IAEA
International Atomic Energy Agency
Atoms for Peace and Development

GENERAL APPROACH AND CONSIDERATIONS: ENVIRONMENTAL BACKGROUND INCLUDING POPULATION DISTRIBUTION

Asian Nuclear Safety Network (ANSN)
Regional Workshop on Radiological Environmental Impact Assessment for Nuclear Installations
Hosted by the Government of the Philippines through the Philippine Nuclear Research Institute (PNRI)
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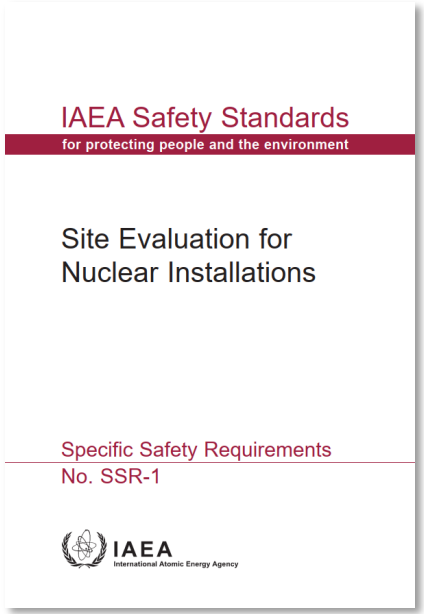
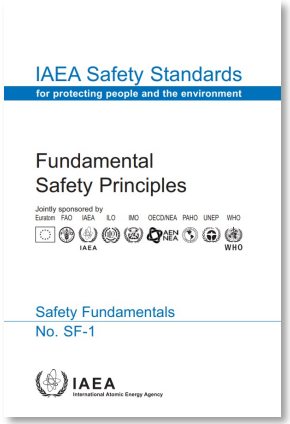
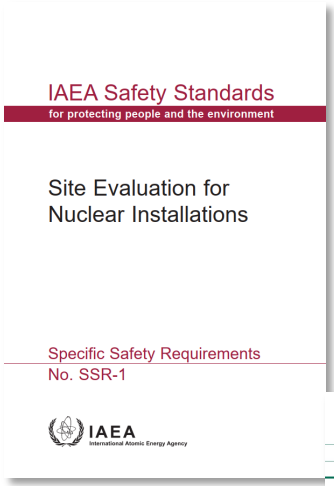
SSR-1: Site Evaluation for Nuclear Installation



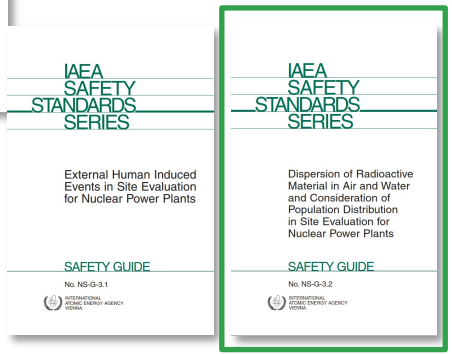
1.2. The requirements for site evaluation for nuclear installations established in this publication are intended to contribute to the protection of workers and the public, and to the protection of the environment, from harmful effects of ionizing radiation, in order to meet the fundamental safety objective established in IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles



SSR-1: Site Evaluation for Nuclear Installation



1.3. This Safety Requirements publication establishes requirements for site evaluation for nuclear installations, in order to meet the fundamental safety objective [SF-1]. Several related Safety Guides … provide recommendations on how to meet the requirements for site evaluation for nuclear installations …



