SMR Regulators' Forum

Pilot Project Report:

Report from Working Group on Emergency Planning Zone

January 2018

APPENDIX IV. REPORT FROM WORKING GROUP ON EMERGENCY PLANNING ZONE

Executive Summary

The SMR Regulators' Forum Emergency Planning Zone Working Group was established to identify, understand and address key regulatory challenges with respect to emergency planning zone (EPZ) sizes that may emerge in future Small Modular Reactors (SMRs) regulatory activities. This will help enhance safety, efficiency in licensing, and enable regulators to inform changes, if necessary, to their requirements and regulatory practices.

Regarding the application of the concept of EPZ size to SMRs, this report:

- Shares regulatory experience and views amongst Forum members.
- Captures good practices and methods and strives to reach a common understanding.
- Communicate the results of these discussions to the Forum Members.

The Working Group (WG) consensus positions are:

- SMRs encompass a variety of nuclear reactor designs.
- There is a need to consider that the EPZ size for SMRs can be scaled based on the specific design characteristics and site specific considerations.
- The IAEA safety requirements and methodology, in general, for determining the EPZ size are effective in establishing emergency planning zones and distances.

1. BACKGROUND

The designers purport to have enhanced safety performance through inherent, passive, and novel safety design features. There are design options being developed for remote regions with less developed infrastructures, siting near urban regions, transportable floating or seabed-based facilities. Some of the SMR features and uses have raised questions regarding the sizes of the EPZ required around the sites, and how the design features can affect the size of the EPZs.

The SMR Regulators' Forum sought to document the bases that underpin decisions on EPZ extent around new SMR sites. The goal was to examine how the EPZ size might be flexible with respect to technological improvements and commensurate with the offsite consequences. The working group documented its conclusions drawn from the discussions and analysis in this paper.

SMR designers have incorporated over 60 years of experience into the proposed designs to improve operational and safety performance. As a result, designers are attempting to reduce the need for emergency planning by instituting additional design features based on the lessons learned from prior industry events. SMR designers and potential applicants raised questions about the need for offsite planning zones and distances, and they are approaching regulators in many countries to examine and revise existing requirements.

2. OBJECTIVES

The EPZ WG established objectives to guide the work. These included:

1. Share regulatory experience among Forum Members and strive to reach common understanding on EPZ size and scalability of EPZs
    a) Document and disseminate the results of the discussions.
    b) Interact with designers, regulators, emergency preparedness specialists, where possible, to effectively inform forum activities that would prompt further insights.
    c) Present conclusions on EPZ sizes.

2. Draft a document outlining the following:
    a) Common terminology.
    b) Technology-inclusive general principles for determining EPZs sizes.
    c) Cross-cutting EPZ-related issues derived from among member nations.
    d) Potential environmental impacts of scaled EPZ size.
    e) Methodology to determine EPZ size.
    f) Feedback to the IAEA on suggestions for future work regarding changes to IAEA general requirements and safety guide documents, international codes and standards with respect to EPZ sizes and scalability.

3. SCOPE OF THE ACTIVITIES

Within the 2-year pilot project, the EPZ WG endeavored to identify general principles related to the size of the EPZ and siting criteria for SMRs with novel design features.

The scope of SMR design information provided was mainly limited to documents available through the IAEA with the addition of information provided by member experience through their regulatory organizations.

The working group examined the implications of the SMR design features upon EPZ sizes. Furthermore, the EPZ WG did not examine the public and political policies of the host states. Also, the EPZ WG limited the extent of its consideration of defence in depth and Graded Approach (risk informed) topics because those topics are the subjects of other working groups in the SMR Regulators Forum. The WG used a perspective that EPZ sizes are only as large as the areas that would be reasonably required for protecting the public.

Unlike the Defence-in-Depth and Graded Approach Working Groups, the EPZ WG chose not to use a survey in order to collect relevant, state-specific approaches to the EPZ and Siting criteria. The EPZ WG relied upon input from the working group members to obtain the information at the first meeting of the working group and determined that between the members' and IAEA resources, sending a survey would provide no significant additional information.

4. TERMINOLOGY

The use of "emergency planning zones" within this document means the regions encapsulating the advanced planning areas [for prompt or urgent response areas] and the planning distances [designated during the response as a result of the evolving accidents]. Advanced emergency planning should be conducted in order to avoid or minimize severe deterministic effects1, reasonably reduce stochastic effects2 and mitigate the consequences of the accident at its source. The types of EPZs and recommended distances for each type of EPZ are found in IAEA Documents General Safety Requirements (No. GSR Part 7), "Preparedness and Response for a Nuclear or Radiological Emergency," and Emergency Preparedness and Response (EPR) Nuclear Power Plant (NPP) EPR-NPP Public Protective Actions 2013, "Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor," Section 4.

Additionally, safety related terms are defined in the IAEA Safety Glossary, which can be located at http://www-ns.iaea.org/standards/safety-glossary.htm.

5. OVERVIEW OF CURRENT IAEA METHODOLOGY

General Safety Requirements, Part 7, requirements 4.19, 4.20 and 5.38(a) contain the requirements to conduct a hazard assessment and its considerations, and the requirement to establish emergency planning zones and distances. The methodology presented in determining the EPZ extent and size can be found in IAEA document EPR-NPP PAA 2013, in Appendix I, "Basis for the Suggested Size and

[1] IAEA GSR Part 7, Item 5.38(i)
[2] IAEA GSR Part 7, Item 5.38 (ii)

Protective Actions within the Emergency Zones and Distances." The working group reviewed the requirements and methodology and found that they are sufficient in their scopes and practices to be used to determine the size of the emergency planning zones (PAZ and UPZ) around an SMR site. The WG developed a diagram that represents a generalized approach from EPR-NPP PAA 2013 and the participating Member States' own processes. The areas of the emergency planning distances (EPD and ICPD) are not determined by the use of the approach. Rather, the emergency planning distances are determined by surveys after a release. The following are design considerations and comments about applying an approach for SMR PAZ and UPZ that the authors thought would be informative.

The WG approach, which is considered to be a common position, is presented at a high level in figure 1 and allows for flexibility by the various states in applying each step in the process, taking into account differences in the national regulatory frameworks. An example of this is considering the effectiveness in applying protective actions (i.e. dose reduction factors) when determining dose consequences. The dose reduction factors applied from EPR-NPP PAA 2013 Appendix I are based on simple assumptions in regards to public behaviour. These assumptions can vary from state to state, and some states may choose not to incorporate any protective actions into the dose consequence calculations.

In the subsections following figure 1 the WG has provided text for each box in the diagram to describe differences that may exist between Member States and factors that should be considered in the step of the approach.

