wastes

The bulk of the non-hazardous waste materials generated during the decommissioning will be produced during the Dismantling, Disposal, and Site Restoration Phase. Non-hazardous wastes that meet the established clearance levels will be re-used or recycled wherever possible.

If the volume or value of the contaminated scrap metal generated during the decommissioning is sufficient to justify further processing, chemical cleaning, electro polishing, mechanical abrasion or melting might be used to decontaminate scrap metal. Any metals that are decontaminated to levels below the clearance levels established in the DDPs will be released for recycling or disposal.

Concrete rubble may be used on site for fill. Other non-contaminated materials will be released for disposal according to regulations applicable at that time.

2.9.5 Potential Hazards and Protection Strategies

2.9.5.1 Hazards

The principal radiological, chemical and construction hazards that might be encountered during the decommissioning are a combination of hazards likely to be encountered during a routine shutdown or outage of an operating station and which may arise during dismantling or demolition work.

The main feature that distinguishes the decommissioning of a nuclear station from that of any other large industrial plant is the radiological hazard. Thirty years after shutdown, the radiological dose would have greatly been reduced.

A thorough assessment of hazards that may be encountered during the decommissioning project will be performed during the preparation for decommissioning.

Radiological Hazards

During Phase I – Preparation for Safe Storage, the potential radiation hazards are likely to be associated with handling used fuel, tritiated heavy water, filters and resins, performing decontamination work and working in gamma radiation fields in station systems and components. Used fuel will continue to be stored in the facility for at least ten years after shutdown and the work required to transfer this fuel to a long-term facility or dry storage will continue.

At the beginning of Phase II - Safe Storage Phase, the radiation hazards will primarily be due to tritium and cobalt-60 and these hazards will decay significantly over the course of this Phase. It is expected that all of the radiological hazards will be removed by the end of the decontamination and disposal work during Dismantling, Disposal, and Site Restoration.

Non-Radioactive Hazards

Decommissioning will also involve non-radioactive hazards such as chemical, industrial and construction, biological and transportation hazards. These are described below.

Chemical Hazards

During Phase I - Preparation for Safe Storage, chemical hazards may be encountered during chemical decontamination of the primary heat transport system and processing the waste, draining and cleaning the water treatment facility tanks, or while handling cleaning agents during decontamination work. No unusual chemical hazards are expected during Phase II - Safe Storage Phase. During Phase III - Dismantling, Disposal and Site Restoration Phase, chemical hazards are expected during handling of the cleaning agents used during decontamination work, during transportation of the bulk or waste chemicals, and the concrete dust generated during dismantling.

Industrial and Construction Hazards

No unusual industrial and construction hazards are likely to be encountered during the Preparation for the Safe Storage and Safe Storage Phases.

Construction hazards during the Dismantling, Disposal and Site Restoration Phase will likely be similar to those encountered during other industrial decommissioning projects. Some of these construction hazards include:

- The operation of heavy construction equipment in close proximity to workers;
- Fire caused by cutting torches and grinders;
- The collapse of equipment or structures during dismantling;
- The use of blasting and other techniques to demolish concrete structures;
- Falls, lifting heavy objects, falling objects, use of hand tools and other hazards routinely encountered during construction work; and
- Working at heights inside the station.

Biological Hazards

Biological hazards from organisms and materials that might be found on the site during the decommissioning could include:

- Stings and bites from insects, rodents, birds or other animals that might live or nest inside accessible buildings;
- Toxins and antigens produced by molds and other fungi that might grow on surfaces (particularly those made of wood or other biological materials); and
- Infections or adverse reactions resulting from exposure to organisms living in decaying biological material or their by-products.

Transportation Hazards

Throughout the decommissioning project, radiological hazards to the public would most likely result from accidents during the off-site transport of radioactive wastes. Given OPG's experience in transporting radioactive waste safely, there should not be any increased radiological risk to the public due to waste shipments during decommissioning.

Transportation hazards mainly include motor vehicle accidents such as highway travels, vehicle-pedestrian collisions, and vehicle-wildlife collisions. However, there are mitigation measures to ensure that transportation hazards are reduced and those measures are expected to remain in place until decommissioning activities are complete. In addition, the transportation of all radioactive materials will comply with the requirements of the *Transportation of Dangerous Goods Act* and all other applicable regulations.

Other Hazards

Other hazards include:

- Working under inclement weather during temperature extremes, lightning and high winds;
- Working around open water such as the forebay;
- Working at heights such as the working on the meteorological tower and stacks;
- Risk of fire or use of cutting torches;
- Flying / falling objects falling to the ground;
- Sharp objects e.g. torn or cut metals;
- Heavy objects (e.g. some objects may be too heavy to lift by hand);
- Working in open, or below-grade concrete structures; and
- Working near live services.

2.9.5.2 Protection Strategies

A DDP will be prepared to support the application for a Decommissioning Licence. The DDP will identify all the decommissioning activities which will be carried out.

Radiological Protection Strategies

All decommissioning activities will be carried out in accordance with the As-Low-As-Reasonably-Achievable (ALARA) principle and the Radiation Protection Program of OPG. The procedures set out in the Radiation Protection Program with respect to dose control and contamination control will continue to be followed until they are suspended or modified in consultation with the CNSC. Where required, Radiation Work Plans and detailed procedures will be prepared before work begins.

Chemical and Construction Protection Strategy

OPG will ensure that all decommissioning work is conducted in accordance with the requirements of the applicable federal and provincial Occupational Health and Safety (OH&S) regulations. OPG currently has a comprehensive OH&S program that meets the requirements of the *Occupational Health and Safety Act* of Ontario. This program recognizes:

- The right of employees to know of the hazards associated with their work;
- The right of employees to participate in decisions related to health and safety; and
- The right of employees to refuse to perform work that is considered to be unsafe.

A Decommissioning Operations Contractor (DOC) will be retained on behalf of OPG to perform the decommissioning work during the Dismantling, Disposal and Site Restoration Phase of the decommissioning project. The DOC will be given charge and control of the work area (or designated parts of the work area) as the “Constructor”. The DOC will be responsible for:

- Registering the Construction Project with the Ontario Ministry of Labour as required by the Construction Safety Regulations made pursuant to the *Occupational Health & Safety Act*; and
- Providing the personnel, equipment, procedures and training required for the protection of workers, the public and environment.

OPG will supervise the activities of the DOC to ensure that the work is performed in accordance with the requirements of the decommissioning licence, OPG policies and the contract.

Security

During decommissioning, OPG will continue to comply with the CNSC’s Nuclear Security Regulations and Standards regarding the physical security of nuclear facilities. OPG will be responsible for the security of the site throughout the course of the decommissioning project.

The DOC and sub-contractors will be required to comply with OPG procedures regarding physical security. During most of the decommissioning of the PNGSs, the PWMF will still be operational. Even though they are two different facilities that are under separate licences, the same security staff will be responsible for all facilities during that period.

Safeguards

In accordance with an agreement between the Government of Canada and the IAEA, nuclear Safeguards are implemented at OPG’s nuclear generating stations. These international Safeguards apply to fuel and other designated nuclear materials used at the station.

The existing Safeguards provisions will continue until modified or terminated by agreement with the CNSC.

2.10 MANAGEMENT STRUCTURE OF PROPONENT

OPG announced on December 1, 2006, an organizational change that established two separate nuclear organizations, the Nuclear Business Unit and the Nuclear Generation Development and Services Unit. These nuclear organizations report directly to the Executive Vice-President and Chief Operating Officer as shown in Figure 2.10-1.

The Chief Nuclear Officer is responsible for the Nuclear Business Unit which focuses on operating the ten nuclear units and for the continuing improvement to the performance of these units. The divisions within the Nuclear Business Unit include PNGS A, PNGS B, Darlington NGS, Nuclear Programs and Training, Engineering and Modifications, Nuclear Supply Chain, Performance Improvement and Oversight, and the Integrated Maintenance Strategy Project.

A Senior Vice-President is responsible for the second nuclear organization, the Nuclear Generation Development and Services Unit. This unit focuses on future generation development and services. Divisions in the Nuclear Generation Development and Services Unit include Nuclear Generation Development (formerly Plant Life Extension Project), Inspection and Maintenance Services, and Commercial Services.

2.10.1 Organization and Structure

This section provides the relevant structure of the two nuclear organizations and Nuclear Waste Management Division (NWMD) as they pertain to safety and environment.

The organizational structure for the refurbishment work on PNGS B has not yet been established.

Nuclear Business Unit - PNGS B and Nuclear Programs and Training

All operations and maintenance activities associated with the PNGS B are under the responsibility of the Senior and Deputy Vice-Presidents for PNGS B. The Senior VP is responsible for:

- (a) Planning and setting strategic direction to deliver on an ongoing basis, targeted performance and results through the production of energy, and related projects and services in a safe manner. The scope of required work includes operations, maintenance, commissioning and decommissioning, and the on-site support functions necessary to accomplish this work.
- (b) Ensuring all work performed is in compliance with regulatory requirements and nuclear standards for public safety, employee safety and environmental protection.

PNGS B is organized into four functional groups: Work Management, Support Services, Operations and Maintenance, and Station Engineering which includes the Reactor Safety Department. The Chemistry and Environment Manager within the Operations and Maintenance Division is responsible for environmental programs to meet regulatory and OPG requirements in the areas of emissions, pollution prevention and environmental impact.

The Senior Vice-President of Nuclear Programs and Training provides the overall business strategies for the Nuclear Protection Programs and Training, Nuclear Integration, Nuclear Security, Operations and Maintenance Programs and Training, and Technical Programs and Training. The VP ensures that radiation protection and environment program requirements, standards and procedures are established in nuclear governance, and ensures that radiation protection and environment training programs are established. The Environment Programs Department Manager is responsible for ensuring the consistency and regulatory compliance of the site environmental programs such as general emissions monitoring, and the control of environmentally significant materials, as well as the supplying of specialty programs and monitoring support services for the nuclear units such as the Radiological Environmental Monitoring, Groundwater Monitoring, and Biodiversity Management Programs.

