Analysis of a BWRX-300 Severe Accident: Implications for Emergency Protective Actions

Richard Hydomako (M.ASc. Student, Nuclear Engineering),
Filippo Genco (Co-Supervisor), Akira Tokuhiro (Co-Supervisor)
Ontario Tech University

linkedin.com/in/richard-hydomako
richard.hydomako@ontariotechu.net

Introduction

The final layer of protection for the public in the event of a severe nuclear accident is the mitigation of radiological consequences through off-site emergency response. In Ontario, emergency response planning is divided into the following zones (Figure 1):

- *Automatic Action Zone (AAZ)*: includes preplanned protective actions to prevent severe deterministic effects,
- *Detailed Planning Zone (DPZ)*: preplanned protective actions reduce or avoid stochastic effects,
- *Contingency Planning Zone (CPZ)*: planning such that protective actions can be extended beyond the DPZ,
- *Ingestion Planning Zone (IPZ)*: planning to ensure the protection of food and water supplies.

This project uses publicly accessible information to estimate the radiological consequence of a severe accident at a BWRX-300 reactor to inform the sizing of emergency planning zones. Appropriate emergency planning zone sizing is relevant, given the construction of a first-of-a-kind BWRX-300 unit at the Darlington New Nuclear Project site.

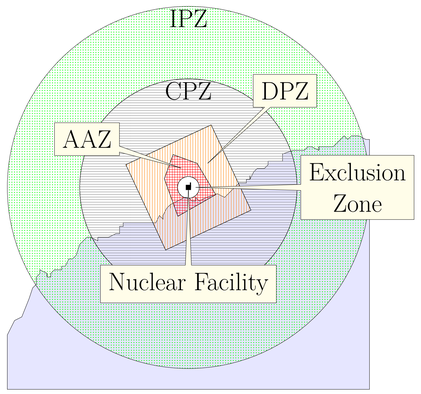


Fig. 1: Emergency planning zones, following the Ontario Nuclear Emergency Response Plan framework [1].

Results

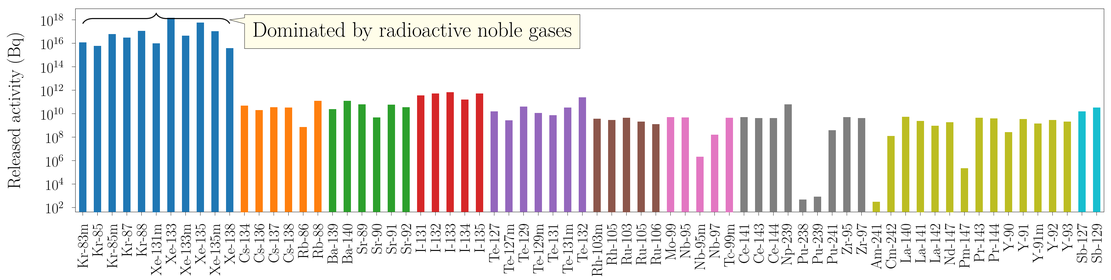


Fig. 2: Estimated source term of total radionuclide activity released to the environment. Colours correspond to radionuclide class.

Figure 2 shows the estimated atmospheric source term, grouped by radionuclide class (shown as colours). The total activity released over a simulated 24 hr period is 2.4×10^{18} Bq, which the vast majority of the activity attributed to radioactive noble gases. The chemically inert noble gases are able to pass through the pool as vapor, while other radionuclides undergo significant scrubbing and remain in the pool.

Figure 3 gives the estimated total effective dose equivalent (TEDE) that someone would receive if they were incident with the passing radioactive plume at various distances from the release point. The off-site dose estimate for this accident remains below a level where severe deterministic effects would be expected, and at a distance of 10 km drops below public dose limit.

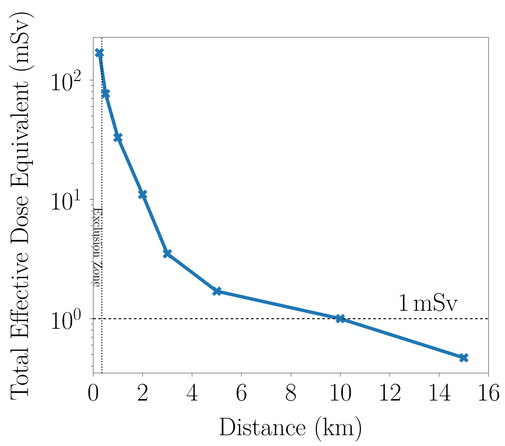


Fig. 3: Estimated effective dose as a function of distance from the release.