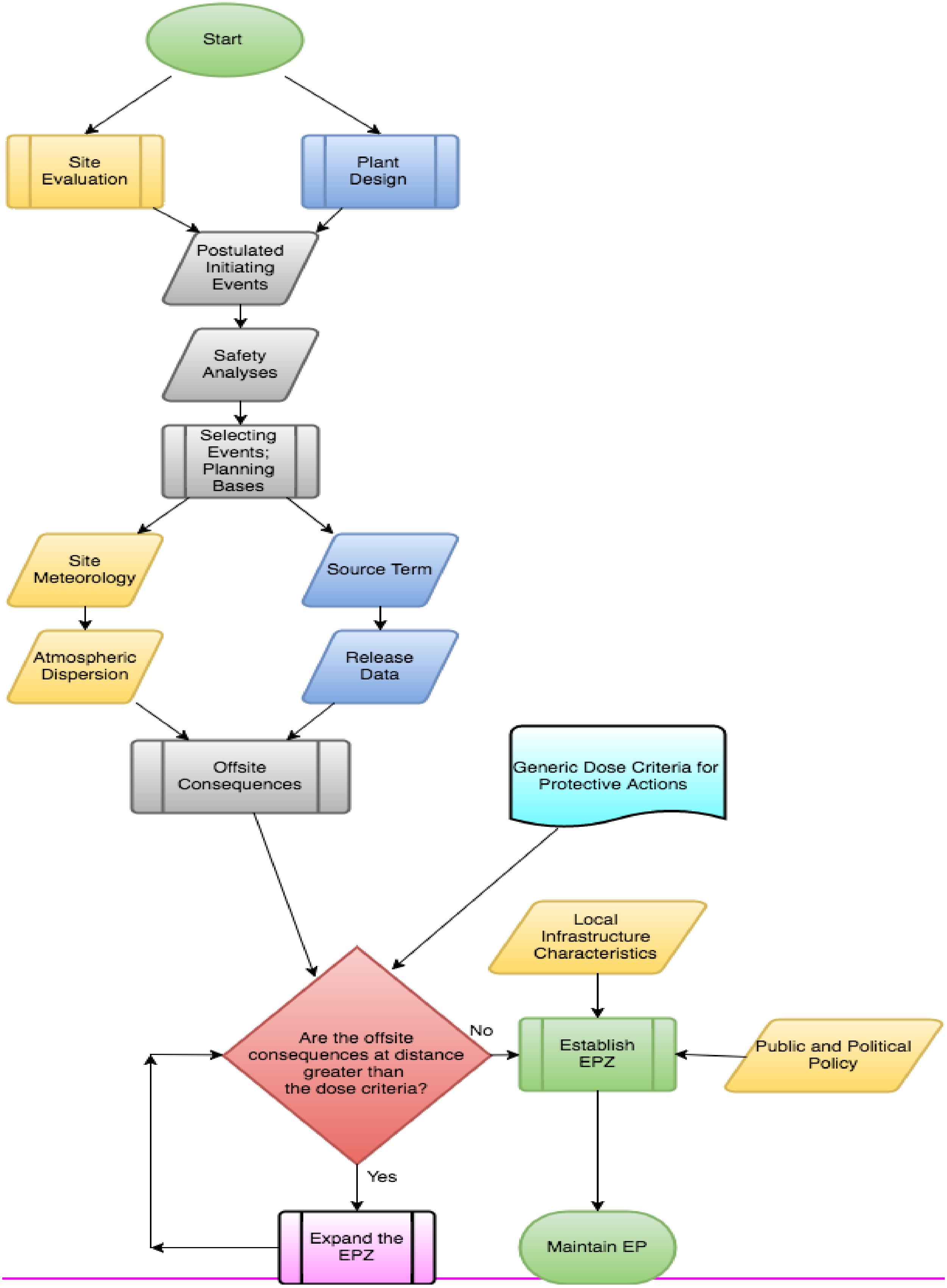

Figure 1 -- Generalized Approach to Determine EPZ Sizes

1. Start Generalized Approach to Determine EPZ Sizes
2. Site Evaluation for determining site suitability or for EPZ size determination. In some Member States, the siting requirements and the size of the EPZ are determined using different criteria as well as at differing times during a licensing process. In other Member States, the same criteria apply to siting and EPZ sizes.

    a) The site evaluation should identify those factors beyond the consideration of the plant design elements that could affect plant safety and any significant impediments to developing the emergency plans.

    b) The applicant should provide information that details the seismic, hydrological, geological, tidal, and other technically relevant subjects that support the site being suitable for the operation of a SMR. This would include the description of the uses of the surrounding land and waterways.

    c) The applicant should address the ability to return the site to a near-original condition at the end of plant life and the effects of long-term operation on the site.

    d) In determining the suitability of the site, the applicant should consider the ability to decontaminate and to have long-term storage of spent fuel.

    e) Population density and plans to maintain the population low such that the population itself does not become an impediment to implementing the emergency plan.

    f) Physical protection of the site

    g) Essential human assistance response means and times (fire, police, medical assistance, and so forth)

    h) Transportation routes (air, land, and waterways)

    i) Sensitive environmental characteristics for cultural, biological, societal impacts.

3. Plant Design

    a. The plant design should detail the planned number of operating reactors, power levels, electrical distribution, water sources and returns, emergency core cooling systems, spent fuel storage, and other design considerations.

    b. The plant design should provide a description of containment or the satisfaction of any containment function requirements.

    c. The EPZ WG considered major design features typical to SMRs that may affect the considerations and determinations of the sizes of the EPZ and the information and analysis that would be required to form the bases of the sizes of the EPZs. To determine the effect of each of the design features below, the EPZ WG members evaluated the feature without regard to another feature.

    d. Small reactors and low rated thermal power levels: The reactor core sizes and the low rated thermal power levels that are exhibited in the SMR designs work together to reduce the amount of radioactive materials for potential releases to the environment. Since the amounts of materials are reduced, the distances at which doses that exceed health or environmental limits resulting from any release could be lower. Therefore, an EPZ limited by the site boundary may be considered.

e. Modularity and Multiple Module Facilities: The use of "modularity" divides the source term into smaller, discrete reactors. A small modular reactor's core contains much less fuel than an existing large reactor core. The adding of the modules over time may allow the operator to obtain comparable power levels at the site as that provided by an existing power plant. However, the independent construction and operation of the modules makes a large-scale offsite consequence less possible as compared to a single, larger unit. Therefore, an EPZ limited by the site boundary may be considered.

f. Containment or Containment Function: Since the designers of SMRs are using different methods to contain any source term available for release, such as compact containment structures, high-pressure containment structures, double-wall construction, or water-immersed containment, the potential for offsite consequences is will be lower. Many factors will play a role in the effectiveness of the containment function, but with more robust the containment features, a large release is less possible. Therefore, an EPZ limited by the site boundary may be considered.

g. Subterranean Location: Some designers have designed plants for subterranean construction and operation. As such, any effluents would be at or near ground level. Hence, the effective extent of any release would be smaller than for a comparable release from an existing plant built above ground. Therefore, an EPZ limited by the site boundary may be considered.

h. Separate Operating and Maintenance Facilities: There are some small reactor designs without on-site refuelling capability. Rather the refuelling and maintenance of the reactor are done at another location. As those designs are deployed, separate emergency preparedness programs would need to be established around the operating site, maintenance site, and any port, depot or terminal during transit between the operating site and maintenance site.

i. Novel Features and Technologies: The use of novel features and technologies to lengthen the time between initiating event and the need for protective actions allows for additional time for accident prevention and mitigation. Therefore, an EPZ limited by the site boundary may be considered.

4. Postulated Initiating Events. The various Member States have differing processes in which to identify the postulated initiating events and to evaluate the impacts of the events. Some states employ a specific set of events to consider with the applicant supplementing any additional events required by regulations. Other Member States have set criteria for which an applicant evaluates the initiating events and determines the most severe set of events to include in the consideration of siting and EPZ sizes.

   a) The applicant should identify the postulated initiating events which could or does result in releases of radioactive material, referred to as source term, in accordance with the regulations and guidance provided by the licensing authority.

   b) The applicant should address how lessons learned from industry events are met through the design.

5. Safety Analyses. The type of analysis may differ from state to state depending on the systems involved, system integration, and safety-significance of the system. For example, a system that may have little to do with accident mitigation or prevention may not need extensive analysis to determine that system's function remains intact during an event. By contrast, the analysis required for a system relied upon for event prevention and mitigation may need redundant tests and analyses to deem its safety system function resilient during the event.

   a. Evaluating the plant's safety

b. Selecting Events and Establishing a Planning Bases

   i. Establish a list of credible accidents that would bound the analysis. (The use of probability risk analyses or probability safety analyses is meant to bound the analysis to determine a planning basis. It is not meant to bound the emergency preparedness and planning for the plant or site. The licensee and operator of the site would be required to respond to any emergency or event under its control.)

   ii. Practically eliminated accident sequences. As part of the analyses, the design would need to address which accident sequences were analysed and the results. The application should contain sufficient information for the technical staff to review the results and determine the appropriateness of the inclusion and exclusion of accident sequences. Those accident sequences that are subject to lessons learned, for example, Three-Mile Island, Browns Ferry Fire, Chernobyl, and Fukushima, should be included, or if not included, the basis for not including them.

c. Source Term

   i. Estimation of source terms for accident scenarios identified in safety analyses. The designers may use mechanistic source terms to account for the design-specific accident scenarios and accident progression. This use may form part of the applicant's or designer's request for a smaller EPZ than those which would granted to a large-light water reactor site. Additionally, the use of the mechanistic source terms to determine the suitability of a site may be considered.

d. Release Data

   i. Release height; stack or ground release.

   ii. Time before releases (hold-up)

   iii. Magnitude of releases (gross activity, isotopic activity, effluent flow rates)

   iv. Duration of releases

   v. Type of effluent (liquid, gas, metallic, and so forth)

e. Site Meteorology

   i. Wind direction

   ii. Wind speed

   iii. Stability Category

   iv. Precipitation

   v. Mixing height

   vi. Humidity

f. Atmospheric Dispersion Modelling

   i. Site specific meteorological data from nearest weather station

   ii. Recent data period of 1 year should be used

iii. Weather data should be statistically analyzed to determine weather conditions used for planning purposes.

6. Determining Offsite Dose Consequence –Analyze the offsite dose consequences resulting from the postulated initiating events and the source term. Member states' approaches to determining the offsite dose consequences may vary.

7. Generic Dose Criteria— Among the differing Member States, the generic dose criteria may be determined by diverse levels of government and by differing ministries or agencies. For example, the dose criteria in one state may be a published by various ministries for the individual societal or industrial sectors regulated by the ministries. For example, the agricultural standards for dose may be under the oversight of one ministry and the human dose criteria may be under the oversight for health, and yet another for the environment or interior land dose criteria. Applicants or licensees should determine the distances at which the offsite dose consequences exceed the dose criteria. (Notes: The criteria are frequently called intervention levels, protective action levels, and protective action guides. The generic dose criteria may differ among the states.)

