APPROACH TO ECOLOGICAL RISK ASSESSMENT AT PICKERING NUCLEAR

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1.0 INTRODUCTION

Pickering Nuclear (PN) conducted an issue-based *Environmental Review* of its operations in 1998 and submitted a comprehensive report summarizing this review to the Atomic Energy Control Board (AECB) in November, 1998 (SENES and GLL 1998). AECB staff comments on the report indicated a desire to see a Screening Level Ecological Risk Assessment (ERA) done to identify the key effects of the station's operations on biota in the vicinity of PN.

At the AECB hearings on PN's licence application, held on 25 March 1999, the Chief Nuclear Officer of Ontario Power Generation (Mr. C. Andognini), confirmed to the AECB (Dr. A. Bishop) that PN will undertake an initial screening level ERA for PN operations, and submit a Work Plan document to the AECB in October 1999. It was further agreed that PN staff would meet with AECB staff in June 1999, to discuss and confirm the scope of the assessment. These agreements became a regulatory commitment. The ERA project for PN is the result of this regulatory commitment. It takes into consideration the comments and recommendations received from AECB staff members, the PN *Environmental Review* project and a Community Advisory Committee (CAC).

2.0 APPROACH TO ERA AT PICKERING NUCLEAR

An ERA is the process of evaluating the risk of an adverse effect from an activity in order to improve decision making for the protection of plants and animals.

PN is following standard key elements of ERA as outlined in guidance documents (Environment Canada 1994, CCME 1996, MOEE 1996). Given that a considerable amount of environmental information was assembled as part of the PN *Environmental Review* project, the focus of the PN Screening Level ERA is on extracting relevant information from that report, integrating the various findings and using the ERA methodology to identify key effects and risks of PN operations on ecosystem components of concern at the PN site.

Typically, ERAs follow an iterative, tiered approach beginning with an ERA Plan and a Screening Assessment, or a Tier 1 ERA. Depending on the results of these two stages, there may be a need for a more detailed ERA.

The PN ERA project is being carried out in phases as shown in Figure 1:

(i) The objective of *the first phase* (Phase (i)) was to prepare an ERA Work Plan document for review by the AECB. This ERA Work Plan has been based on a framework developed by the Canadian Council of Ministers of the Environment (CCME) and Environment Canada. This framework identifies the work plan as an important first step in undertaking a screening level ERA. It defines and places boundaries on the problem and approach to undertaking the ERA. The first phase draws on the existing PN *Environmental Review* report, as well as findings of other studies recently completed or underway.

The work plan was submitted to the AECB October 30, 1999.

(ii) *The second phase* (Phase (ii)) of the project implements this Work Plan. This phase of the work was initiated in 2000 and is currently underway. A follow-up program (Phase (iii)) will be defined if necessary (Figure 1).

3.0 VALUED ECOSYSTEM COMPONENTS AND INDICATOR SPECIES AT PN

Broad Valued Ecosystem Components (VECs) were identified in the PN *Environmental Review*. These are:

- Hydro Marsh and Frenchman's Bay
- groundwater resources
- Lake Ontario surface water and drinking water
- inshore and lake-wide fish
- air quality

Although these VECs provide the focal point for the ecological assessment, they are too broad and too vague for scientists to quantify and measure. Specific indicator species were therefore selected to represent the broad VECs. They are used as "receptors" in ERA calculations. Not all species need to be considered as indicator species. The intention is to select one or two species which would best represent change or impact to the VEC from the defined site activities. The indicator species, for the most part, reflect the top trophic level, or a key food source in the food chain.

The criteria used to select indicator species for the PN Screening Level ERA study include both sociological and scientific criteria. Sociological criteria include, for example, socio-economic status and conservation status of the biota. The choice of indicator species is also guided by scientific selection criteria to ensure that the choice is relevant and practical.

A recent biological inventory compiled by the Toronto Regional Conservation Authority in the PN area provided input into the compiled list of indicator species.