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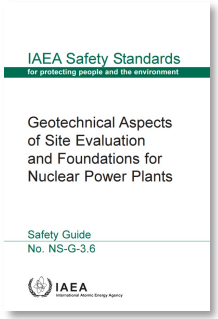
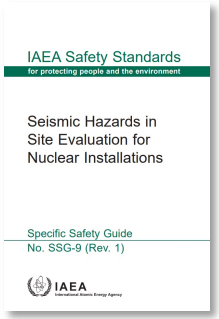
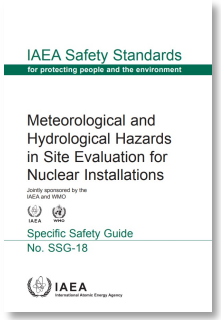
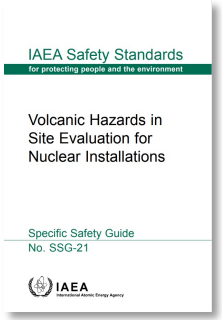
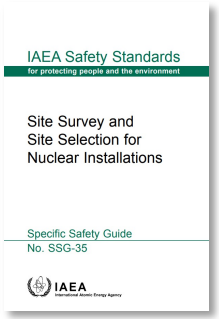




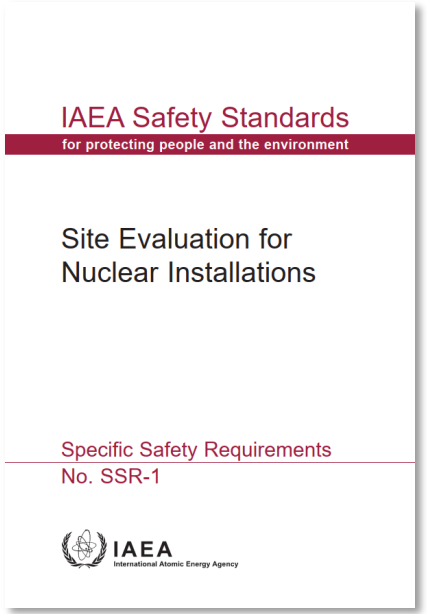






This presentation will cover the Guide NS-G-3.2

SSR-1:Objectives



OBJECTIVE

1.4. The objective of this publication is to establish requirements for:

(a) Defining the information to be used in the site evaluation process;

(b) Evaluating a site such that the site specific hazards and the safety related site characteristics are adequately taken into account, in order to derive appropriate site specific design parameters[3];

(c) Analysing the characteristics of the population and the region surrounding the site to determine whether there would be significant difficulties in implementing emergency response actions effectively [9].

1.5. The requirements in this publication are to be applied:

(a) To identify the natural and human induced external hazards that could affect the safety of the nuclear installation;

(b) To assess the interactions between the site and nuclear installation for operational states and accident conditions, over the lifetime of the nuclear installation, including accidents that could warrant the implementation of emergency response actions.

This presentation will cover

✓ ✓ ✓

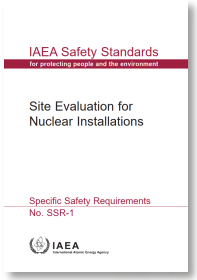
In other words – assessing the impact of the installation on the environment

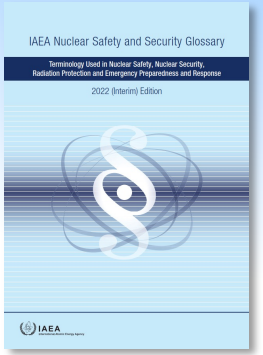
Other work will need to assess the impact of the environment on the installation – external hazards

Scope

- What is a nuclear installation?
- What is meant by the region?
- What is meant by planned exposure situations?
- What is meant by potential exposure?

Nuclear Installation





1.7. The requirements in this publication apply to all nuclear installations [10], as follows:

- Nuclear power plants;
- Research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities;
- Storage facilities for spent fuel;
- Facilities for the enrichment of uranium;
- Nuclear fuel fabrication facilities;
- Conversion facilities;
- Facilities for the reprocessing of spent fuel;
- Facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities;
- Nuclear fuel cycle related research and development facilities.

nuclear installation

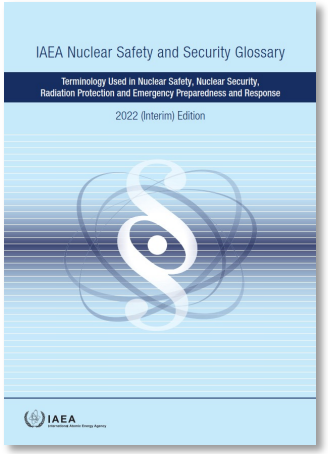
1. Any *nuclear facility* subject to *authorization* that is part of the *nuclear fuel cycle*, except *facilities* for the mining or processing of *uranium* ores or thorium ores and *disposal facilities* for *radioactive waste*.