8. The EPZ size evaluation should identify those local infrastructure characteristics and factors that could affect plant safety and any significant impediments to implementing emergency planning and response. The infrastructure may provide familiar boundaries in setting the EPZ size.

9. Address public and political policy. In the various Member States, the public and political policies concerning energy and public health have differing degrees of influence into the decision making process. In some Member States, one policy may lean heavily in one direction, where in others, it may lean heavily in the other. A balance of the competing or complementary policies is found in the decision. Public and political policies could consider affected groups' input within the area of the proposed site, neighbouring states, and the states' public policies to determine minimum size of the EPZ. (Not all states use public or political policies in determining the EPZ sizes. The WG is neither recommending its adoption where it is not used nor the removal of the use of the policies.)

10. Establish EPZs. The decision making bodies may differ among Member States. In some states the local or provincial governments make a final decision as to the suitability of the site or the exact size and configuration, and in others, the national government makes the final determination.

    a) Evaluate the plant's safety, incorporating the hazard analysis, safety analysis, offsite dose consequences holistically.

    b) Compare the offsite dose consequences to the established dose criteria.

        i. If the offsite dose consequences exceed the dose criteria at a given distance, then expand the EPZs.

        ii. Continue to compare the offsite dose consequences to the dose criteria for a longer distance until the offsite dose consequences do not exceed the dose consequences.

        iii. States confirm the analysis and establish the EPZs.

        iv. Applicants and states establish and maintain emergency preparedness and planning within the EPZs.

6. CONCLUSIONS OF THE EPZ WG

- SMRs encompass a variety of nuclear power plant designs. Managing SMR events involving the potential for releases of radioactive material that challenge public safety and the environment requires a coordinated response
- There is a need to consider that the EPZ for SMRs is scalable depending on the results of a hazard assessment, the technology, novel features and specific design criteria, as well as for some, policy factors. The IAEA safety requirements and methodology for determining the EPZ size are effective in establishing an emergency preparedness and planning program, such that if a release does occur, protective actions will be implemented to protect the public and environment.
- A pre-application process may be considered to discuss the requirements and standards for siting and determining EPZs with potential applicants.
- For SMRs without on-site refueling capability, there is a need to consider the establishment of an EPZ at any intermediate stop and land-based maintenance facility used for the handling and the storage of the fuel assemblies.
- There is a need to consider some level of community emergency preparedness, for example, to receive public information and perform response drills, specifically when the size of the EPZs for SMRs are reduced to be in close proximity to densely populated centers.
- For SMR designs employing novel features and technology, there is a need to consider mechanistic methods for the approach for the determination of EPZ size. Operating feedback will help to reduce uncertainties and to determine future EPZ sizes for newer sites accordingly.
- The same design of SMR implemented in different countries may result in different EPZ sizes depending on dose criteria, policy factors, and public acceptance.

7.0 SUGGESTIONS FOR FUTURE WORK

The WG members had a variety of discussions and insights while writing this document. Many of the discussions pertained to the following topics, which were determined to beyond the scope of the WG's purpose. Therefore, the WG makes the following suggestions for the future work of the SMR Regulators Forum.

- Explore further the necessity to develop safety standards specific to establishing the necessary analyses, health or environmental standards for radiological releases, or public interactions for determining the EPZs.
- Examine the safety culture with respect to SMR industry. This topic arises from new designers and operators entering the industry, as well as, creating a culture from the beginning to not become complacent by "safety by design".
- Examine the physical security requirements for SMRs. Do SMRs adopt a "security by design" philosophy?
- Examine the elements for community emergency preparedness or off-site response planning.
- Examine the licensing of materials, reactors and irradiated fuel while in transit and among transit state.
- Explore further the "One design, one review" concept.
- Define a "Prudent proven" technology.
- Examine the advances in "human factors engineering" and how novel features of SMRs expand leverage HFE.

EPZ WG Membership

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Appendix A. Example of Member State approaches to determining EPZ

The following appendices outline some Member State approaches used to determine the EPZs and EPDs.

	EPZ		EPD			Verification of Source Term/Offsite Consequences [see itemized list below]	
Country	PAZ	UAZ	EPD	ICPD			
Canada	2 km					3	
China	7-10 km		30-50 km			6	
France	20 km		20 km			4	
Korea							
Russian Federation	2 km					5	
USA	16 km (10 miles)		80 km(50 miles)			1	

1. The use of approved codes and methodology, the regulators require the input and output files for the verification of the source terms and offsite consequences. If the applicant uses a method or code other than an approved, the applicant must supply the input and output files and the source codes for the computer modeling that support the analysis and determination of source terms and offsite consequences with respect to the specific designs are part of an application.

2. Not pre-determined.

3. The applicant needs to provide all relevant information for the offsite authorities assess or make an informed decision on the EPZ, such as the source term and accident sequences. The calculation is not required.

4. The applicant needs to provide all relevant information for the offsite authorities assess or make an informed decision on the EPZ, such as the source term and accident sequences. The calculations need to be included in the safety case.

5. Russian Federation – Offsite consequences are verified by using nuclear regulator guidance.

6. The applicant needs to provide all relevant information for determining the EPZ, such as source term and accident sequences. All above should be in accordance with nuclear safety regulations.

The Canadian approach to EPZs

Definition of Nuclear Facility

The Class I Nuclear Facilities Regulations under the Nuclear Safety and Control Act [1] defines a nuclear facility as follows:

> "Class I nuclear facility" means a Class IA nuclear facility and a Class IB nuclear facility.
>
> "Class IA nuclear facility" means any of the following nuclear facilities:
>
> a. a nuclear fission or fusion reactor or subcritical nuclear assembly; and
> b. a vehicle that is equipped with a nuclear reactor.
>
> "Class IB nuclear facility"
>
> "Class IB nuclear facility" means any of the following nuclear facilities:
>
> a. a facility that includes a particle accelerator, other than a particle accelerator described in paragraphs (d) and (e) of the definition "Class II prescribed equipment" in section 1 of the Class II Nuclear Facilities and Prescribed Equipment Regulations;
> b. a plant for the processing, reprocessing or separation of an isotope of uranium, thorium or plutonium;
> c. a plant for the manufacture of a product from uranium, thorium or plutonium;
> d. a plant, other than a Class II nuclear facility as defined in section 1 of the Class II Nuclear Facilities and Prescribed Equipment Regulations, for the processing or use, in a quantity greater than 1015 Bq per calendar year, of nuclear substances other than uranium, thorium or plutonium;
> e. a facility for the disposal of a nuclear substance generated at another nuclear facility; and
> f. a facility prescribed by paragraph 19(a) or (b) of the General Nuclear Safety and Control Regulations.

Definition of Planning Zones

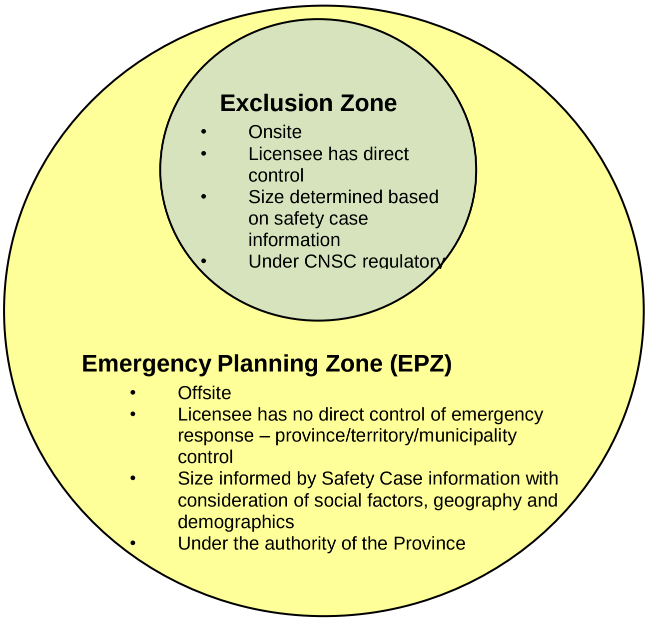
Exclusion Zone

Per section 1 of the Class I Nuclear Facilities Regulations, "Exclusion Zone" means a parcel of land within or surrounding a nuclear facility on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control. Appendix A contains a summary of the Canadian process on determining the exclusion zone. Details on the exclusion zone are found in Regulatory Document RD-346 Site Evaluation for New Nuclear Power Plants.

Emergency Planning Zone

An Emergency Planning Zone (EPZ) is defined to be the area in which implementation of operational and protective actions might be required during a nuclear emergency, in order to protect public health, safety, and the environment. An EPZ addresses emergency measures to be utilized outside the licensee's exclusion zone and are normally controlled and executed by an external emergency planning authority.