Nuclear Generation Development and Services Unit - Nuclear Generation Development Division

Nuclear Generation Development (formerly known as Plant Life Extension Project) has been tasked to develop the Business Case Assessment and recommendation in regard to refurbishment of PNGS B. In developing the Business Case Assessment, one of its objectives is to obtain all the necessary regulatory approvals such as EA approval. Completion of the EA for this Project is under the responsibility of the EA Department Manager. Although this EA is undertaken by the EA Department within Nuclear Generation Development, it is supported by many departments in other business units such as the Nuclear Business Unit and the NWMD.

The Nuclear Safety Division within Nuclear Generation Development provides nuclear safety support for the plant life extension projects. The two departments in the division, Nuclear Safety Compliance Department and Nuclear Safety Department, have the accountability for preparing the station Integrated Safety Review as required by the CNSC, and for providing nuclear safety support and oversight for all aspects of the project. The scope of the Integrated Safety Review (ISR) involves an assessment of the current state of the plant and plant performance to determine the extent to which the plant conforms to modern high-level safety goals and requirements. Results of the EA Study and ISR will be used to develop the Safety Improvement Plan. This Plan will integrate all necessary corrective actions, proposed plant modifications, safety

upgrades, compensatory measures, and improvements to operation and management programs that will apply to the Project and to long-term operation (CNSC 2006).

Nuclear Waste Management Division

The Senior Vice-President of NWMD is responsible for providing guidance on managing OPG's nuclear waste. NWMD supports the continued operation of the nuclear generating units by providing effective and efficient radioactive waste management systems. NWMD operates all the radioactive waste management facilities located on the PN and Darlington sites, and WWMF located on the Bruce site. NWMD is also responsible for the radioactive waste transportation system.

2.10.2 Staff Qualification Requirements

This section focuses on staff qualification requirements with emphasis on safety and environmental programs.

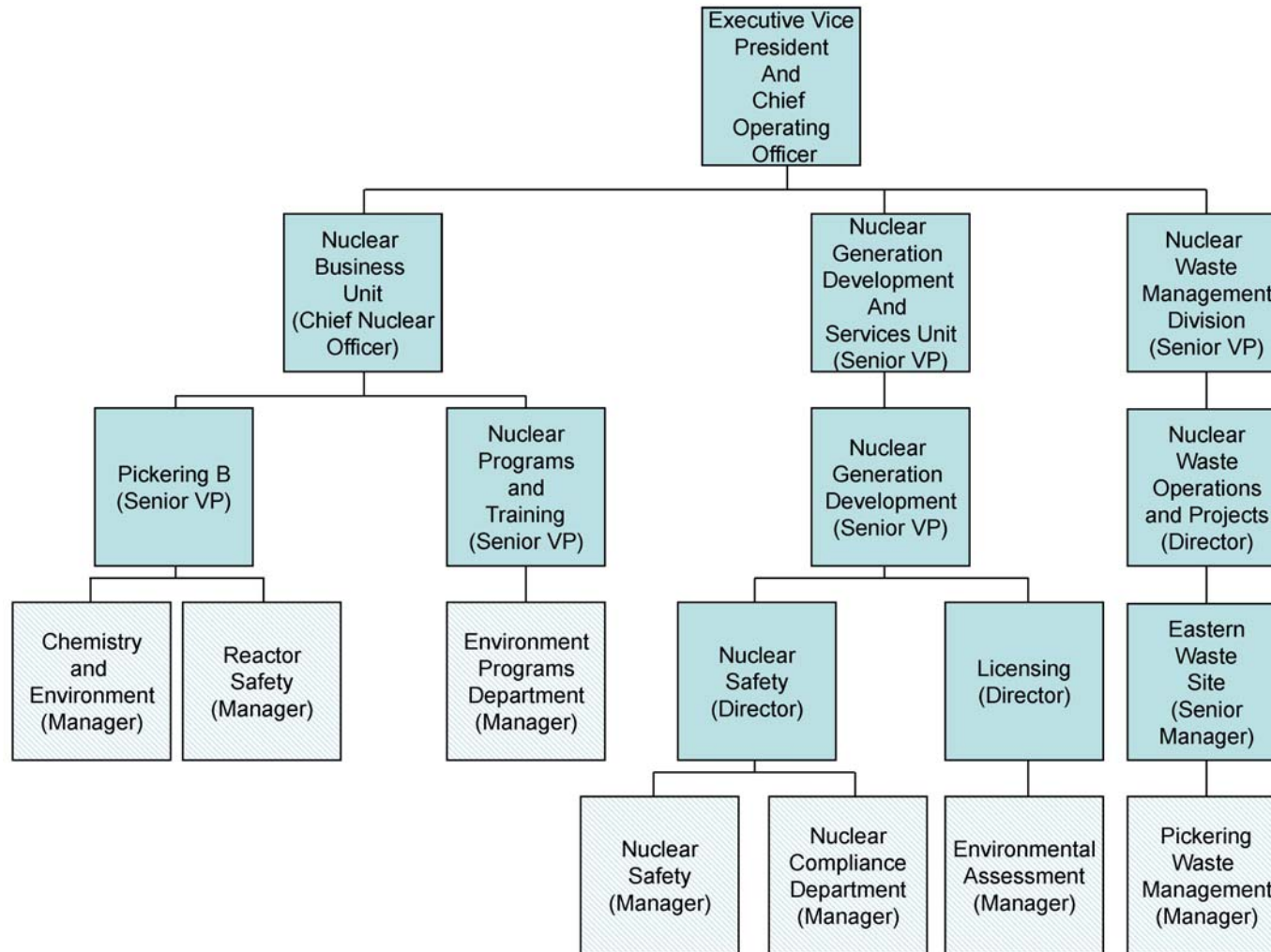
OPG is committed to responsibly addressing the public's safety, environmental and other concerns while protecting the commercial interests of the corporation. As such, OPG has established a program for developing and implementing training for OPG Nuclear staff who operate, maintain, engineer, and provide technical support for nuclear facilities.

Training is key to the strategy for improving nuclear station safety, reliability, cost effectiveness, and high levels of worker competence required by the complexity of the nuclear industry.

OPG has developed Training and Qualification Descriptions (TQD) for different types of staff working within a nuclear environment, including one for the environmental professions, conventional safety and radiation protection. These TQDs establish the entry-level criteria, prerequisite training, initial training and continuing training requirements at OPG Nuclear for these functions. The TDQs list the mandatory core training required in each group.

Many of these training programs are available as classroom training, self-study or computer assisted learning which is readily accessible by staff. OPG supports and expects staff to continually train to ensure work is performed in compliance with regulatory requirements and nuclear standards for public safety, employee safety and environmental protection. The safety and monitoring programs are described in Section 2.11.

**FIGURE 2.10-1
NUCLEAR ORGANIZATIONS AT OPG RELEVANT TO PNGS B PROJECT**



[Note: This chart does not show all positions within these organizations].

2.11 EXISTING SECURITY, SAFETY AND ENVIRONMENTAL PROGRAMS

2.11.1 Security and Safeguards

The CNSC's EA Guidelines require that information of a general nature be included in the EA Study Report regarding facilities and systems for maintaining the security of the station, with the exception of prescribed information. Prescribed information in the *Canadian Nuclear and Safety Control Regulations* is defined as information that concerns security arrangements, security equipment, security systems and security procedures established by a licensee in accordance with the *Nuclear Safety and Control Act (NSCA)*. Disclosure of such information is restricted. Accordingly, the following description of these systems is limited and general in nature. Major aspects of these systems are described briefly below.

2.11.1.1 PNGS B Security Systems

As a Class I Nuclear Facility, PNGS B has appropriate security systems to comply with the latest CNSC security requirements. Security systems may change in the future based on licensing requirements.

The PN site is entirely surrounded by a perimeter fence that restricts access to the site from land or water. The site is routinely patrolled. Only authorized personnel and vehicles are allowed on site. Security clearances are obtained for all employees and contractors.

The restricted area is completely surrounded by security fencing equipped with lighting, security cameras and other surveillance devices. The security perimeter is patrolled by security personnel. Access to this restricted area by vehicle or on foot is through checkpoints at which radiation detectors, x-ray machines and related inspection devices are used to monitor incoming and outgoing materials.

Security procedures include staff training (including appropriate on-site weapons training), positive identification of personnel, verification of documentation, physical searches, visitor escorts, and background checks. Physical barriers, monitoring devices and surveillance systems constrain and monitor activity at the PN site.

Security at PNGS B and the PN site is maintained by security staff including a force of appropriately equipped and trained security officers responsible for day-to-day operations, maintenance staff who ensure the condition and upkeep of the security infrastructure, Armed Nuclear Response Force Officers, who are provided under contract to OPG by the Durham Regional Police Service, and engineering staff who are responsible for system surveillance.

2.11.1.2 Safeguards

In 1970, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was established. Canada was one of the first countries to ratify the treaty and accept IAEA inspection at its nuclear facilities. Section 9 in the PNGS B operating licence requires OPG to take all necessary measures to facilitate Canada's compliance with any applicable Safeguards agreement.

OPG reports and provides information to the CNSC as required. OPG also discloses to the CNSC, the IAEA or an IAEA inspector, any records required to be kept or any reports required to be made under a Safeguards agreement. Also, in accordance with the requirements of the NPT, OPG provides access and assistance to IAEA inspectors for the purpose of verification of the declared nuclear material inventory, as well as the installation and maintenance of IAEA monitoring equipment. The IAEA Safeguards equipment includes surveillance cameras, fuel bundle counters, fuel verifiers and core discharge monitors.

2.11.2 Safety and Health Management System

2.11.2.1 PNGS B Facility

The PNGS B operating licence requires OPG to operate PNGS B in accordance with established safety procedures and practices. These practices and procedures are administered by the Conventional Safety Department. The Department's major responsibilities are for all aspects of conventional health and safety. Some of the functions are shared between PNGS A and B.

The Conventional Safety Section implements conventional health and safety policies, standards and programs, including Contractor Safety and Injured Worker. It implements risk assessment and controls for health and safety, and monitors the effectiveness of health and safety programs. The Conventional Safety Section also provides support for accident and incident investigations.

Occupational Health and Safety (Non-radiological)

PNGS B is subject to all provincially-legislated requirements with respect to health and safety in the workplace. Most notable among these requirements is the *Occupational Health and Safety Act (OHSA), R.S.O. 1990* and its associated regulations.