ⓘ This definition thus includes: nuclear power plants; *research reactors* (including subcritical and *critical assemblies*) and any adjoining radioisotope production *facilities*; *storage facilities* for *spent fuel*; *facilities* for the enrichment of *uranium*; *nuclear fuel* fabrication *facilities*; conversion *facilities*; *facilities* for the *reprocessing* of *spent fuel*; *facilities* for the *predisposal management* of *radioactive waste* arising from *nuclear fuel cycle facilities*; and *nuclear fuel cycle* related research and development *facilities*.

ⓘ For safeguards purposes, see the definition of *nuclear installations* in the Safeguards Glossary [14].

2. [For each Contracting Party, any land-based civil nuclear power plant under its jurisdiction, including such *storage*, handling and treatment *facilities* for radioactive materials as are on the same site and are directly related to the *operation* of the nuclear power plant. Such a plant ceases to be a *nuclear installation* when all nuclear fuel elements have been removed permanently from the reactor core and have been stored safely in accordance with approved procedures, and a *decommissioning* programme has been agreed to by the *regulatory body*.] (See Ref. [10].)

Nuclear Facilities and Activities



facilities and activities

A general term encompassing *nuclear facilities*, uses of all *sources* of *ionizing radiation*, all *radioactive waste management activities*, *transport* of *radioactive material* and any other *practice* or circumstances in which people may be subject to *exposure* to *radiation* from naturally occurring or artificial *sources*.

- ***'Facilities'*** includes: *nuclear facilities*; *irradiation installations*; some mining and raw material processing *facilities* such as *uranium* mines; *radioactive waste management facilities*; and any other places where *radioactive material* is produced, processed, used, handled, stored or disposed of — or where *radiation generators* are installed — on such a scale that consideration of *protection and safety* is required.
- ***'Activities'*** includes: the production, use, import and export of *radiation sources* for industrial, research and medical purposes; the *transport* of *radioactive material*; the *decommissioning* of *facilities*; *radioactive waste management activities* such as the *discharge* of effluents; and some aspects of the *remediation* of sites affected by residues from past *activities*.
- The intention is to include any human *activity* that introduces additional *sources* of *radiation* or additional *exposure pathways*, or that modifies the network of *exposure pathways* from existing *sources*, so as to increase the *exposure* or the likelihood of *exposure* of people or the number of people exposed.
- The term '*facilities and activities*' is intended to provide an alternative to the terminology of *sources* and *practices* (or *interventions*) to refer to general categories of situations.
- For example, a *practice* may involve many different *facilities and/or activities*, whereas the general definition (1) of *source* is too broad in some cases: a *facility or activity* might constitute a *source*, or might involve the use of many *sources*, depending upon the interpretation used.
- The term '*facilities and activities*' is very general, and includes those for which little or no *regulatory control* may be necessary or achievable: the more specific terms ***authorized facility*** and ***authorized activity*** should be used to distinguish those *facilities and activities* for which any form of *authorization* has been given.
- In the Fundamental Safety Principles (Safety Fundamentals), the term '*facilities and activities* — existing and new — utilized for peaceful purposes' is abbreviated for convenience to *facilities and activities* as a general term encompassing any human activity that may cause people to be exposed to *radiation risks* arising from naturally occurring or artificial *sources* (see SF-1 [24], para. 1.9).
- For safeguards purposes, see the definition of *facility* in the Safeguards Glossary [14].
- *Facilities and activities* are listed as follows in GSR Part 4 (Rev. 1) [19]:

  '***Facilities***' includes:

  (a) Nuclear power plants;

  (b) Other reactors (such as *research reactors* and *critical assemblies*);