Figure 1: Relationship between the EPZ and Exclusion Zone



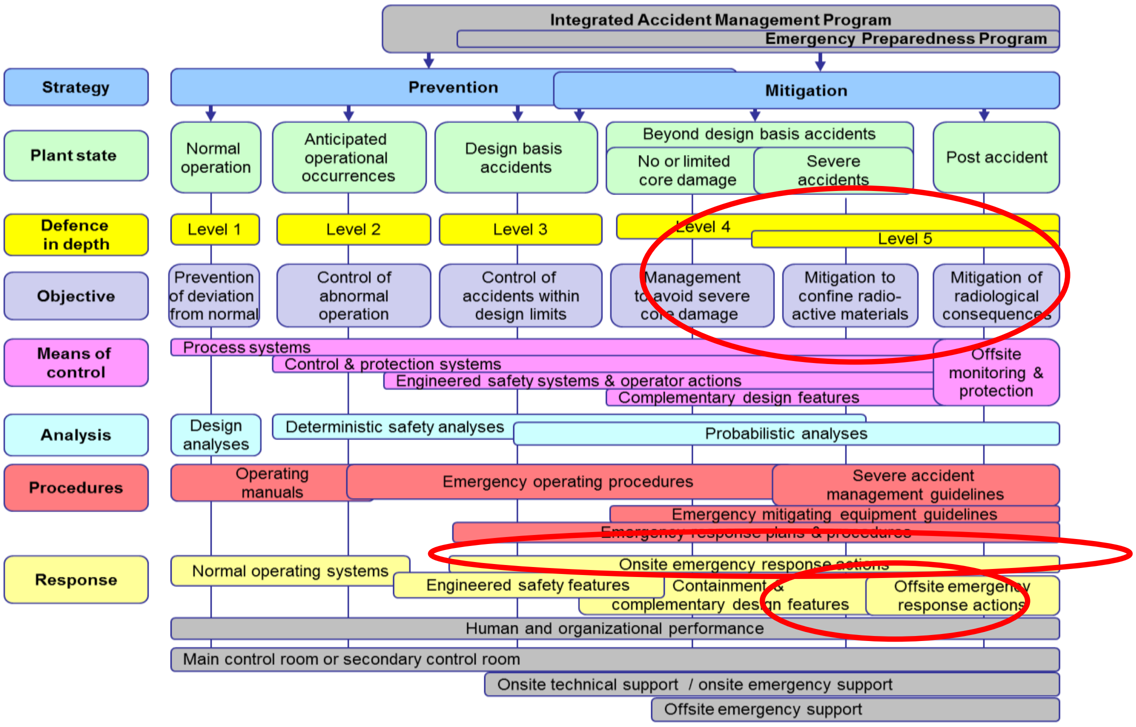
EPZ can be further broken down into additional sub-zones to address the following objectives (CSA N1600-General Requirements for Nuclear Emergency Management Programs):

- Provisions for automatic actions: A designated area (Automatic Actions Zone, AAZ) immediately surrounding a nuclear power plant (NPP) where pre-planned protective actions are implemented by default on the basis of NPP conditions with the aim of preventing or reducing the occurrence of severe deterministic effects. This includes licensee actions within the Exclusion Zone.
- Detailed planning: A designated area (Detailed Planning Zone, DPZ) surrounding a NPP, incorporating the AAZ, where pre-planned protective actions are implemented as needed on the basis of NPP conditions, dose modelling, and environmental monitoring, with the aim of preventing or reducing the occurrence of stochastic effects.
- Contingency planning: A designated area (Contingency Planning Zone, CPZ) surrounding a NPP, beyond the DPZ, where plans or arrangements are made in advance, so that during a nuclear emergency:
    - protective actions can be extended as required to reduce potential for exposure; and
    - dose rate monitoring of deposition is conducted to locate hotspots that could require protective actions following a release.
- Ingestion control planning: A designated area surrounding a NPP where plans or arrangements are made to
    a) protect the food chain;
    b) protect drinking water supplies;
    c) restrict consumption and distribution of potentially contaminated produce, wild-grown products, milk from grazing animals, rainwater, animal feed; and
    Note: Wild-grown products can include mushrooms and game.
    d) restrict distribution of non-food commodities until further assessments are performed

EPZ as Part of Defence in Depth

As illustrated in Figure 2 below, offsite emergency response measures, which are conducted in each of the EPZ, are considered to be Level 5 of Defence-in-Depth but, more importantly, are part of an integrated Accident Management Approach that works in concert with all five Defence in Depth levels.

Figure 2: Defence-in-Depth: Integrated Accident Management



Regulatory Requirements that address Planning Zone role in Class 1 Facility Activities

Regulations under the Nuclear Safety and Control Act

Specific requirements for EPZs are not explicitly stated in CNSC regulations such as the *Class I Facilities Regulations* as they are under the jurisdiction of the Province. However, information resulting from the licensing to construct and environmental assessment (EA) processes are used to support the EPZ requirements. In Canada, emergency measures are to be integrated into the overall facility safety case (that implements the defence-in-depth approach) (see Section 2.1.3 and Figure 2). That is, such measures are expected to be addressed in the following key *Class I Facilities Regulations* among others:

§3, *General Requirements*

"*An application for a licence in respect of a Class I nuclear facility, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the* <u>*General Nuclear Safety and Control Regulations*</u>:

(a) a description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone;"

§4, *Licence to Prepare Site*

"*An application for a licence to prepare a site for a Class I nuclear facility shall contain the following information in addition to the information required by section 3*:

(a) a description of the site evaluation process and of the investigations and preparatory work that have been and will be done on the site and in the surrounding area;

(e) the effects on the environment and the health and safety of persons that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects."

§5, *Licence to Construct*

"An application for a licence to construct a Class I nuclear facility shall contain the following information in addition to the information required by section 3:

(a) a description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are taken into account in the design;

(b) a description of the environmental baseline characteristics of the site and the surrounding area;

(f) a preliminary safety analysis report demonstrating the adequacy of the design of the nuclear facility;

(i) the effects on the environment and the health and safety of persons that may result from the construction, operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;

(k) the proposed measures to control releases of nuclear substances and hazardous substances into the environment;"

§6, *Licence to Operate*

"*An application for a licence to operate a Class I nuclear facility shall contain the following information in addition to the information required by section 3:*

(c) a final safety analysis report demonstrating the adequacy of the design of the nuclear facility;

(d) the proposed measures, policies, methods and procedures for operating and maintaining the nuclear facility;

(h) the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;

(j) the proposed measures to control releases of nuclear substances and hazardous substances into the environment;

(k) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security, including measures to:

> *(i) assist off-site authorities in planning and preparing to limit the effects of an accidental release,*
>
> *(ii) notify off-site authorities of an accidental release or the imminence of an accidental release,*
>
> *(iii) report information to off-site authorities during and after an accidental release,*
>
> *(iv) assist off-site authorities in dealing with the effects of an accidental release, and*
>
> *(v) test the implementation of the measures to prevent or mitigate the effects of an accidental release;*

() the proposed measures to prevent acts of sabotage or attempted sabotage at the nuclear facility, including measures to alert the licensee to such acts;

§7, *Licence to Decommission*

"*An application for a licence to decommission a Class I nuclear facility shall contain the following information in addition to the information required by section 3:*

(f) *the effects on the environment and the health and safety of persons that may result from the decommissioning, and the measures that will be taken to prevent or mitigate those effects;*

(h) *the proposed measures to control releases of nuclear substances and hazardous substances into the environment;*

(i) *the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security, including an emergency response plan;*

Supporting requirements and guidance in CNSC Regulatory Documents

CNSC Licence Application Guides (LAG) identify information that should be submitted to support an application for a licence and address the submissions and level of detail needed to address the above regulations for each phase of licencing. For example, in RD/GD-369, Licence Application Guide, Licence to Construct a Nuclear Power Plant, addresses emergency planning considerations in:

- Chapter 4, Site Evaluation
- Chapter 12, Emergency Preparedness

The following key regulatory documents contain requirements and guidance that influence the information submitted by an applicant to support Exclusion Zone and EPZ decision-making:

- RD-346: Site Evaluation for New Nuclear Power Plants
- RD/GD-369: Licence Application Guide: Licence to Construct a Nuclear Power Plant
- REGDOC-2.3.2, Accident Management
- REGDOC-2.4.1: Deterministic Safety Analysis
- REGDOC-2.4.2: Probabilistic Safety Assessment (PSA) for Nuclear Power Plants
- REGDOC 2.5.2: Design of Reactor Facilities: Nuclear Power Plants
- RD-367: Design of Small Reactor Facilities
- REGDOC 2.10.1: Nuclear Emergency Preparedness and Response

Other regulatory documents under the following Safety and Control Areas further support the facility safety case, including evidence to support provisions in level 5 of Defence in Depth as well as confidence in the ongoing safe operation of the facility:

- Management System
- Human Performance Management
- Operating Performance
- Fitness For Service
- Radiation Protection
- Emergency Management – specifically Fire Protection
- Security

Supporting Requirements in CSA Standards

In addition to the above CNSC Regulatory Documents, the Canadian Standards Association (CSA) also maintains standards that support and address areas relevant to information used to support cases for Emergency Planning. The following published and draft standards are pertinent to post-accident conditions; however, many other CSA standards exist to support design and safety analysis activities that address preventative means:

- CSA-N288.2: Guidelines For Calculating The Radiological Consequences To The Public Of A Release Of Airborne Radioactive Material For Nuclear Reactor Accidents
- CSA-N290.15: Requirements for the Safe Operating Envelope of Nuclear Power Plants
- N290.16-16: Requirements for Beyond Design Basis Accidents
- CSA-N1600: General Requirements for Nuclear Emergency Management Programs

Overview of Process for Determining EPZ Extent in Canada

Roles and Responsibilities of Responsible Participants and Agencies

Provinces

Provincial governments have the primary responsibility for offsite emergency planning and response to protect public health, property and the environment. As such, the province prepares its provincial nuclear emergency response plans (PNERP) in coordination with the federal government, under the Federal Nuclear Emergency Plan (FNEP). For example, in the province of Ontario, where the majority of the nuclear power stations in Canada operate, the PNERP is described at the following web-link: Emergency Management Ontario: Emergency Response Plans.