The goal of OPG's Occupational Health and Safety Management System (OHSMS) is to ensure employees work safely in a healthy and injury-free workplace by reducing the risks associated with the activities, products, and services of nuclear operations to a value considered ALARA. Risk reduction is primarily achieved through the effective execution of operational controls and

proper job planning. Together these constitute the basis of OPG Nuclear's control strategy over occupational health and safety risks.

This OHSMS complies with the British Standards Institution (BSI) Occupational Health and Safety Assessment Series (OHSAS) 18001:1999 Specification for OHSMS. The 18001 Specification comprises seventeen elements that make up the systematic process for managing Occupational Health and Safety risks. This systematic approach is consistent with the Plan-Do-Check-Review principles within OPG Nuclear. The OHSMS uses a fundamental control and improvement model as the basis for effective risk management. There are five primary elements in the model:

- Policy;
- Planning;
- Implementation and operation;
- Checking and corrective action; and,
- Management review.

This program implements governing documents that represent the framework for effective identification and control of conventional safety hazards:

Ensuring the safety of staff at PNGS is the legal responsibility of OPG management supervisors and workers. To support management in the fulfillment of this responsibility, a Safety Oversight Committee, Operation and Worker Trades Joint Health and Safety Committees, and a Conventional Safety Department have been established. The Conventional Safety Department provides technical services and assistance to management and the various committees.

Conventional health and safety throughout PNGS is administered through a protocol hierarchy comprising the following elements:

- Policy – establishes the overall objectives of health and safety initiatives and defines the commitments and responsibility of management and staff;
- Program – provides the framework for implementation of health and safety initiatives; and,
- Procedures – defines the method(s) for effecting safe work practices as they relate to specific situations.

Expanded descriptions of each of the above elements of PNGS occupational health and safety protocol are presented in the following subsections.

Health and Safety Policy

The OPG Health and Safety Policy (effective December 15, 2006) advocates the right of employees to a safe and accident-free workplace. The key elements of the policy include:

- a commitment to the protection of health and safety through the design of the physical, physiological and psychological aspects of the work environment, the planning and performance of the work, and the provision and use of appropriate tools, equipment, procedures and support;
- a commitment to the involvement of employees in decisions that have an impact on their health and safety;
- continuous evaluation of and improvements to health and safety performance;
- recognition of standards of health and safety performance with correction as necessary; and,
- a commitment to compliance with legislated requirements for health and safety.

Health and Safety Program

A division-level Health and Safety Program implements and integrates a series of standards and procedures to ensure the health and safety of personnel and contractors.

The Health and Safety Program applies to all (PNGS B) employees, visitors and contractors. It is limited to conventional occupational health and safety. The Program establishes the framework necessary for employee health and safety to be an integral part of business management, and plant operation and maintenance. All requirements of legislation, OPG corporate policies and nuclear governing documents are included in the Program. It also integrates a number of broad-based implementation documents that represent the primary health and safety related aspects of plant operations.

Health and Safety Procedures

PNGS has many procedures to be followed addressing safety issues such as electrical safety, falling object prevention, confined space and personal protective equipment. The procedures are readily available to all staff.

2.11.2.2 *Health, Safety and Environmental Protection at Nuclear Waste Management Division*

The NWMD of OPG is committed to the prevention of foreseeable hazards that may result in a loss, and fully supports the development and implementation of activities and systems that ensure the prevention of loss in all aspects of Waste Management Facility operations.

Inputs from conventional safety assessments, human factors assessments, and operational experience (lessons learned) have been incorporated in the final design and construction of new buildings. An evolutionary type of process is in place to constantly improve safety and performance. The design and construction teams have taken inputs as part of the design approach and incorporated them into the final facility.

NWMD has established an Environment, Safety and Health (ES&H) Program that utilizes the principles and tools of "Loss Control" as an effective method of managing risks associated with loss due to:

- Personal injury and illness,
- Property/equipment damage,
- Process loss,
- Environment,
- Work environmental damage, and
- Regulatory non-compliance.

This ES&H Program identifies the system purpose, scope, associated roles and accountabilities, program objectives, element descriptions and performance measures specifically assigned to Senior, Middle and First Line Managers. Program activities and performance measures have been developed based upon the requirements of Det Norske Veritas (DNV) International Safety Rating System (ISRS) audit protocol. NWMD is certified/audited to the ISO 14001 environmental management system standard.

OPG's ISRS consists of 17 elements designed to control exposure to potential loss at the pre-contact, contact and post-contact stages of an incident or undesirable event. Control measures are specified in administrative and technical procedures, employee training, and scheduled activities in the work control system. Elements of the Managed System include:

- Leadership and administration;

- Leadership training;
- Planned inspections and maintenance;
- Task analysis and procedures;
- Incident / accident reporting and investigation;
- Emergency preparedness;
- Rules and work permits;
- Analysis of incidents / accidents;
- Employee knowledge and skill;
- Personal protective equipment;
- Health and hygiene controls;
- Environment, health and safety system evaluation;
- Engineering and change management;
- Group communications;
- Hiring and placement;
- Materials and services management; and
- Personal communications.

The performance of the ES&H Program is evaluated in terms of:

- The degree of conformance with requirements specified in the ISRS;
- Completion of internal and external system audits on a predetermined frequency; and
- Traditional measurements of consequence (i.e., severity and frequency).

The potential environmental impacts caused by Pickering Nuclear Waste operations will be managed following the principles of ISO 14001 standard which is documented in NWMD Environmental Management System Manual. This Manual explains and documents the core elements of the NWMD Environmental Management System (EMS) and their interrelationships and provides direction to related documentation. The EMS was based on the ISO 14001:2004 Environmental Management Systems – Requirements with Guidance for Use. Corporate and Nuclear requirements (e.g., policies, procedures, targets etc.) were taken into consideration and integrated into the EMS where appropriate. The goals of the EMS are to:

- improve environmental performance and demonstrate continual improvement;
- identify environmental aspects related to operations, and implement operational controls and monitoring and measurement activities to ensure that they are being managed;
- promote environmental protection and prevention of pollution in balance with socio-economic needs; and
- ensure compliance to applicable environmental, legal and other requirements.

2.11.3 Radiation Protection

PNGS B's and PWMF's operating licences require OPG to operate and maintain PNGS B and PWMF according to the methods and procedures, for the purposes and within the limits described in the documents entitled "*Radiation Protection Policies and Principles*" and "*Radiation Protection Requirements – Nuclear Facilities*". These radiation protection requirements have been developed within a broad framework of radiation protection within OPG and the principles which govern As Low As Reasonably Achievable (ALARA). The following sections describe the radiation protection policies and requirements designed to meet the requirements of the operating licence and protect the health and safety of workers and the public.

2.11.3.1 Radiation Protection Policy

OPG is committed to the radiation safety of its employees and the public. This commitment is evident in the comprehensive and effective radiation protection program present at all its nuclear generating stations. Primary guidance for radiation protection is provided in OPG's *Radiation Protection Policies and Principles*. The policy identifies three governing objectives for the Radiation Protection Program:

- to prevent detrimental non-stochastic effects to employees and members of the public;
- to limit detrimental stochastic health effects (i.e. cancer, hereditary genetic effects) occurring in employees or members of the public to ALARA levels, social and economic factors being taken into account; and,
- to provide a level of health and safety which is as good as, or better than, comparable safe industries.

Policies regarding accidents and mitigative measures are dealt with by different parts of the organization (safety assessment, risk assessment, emergency response, etc.).

To implement the objectives of the *Radiation Protection Policies and Principles*, OPG has a number of radiation protection programs that address specific aspects of radiation protection and ensure that they comply with corporate and legislated radiation protection requirements.

2.11.3.2 *Radiation Protection Requirements*

The corporate Radiation Protection Requirements are given in the document titled “*Radiation Protection Requirements – Nuclear Facilities*”. The requirements are summarized as follows:

- The Radiation Protection Program shall meet the intent of all applicable legislated and related regulations, and specifically the *NSCA* and Regulations. These regulations set the limits for the doses to station staff and doses to members of the public from station-related activities. OPG also has derived dose limits for occupational exposures of staff that are more restrictive than the legislated requirements;
- Where specific applicable legislation or regulations do not exist, the program shall meet the intent of the recommendations of the International Commission on Radiological Protection (ICRP). The ICRP is an international organization that provides guidance on radiation protection and is widely accepted as the international authority on radiation protection issues;
- Radiation hazards shall be generally managed by adhering to the following basic directives in order of priority:
 - identification of hazards;
 - elimination of hazards where feasible;
 - control of hazards where they cannot be eliminated; and,
 - control exposures to acceptable levels.
- The Radiation Protection Program shall make provisions for radiation protection throughout the entire life cycle of facilities.

The *Radiation Protection Requirements – Nuclear Facilities* document also includes directives on other corporate mandates, personnel management, specific limits, facility design and operation, hazard and exposure management, radioactive material management, incidents and emergencies and information management.

2.11.3.3 *Radiation Protection Program*

The Radiation Protection Program implements a series of programs, standards and procedures for the conduct of activities within nuclear sites and with radioactive materials to achieve and

maintain high standards of radiation protection including the achievement of the following objectives:

- (a) Controlling occupational and public exposure:
 - Keeping individual doses below regulatory limits;
 - Avoiding unplanned exposures;
 - Keeping individual risk from lifetime radiation exposure to an acceptable level; and
 - Keeping collective doses ALARA, social and economic factors taken into account.
- (b) Preventing the uncontrolled release of contamination or radioactive materials from the nuclear sites through the movement of people and materials; and
- (c) Demonstrating the achievement of (a) and (b) through monitoring.

This program complies with the CNSC requirement that all licencees implement a radiation protection program, and establishes a quality program that meets with the specific Canadian Standards Association (CSA) standards pertaining to radioactive contamination control and radiation safety.

2.11.4 Fire Protection and Emergency Response Systems

2.11.4.1 *Fire Protection*

Each of OPG's nuclear facilities maintains facility-specific fire protection documentation regarding the physical details of fire prevention, fire detection and fire suppression systems and features for the facility. These systems and features have demonstrated that the existing fire protection features have been evaluated against the requirements of CSA N293-95, "*Fire Protection for CANDU Nuclear Power Plants*", and associated Codes and Standards. The requirements of the National Building Code (NBC) and the National Fire Code (NFC) apply to the structures, systems and components comprising the nuclear facility.

