

# A Critical Review of Health Impact Assessments in Ontario's Nuclear Industry

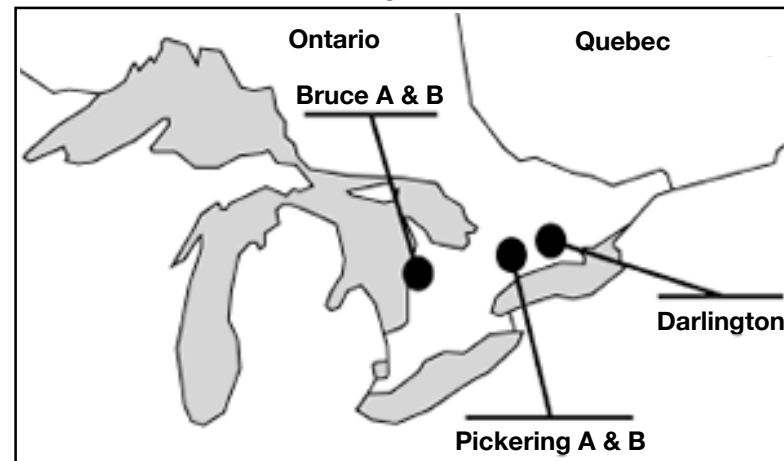
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## Introduction

For the first time since the 1970s, the construction of new nuclear installations is being considered in Ontario. The approval process is governed by EA, which has not traditionally been geared toward human health. Recent practices in Canadian EA, however, have been to embed a parallel Health Impact Assessment (HIA) into the EA process, although uncertainties remain over methods and impact prediction. Risk is central to the health effects of nuclear power plants; such regulatory tools as Health Risk Assessment (HRA) and Probabilistic Risk Assessment (PRA) are used to quantify chronic and catastrophic risks, respectively. The regulator in Canada, the Canadian Nuclear Safety Commission (CNSC), purports to employ a combination of International Best Practices and risk-informed decision-making to ensure the safety of Canadian plants. The main objective of this research was to identify a set of HIA Best Practices, established by the concordance of authorities in the peer-reviewed literature and an interview process, and use these criteria to evaluate six EISs of recent nuclear power projects at the Bruce, Darlington, and Pickering stations in Ontario.

## Study Area

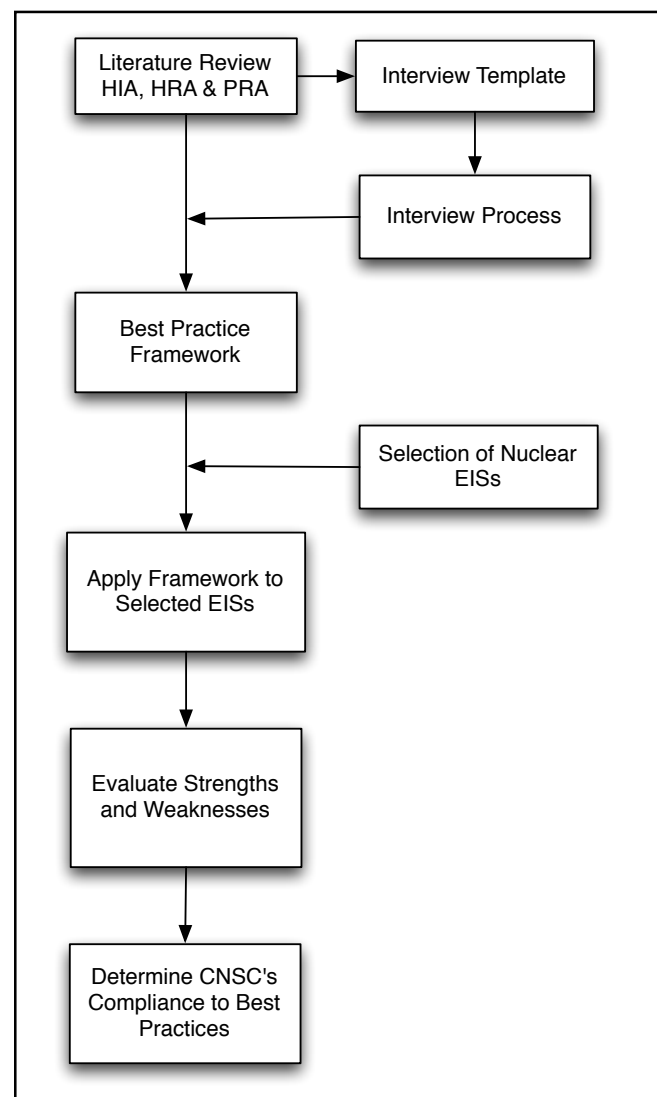


## Best Practices Evaluation Criteria

## Results

Reviewed EA	Hazard Identification	Exposure Assessment	Dose-Response Assessment	Risk Characterization	Process
Pickering A Restart	C 7/11	B 17/22	C 9/15	C 13/19	A 13/16
Bruce A Restart	C 7/11	B 17/22	C 9/15	D 11/19	C 11/16
Bruce A Refurbishment	B 8/11	B 17/22	F 6/15	C 12/19	F 8/17
Pickering B Refurbishment	B 8/11	A 18/22	C 10/15	B 14/19	B 13/17
New Bruce	B 9/12	A 18/22	F 5/15	C 13/19	B 12/17
New Darlington	D 7/12	A 18/22	C 10/15	B 15/19	B 13/17