Health Canada

Health Canada, as the lead department under the FNEP (Health Canada, 2002), provides Guidelines for intervention following a nuclear emergency in Canada or affecting Canadians Canadian Guidelines for Intervention During a Nuclear Emergency, November 2003.

These Guidelines are a key reference for provincial governments when preparing provincial nuclear emergency plans, as well as other responsible agencies and applicants for licences for activities regulated under the Nuclear Safety and Control Act.

CNSC

The CNSC is the regulatory authority for licensing, compliance and enforcement for nuclear reactor facilities in Canada. As part of the licensing process, CNSC takes into consideration the design basis accident dose limits and confirms the determined Exclusion Zone distance is appropriate to meet all required safety requirements. The CNSC works closely with the province to provide information regarding the nuclear facility safety case and licensing process to assist the province in determining the EPZ extent.

Applicants for Activities Involving New Reactor Facilities

Applicants and licensees for activities involving the use of reactor facilities are responsible for submitting complete applications outlining how the site evaluation and chosen technology will, through their safety analysis, result in appropriate Exclusion Zone and emergency response plans to meet the provincial requirements. In addition, in accordance with the REGDOC 2.10.1, the applicants and licensees are required to work with and support the province in determining the EPZ extent.

Considerations for Determining EPZ

Physical Design of Reactor Facility

Reactor vendors must consider the range of applications and environments as well as the regulatory requirements, for all countries of commercial interest, when developing their designs. The entire process of ensuring an appropriate Exclusion Zone starts with the design of the reactor facility and the design data that supports safety claims.

Vendors must ensure their designs are robust enough to meet their intended safety objectives, protective action limits and to address all these potential conditions.

CNSC provides requirements and guidance on key areas of importance to planning zones such as physical design of reactor facilities and safety analysis for applicants as well as to assist reactor vendors in the development of new reactor designs they are intending for Canadian applications.

The Class 1 Nuclear Facilities Regulations requires that an application for a licence for a reactor facility to demonstrate that the selected design has accommodated specific site and regional characteristics. Composite bounding designs submitted as a bounding approach are possible; however, the applicant is limited to the projected releases as set in the Environmental Assessment (EA) and confirmed at the time of the construction licence review.

Design requirements are provided in REGDOC-2.5.2, Design of Reactor Facilities: Nuclear Power Plants and RD-367, Design for Small Reactor Facilities. Safety analysis requirements are found in REGDOC-2.4.1, Deterministic Safety Analysis, and REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants.

Postulated Initiating Events (PIE)

PIEs are theoretical events that can cause one or more adverse effects on the facility. They form a key input to the safety analysis of a facility design in all of its potential environments.

These events consider internal events, such as the breaking of an installed component within the plant, or an electrical fire. They also consider external events such as a significant earthquake or flooding.

There is a significant body of ongoing knowledge capture, best practice and lessons learned in this field. Vendors, owners groups, regulators, researchers and other nuclear safety organizations are involved in developing and maintaining the body of practice around determination of PIEs.

Site evaluation also plays a key role in the identification of PIEs for the specific site. The CNSC provides requirements and guidance on site evaluation for new NPPs. Please refer to the following for further information RD-346, Site Evaluation for New Nuclear Power Plants. In addition, information on identification of PIEs can be found in REGDOC-2.4.1, Deterministic Safety Analysis and REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants.

Probabilistic Safety Assessment (PSA)

PSA is a comprehensive and integrated assessment of the safety of a reactor facility. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of the safety of reactor facility, as follows:

A level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.

A level 2 PSA starts from the level 1 results, analyses the containment behaviour, evaluates the radionuclides released from the failed fuel, and quantifies the releases to the environment. A level 3 PSA starts from the level 2 results, and analyses the distribution of radionuclides in the environment and evaluates the resulting effect on public health.

In Canada, CNSC provides requirements and guidance on conducting a PSA which includes targeted requirements to address the lessons learned from the Fukushima event, allows for a Graded Approach, and commensurate with the risk. Please refer to the following for further information REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants.

Deterministic Safety Analysis (DSA)

DSA predicts the facility's response to a range of events based on the current state of the facility as well as operator actions. This analysis addresses a range of scenarios for which the acceptance criteria must be met. It is another tool for early identification and mitigation of potential risks.

A DSA of a reactor facility's responses to an event is performed by an applicant/licensee using predetermined rules and assumptions (such as those concerning the initial facility operational state, availability and performance of the facility systems and operator actions). DSA can use either conservative or best-estimate methods.

CNSC experts review licensee DSA as part of verification and compliance activities.

In Canada, CNSC provides requirements and guidance on conducting a DSA which includes targeted requirements to address the lessons learned from the Fukushima event and allows for a Graded Approach, and commensurate with the risk.

Requirements for DSA are articulated in REGDOC-2.4.1, Deterministic Safety Analysis.

Limiting Credible Accident and Criteria for Identification of the Planning Accident

Based on the safety analysis, the applicants/licensees would identify a list of limiting credible accidents. It is the responsibility of the applicants/licensees to propose the planning basis taking the guidance into account when selecting the limiting credible accidents. Requirements for planning basis are articulated in: REGDOC 2.10.1, Nuclear Emergency Preparedness and Response §2.1 as follows:

All licensees shall:

1. establish a planning basis for their EP program
2. ensure the planning basis considers the hazards that have, or could have, an adverse impact on the environment and the health and safety of onsite personnel or the public, and also consider:
    a. all accidents and internal or external events that have been analyzed as having an unacceptable impact on their facilities
    b. the inclusion of multi-unit accidents scenarios for multi-unit power reactor facilities
    c. extended loss of power
3. use the results from the planning basis to determine the scope and depth of EP program requirements

Additional requirements for licensees of reactor facilities with a thermal capacity greater than 10 MW. These licensees shall:

4. provide regional and provincial offsite authorities with necessary information to allow for effective emergency planning policies and procedures to be established and modified, if needed, periodically.

As stated in bullet 4, the applicants/licensees are required to provide the necessary information (credible limiting accidents and associated source terms) for the provincial and regional authorities to effectively establish their emergency planning policies and procedures. This includes the establishment of the provincial planning accident and the eventual establishment of the EPZ.

The Source Term and releases

The resulting source term is a list of all of the radionuclides that would be released to the environment for the selected accident, following the functioning of all the safety systems to their expected performance under the accident conditions. The source term also includes the release duration and other parameters such as stack height.

Considerations of Meteorology for Atmospheric Dispersion and Deposition Models

The sites meteorological characterization data and modelling is applied to the release to see how the types of isotopes would travel through the air and be deposited throughout the environment.

Dose Assessment and Distribution in consideration of pre-established dose criteria

Once the dispersion and deposition models have been characterized, the resulting exposure pathways and dose calculations are performed. These are assessed against pre-established dose criteria for emergency response measures to determine the distances to which certain protective actions such as sheltering and evacuation would be required (PALS).

Assessment of other external factors

Other external factors are then applied as they may have requirements for their proper consideration in the planning basis or for security reasons that may require adjustments to the EPZ. These considerations take into account for example, security, town limits, the emergency response plans, social factors as considered through the public EA and licensing process.

EPZ Determination Process Map

Figure 3 illustrates the overall process for determining EPZ extent in Canada. It is important to note that several responsible Federal and Provincial agencies are involved as indicated in Section 2.2.1, each according to their mandates and respective roles and responsibilities. A similar discussion on the establishment of the Exclusion Zone is described in Appendix A.

It is important to note that the applicants/licensees are required to provide regional and provincial offsite authorities with the necessary information to allow for effective emergency planning policies on a periodic basis. This requires the applicants/licensees to provide information to the provincial authorities that would assist the province to establish the appropriate EPZ around the nuclear facility. This information may include the limiting credible accidents and their associated source terms. From the list of limiting credible accidents, the province will determine the planning accident based on established criteria.