Source Term Estimation

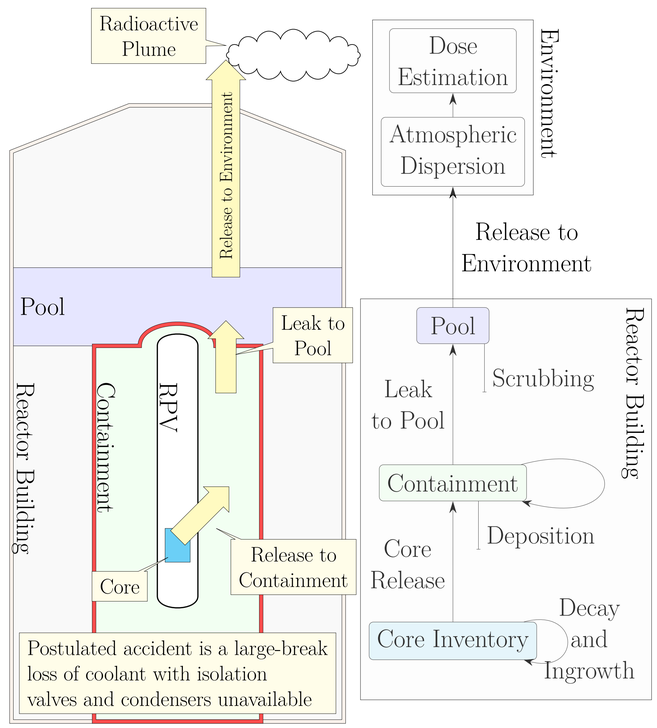


Fig. 4: Overview of BWRX-300 Source term estimation method.

A source term is the amount and composition of radioactive materials released to the environment.

For this model, the movement of radioactive mass is tracked using a set of control volumes called Compartments (see the boxes on the right side of Fig. 4).

The radionuclide release pathway is shown in Fig. 4, and represented as connections between compartments. The release pathway starts in the reactor core, where severe core damage results in radionuclide release into the containment structure. Containment overpressure results in a leak pathway into the bottom of the pool. Finally, radionuclides that make it through the pool are counted as the released source term.

Physical mechanisms, such as radioactive decay, aerosol deposition, and pool scrubbing, are modelled as radionuclide removal and transformation processes within compartments.

Once the release source term is calculated, the resulting dose consequence to the surrounding public can be estimated using typical atmospheric stability, wind speed, and wind direction.

Implications and Conclusions

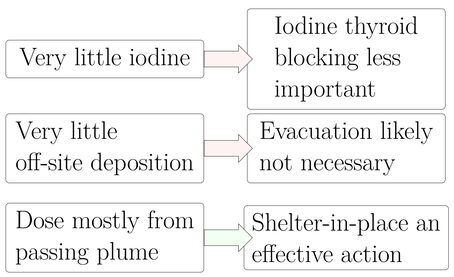


Fig. 5: Implications for emergency protective actions.

Figure 5 outlines several implications that the noble gas dominated source term has for emergency protective actions. Specifically, de-emphasizing iodine thyroid blocking and evacuation in favour of sheltering-in-place.

Furthermore, Fig. 3 suggests setting a CPZ size of about 10 km and forgoing both the AAZ and DPZ. This arrangement would be consistent with the 'Site-Boundary EPZ' framework proposed by Lebel et al. [2], which places focus on contingency planning for 'worse-than-conceivable' scenarios, rather than pre-planning automatic protective actions.

References

[1] Government of Ontario. *Provincial Nuclear Emergency Response Plan (PNERP)*. Aug. 22, 2025. URL: `http://www.ontario.ca/document/provincial-nuclear-emergency-response-plan-pnerp` (visited on 10/02/2026).

[2] Luke Lebel, Feng Zhou, and David Hummel. "Beyond EPZs: Nuclear Emergency Management Frameworks When Using Site Boundary Emergency Planning Zones, with a Case Study on High Temperature Gas Reactors". In: *Annals of Nuclear Energy* 226 (Feb. 2026), p. 111808. DOI: `10.1016/j.anucene.2025.111808`.