The selected indicator species were assessed for their potential to represent environmental changes due to thermal effects and impingement/entrainment, as well as their potential to be affected by radiological or non-radiological contaminants. Not all indicator species are equally vulnerable to all stressors and therefore different ones are used depending on the specific assessment being undertaken.

The indicator species assessed in the PN Screening-Level ERA include:

- fish: alewife, round whitefish, smallmouth bass, northern pike, brown bullhead
- terrestrial birds: great horned owl, herring gull
- aquatic birds: double-crested cormorant, lesser scaup
- terrestrial mammals: red fox
- aquatic mammals: muskrat
- amphibians: northern leopard frog
- invertebrates: earthworms, benthic invertebrates
- terrestrial plants: pines
- livestock: dairy cows, poultry
- humans (visitors and contractors) are assessed (within a human-health risk assessment framework) as an indicator on drinking water quality and air quality

Additional indicator species are being considered for the PN Screening-Level ERA based on comments received from the public through the CAC and based on discussions during a technical workshop conducted as part of the study. These additional indicator species include: trumpeter swan, white sucker, meadow vole and pets (a cat and a dog).

4.0 THE CONCEPTUAL MODEL

The list of main stressors included in the PN Screening Level ERA is provided in Table 1. Both radioactive and non-radioactive contaminants are listed, along with the environmental pathway which they follow, i.e. emission to surface water, groundwater, air or soil.

Table 1
SUMMARY OF STRESSORS INCLUDED IN THE PN SCREENING LEVEL ERA

CATEGORY	STRESSOR
Radioactive Contaminants	
Radioactive emissions to air	H-3, noble gases, C-14, I (mixed fission products), particulates, Cr- 51, Mn-54, Fe-59, Co-58, Co-60, Zn-65, Sr-89, Sr-90, Zr-95, Nb-95, Ru-103, Ru-106, Sb-124, Sb-125, Cs-134, Cs-137, Ba-140, Ce-141, Ce-144, Eu-152, Eu-154, Gd-153
Radioactive emissions to surface water	H-3, C-14, Mn-54, Fe-59, Co-58, Co-60, Zn-65, Sr-89, Sr-90, Zr-95, Nb-95, Ru-103, Ru-106, Sb-124, Sb-125, I-131, Cs-134, Cs-137, Ba-140, Ce-141, Ce-144, Eu-152, Eu-154, Gd-153
Radioactive emissions to groundwater	H-3, C-14, Cs-137
Radioactive contaminated soil	Gamma, H-3, C-14, Cs-137
Non-radioactive Contaminants	
Non-radioactive emissions to air	SO_x, NO_x, CO_2, CO, hydrocarbons, particulates, Ozone-Depleting Substances, hydrazine, chlorine
Non-radioactive emissions to surface water	residual chlorine hydrazine and morpholine and degradation products Cu, Zn, Pb, As suspended solids, oil and grease, road salts
Non-radioactive emissions to groundwater	TPH[1] (e.g. fuel oil) metals (Cu, Hg, Zn, Ag) PCBs, solvents hydrazine and degradation products
Non-radioactive contaminated soil	PCB TPH (e.g. fuel oil) inorganics (Cu, Zn, B)
Direct Losses	
	impingement/entrainment
Physical Effects	
	thermal plume

1 TPH - Total Petroleum Hydrocarbon.

A conceptual model that shows the relationship between the ecological receptors, the relevant contaminated environmental media, the expected potential modes of exposure and the ecological effect of interest is shown schematically in Table 2. The model is designed to consider food web relationships among receptors.