The resulting source term from the selected planning accident would be used with the sites meteorological characterization data and modelling to determine the isotopic dispersion. Once the dispersion and deposition models have been characterized, the resulting exposure pathways and dose calculations are performed. These are assessed against pre-established PALS. PALS are dose criteria for emergency response measures to determine the distances to which certain protective actions such as sheltering and evacuation would be required.

In addition, the provincial authorities would also consider social factors, geography and demographics in determining the EPZ around the nuclear facility. It is important to note that although the determination of the EPZ size is under the authority of the province, the province works with multiple supporting organizations to develop a technical planning basis which would be used to determine the EPZ.

In summary, the EPZ extent is based on the nuclear reactor’s technology, the resulting dose assessments against the provincial PALs, and various external factors such as social considerations, demographics and geography.

Glossary

Licensing basis

A set of requirements and documents for a regulated facility or activity comprising:

- the regulatory requirements set out in the applicable laws and regulations
- the conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence
- the safety and control measures described in the licence application and the documents needed to support that licence application

Bounding Approach

A design approach used for developing a representative source term based on the design of a theoretical composite reactor facility derived from the weakest systems of multiple competing vendor designs. This bounded design represents the most conservative (worst case) source term, thereby ensuring the eventual selected technology will meet any requirements of the Environmental Assessment and is confirmed at the time of the Construction Licence review for new reactor facilities.

Exclusion Zone

Overview of Process for Determining Exclusion Zone in Canada

The information that informs discussions around Exclusion Zone extent for a specific nuclear reactor facility site is developed during the Environmental Assessment (EA) process3 and refined in the Construction Licence application process. In the EA process, the proponent may choose to consider a range of different reactor technologies being considered.

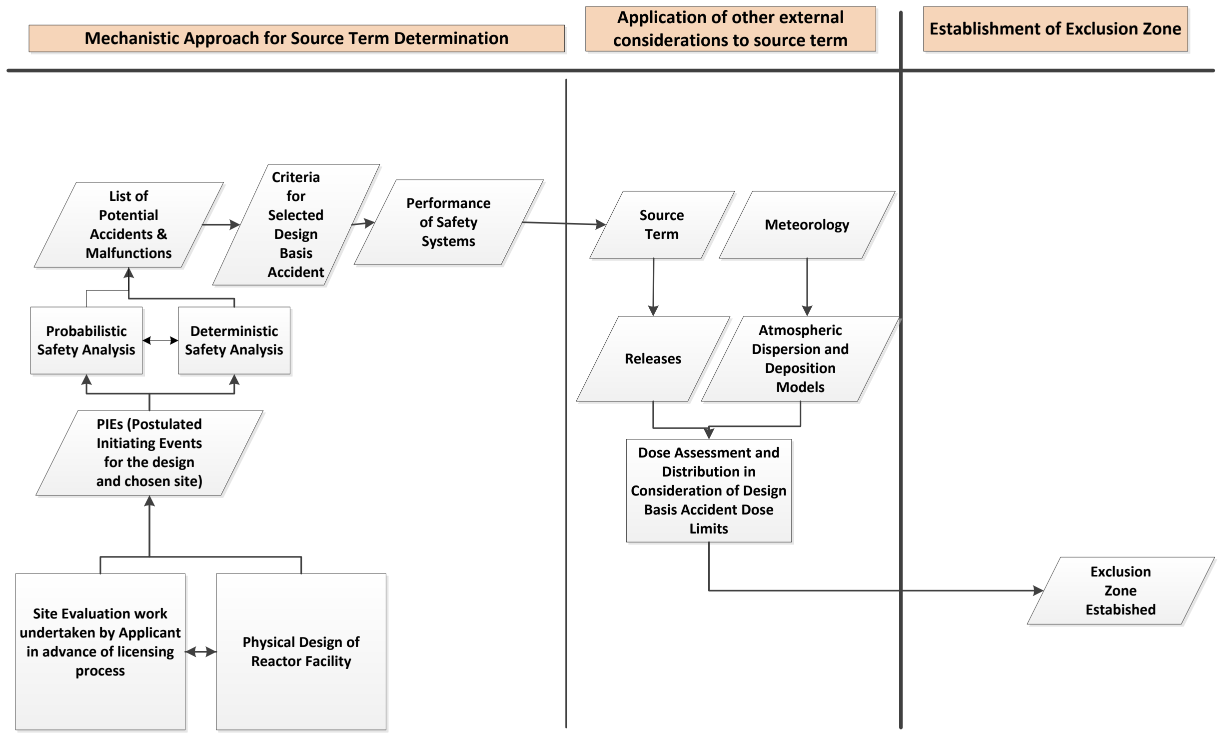
The applicant for a construction licence must demonstrate that:

- The selected Exclusion Zone distance meets the protective action limits set by the Province.
- The reactor facility design has demonstrated that it can, under the selected accidents, meet the pre-established dose criteria for its projected releases.
- That the selected Exclusion Zone distance has taken into consideration all necessary external considerations.

Figure 3 illustrates the overall process for determining the Exclusion Zone extent. The CNSC licensing process results in the acceptance of the Exclusion Zone for a given site. This approach ensures all required regulatory requirements for safety are met while maintaining flexibility to allow for various combinations of technologies and sites.

[3] Normally done in conjunction with an application for a Licence to Prepare Site

Figure 3: Overview of Canadian Process for Determining Exclusion Zone



Considerations for Determining Exclusion Zone

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Vendors must ensure their designs are robust enough to meet their intended safety objectives to address all these potential conditions.

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The Class 1 Nuclear Facilities Regulations requires that an application for a licence for a reactor facility demonstrate that the selected design has accommodated specific site and regional characteristics. Composite bounding designs submitted as a bounding approach are possible; however, the applicant is limited to the projected releases as set in the EA and confirmed at the time of the construction licence review.

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Postulated Initiating Events (PIE)

PIE are theoretical events that can cause one or more adverse effects on the facility. They form a key input to the safety analysis of a facility design in all of its potential environments.

These events consider internal events, such as the breaking of an installed component within the plant, or an electrical fire. They also consider external events such as a significant earthquake or flooding.

There is a significant body of ongoing knowledge capture, best practice and lessons learned in this field. Vendors, owners groups, regulators, researchers and other nuclear safety organizations are involved in developing and maintaining the body of practice around PIE.

Site evaluation also plays a key role in the identification of PIE for the specific site. The CNSC provides requirements and guidance on site evaluation for new nuclear power plants. Please refer to the following for further information RD-346, Site Evaluation for New Nuclear Power Plants. In addition, information on identification of PIE can be found in REGDOC-2.4.1, Deterministic Safety Analysis and REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants.

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- A level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.
- A level 2 PSA starts from the level 1 results, analyses the containment behaviour, evaluates the radionuclides released from the failed fuel, and quantifies the releases to the environment. A level 3 PSA starts from the level 2 results, and analyses the distribution of radionuclides in the environment and evaluates the resulting effect on public health.

In Canada, CNSC provides requirements and guidance on conducting a PSA which includes targeted requirements to address the lessons learned from the Fukushima event and allows for a Graded Approach, commensurate with risk. Please refer to the following for further information REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants.

Deterministic Safety Analysis (DSA)

DSA predicts the facility's response to a range of events based on the current state of the facility as well as operator actions. This analysis addresses a range of scenarios for which the acceptance criteria must be met. It is another tool for early identification and mitigation of potential risks.

A DSA of a reactor facility's responses to an event is performed by an applicant/licensee using predetermined rules and assumptions (such as those concerning the initial facility operational state, availability and performance of the facility systems and operator actions). DSA can use either conservative or best-estimate methods.

CNSC experts review licensee deterministic safety analyses as part of verification and compliance activities.

In Canada, CNSC provides requirements and guidance on conducting a DSSA which includes targeted requirements to address the lessons learned from the Fukushima event and allows for a Graded Approach, and commensurate with risk.

Requirements for DSA are articulated in REGDOC-2.4.1, Deterministic Safety Analysis.

List of Potential Accidents and Malfunctions

The list of potential accidents and malfunctions are derived from the analysis of the plant response to the PIE, and are an output of the safety analysis and are used to identify the limiting accident.

Criteria for Identification of the Limiting Credible Accident

The identification of the limiting accident is one of the most critical steps in the overall system of arriving at an appropriate Exclusion Zone extent; however, CNSC recognized that prescribing a limiting accident could place unnecessary constraints on the ability to apply new technological approaches to ensuring safety. As a result, the following approach is used to maintain a certain level of flexibility while ensuring safety:

From the list of accidents and malfunctions coming out of the safety analysis, a range of representative design basis accidents must be identified that appropriately represent criteria that are technically credible and acceptable from an emergency planning basis.