Steps taken at the PN site to prevent fires include:

- Strict controls for storage of flammable and combustible materials and transient materials;
- Requirement of ignition source permits for tasks that involve a risk of fire (e.g., welding); and
- Fire prevention inspections.

An Emergency Response Team (ERT) is the first line of defence in the event of a fire at the PN site. Full-time teams are on duty around the clock and ready to respond promptly to any kind of emergency.

Team members continuously practice and upgrade their skills, training for two hours per crew per day on average. When not training, they patrol the station to ensure that fire prevention procedures are being followed and that fire protection equipment is in good working condition. The crews receive extensive fire-fighting, first aid, rescue and hazardous materials (HAZMAT) training. In an emergency, the City of Pickering Fire Department, which is called upon after confirmation of a fire event, provides back-up support for the ERT.

2.11.4.2 First Aid

OPG's First Aid document identifies processes, overall requirements, and staff accountability to ensure that an effective First Aid Program is established and maintained to satisfy legislative requirements and ensure compliance with the *Workplace Safety and Insurance Board (WSIB) Act, 1997* (Reg. 1101, First Aid Requirements).

The ERT at the PN site provides and ensures the maintenance of first aid equipment.

2.11.4.3 Emergency Response

The PN site has emergency response capabilities that are initiated to deal with many differing emergency situations. These can include conventional emergency incidents or radiological-based incidents. A nuclear site's response capability is consistent with the on-site planning basis and process of determining shift minimum complement. This process requires a review and justification of the staffing requirements to deal with the spectrum of events that require both operational and emergency response. Initiating events can be non-nuclear and can result from situations and conditions external to the plant site. The designed emergency response capability and infrastructure is sufficiently flexible to be used for the broad range of potential events and accidents. The response infrastructure is able to draw upon additional support resources and use prioritization techniques when dealing with major events.

2.11.4.4 Emergency Response Organization

On-site emergency response is the responsibility of the ERT (see Section 2.11.4.1) and the emergency response organization (ERO). The ERT responds to any conventional emergencies such as HAZMAT, fire or first-aid incidents. This team is also an integral component of the ERO which responds to large-scale conventional and all radiological-based incidents.

ERO is made up of three tiers. The first two tiers comprise the site response organization. This includes shift ‘duty’ staff and augmentation staff who are called in to fill the Site ERO. Management, technical, operations, and support staff of the Site Management Centre (SMC) are assembled to fulfill their responsibilities and duties under the consolidated nuclear emergency plan. The third tier is the Corporate Emergency Operations Facility (CEOF).

Staff in the ERO are required to be relieved by replacement staff over the duration of the response. Staffing and procedures are in place to facilitate this. Shift ERO is covered by five rotating crews. The SMC and the CEOF are covered by three rotating duty on-call teams with a pool team in reserve for coverage and emergencies.

ERO is responsible for the following:

- Initial notifications;
- Performing site surveys;
- Deploying the off-site survey teams (OSST);
- Bringing the incident unit under control;
- Any immediate personnel protective actions for the site; and
- Providing data for off-site agencies to make public protection decisions.

All members of the ERO are qualified individuals who undergo an initial training program and a requalification program to maintain their qualifications.

2.11.5 Nuclear Emergency Plan

2.11.5.1 *Basis for Emergency Planning*

OPG’s generating stations are designed and operated in accordance with strict safety standards to ensure that station personnel, members of the public, and the surrounding environment are protected from the effects of abnormal events that might occur during the life of the station. Facilities are governed by and operated according to licensed regulatory requirements. Design of the station accommodates all abnormal events that might reasonably be postulated to occur. Operation and maintenance of the station within the confines of the ‘safe operating envelope’ ensures a high level of safety. Since it is not possible to guarantee that abnormal events will never occur, it is considered prudent to develop and maintain an emergency plan and an organization to implement that plan should the need arise. As described in Section 2.11.4.4, one of the responsibilities of the ERO is to respond to radiological-based incidents.

The Provincial Nuclear Emergency Plan (PNEP) provides the off-site basis for emergency planning with the aim of ensuring public safety in the event of an emergency related to a radiological incident at the PN site. In the context of this plan, a nuclear emergency is any emergency which poses a radiation hazard to people or property off site. Part 1, Provincial Master Plan of the PNEP, lays down the principles, concepts, organization, responsibilities, policy, functions, and interrelationships which will govern all off-site nuclear emergency planning, preparation, and response in Ontario. Other constituent parts are site-specific in nature and deal with the local characteristics, planning, and operational detail, including evacuation plans.

The PNEP requires OPG to support emergency planning and response for areas within a 10 km radius of all nuclear plants (i.e. the Primary Zone). The PNEP is implemented through OPG's Consolidated Nuclear Emergency Plan (CNEP). The CNEP is also integrated with municipal emergency plans, including the Region of Durham's, the City of Pickering's, and the City of Toronto's. Each year OPG Nuclear provides direct support, including both funding and joint exercises, to the Province and the Region of Durham. It jointly tests and evaluates its integrated emergency response during large-scale exercises involving off-site emergency Reception Centres, and local schools.

The CNEP and supporting procedures are tested and evaluated at least five times per year at PNGS to maintain an effective response capability and ensure continuous improvement; these tests and evaluations will continue out to 2060 in support of the continued operation of PNGS B. In this EA Study Report, OPG has included an evaluation of population growth for the Greater Toronto Area and the Region of Durham, as well as regional and local transportation plans. OPG has determined that the predicted population growth, population distribution and expanding transportation network out to 2060 will not impede the implementation of emergency measures in the future (see Sections 5.10.2.2 and 5.12.4.1). The Province, along with the other participants in the CNEP, will review and update emergency plans to ensure a robust emergency response system will be in place to accommodate the entire area studied to the refurbished end of life of PNGS B.

2.11.5.2 *Emergency Public Information*

OPG has a responsibility to communicate with the public, media, stakeholders, and employees during (potential) nuclear emergencies. To facilitate this, OPG has in place a plan and procedure that govern the emergency communications response. OPG also participates with the Province and municipalities in a coordinated emergency communications response under the jurisdiction of the PNEP.

The main target audience of OPG's emergency public information program is the public living or working near the nuclear sites. Another audience is employees who need to know about the state

of the facility. To reach this audience, the corporation will rapidly communicate with media outlets, employees and stakeholders in order that they are informed quickly about developing issues.

2.11.5.3 *External Mutual Aid*

Agreements exist with local fire departments for on-site fire fighting support. Arrangements and procedures also exist for local ambulance service and hospital support for casualties from the nuclear sites. Toronto Hospital Corporation, Western Division has been provincially designated and funded as the radiation trauma centre for Ontario. This includes the capability to deal with contaminated casualties, trauma, and acute radiation syndrome. Agreements are in place to provide support from the local police force in the event of a security-related incident.

Provision for emergency engineering and technical support is available from Atomic Energy of Canada Ltd. (AECL). Similar contacts are made available by CANDU Owners Group for securing support from other Canadian Nuclear utilities.

A series of protocols exist for provincial and federal government support and provision of emergency services. These are triggered through the provincial emergency operations functions to the federal government. Military support and access to the U.S. Federal Emergency Management Agency (FEMA) and U.S. Department of Energy (DOE) services are available at the federal government level. The federal government also has access to support from the International Atomic Energy Agency (IAEA) and member states.

2.11.5.4 *Off-Site Interfaces*

The safety of the public and the environment outside the boundaries of the facility is the primary responsibility of the Province with support from OPG and local municipal organizations. A number of provincial ministries, including the MOE, are represented at the Provincial Operations Centre (POC). Provincial decisions regarding emergency response are coordinated with Emergency Operations Centres in Durham Region, City of Pickering, Town of Ajax, and City of Toronto, as well as with OPG through its Corporate Emergency Operations Facility (CEOF). Additional information with respect to emergency planning and response in the above-noted municipalities is provided in the Human Health TSD.

There are external off-site organizations defined in the provincial and municipal Nuclear Emergency Plans that OPG must interface and interact with during the course of an emergency response. These include the following:

- Provincial Operations Centre (POC);
- Municipal Operations Centre (MOC) or Regional Operations Centre (ROC);
- Reception Centre (RC);
- Emergency Worker Centre (EWC) and Monitoring and Decontamination Unit (MDU);
and
- Joint Information Centre (JIC).

The CEOF would also interface with the CNSC Headquarters Emergency Operations Centre (HQEOC) and its respective staff.

Provincial Operations Centre

The POC is the provincial facility and organization that controls overall operations of emergency response. POC makes the decision on what public protective actions are to be undertaken. POC is composed of representatives primarily from provincial ministries needed to manage an emergency. Staff expertise includes technical assessment, response operations, analytical and technical support and information dissemination. OPG supplies call-in staff to fulfill some technical positions in the POC Scientific Group and an official liaison position in the POC Operations Group. OPG has supported capital construction of the POC facility, provided software codes and development, technical documents and manuals, dedicated telecommunications links, and training and drills support to the POC.

2.11.6 Environmental Programs

2.11.6.1 Environmental Management System

OPG Nuclear has developed an Environmental Management System (EMS) to manage environmental aspects in accordance with core elements of ISO 14001 Environmental Management Systems Standard. An environmental aspect is defined as an element of an organization's activities, products or services that can interact with the environment (e.g. a discharge, an emission, consumption or reuse of a material, or noise).

The OPG Environment Policy establishes guiding principles for environmental management and environmental performance for Nuclear employees and those working on behalf of Nuclear. It documents the principles and provides a framework for setting objectives and targets on which Nuclear EMS is founded. The key principles of the policy are the following:

- Pollution Prevention;
- Adherence to Regulations; and
- Continual Improvement.

An important component of the EMS is the identification of environmental aspects which are ranked to determine those that are significant. These significant environmental aspects (SEAs) are considered when setting Environmental Objectives. Environmental Programs include responsibilities for achieving objectives and targets at each relevant function and level of the organization, and the means and timeframe by which objectives and targets are to be achieved. Environmental programs include:

- Biodiversity Enhancement Management;
- Spills Management;
- Land Assessment and Remediation Management;
- PCB Management;
- Ozone-Depleting Substances Management;
- Radioactive and Conventional Emissions Management;
- Environmental Compliance; and
- Waste Management.