  (c) Enrichment *facilities* and *nuclear fuel* fabrication facilities;

  (d) Conversion facilities used to generate *uranium* hexafluoride (UF_6);

  (e) *Storage* facilities and *reprocessing* plants for irradiated fuel;

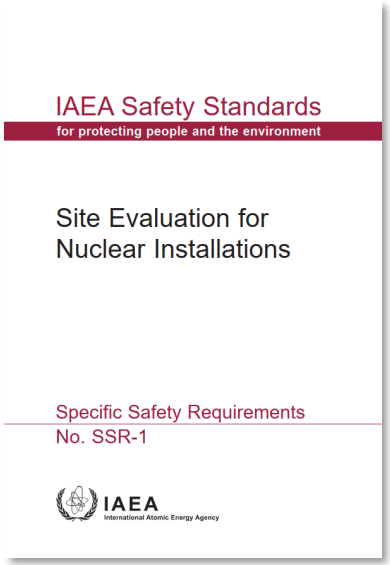
  (f) *Facilities* for *radioactive waste management* where *radioactive waste* is treated, conditioned, stored or disposed of;

Nuclear Installations

- ‘Nuclear Installation’ includes more than just NPPs but is a narrower term than ‘Nuclear Facility’
- Nuclear Installations include
    - Nuclear power reactors
        - Large ~1 GWe
        - SMRs < ~300We
        - Micro < ~ 10 Mwe
        - In operation or under decommissioning (before fuel removed)
    - Research reactors
    - Reprocessing facilities
    - Uranium enrichment plant
    - Fuel manufacturing plant
- NOT
    - Uranium mines
    - Near surface repositories
    - Geological disposal facilities
    - Reactors under decommissioning once fuel removed

- SSR-1, the updated NS-G-3.2, and this Presentation consider only Nuclear Installations

Nuclear Installations other than NPPs



4.5. For site evaluation for nuclear installations other than nuclear power plants, the following shall be taken into consideration in the application of a graded approach:

(a) The amount, type and status of the radioactive inventory at the site (e.g. whether the radioactive material on the site is in solid, liquid and/or gaseous form, and whether the radioactive material is being processed in the nuclear installation or is being stored on the site);
(b) The intrinsic hazards associated with the physical and chemical processes that take place at the nuclear installation;
(c) For research reactors, the thermal power;
(d) The distribution and location of radioactive sources in the nuclear installation;

Region

How big is ‘the Region’?

- It should include area where people can receive significant exposure
  - For individuals, this would be exposure that is significant in comparison with the exposure of the more exposed individuals
  - It is as large as it needs to be to demonstrate that the effects can be fully assessed
    - May depend on pathway – atmospheric dispersion and rivers can carry radioactivity large distances
    - May depend on scenario considered – normal operation or accidental releases

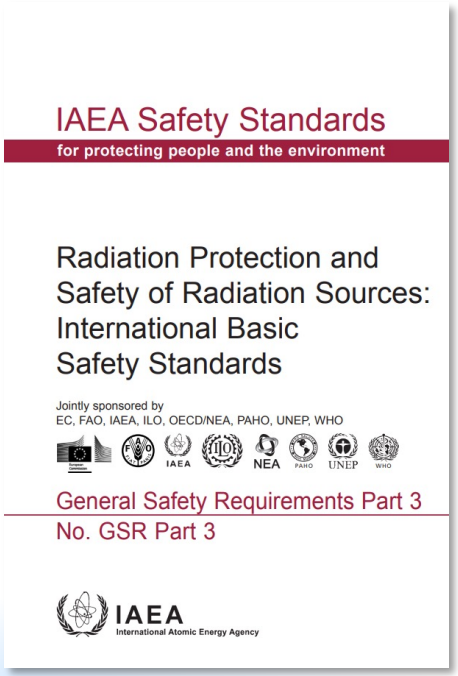
See SSR-1, paragraphs 1.9 -1.12

There are extremely sensitive measurement techniques for radioactivity so not the area over which radioactivity can be detected