Performance of Safety Systems and Emergency Operating Procedures (EOPs) and Severe Accident Guidelines (SAMG)

Following the selection of the limiting credible design basis accident, an assessment of the reactor facility's ability to respond to the accident is performed in order to come up with the postulated source term. This includes the effectiveness of safety systems in limiting fuel damage, and preventing uncontrolled releases of radionuclides to the environment.

The Source Term and releases

The resulting source term is a list of all of the radionuclides that would be released to the environment for the selected accident, following the functioning of all the safety systems to their expected performance under the accident conditions. The source term also includes the release duration and other parameters such as stack height.

Considerations of Meteorology for Atmospheric Dispersion and Deposition Models

The sites meteorological characterization data and modelling is applied to the release to see how the types of isotopes would travel through the air and be deposited throughout the environment.

Dose Assessment in Consideration of Pre-Established Design Basis Accident Dose Limits

Once the dispersion and deposition models have been characterized, the resulting exposure pathways and dose calculations are performed. These are assessed against pre-established design basis accident dose limits.

China

EPZ regulation of NPP

Within China, EPZ should be set around the NPP. It contains Plume Emergency Planning Zone (PEPZ) and Ingestion Emergency Planning Zone (IEPZ). The set and size of EPZ for NPP normally refer to the national standard *emergency plan and preparedness criterion part I: the division of EPZ (*GB/T 17680.1*)*. According to the national standard, the PEPZ includes inner zone and outer zone. The size of PEPZ generally is about 7~10km and inner zone is about 3~5 km, considering heat power of reactor and radiological consequences of postulated accident sequences as well as political factors. IEPZ can be considered with results of accident radioactive consequence assessment in the stage of emergency plan and preparation.

Siting regulation of NPP

Exclusion Area (EA) and Planning Restricted Area (PRA) must be set around NPP. The size of both areas shall be determined with radioactive consequences of Postulated Siting Accident. Boundaries of EA is no less than 500m from reactor, can be made base on terrain, landform, weather and traffic of site. The radius of PRA must be no less than 5 km distant from the reactor.

NPP shall be built away from cities. Town with the population of 10,000 can't be included in the PRA. Cities with the population of 100,000 can't be in a radius 10 km of the site.

France

POST –ACCIDENT ZONING IN FRANCE[4]

Post-accident zoning is designed to provide a structuring framework within which actions to protect the population and manage contamination across the territories affected by the accident can be instituted.

The first post-accident zoning is established on the basis of a predictive model of future population exposure to the ambient radioactivity in the inhabited zones and contamination in the food chain, as a result of deposited radioactivity. The zoning is determined by the local authority on the basis of dosimetric guidance values taking into account the latest international references and European regulatory framework. The distinction is to be made between two zones each with a distinctive purpose:

- a public protection zone (ZPP) inside which action is needed in order to lower as much as possible population exposure to ambient radioactivity and ingestion of contaminated foods;
- a heightened territorial surveillance zone (ZST), which is broader and more focused on economic management, within which specific monitoring of foodstuffs and farmed crops is to be instituted.

Where applicable, within the public protection zone, a relocation perimeter determined in accordance with the ambient radioactivity (external exposure), is to be defined. Residents must be relocated for a duration that shall vary according to the level of exposure in their living environment.

The public protection zone (ZPP) is defined as the area within which actions designed to reduce exposure to ambient radioactivity for residents of the said areas as low as reasonably achievable are warranted. This area is defined for the purpose of providing radiation protection for the population living in the most contaminated territories, based on dosimetric guidance values. The initial definition of the ZPP will be made on the basis of assessment of projected doses likely to be received during the month following the end of release, without taking into account the effectiveness of the contamination reduction actions implemented in the area. The ZPP is in other words delineated based on the most disadvantageous of the two following exposure indicators:

- the projected effective dose received during the first month following the end of release, regardless of pathways of exposure, including ingestion of contaminated local foodstuffs, the guidance value used being approximately 10 mSv over the first month;
- the projected thyroid equivalent dose received over the course of the first month following the end of release, regardless of pathways of exposure, in particular ingestion of contaminated local foodstuffs, the selected guidance value being approximately 50 mSv over the first month.

The dosimetric guidance values are not to be interpreted as thresholds or limits. The uncertainties on estimated dose are such that other factors than dose should be considered. These factors are connected with the conditions under which the actions envisioned are carried out in reality, and are best assessed at the local level.

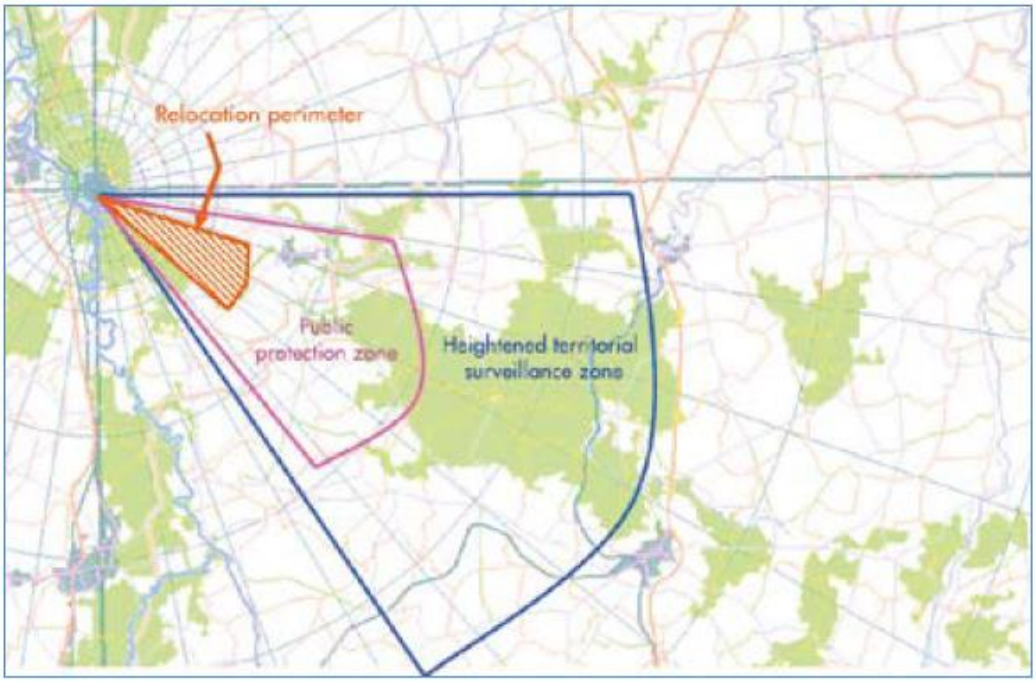
The relocation perimeter shall be delineated based on the results of an assessment showing the projected effective doses over the first month following release, not taking into account the contaminated foodstuffs of local origin ingested, comparing them to a guidance value on the order of 10 mSv over the first month.

The heightened territorial surveillance zone (ZST) extends beyond the borders of the public protection zone. As the emergency phase comes to an end, the ZST is also delineated, using forecast assessments derived from models of the transfers of radioactivity deposited in farming areas. It is characterized by

[4] Policy elements for post-accident management in the event of nuclear accident – Final version – ASN 5/10/2012

lower environmental contamination that does not require the automatic implementation of population protective actions.

This contamination is nonetheless significant and can affect in particular foodstuffs and agricultural products, substantiating the institution of specific systems to monitor the radiological quality of the relevant products. In some agricultural products and foodstuffs, contamination may exceed, albeit temporarily, the maximum permitted levels (NMA), considered of regulatory value and set at the European level to regulate the placing on the market of the said foodstuffs.



Rough depiction of post-accidental zoning

During the exit period from the emergency phase, an approach based on predictive modelling is the only way to provide the public authorities with dose assessments for the population and on agricultural foodstuff contamination, making it possible to define the ZPP and ZST.

In order to secure the most accurate assessment possible, the modelling-based approach requires a large amount of data and information on the characteristics of the affected facility and its environment (in particular on the agricultural production), as well as assumptions about the lifestyles and diet of the populations affected. It is important to emphasize that this method, even when applied using realistic data, yields results worked with significant uncertainties. These are due to the great variability of the phenomena in play, the partial or imprecise understanding of the data used for the assessments, as well as the imprecision intrinsic to the models used.

In such an environment, IRSN, in charge of the first predictive assessments used to define the zoning, uses the data and reasonably conservative assumptions to compute the consequences, in order to prevent the risk that the actions used when establishing the ZPP and ZST are “adjusted upward”. The expression “reasonably conservative assumptions” here refers to assumptions leading to dose or foodstuff contamination estimates on the basis of which sufficiently-protective actions can be adopted, without the ZPP’s or ZST’s becoming oversized as a result, as this could put the populations and local economy at an unwarranted disadvantage. The first assessments are regularly updated, taking into account the new data gained on site, in particular the results of measurement campaigns on the actual environmental contamination gained using the existing resources (radiation monitors, measurement stations) and resources deployed to an exceptional extent (mobile laboratories, helicopter transported monitors, etc.) as well as the local environment (agricultural production, for example).