Senior management periodically reviews the EMS to assess its suitability, adequacy and effectiveness. The information review includes:

- Audit results;
- Environmental Aspects;
- Station Condition Records;
- Progress towards achieving environmental objectives, targets and programs; and
- Concerns of interested parties.

2.11.6.2 Environmental Monitoring

OPG and its predecessor, Ontario Hydro, have almost four decades of experience sampling, testing, documenting and reporting on air, water, soil and other media for substances related to the generation of electricity using nuclear power at the PN site. The procedures and policies

developed over that time to protect workers, the public and the environment are designed to ensure that the electricity is generated safely and responsibly. Through its monitoring programs, OPG demonstrates that emissions are kept within the appropriate limits. Data analysis and reporting have been refined to facilitate early identification of unexpected events and implementation of subsequent corrective action.

This section outlines the programs which OPG maintains to monitor emissions and the environment for radiological and conventional substances.

The emissions and environmental media monitored at PNGS are comprehensive in terms of substances and locations, including:

- air and water emissions;
- radiological and conventional substances;
- radioactivity in air on-site at the property boundary, and at locations remote from PNGS;
- tritium in municipal water;
- tritium in groundwater;
- petroleum hydrocarbons in soil and groundwater proximate to likely sources (e.g., the standby generators);
- tritium, carbon-14, radioactive noble gases, iodine-131, radioactive particulates such as cobalt-60, cesium-137, gross beta and gross gamma radiation;
- thermal emissions in cooling water; and
- total residual chlorine in cooling water.

It is important to note that emissions from PNGS B are reviewed and regulated by the CNSC and the MOE at the point of discharge.

The following sections provide a brief overview of the environmental and other monitoring programs. Much of the radiological monitoring is conducted to meet the requirements of the Operating Licence. Other environmental monitoring programs are carried out in compliance with the requirements of the Certificate of Approval issued by MOE or as required by the MISA regulation.

Dilution alone is not an appropriate method to deal with emissions. It should be accompanied by source control, ALARA for radioactive emissions, and BATEA (Best Available Technology Economically Achievable), where appropriate, for conventional emissions. PNGS B

complements dilution by source control measures (e.g., through the Radiological Emission Reduction Project and the MISA Compliance Project).

Background Monitoring

PNGS has used various monitoring programs since the initial environmental effects monitoring commenced in 1969. Environmental effects monitoring studies of 10-year duration were required for both PNGS A and B to comply with the conditions of the MOE permits under the *Ontario Water Resources Act* (i.e. Sewage Works Approval and Permit to Take Water). The PNGS A studies were completed in 1979, and those for PNGS B in 1988. This EA study is a continuation of this process and is based on the most up-to-date legislation, regulations, policies and procedures.

Background levels are established by monitoring at locations which are physically remote from PNGS (e.g., Thunder Bay, Kapuskasing and Sudbury) and are believed to be unaffected by the presence of PNGS by virtue of their distance.

OPG, Health Canada and the Ontario Ministry of Labour routinely collect samples and measure the concentration of selected radionuclides in the atmospheric, aquatic, and terrestrial environments at background locations around PNGS. Existing conditions have been characterized as the baseline for this EA study and will continue to be monitored.

The following sections provide a general overview of the types of monitoring programs carried out at PNGS.

Effluent Monitoring

Effluent monitoring systems measure the releases of radioactive substances from PNGS B to air and to Lake Ontario. In addition, there is effluent monitoring to measure the releases of non-radioactive substances to Lake Ontario. The following sections summarize the key effluent monitoring practices and procedures applied at PNGS.

Radioactive Emissions to Air

Radioactive gaseous emissions to the atmosphere are monitored continuously. Tritium is monitored by drawing an air sample from a stack and subsequently passing it through a desiccant, and counting the low-energy beta rays emitted by the tritium trapped by the desiccant in a liquid scintillator counter. Carbon-14, in the form of CO₂, is monitored by bubbling a stack

air sample through a sodium hydroxide solution, and subsequently counting with a liquid scintillator the low-energy beta rays emitted by the carbon-14 trapped by the solution. Noble gases, radioactive iodine and radioactive particulates are monitored by the PING (particulates, iodine, noble gas) monitor which includes a particulate filter, an iodine cartridge and a noble gas chamber placed in series. The particulates and radioactive iodine are trapped by the particulate filter and iodine cartridge respectively, and the noble gas is passed through the noble-gas chamber. The radioactive content of the particulate filter is counted by a plastic scintillator while those in the iodine cartridge and noble gas chamber are counted by sodium iodide detectors. From these measurements the radioactivity concentration in air is determined.

Radioactive Discharges to Lake Ontario

The Monitoring of Radioactivity in Effluents Standard (OPG 2005f) established the sampling and monitoring requirements for liquid effluent discharges in order to determine radioactive releases to the environment.

Radioactive substances are discharged from the Radioactive Liquid Waste Management System (RLWMS) to Lake Ontario after sampling and analyzing to verify compliance of the contents of the storage tank to be discharged. In addition, there is continuous tritium monitoring of the surface water discharges from PNGS B.

Because of control and/or compliance requirements, radioactive liquid effluents are monitored for their contents of tritium and gross beta activity while being discharged to Lake Ontario. In general, each monitor consists of a sampling system that draws a representative sample from the monitored liquid stream and radiation detectors that are operated either on-line or off-line to count the radiation emitted by the collected sample. The radioactivity level is then calculated from the radiation counts, together with the knowledge of flow rates.

“Emissions to air and water for each radionuclide or radionuclide group are kept well below their respective DRLs. In addition the sum of emission activities for all radionuclide groups from PNGS A and PNGS B, expressed as a fraction of their respective DRLs is kept well below a value of 1, thus ensuring that the dose to members of the public from all site sources combined remains below the regulatory limit.” We could also add “Emissions are also checked against Action Levels which are set at a fraction of the DRLs to ensure that timely actions are taken to reduce emissions before they approach DRL levels.”

Non-Radiological Discharges to Lake Ontario

OPG monitors various effluent streams for chemical contaminants to the environment. This monitoring is undertaken to ensure compliance with MISA limits in accordance with the requirements of Ontario Regulation 215/95 and system specific Certificates of Approval from the MOE.

The Ontario Regulation 215/95 (*Effluent Monitoring and Effluent Limits - Electric Power Generation Sector Regulation*) is part of the MISA regulation. OPG began this program in all its nuclear generating stations in 1989/1990 when all discharges were monitored for a large number of contaminants. In 1990, the program was focused and monitoring was limited to identified discharge streams deemed to be significant. In 1995, the regulation was promulgated in anticipation of the MISA limits implementation in April 1998. Table 2.11-1 shows the discharge streams monitored at PNGS B, the parameters measured, frequency and the limits.

In addition, effluents must be monitored as regulated under Certificates of Approval issued by the MOE. Table 2.11-1 shows the discharge streams monitored at PNGS B, the parameter and the limit specified on the Certificates of Approval. More details with respect to the location control points, the regulated parameters and monitoring results are provided in Section 4.2.

**TABLE 2.11-1
DISCHARGE STREAMS AND PARAMETERS MONITORED**

Municipal/Industrial Strategy for Abatement (MISA)

Control Point	Parameter	Daily Limits mg/L	Monthly or Quarterly Limits mg/L
Radioactive Liquid Waste Management System	Phosphorus	-	1.0
	Total Suspended Solids	73.0	21.0
	Zinc	1.0	0.5
	Iron	9.0	3.0
	Oil and Grease	36.0	13.0
	pH	6.0 – 9.5 (no units)	-
	Lethality/Toxicity	-	non-toxic
Old Water Treatment Plant Neutralizing Sump and New Water Treatment Plant	Total Suspended Solids	70.0	25.0
	Aluminum	13.0	4.5
	Iron	2.5	1.0
	pH	6.0 – 9.5 (no units)	-
	Acute Lethality / Toxicity	-	non-toxic
	Chronic Lethality / Toxicity	-	non-toxic
Units 1 – 8 Building Effluent	Total Suspended Solids	-	-
	Oil and Grease	-	-
	Lethality / Toxicity	-	non-toxic

Certificate of Approval

Stream	Parameter	Limit
Condenser Circulating Water (CCW)	Final outfall temperature	< 32°C – winter < 36°C – summer < 37°C – during algal run or IESO power emergency
	Temperature Increase	< 11 °C
Condenser Circulating Water (CCW)	Unionized ammonia	0.02 mg/L
	Hydrazine	0.10 mg/L
	Morpholine	0.02 mg/L
	Total residual chlorine	0.01 mg/L
	pH	6-9.5 (no units)
Reactor Building Service Water	Total residual chlorine	< 0.01 ppm in outfall
Units 1-8 Building Effluent (inactive drainage)	Oil and grease	15 mg/L
	Total residual chlorine	0.04 mg/L
	Total suspended solids	25 mg/L
Oily Water Separator-A	Oil and grease	15.0 mg/L
Boiler Blowdown	Ammonia	Normal 5 mg/L Outage 100 mg/L
	Hydrazine	Normal 1 mg/L Outage 200 mg/L
	Morpholine	Normal 50 mg/L Outage 50 mg/L

Environmental Monitoring of Radioactivity

OPG has comprehensive programs for monitoring radiation in diverse environmental compartments (e.g., air, well water, lake water, foodstuffs). In addition, OPG, Health Canada and the Ontario Ministry of Labour routinely collect samples and measure the concentration of selected radionuclides in the atmospheric environment near PNGS and across the province. The types of data collected in OPG's environmental monitoring program include:

- external gamma dose rates;
- airborne tritium;
- tritium and gross beta in precipitation;
- tritium, carbon-14 and gamma emitters (such as iodine-131) in milk;
- tritium, gross beta in drinking water;
- tritium, carbon-14, and gamma emitters in fish;
- tritium and carbon-14 in garden vegetables and other terrestrial media; and
- gamma emitters in soil, beach sand and lake sediments.

Monitoring is carried out by OPG at boundary, area, control and background monitoring locations as described below. These locations are established to allow evaluation of impacts attributable to PNGS and conditions created by other sources:

- Indicator locations are used to assess the potential dose to the public. These locations are outside the facility perimeter, at points where the most significant public exposure (direct or indirect) occurs or is predicted to occur;
- Area locations are used to provide information at sites further away from the site boundary; and
- Control or background locations provide radiological information on the presence of naturally occurring radiation and radioactivity from nuclear atmospheric weapons testing, at locations well away from nuclear sources.