Table 2
SCHEMATIC CONCEPTUAL MODEL[(1)]

Receptor	Screening Level Environment	Environmental Pathways	Modes of Exposure	Effect of Interest
Fish	Outfall	- surface water - sediment	- ingestion (as appropriate: water, plankton, other fish, benthos) - immersion in water (radioactive dose only) exposure to sediment (radioactive dose only)	population
Amphibians	Hydro Marsh	- surface water - sediment	- ingestion (as appropriate: water, aquatic invertebrates) - immersion in water (radioactive dose only) exposure to sediment (radioactive dose only)	population
Invertebrates (Aquatic)	Frenchman's Bay	- surface water - sediment	- ingestion (as appropriate: water, plankton) - immersion in water (radioactive dose only) exposure to sediment (radioactive dose only)	population
Plants (Aquatic)	Hydro Marsh	- surface water	- uptake - immersion in water (radioactive dose only)	population
Invertebrates (Terrestrial)	PN site	- soil - groundwater	- ingestion (as appropriate: soil,) - immersion in soil (radioactive dose only)	population
Plants and Crops (Terrestrial)	PN site	- soil	- uptake - exposure to soil (radioactive dose only)	population
Birds	Outfall DFSF[(2)] roof and reactor roof	- air - surface water	- ingestion (as appropriate: water, fish, benthos, terrestrial vegetation, aquatic vegetation, rodents, soil) - inhalation - immersion in air (radioactive dose only)	population
Non-human mammals	Hydro Marsh PN site	- surface water - air - soil	- ingestion (as appropriate: water, fish, terrestrial vegetation, aquatic vegetation, rodents, soil) - inhalation - immersion in air (radioactive dose only) - exposure to soil (radioactive dose only)	population
Livestock	Nearby agricultural location	- air - soil	- uptake of radionuclides by vegetation - ingestion of radionuclides by livestock (terrestrial vegetation) inhalation of radionuclides by livestock	individual livestock
Humans	PN site and vicinity	- surface water - air	- ingestion - inhalation - immersion in air (radioactive dose) - exposure to soil (radioactive dose)	individual health

Notes:

1 Conceptual model developed as per CCME (1996, p. 9). Mechanism of transport addressed by using either an end-of-pipe concentration or monitored concentration at receptor locations. Transfer factors are documented in Supporting Document.

2 Dry Fuel Storage Facility.

5.0 ERA METHODOLOGY

The methodology used in the ERA Study follows standard procedures for pathways analysis and contaminant uptake by biota.

For radioactive contaminants the PN Screening Level ERA focuses on estimating dose to flesh using the methods recommended by IAEA (1992) and UNSCEAR (1996). Relative Biological Effectiveness (RBE) factors in included in the analysis. These factors account for differences in effects between different types of radiation. An RBE factor of 3 for tritium, and 1 for beta and gamma emitters is used (UNSCEAR 1996).

For non-radioactive contaminants, the proposed methodology follows standard procedures for estimating uptake and exposure (U.S. EPA 1997). Data for the models (e.g. transfer factors) are compiled in the ERA Phase (i) Supporting Document (SENES, 1999).

Regarding the methodology for physical alteration and thermal effects, past PN-A and PN-B studies and more recent studies (PARTS EA) evaluate ecological risks from physical alterations, temperatures, intake water withdrawal and discharge fishing. The Past PN-A/PN-B environmental effects monitoring and Fish Impingement Technical Committee (FITC 1992) work also dealt with these issues in depth. The PN Screening Level ERA revisits these studies to decide what gaps there are that may need filling.

The evaluation of direct losses due to impingement/entrainment is also based on existing reports.

The PN Screening ERA is currently underway and a draft will be submitted to the AECB for review in August 2000. A final Screening ERA report will be submitted in October 2000. The results of the ERA will be used to define the need for a more realistic ERA taking uncertainty in the data into account and to evaluate the need for other follow-up programs.

This study of the ecological effects of radioactive and chemical contaminants, physical stressors and direct losses within a single ERA framework is a new, emerging science and is not currently routinely done by industry. The additional complexity (in the PN assessment) caused by the urban/industrial location of the PN site further increases the technical challenge faced by the ERA team. However, the assessment of multiple stressors within an ERA framework is important, even at a conservative screening level, in that it provides insight for screening out some stressors to help define any followup actions concerning the natural environment of PN.

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FIGURE 1

THE ERA PROCESS