USA

Within the United States, the regulations for determining the size of the EPZ for large light-water reactors are for fixed distances around NPPs, and deviations from the fixed distances are allowed only by explicit permission of the Nuclear Regulatory Commission. Additionally, siting and emergency preparedness are separate regulations, and both have different bases and require different licensing actions.

The regulations that govern the size of the EPZ for large light-water reactors can be found in two separate locations within the Code of Federal Regulations. In Energy (Title 10 of the Code of Federal Regulations (CFR)), the EPZ sizes are defined to be at 10 miles (16 km) for the plume exposure pathway EPZ and 50 miles (80 km) for the ingestion exposure pathway EPZ. In Emergency Management and Assistance (Title 44 of the CFR), the same distances are defined. The Nuclear Regulatory Commission (NRC) regulates the nuclear licensees and the Federal Emergency Management Agency (FEMA) inspects and evaluates the radiological emergency preparedness for the offsite communities and governments. The relationship between the NRC and FEMA with respect to radiological emergency preparedness is described in a memorandum of understanding (Appendix A to 44 CFR 353) that defines the roles, responsibilities and the authorities that are shared between the two agencies.

The regulations that exist pertain to light-water reactor designs with a reactor power output of greater than 300 megawatts-electric. The NRC is developing a set of regulations for emergency preparedness for small modular reactors, advanced reactor designs and for medical isotope production and utilization facilities. Those efforts can be followed through the website http://www.regulations.gov/ and search for either the NRC rule identification number: 3150-AJ68 or the NRC docket identification number: NRC-2015-0225.

The current practice for the NRC is that if an application for a small reactor design or license were submitted to the NRC for evaluation, the applicant needs to provide such information and analysis to support its application and request for an exemption to the regulations. The NRC staff would evaluate the application, perform or confirm the safety and hazard analyses. After the staff completes its evaluation, the Commission would make a determination of the adequacy of the request. The NRC has granted exemptions to the EPZ regulations in the past.

Russia

Regulation of EPZ issues in Russia is implemented by two regulatory bodies i.e. by Rostechnadzor (nuclear regulatory body), who mainly regulates EPZ sizing and their implementation as early as on siting phase for site selection, and the Ministry of emergency situations (further - EMERCOM), who regulates the issues of the usage of EPZs for emergency planning.

1. **Setting of EPZ sizes based on Rostechnadzor regulations**

Rostechnadzor requirements on NPPs EPZs' sizes are established in [5]. Dose criteria (see tables 1 and 2) which shall be used as a basis for defining the EPZs' sizes are set in [6] are referenced in [5].

Table 1 - Generic intervention levels applicable for planning of response on initial phase of accident

Protective measures	Averted dose (10 days), mSv			
	Whole body		Thyroid, lungs, skin	
	A-level	Almost always justified	A-level	Almost always justified
Sheltering	5	50	50	500
Stable iodine administration: adults children	- -	- -	250* 100*	2500* 1000*
Evacuation	50	500	500	5000
* - thyroid only; If averted dose higher than A-level but lower than “Almost always justified”, than decision on intervention made based on optimization procedures				

It's notably that threat categorization is linked with the buffer zone concept. Buffer zone size in case of NPP (for all units which are in the design) is defined based on normal operation airborne radioactive discharges due to which dose constraint (set by Rospotrebnadzor) shall not be exceeded.

Table 2 - Generic intervention levels applicable for planning of response on intermediate and later phase of accident

Protective measures	Averted dose, mSv	
	A-level	Almost always justified
Restriction of food and drinking water consumption	5 for the first year 1 /y at following years	50 for the first year 10 /y at following years

[5]Baseline criteria and safety requirements on siting of NPPs” NP-032-01.

[6] Norms for radiation safety NRB-99/2009. Sanitary norms and rules SanPiN 2.6.1.2523-09. Approved 07.07.2009 by decree of Chief Medical Officer № 47.

Relocation	50 for the first year	500 for the first year
If averted dose higher than A-level but lower than “Almost always justified”, than decision on intervention made based on optimization procedures		

The application of EPZs partially depends on threat category of facility. Procedure for defining threat category is established in regulatory document OSPORB-99/2010 [7]. According to [7] facilities are categorized as shown in table 3.

Table 3 - Facilities threat categorization

I category	If worst-case accident can lead to exposure that exceeding 1 mSv for member of public (beyond the buffer zone) than this facility is I category
II category	If facility not related to I category and worst-case accident can lead to exposure of personnel that exceeding 5 mSv (in area that between buffer zone and facility site boundary) than this facility is II category
III category	If facility are neither related to I category nor to II category and if there is a possibility of workers exposure (in the site of facility, but not taking into account the rooms, where only group A personnel have access) that exceeding 5mSv than this facility is III category facility
IV category	remainder

This is the criterion for defining size of the buffer zone. In the buffer zone it's prohibited:

- permanent or temporary dwelling of members of public;
- deployment of child-care facilities;
- deployment of industrial and auxiliary facilities not related to facility.

Typical NPPs buffer zone radius is less than 4 km.

The off-site emergency response is necessary only for threat categories I and II. In case of threat category I facility protective measures shall be implemented with regard to public (i.e. beyond the buffer zone) and to the personnel of organizations which are not the facility workers, but which provide various services to facility (i.e. beyond the site boundary and inside the buffer zone). In case of threat category II protective measures shall be implemented only with regard to the personnel of organizations which are not the facility workers, but which provide various services to facility (i.e. inside the buffer zone).

According to [5] and to [8] for NPPs whose design was approved before the year 2003 projected dose shall not exceed "Almost always justified levels" (see table 1) beyond the site boundary in case of possible design basis accidents. This limitation is treated as acceptance criterion. According to [5] and [8] for NPPs whose design was approved after the year 2003 the acceptance criterion almost the same. The only difference from older designs is that more stringent acceptance criterion equal to level A (see table 1) shall not be exceeded. Thus EPZs sizes are defined only for beyond design basis accidents are taken into account.

The Rostechnadzor regulatory document OPB-88/97 [9] states that for purposes of emergency planning only BDBAs with release occurrence frequency of 10-7 per reactor per year are taken into account.

[7] Basic sanitary rules for radiation safety (OSPORB-99/2010). Sanitary norms and rules SP 2.6.1.2612-10 (as amended 16.09.2013). Approved 26.04.2010 by decree of Chief Medical Officer № 40.

[8] Sanitary rules for nuclear power plants design and operation (SP AS-03). SanPiN 2.6.1.24-03. Approved 28.04.2003 by decree of Chief Medical Officer № 69.

9 NP -001-97 (OPB-88/97) “General regulations on nuclear power plants safety”

In [5] there is two kinds of EPZs are subdivided:

- all-phase (initial, intermediate and later phase) emergency planning zone;
- obligatory evacuation emergency planning zone.

In NP-032-01 [5] it's established that all-phase emergency planning zone is defined based on generic intervention levels (see tables 1 and 2) as the zone of maximum radius of all the subzones, the radii of which are determined by the particular protective action (i.e. evacuation, ITB, sheltering, relocation and agricultural countermeasures). Subzone for restriction of food and drinking water consumption (see table 2) has the maximum radius, so all-phase EPZs' size are defined by size of this subzone.

The obligatory evacuation EPZs' size is defined based on "Almost always justified level" (see table 1). NP-032-01 [5] also regulates application of an obligatory evacuation EPZ for NPP site selection purposes. There are restriction imposed in [5] on population density and on presence of hardly evacuated organizations (prisons, hospitals, etc) in obligatory evacuation EPZ.

2. Setting of EPZ sizes based on EMERCOM recommendations

Basic EMERCOM document, which defines EPZs sizes is [10]. According to [10] EPZs of commercial reactors have sizes specified in table 4.

According to [10] in the precautionary protective actions planning zone for purposes of reduction of stochastic effects and eliminating of deterministic effects following measures should be planned:

- total evacuation during 4- 6 hours;
- sheltering;
- iodine prophylaxis.

Protective measures are to be planned within the urgent protective actions planning zone (for purposes reduction of stochastic effects) are: total evacuation within 6-8 hours, iodine prophylaxis and sheltering.

Table 4 - EPZs' sizes of commercial reactors

Thermal power, MWt	Radius of precautionary protective actions planning zone, km	Radius of urgent protective actions planning zone, km		Radius of intermediate and longer term protective actions planning zone, km	
		inner	outer	inner	outer
> 1000	5	5	25	25	100
100 - 1000	3	3	25	25	100
10 - 100	n.a.	0	5	5	50
2 - 10	n.a.	0	0,5	0,5	5

In intermediate and longer term protective actions planning zone a means should be planned for monitoring in order to impose or remove the restrictions on food and water consumption.

[10] Standard contents of off-site protection plan. Approved 14.05.2006 by Minister for emergency situations.