Other Monitoring Programs

The water quality from the Ajax Water Supply Plant (along with other nearby facilities), already monitored by the MOE as part of the drinking water surveillance program, is also monitored for tritium by OPG since the plant intake is in Lake Ontario and periodically down current from PNGS. OPG also monitors for tritium at Hogan, Harris, Ajax, Whitby, Oshawa, Bowmanville and Newcastle WSPs.

Site Biodiversity Plan

The corporate ***Environmental Policy*** (OPG 2006f) requires environmental factors and stakeholder considerations to be integrated during planning, decision-making and business practices. The corporate ***Biodiversity Policy*** (OPG 2000c) requires the development and maintenance of management plans to address the biodiversity needs and enhancement opportunities of significant natural areas and species across all OPG properties, including PN. The OPG ***Nuclear Biodiversity Management Standard*** (OPG 2006g) requires that each site develop a biodiversity management plan that includes management of any significant natural areas and species and seeks partnerships with external stakeholders.

The Pickering Nuclear Site Biodiversity and Natural Area Management Plan (OPG 2003b; OPG 2006h) is a general plan for wildlife and biodiversity conservation management of PN site lands and waters. Biodiversity and natural areas management is a component of the Environmental Management System (EMS) for PN (OPG 2006i). Disturbance to the natural environment and changes to biodiversity are identified as a Significant Environmental Aspect (SEA) in the PN EMS.

The PN Site Biodiversity and Natural Area Management Plan includes goals, rationale, objectives, and tasks scheduled for implementation. This plan is reviewed every three years. The ten goals in the current plan are

- Goal 1: Establish a wildlife corridor linking Frenchman's Bay to Duffins Creek Marsh.
- Goal 2: Expand and maintain woodlots.
- Goal 3: Enhance and protect the ecological value of Hydro Marsh.
- Goal 4: Enhance and protect the ecological value of Duffins Creek Marsh.
- Goal 5: Enhance and protect the ecological value of Frenchman's Bay.
- Goal 6: Enhance the aquatic environment to support native fish species.
- Goal 7: Provide environmental education, information, communications, community involvement, and employee engagement.
- Goal 8: Maintain Wildlife Habitat Council Certification.
- Goal 9: Maximize the biodiversity potential of lands within the controlled area and along the Lake Ontario shoreline.
- Goal 10: Compile an Inventory of Species and Identify Species at Risk.

This plan was developed based on present and past scientific studies of biophysical effects, biodiversity monitoring of the PN site, and concerns expressed by the local community. The plan also supports the Pickering Waterfront Task Force Report recommendations for re-integration of PN lands into the waterfront (OPG 2003b).

The wildlife management program at PN was certified by the Wildlife Habitat Council (WHC) in 1999, and was re-certified in 2001 and 2004. WHC is a US-based non-profit organization dedicated to increasing the quality and amount of wildlife habitat on private lands. The PN Corporate Lands for Learning Program was certified by WHC in 2001 and was re-certified in 2003 and 2006. PN received the WHC Wildlife Habitat of the Year Award in 2001 and was nominated for the same award in 2004.

2.11.7 Quality Assurance

OPG has programs in place to ensure that the required quality of products, services and operations is properly defined and efficiently achieved. These programs provide a disciplined approach to determining, communicating and attaining the required level of safety, reliability, maintainability, environmental protection and performance. The programs define requirements for work to be done and provide for the integration and co-ordination of pertinent activities.

The existing Nuclear Quality Program will govern the work performed at and for the PNGS B site during both phases of the Project. The existing Nuclear Waste Management Division (NWMD) Quality Program will govern the work performed at PWSMF during both phases of the project. These programs encompass all aspects of NWMD and PNGS B activities including engineering and design, procurement, manufacturing, construction and installation, commissioning, operation, human performance, maintenance, decommissioning and record keeping. The expectations establish requirements to which all employees must comply. Contractors performing work for OPG must also comply with OPG's Quality Program unless they have a separate quality program that has been approved by OPG.

Quality assurance is accomplished by control of activities to comply with the Canadian National Standard CAN/CSA-N286-05. The following processes implement the program:

- a managed system consisting of governing documents that prescribe controls and responsibilities to ensure activities are carried out in a safe, effective manner, by qualified personnel;
- individual accountability for implementing and adhering to the managed system elements; and

- evaluation and enhancement of program elements through continuous improvement processes.

The Quality Programs include provisions for a system of planned audits and assessments designed to provide a comprehensive, critical and independent evaluation of all activities. The audits and assessments monitor compliance with governing codes, standards and technical requirements, and confirm that Quality Program requirements are being effectively implemented. Audit and assessment results are documented, reported to and assessed by a level of management having sufficient breadth of responsibility to assure that action is taken to address findings.

Additional oversight is provided through self-assessments and the corrective action program. In particular, the corrective action program assures that adverse conditions are identified, documented, reported, evaluated and corrected in a timely manner.

2.12 BASIS FOR THE ENVIRONMENTAL ASSESSMENT

Table 2.12-1, referred to as the “Basis for Environmental Assessment”, provides a listing and description of each of the works and activities associated with the Project. This information provides the basis for the assessment of the effects on each of the environmental components.

Since many of the project works and activities have a common interface with the environment, for the purposes of this EA Study, some of them are reorganized and regrouped to reflect how they interface with the environment. The project works and activities are grouped according to the two phases selected for EA purposes, namely: Refurbishment Phase; and Continued Operation Phase.

More details of each of the project works and activities in the Basis for Environmental Assessment table are provided in Sections 2.6 and 2.7.

**TABLE 2.12-1
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Refurbishment Phase</i>	
Site and Facility Preparation for Refurbishment	Site preparation activities include: possible creation of laydown areas; set up of temporary construction facilities; mobilization and positioning of heavy equipment, including cranes, platform trailers, crushers, and solid waste containers; the relocation of temporary and/or permanent structures or buildings in order to position the large crane used for removal and replacement of steam generators; and construction of additional waste storage structures or buildings at the Pickering Waste Management Facility (PWMF).
Defuelling and Dewatering of Reactor	<p>Defuelling and Dewatering includes removing the fuel bundles from the reactor and draining the heavy water from the moderator system and primary heat transport system, and their auxiliaries. Used fuel will be transferred to the irradiated fuel bay consistent with current practice and, after at least ten years of wet storage, transferred to dry storage at the on-site PWMF. After defuelling, the unit to be refurbished will be isolated, to a certain extent, from the operating units; this is called “islanding the unit”.</p> <p>For EA purposes, it is assumed that up to two reactors at a time will be shut down, and thus at least two will continue to operate during that same time. Initial dewatering may result in some increase in radiological emissions from the radioactive liquid waste management system. After the initial dewatering, for each unit shut down for refurbishment, there will be a corresponding approximately proportional decrease in liquid effluent discharges of the Steam and Feedwater System (e.g. boiler blowdown) and Auxiliary Systems, including the Condenser Circulating Water system, Service Water Systems and De-mineralized Water System (and associated water treatment plant effluents). Liquid effluent discharges from the Inactive Drainage System, and the Active Drainage System (and associated Radioactive Liquid Waste Management System) will likely be unchanged during refurbishment.</p>
Management of Heavy Water	Heavy water will be removed from the moderator and primary heat transport systems of the unit being refurbished. The removed heavy water will be collected, packaged and stored in a manner similar to current operating practice. Additional storage capacity will likely be required during the Refurbishment Phase. This could potentially include a new storage building or use of an existing on-site facility. The heavy water will be reused once refurbishment is complete. Heavy water from the moderator and primary heat transport systems will be stored separately.
Replacement of Reactor Components	The following components will be replaced or otherwise refurbished; pressure tubes; calandria tubes; endfittings; shield plugs; closure plugs; spacers; feeder coupling hardware; feeder tubes (up to headers); feeder tube supports; feeder cabinet insulation; and positioning assemblies. Refurbishment/replacement of fuel channels and associated auxiliary system components will be carried out in four stages: vault preparation; removal of fuel channels; installation of new fuel channels; and waste handling.
Removal and Replacement of Steam Generators	Each reactor unit has 12 steam generators, all of which will be removed and replaced. Temporary construction openings will be created in the reactor building domes. The steam generators will be lifted from the reactor building with a large crane through the opening. They will be transferred for interim storage at the PWMF and processed for long-term storage, which will likely be at the Western Waste Management Facility (WWMF). New steam generators will be installed through reversal of the procedure used for removing the old steam generators.

TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY

Project Phase / Works and Activities	Description
<i>Refurbishment Phase (Cont'd)</i>	
Refurbishment of Reactor Auxiliary Systems and Feedwater Systems	Refurbishment/upgrades of the reactor auxiliary systems includes normal maintenance and repair to be undertaken during each refurbishment outage, and maintenance activities normally required for the refuelling and restart of any reactor unit.
Upgrades and Maintenance to Other Systems (Balance of Plant)	Upgrades and Maintenance to Other Systems (Balance of Plant) includes the normal repair and maintenance of nuclear and non-nuclear components to be undertaken during each refurbishment outage. One possible upgrade is the replacement of the low pressure turbines with new higher efficiency turbines. Radioactive wastes generated as a result of this activity are expected to be the same as the wastes generated during normal station operation.
Construction of Structures for Low and Intermediate Level Refurbishment Waste	New structures and buildings, which may be required for managing refurbishment waste (steam generators and fuel channel assemblies) within the PN site, will include structures similar to the storage buildings at the PVMF or WWMF, modified as required to address the specific waste packaging requirements. The building design will envelope the requirements for both retube waste storage and used fuel dry storage applications. The building will be provided with the necessary shielding to meet OPG dose rate target for the public of 10 µSv/y at the Pickering site boundary. These are single storey, commercial-type pre-engineered or pre-cast concrete structures with a concrete slab-on-grade floor, and passive ventilation. The structures will be designed to meet the requirements of the National Building Code of Canada in effect at the time of construction approval.
Management of Refurbishment (nuclear) Waste (interim storage of waste at PVMF)	<p>Refurbishment activities will generate intermediate and low-level radioactive wastes (ILW and LLW, respectively). The volume of ILW and LLW generated (as-shipped) resulting from refurbishment activities will amount to approximately 10,000 m³.</p> <p>Pressure and calandria tubes will be removed and disposed of by cutting, crushing, chopping and packaging. End fittings will be removed and packaged. Packages will be transferred to the PVMF or WWMF for management.</p> <p>The steam generators will be sealed and loose contamination on exterior surfaces will be removed or fixed prior to removal from the reactor building, then transferred to the PVMF for possible processing and interim storage, or transported to the WWMF for centralized storage. Processing of steam generators may include: segmentation, welding of steel plates over openings, backfilling of the shell and/or tubes with grout, separation of shell from tubes, or other similar activities in order to size reduce the vessels and/or prepare them for emplacement in a repository. The processing may occur at Pickering or at an external site (such as an appropriate third party vendor facility or at the WWMF). Processing may occur shortly after removal or may occur in the future after some years of interim storage.</p> <p>Upgrades to the heat transport and feedwater systems are expected to generate low-level waste which will be processed on site (reduced and packaged), and may be placed in interim storage. All LLW and ILW will subsequently be transported to the WWMF for long term storage and eventual disposal.</p>
Transfer of Low and Intermediate-Level Refurbishment Waste on the Pickering Site	<p>Old steam generators will be prepared for transfer (decontamination of exterior surfaces, sealing of perforations), loaded onto multi-wheeled transporters, and transferred for interim storage at the East Complex (PVMF).</p> <p>Fuel channel assembly wastes will be placed into retube waste containers which will be transferred from the reactor face, through the station, and out to the proposed storage buildings at the PVMF.</p> <p>Feeder pipes and similar wastes will be packaged into standardized waste containers for transfer to the WWMF.</p>

TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY

Project Phase / Works and Activities	Description
<i>Refurbishment Phase (Cont'd)</i>	
Transportation of Low and Intermediate-level Refurbishment Waste to the WWMF	OPG has been safely transporting LLW and ILW and other radioactive materials from the PN site to the WWMF for over 32 years. All wastes requiring off-site transportation would be managed using OPG's existing, approved transportation processes. Any additional transportation packages required for specific wastes would be designed, licensed, and procured according to OPG's existing processes and applicable CNSC regulations.
Management of Non-Nuclear Waste	Non-radioactive wastes (e.g. lubricants, oils, construction debris) will be generated during refurbishment activities. Non-radioactive wastes will be re-used or recycled where feasible. Hazardous wastes will be handled in accordance with regulations and shipped off site to licensed disposal facilities. Non-hazardous solid wastes meeting landfill requirements will be disposed of at an off-site landfill.
Refuelling Reactors	Refuelling includes loading the reactors with the initial load of fuel, refilling the moderator and refilling the primary heat transport system. Each reactor will require 4,560 natural uranium fuel bundles for the initial refuelling. Fresh fuel receipt and storage will be consistent with current normal operating practices. Refilling the moderator and primary heat transport system involves the transportation of and pumping in of 242 m ³ and 139 m ³ of heavy water, respectively.
Restarting Reactors	Restarting reactors consists of system startup and testing, raising power and generating electricity for the electrical grid. At each regulatory hold point, specified requirements will be met and regulatory approvals will be obtained prior to proceeding. Following the extended planned outages, reactor systems will be systematically started up, configured for reactor operation, and tested as needed. Newly installed equipment and components will be tested. Nuclear fission reactions in the reactor core will be increased in a controlled manner until criticality is achieved. Reactor power will then be increased in a controlled manner. The unit's electrical generator will be connected to the grid and the unit will return to full power operation. Once the reactor core approaches equilibrium conditions, routine on-power refuelling will begin. Returning the reactor to full power will produce used nuclear fuel and purification wastes, such as filters and ion exchange resins. At the end of the Refurbishment Phase, all four reactors will be operational.
Workforce, Payroll and Purchasing	In addition to the approximately 1,650 OPG full-time employees at PNGS B, and 1,200 full-time employees at PNGS A, refurbishment would require, as a maximum for the refurbishment of each unit, an incremental labour force (contractors) of approximately 2,000 workers. In addition to labour force transportation, this activity also captures the transport and materials and replacement components to the site for refurbishment activities.

TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY

Project Phase / Works and Activities	Description
<i>Continued Operation Phase</i>	
Reactor Core	<p>The reactor consists of the reactor assembly and reactivity control devices.</p> <p>The calandria vessel is axially penetrated by 380 calandria tubes. The calandria tubes provide access through the calandria vessel for the 380 fuel channel assemblies containing nuclear fuel.</p> <p>The reactor core has neutron absorbing devices, both liquid and solid, to control reactivity. During operations, reactivity is controlled by adjuster rods, control absorbers and zone controllers. Under emergency or accident conditions, shutoff rods or liquid poison injection into the moderator achieves fast reactor shutdown.</p>
Reactor Process Systems and Safety Systems	<p>Reactor Process Systems comprise the heat transport and auxiliary systems, steam and feedwater systems, and the moderator and auxiliary systems.</p> <p>Heat Transport Systems: The heat transport system circulates heavy water through the reactor fuel channels to remove the heat produced by the fission of uranium fuel within the fuel bundles. The heat is transferred to light water in the steam generators located inside the reactor building. This system is entirely separate from the moderator system and captures the vast majority of the reactor's heat output. It consists of 380 reactor fuel channels, 12 steam generators, 16 main circulating pumps, 2 pressurizing pumps, and 4 shutdown cooling loops. Chemistry of the reactor coolant is controlled by filtering, ion exchange, and chemical addition.</p> <p>Steam and Feedwater Systems: For each reactor, steam from the 12 steam generators flows through main steam piping from the reactor building to the turbines in the powerhouse. The feedwater system consisting of a low pressure (condensate) circuit and a high pressure (boiler feed) circuit, collects the condensed steam from the turbine and supplies it to the boilers.</p> <p>Moderator and Auxiliary Systems: The calandria is filled with a heavy water moderator. The moderator slows down neutrons from fission in the fuel, increasing the opportunity for these neutrons to trigger additional fissions. The heavy water moderator is circulated and cooled. The system is separate from the heat transport system. The moderator auxiliary systems include the moderator purification system, moderator cover gas system, moderator heavy water collection system, and liquid poison system.</p> <p>Special Safety and Safety-Related Systems: A multiple barrier approach has been built into the design of PNGS B to control releases of radioactivity to the environment.</p> <p>There are four independent special safety systems designed to ensure that a reactor is safely shutdown, the fuel remains cooled, and radioactivity is contained in the unlikely event of an accident. The four special safety systems are Shutdown System No. 1, Shutdown System No.2, Emergency Coolant Injection System, and Containment System. These systems have no process function in the production of electricity.</p>

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Turbine/Generator and Auxiliaries	<p>Turbine/Generator and Auxiliaries comprise the turbine/generator, steam supply, main condenser, feedwater heating system and auxiliary systems.</p> <p>Turbine/Generator System: Each of the PNGS B units has one turbine/generator unit and its auxiliary systems. Each turbine generator is independent, operating in conjunction with its own nuclear reactor. The rated speed of the turbine is 1,800 rpm for 60 Hz operation.</p> <p>Steam Supply: For each reactor, steam is produced by 12 steam generators, and transported by four pipes to each turbine/generator.</p> <p>Main Condenser: Steam from the turbines exhausts into the condenser shells where it is condensed using lake water and collected in the hotwells. External makeup to the closed loop steam and feedwater system is into the hotwells from the demineralized water storage tank.</p> <p>Feedwater Heating System: The feedwater heating system supplies feedwater to the steam generators, preheats the water to achieve a good heat rate, deaerates the water at the optimum point in the thermal cycle, provides suction head for the condensate and boiler feed pumps, and is a source of pressurized, treated water for the boiler feed pump gland sealing system and the turbine cooling system.</p> <p>Auxiliary Systems: The major turbine/generator auxiliary systems are: the sampling system, which permits sampling steam and feedwater for chemical analysis; the steam drain system, which recovers heat and treated water from the various plant drains; the chemical injection system, which eliminates the residual oxygen from the deaerated feedwater and controls its pH; and the condenser circulating water system (CCW) which supplies cooling water to the condenser. The open-loop CCW system supplies cooling water to the condensers to condense the turbine exhaust steam. CCW flow is drawn from Lake Ontario at a rate of 29,000 L/s per reactor through the PNGS B screenhouse. After cycling through the condenser, cooling water is discharged to the CCW duct. The CCW discharges from all four units flow into Lake Ontario via the PNGS B discharge channel.</p>
Electrical Power Systems	<p>Electrical Power Systems include electrical distribution (switchyard and main transformers); on-site power system and generation of emergency power. These systems deliver power to the grid and supply electrical power throughout the station.</p> <p>Switchyard and Main Transformers: A 230 kV switchyard is located on the north side of the station and connects to the transmission line. During normal operation, the output of PNGS B goes to the 230 kV system through four, three-phase, 230 kV circuits to Cherrywood Switching Station.</p> <p>On-Site Power System: Power used internally at PNGS B is supplied both from the unit itself and from the grid. This division increases the reliability of the electrical supply. Several buildings largely used for administration or general support functions are supplied with electricity from the grid.</p> <p>Generation of Emergency Power: Standby power is available from six independent gas turbine driven generators in the event that the station is disconnected from the grid. The standby generators are supplied with No. 2 fuel oil which is stored in two storage tanks. Emergency electrical power can also be supplied by two emergency power generators which are independent and separate from the standby generators.</p>

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Electrical Power Systems (Cont'd)	<p>Auxiliary Power System: Consists of two combustion turbine units (system will be available in 2007) to supply electrical power to PNGS B and PNGS B in the event of a loss of power supply from the grid.</p>
Fuel and Fuel Handling	<p>Fuel and Fuel Handling includes receipt, handling and storage of fresh fuel and irradiated fuel, as well as irradiated cobalt storage and handling, and fuel defect detection.</p> <p>Fuel: The reactor is fuelled with natural uranium in the form of pellets of uranium dioxide. Each of the reactor's 380 fuel channels contains 12 bundles to provide 4,560 bundles per reactor.</p>