## Methods



Hazard Identification Criteria
<ul style="list-style-type: none"> <li>1.1 Description of proposed reactor technology?                             <ul style="list-style-type: none"> <li>1.1.1 Mentions safety features of each alternative?</li> <li>1.1.2 Characterizes emission differences?</li> </ul> </li> <li>1.2. Identifies all possible health hazards for each project phase?</li> <li>1.3. Considers increasing reactor emissions (probabilistic distributions)?</li> <li>1.4. Discussion of accident scenarios with PRA?                             <ul style="list-style-type: none"> <li>1.4.1. Includes both internal and external events?</li> <li>1.4.2. Incorporates acts of sabotage?</li> <li>1.4.3. Defines source terms for all accident scenarios?</li> </ul> </li> <li>1.5. Discussion of wastes?                             <ul style="list-style-type: none"> <li>1.6. Mentions types and quantities for each project phase?</li> <li>1.7. Discusses method of long-term disposal?</li> </ul> </li> </ul>
Exposure Assessment Criteria
<ul style="list-style-type: none"> <li>2.1. Exposed population identified?                             <ul style="list-style-type: none"> <li>2.1.1. Geographic description of site?</li> <li>2.1.2. All possible exposure pathways included?</li> <li>2.1.3. Consulted public about habits?</li> <li>2.1.4. Vulnerable groups identified?</li> <li>2.1.5. Environmental fate of radionuclides considered?</li> </ul> </li> <li>2.2. Describes baseline health status of exposed population?</li> <li>2.3. Evidence of environmental monitoring for baseline contamination?                             <ul style="list-style-type: none"> <li>2.3.1. Use of these data in HRA calculations?</li> <li>2.3.2. Use of these data to verify environmental modeling?</li> <li>2.3.3. Distribution of radiation exposures used for public/worker exposures?</li> <li>2.3.4. Upper and lower dose ranges given for workers?</li> <li>2.3.5. Dosimetry for workers practiced?</li> </ul> </li> <li>2.4. All sources of radiation considered?                             <ul style="list-style-type: none"> <li>2.4.1. Voluntary vs. involuntary exposure distinguished?                                     <ul style="list-style-type: none"> <li>2.4.2. Explicit section on tritium?   <ul style="list-style-type: none"> <li>2.4.2.1. Differentiates between HTO and OBT?</li> </ul> </li> </ul> </li> </ul> </li> <li>2.5. Non-radioactive hazardous emissions assessed?                             <ul style="list-style-type: none"> <li>2.5.1. Baseline concentrations established?</li> </ul> </li> <li>2.6. Addresses half-lives of radionuclides?                             <ul style="list-style-type: none"> <li>2.6.1. Geographic and time boundaries justified?</li> <li>2.6.2. Addresses potential harm to future generations?</li> </ul> </li> </ul>
Dose-response Assessment Criteria
<ul style="list-style-type: none"> <li>3.1. Most recent dose-response data used?                             <ul style="list-style-type: none"> <li>3.1.1. Describes low dose-response radiation model?</li> <li>3.1.2. States all important health effects from ionizing radiation?</li> <li>3.1.3. Doses for males and females?</li> <li>3.1.4. Dose Conversion Factors included?</li> <li>3.1.5. Different age groups used to calculate doses?</li> <li>3.1.6. Determines most significant radionuclide(s) for human health?</li> </ul> </li> <li>3.2. Mentions any studies of exposed population/reactor technology (lit. review)?                             <ul style="list-style-type: none"> <li>3.2.1. Discusses limitations of findings?</li> </ul> </li> <li>3.3. Differentiates between internal and external doses?                             <ul style="list-style-type: none"> <li>3.3.1. Alpha, beta, gamma radiation explained?</li> <li>3.3.2. Describes bioaccumulation in certain organs?</li> <li>3.3.3. Discusses possible synergistic relationships of ionizing radiation?</li> </ul> </li> <li>3.4. Predicts potential offsite health consequences of accidents (Full Level 3 PRA)?</li> <li>3.5. Identifies most significant non-radioactive emission?</li> </ul>