Project Phase / Works and Activities	Description
	<p>Fuel Storage and Handling: The fuel handling system comprises equipment required for fuel changing, for the storage of fresh fuel, and for on-site storage of irradiated fuel. There are facilities for bulk storage of fresh fuel, safe transfer of fuel to the reactor building, inspection of the fuel in the fresh fuel loading areas, and manual loading of fresh fuel bundles into motorized fuel magazines.</p> <p>The fuelling system comprises two fuelling machines per reactor. Fresh fuel bundles are pushed into one end of the fuel channel by a remotely operated ram in one fuelling machine. Irradiated fuel bundles are simultaneously discharged at the other end of the channel into another fuelling machine.</p> <p>Irradiated fuel handling facilities consist of discharge and transfer equipment in the reactor building and irradiated fuel receiving, inspection and storage facilities in the irradiated fuel storage bay. The irradiated fuel storage bay is located between Unit 6 and Unit 7. Irradiated fuel is transferred into storage baskets, each holding 16 pairs of bundles, and then into storage modules in the irradiated fuel bay. Modules hold 4 pairs of bundles.</p> <p>The irradiated fuel bay cooling and purification system is designed to: maintain the temperature and level of the storage bay water and conveyor ducts; maintain the optical clarity of the water; and remove radionuclides from the water. Filters, ion exchange columns and heat exchangers are used.</p> <p>Irradiated Cobalt Storage and Handling: Following an irradiation period in the reactor, the cobalt adjuster elements are removed from the adjuster sites, transported to the Auxiliary Irradiated Fuel Bay (AIFB) where they are stored underwater and subsequently processed for shipment off site for use in medical and commercial irradiation facilities.</p> <p>Fuel Defect Detection: Fuel defects in the PNGS reactors are detected by two means. The presence of fuel defects in the reactors is detected through increased levels of fission products in heat transport system water samples. The presence of fuel defects in fuel discharged from the reactor (following channel refuelling) is detected through increases in gamma activity levels during transfer of fuel to the irradiated fuel bay.</p>

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Auxiliary Systems	<p>Auxiliary Systems consists of: water systems, drainage systems, process auxiliaries, heating and ventilation, heavy water management, other auxiliary systems, on-site transportation, and non-radioactive materials management.</p> <p>Water Systems: Water is drawn from Lake Ontario into the powerhouse. Pumps supply water to the condenser circulating water system and the service water systems. The station has the following water systems: condenser circulating water system; low-pressure service water system; high-pressure service water system; re-circulated cooling water system; emergency water system; sediment suction system; demineralized water system; and domestic water system.</p> <p>Drainage Systems: The on-site drainage system is subdivided into inactive drainage, active drainage, sewage system and storm water drainage. The inactive drainage system collects drainage from floor drains and utility drains from the turbine hall and turbine auxiliary bay as well as foundation drains. The water collects in a sump on each unit, and is pumped via a header common to all units to a holding pond where it is sampled as it is discharged to the lake. This water is normally inactive. The active drainage system segregates liquid waste by the degree of contamination and directs it to the receiving tanks of the radioactive liquid waste management system. The sewage system collects waste throughout the PNGS A and B complex and discharges it into the Regional Municipality of Durham sewage mains. Stormwater is discharged directly to Lake Ontario at various locations. Measures such as good housekeeping, drain covers in areas of potential oil contamination and use of swales and ditches are used to minimize contamination of stormwater.</p> <p>Compressed Air Systems: The compressed air systems consist of instrument air, service air and breathing air. Instrument air is provided by compressors at each unit. Air receiver tanks store instrument air for use during a temporary loss of power. The service air for all four units of PNGS B is supplied by one system. The breathing air is also supplied by one system.</p> <p>Heating and Ventilation: The heating systems are required to provide comfort to people working inside the plant and prevent equipment and line freezing during plant shutdown in the winter. Steam, electricity, and hot water are used for heating. Ventilation and air conditioning systems are provided to control temperature, moisture and atmospheric conditions as needed for employees and station equipment.</p>

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Auxiliary Systems (Cont'd)	<p>Heavy Water Management: Measures to minimize the loss and downgrading of the heavy water, which escapes from the heat transport and moderator systems, include the following: heavy water is transferred throughout the station by pumps and piping systems wherever practical; minimizing the use of drums; the number of mechanical joints in heavy water systems is minimized; areas in the reactor building where heavy water leaks can occur are on drying circuits and have vapour barriers and sealed doors; and heavy water collected from leakage and vapour recovery is processed and upgraded for reuse.</p> <p>The heavy water supply system has five storage tanks. The heavy water in the storage tanks can be pumped directly to the moderator or heat transport system of any unit, or to bulk packages or drums for shipment to the Darlington Tritium Removal Facility.</p> <p>There are cleanup (ion exchange columns and filters) and upgrading facilities for recovered heavy water, common to both PNGS A and B. Segregation of moderator (high tritium) and heat transport (low tritium) heavy water is maintained. There are heavy water vapour recovery circuits in each reactor building to dry the atmosphere in areas that are subject to heavy water leakage during operation or servicing of equipment.</p> <p>Other Auxiliary Systems: Other auxiliary systems at PNGS B include: communication systems; lighting systems, site security facilities.</p> <p>On-Site Transportation: There is an extensive existing road network at the PN site including the roadways and parking lots necessary to service PNGS B. The roads are used by employees, contractors and visitors to drive to and from the site, as well as for the transfer of materials.</p> <p>Non-Radioactive Materials Management: Chemicals, gases, lubricants and oils comprise the largest volume of non-radioactive materials handled at PNGS B. Other materials include conventional industrial and office supplies that are shipped to the site by truck, and generally stored in warehouses or where they are used.</p>
Maintenance and Repair	The maintenance program includes preventative and corrective maintenance, as well as improvement or upgrade activities during operations.
Interim Storage of Refurbishment Waste at WWMF	Refurbishment waste will be stored at PWWMF until transferred to the WWMF for long-term storage or eventual disposal.

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Management of Operational Low and Intermediate-Level Waste	<p>Radioactive Solid Waste Management: This includes LLW and ILW such as spent ion exchange (IX) resins, non-processible waste maintenance wastes, incinerable wastes, and miscellaneous wastes including insulation, floor sweepings, etc. PNGS B operations results in LLW and ILW volume of approximately 150 m³ per unit per year (as stored), which is transported to the WWMF for processing and long term storage.</p> <p>Radioactive Liquid Waste Management: The radioactive liquid waste management system (RLWMS) is common to PNGS A and B. The RLWMS receives and treats the waste streams directed to it by the active drainage systems. The system discharges treated wastes at a controlled rate to Lake Ontario through the CCW discharge ducts and the PNGS A and PNGS B discharge channels.</p> <p>Radioactive Gaseous Waste Management: Gaseous wastes from potentially active areas, such as reactor buildings, are monitored for activity before release to the atmosphere. The gases from the active ventilation stacks are filtered through absolute and charcoal filters before being released, to minimize the release of radioactivity.</p>
Transport of Operational Low and Intermediate-Level Waste to the WWMF	OPG has been safely transporting LLW and ILW and other radioactive materials from the PN site to the WWMF and other destinations for over 32 years. All wastes requiring off-site transportation would be managed using OPG's existing, approved transportation processes. Any additional transportation packages required for specific wastes would be designed, licensed, and procured according to OPG's existing processes and applicable CNSC regulations.
Interim Storage of Used Fuel at PWWF	Irradiated fuel is stored in the irradiated fuel storage bay for a minimum period of 10 years before being transferred to Dry Storage Containers (DSCs) for interim storage at PWWF until a long-term storage facility is available. PNGS B produces approximately 3,480 used fuel bundles per unit per year at full power. Used fuel will ultimately be managed in a long-term facility to be sited, constructed and operated by the federally mandated Nuclear Waste Management Organization (NWMO).
Construction of Additional Storage Structures at WWMF for Additional Used Nuclear Fuel	Additional storage facilities for used fuel are planned for the PWWF and are subject to a separate CNSC approval. Used fuel in Dry Storage Containers (DSCs) is placed at PWWF for interim storage. To the end of 2006, 165,500 bundles of fuel were in dry storage at PWWF. There are currently two storage buildings with a combined capacity of 251,000 bundles. A third building, which has EA and construction approval is planned for operation in 2008, and EA and construction approval has also been given for a fourth storage building. It is anticipated that a fifth storage building will be required to accommodate the additional used fuel that is expected from the continued operation of PNGS B; this building is part of the Project. The modular nature of the dry storage concept allows storage buildings to be constructed on an as-required basis.

**TABLE 2.12-1 (Cont'd)
BASIS FOR EA STUDY**

Project Phase / Works and Activities	Description
<i>Continued Operation Phase (Cont'd)</i>	
Management of Non-nuclear Waste	<p>Non-Radioactive Waste Management: Non-radioactive wastes will be re-used or recycled where feasible. Hazardous wastes are handled in accordance with regulations and are shipped off site to licensed disposal facilities. Non-hazardous solid wastes meeting landfill requirements are disposed of accordingly in an off-site landfill. The total solid waste volume arising for disposal in 2005 was approximately 1,600 tonnes while the volume of recycled materials was approximately 2,120 tonnes. Non-radioactive gaseous and liquid emissions are controlled in accordance with provincial Certificate of Approval requirements.</p> <p>Management of PCBs: PNGS B has limited equipment that contains PCB material; however, there are no PCB-containing transformers. Two locked and secured areas have been designated exclusively for PCB waste storage within PNGS B and on the East Complex. These waste materials typically consist of PCB-containing capacitors and lighting ballasts. PCB-containing equipment is disposed of off-site in compliance with MOE and Environment Canada regulations. No treatment occurs on site. PNGS follows specific procedures for the handling and storage of PCB-containing equipment.</p> <p>Management of Asbestos: An asbestos management program exists at PNGS B to ensure that all work that may involve asbestos-containing materials is properly identified and controlled. Procedures, training and equipment are in place to ensure that exposure to asbestos will be minimized and asbestos-containing wastes will be disposed off in accordance with regulatory requirements.</p>
Administration, Purchasing and Payroll	Upon completion of the Refurbishment Phase of the project, the estimated staff and deliveries and supply of equipment required for the operation of PNGS B is expected to be the same as currently required.
Security, Safeguards and Emergency Response	These systems include PNGS B security systems (not described in public material as this is prescribed information); non-proliferation treaty compliance systems (owned by IAEA); fire protection and emergency response systems. The equipment installed at PNGS B for detecting and extinguishing fires complies with the National Building Code and other applicable codes and standards.