Risk Characterization Criteria
<ul style="list-style-type: none"> <li>4.1. Acceptable risk defined?                             <ul style="list-style-type: none"> <li>4.1.1. Identification of any individuals approaching acceptable risk limits?</li> <li>4.1.2. Determines if 'a few tens of people' likely approaching limits?</li> <li>4.1.3. Risks below HRA standards?</li> <li>4.1.4. Risks below PRA standards?</li> </ul> </li> <li>4.2. Addresses perceived risk (radiophobia)?                             <ul style="list-style-type: none"> <li>4.2.1. Explains possible psychological effects?</li> </ul> </li> <li>4.3. Describes various uncertainties, assumptions and confidence levels?                             <ul style="list-style-type: none"> <li>4.3.1. In all calculations?</li> <li>4.3.2. In all models?</li> </ul> </li> <li>4.4. Formal environmental monitoring discussed?                             <ul style="list-style-type: none"> <li>4.4.1. Monitoring of health indicators proposed?</li> <li>4.4.2. Any bio-monitoring of radiation levels in non-human biota?</li> <li>4.4.3. Real-time monitoring available to public?</li> </ul> </li> <li>4.5. Commitment to specific formal mitigation measures?                             <ul style="list-style-type: none"> <li>4.5.1. Describes reduced health risks due to mitigation?</li> </ul> </li> <li>4.6. No biases in presentation of material?                             <ul style="list-style-type: none"> <li>4.6.1. Precautionary principle addressed?</li> </ul> </li> <li>4.7. Addresses sustainability of project?</li> </ul>
Process Criteria
<ul style="list-style-type: none"> <li>5.1. Broad WHO definition of health given?</li> <li>5.2. HRA started before any action?</li> <li>5.3. Communicates risks clearly?                             <ul style="list-style-type: none"> <li>5.3.1. Non-technical summaries?</li> <li>5.3.2. Various dose metrics and units defined?</li> </ul> </li> <li>5.4. Evidence of HRA peer review process?                             <ul style="list-style-type: none"> <li>5.4.1. Reviewed by independent groups?</li> </ul> </li> <li>5.5. Evidence of PRA peer review process?                             <ul style="list-style-type: none"> <li>5.5.1. Reviewed by independent groups?</li> </ul> </li> <li>5.6. Independent health experts consulted?</li> <li>5.7. Early evidence of stakeholder involvement?                             <ul style="list-style-type: none"> <li>5.7.1. Public concerns identified in the HRA?</li> <li>5.7.2. Activities/results of any workshops disseminated?</li> </ul> </li> <li>5.8. Separate section for HRA?</li> <li>5.9. Funding of any new studies to address ongoing public concerns?</li> <li>5.10. Confirms refurbishment would satisfy international safety standards?</li> <li>5.11. Emergency Evacuation Plan guided by Level 3 PRA?</li> <li>5.12. If EA is a panel review, independent reviewers selected?</li> </ul>

The result of an extensive literature review and interview process: an 87-point Best Practices checklist. A "Y" is entered if a criterion is present and an "N" is recorded if a criterion is absent. The satisfied criteria in each of the five sections are then totaled to present an indication of overall quality.

### Strengths

- Used historic environmental monitoring/ previous EAs to validate transport models
- Health hazards assessed and wastes identified for 3 phases of project: construction/ operation/decommissioning
- Conducted surveys on public behaviour to determine if any higher exposures likely
- Conducted doses separately for infants- ionizing radiation more harmful for this group
- Highlighted areas of public concern and where they could be found in EIS
- Adopted WHO definition of health
- Most provided non-technical summaries

### Weaknesses

- Little or no baseline health information provided for exposed population
- Accident scenarios not always reactor specific
- No monitoring for certain types of radiation
- Temporal persistence of radioactivity trivialized
- 1 EIS missing HRA for Hydrazine
- 1 EIS missing section devoted to human health
- Inconsistent reviews of health effects of ionizing radiation, some misleading
- Uncertainties and confidence levels unknown in PRA results
- Instances of breached accident frequency limits
- Limited evacuation plans revealed for serious accidents- considered "impossible"
- Incomplete analysis of reactor accident health consequences

## Conclusions

Nuclear power plants are high risk facilities; their irreducible complexity and unique potential for catastrophic accidents necessitate vigilant regulation to protect public health and safety. This research investigated the regulatory rigor of the CNSC by producing an HIA Best Practices framework for nuclear power projects and using it to evaluate compliance. A review of six such EISs revealed that the CNSC is permitting a fragmentary application of Best Practices and is ultimately failing to account for many non-trivial risks. The CNSC's "risk-informed" regulatory approach is evidently enabling approvals to be made without the full consideration of risk.