NOTE: In some cases – for example transboundary assessments or societal risk assessments if required – larger areas may need to be considered (at least to some extent)

Planned exposure

GSR Part 3, para. 1.20



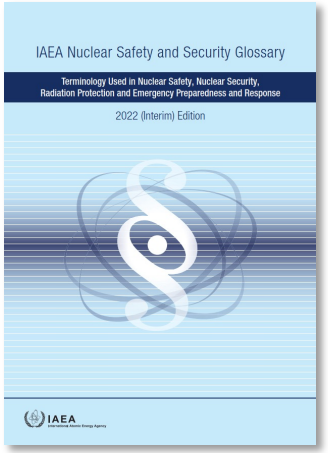
Types of exposure situation

(a) A *planned exposure situation* is a situation of exposure that arises from the planned operation of a source or from a planned activity that results in an exposure due to a source. Since provision for protection and safety can be made before embarking on the activity concerned, the associated exposures and their likelihood of occurrence can be restricted from the outset. The primary means of controlling exposure in planned exposure situations is by good design of facilities, equipment and operating procedures, and by training. In planned exposure situations, exposure at some level can be expected to occur. If exposure is not expected to occur with certainty, but could result from an accident or from an event or a sequence of events that may occur but is not certain to occur, this is referred to as '**potential exposure**'.

(b) An *emergency exposure situation* is a situation of exposure that arises as a result of an accident, a malicious act or any other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences….

(c) An existing exposure situation is a situation of exposure that already exists when a decision on the need for control needs to be taken….

Potential exposure



potential exposure

Prospectively considered *exposure* that is not expected to be delivered with certainty but that may result from an *anticipated operational occurrence* or *accident* at a *source* or owing to an *event* or sequence of *events* of a probabilistic nature, including equipment *failures* and operating errors.

! *Potential exposure* is not an *exposure* and is not a type of *exposure*.

ⓘ *Potential exposure* is considered within *planned exposure situations*.

ⓘ *Potential exposure* includes prospectively considered (i.e. hypothetical or postulated) *exposures* due to a *source* in an *event* or sequence of *events* of a probabilistic nature, including *exposures* resulting from an *accident*, equipment *failures*, operating errors, natural events or phenomena (such as hurricanes, earthquakes and floods) and inadvertent *human intrusion* (such as a *human intrusion* into a near surface *disposal facility* after *institutional control* is removed).

ⓘ In the case of a geological *disposal facility*, *assessment* of the long term action of *processes* and *events* that are uncertain leads to projections of long term *potential exposure*.

Radiological environmental impacts

Include

- Effects from
  - planned routine releases to environment (normal operation)
  - unplanned releases (accidental releases)
- Effects on
  - Workers on site
  - People (public) off-site
  - Other aspects of the environment – fauna & flora, cultural assets

In some cases, assessment of effects needs to be quantitative and compared against established criteria to determine acceptability

In other cases, assessment can be qualitative and the acceptability or otherwise a matter of judgement (see next Slide)

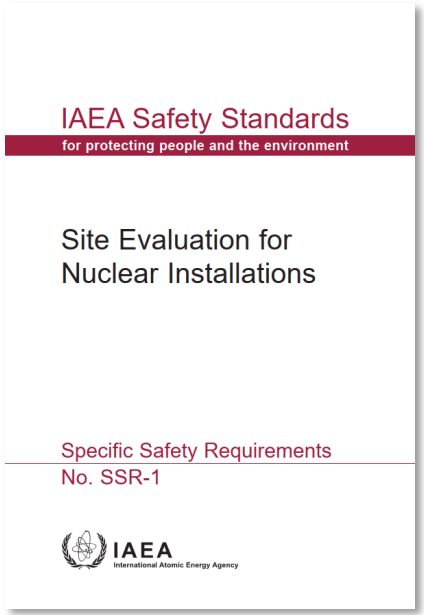
Radiological environmental impacts

	Normal Operation	Potential Exposure Situations
Workers	Quantitative methods and criteria	Quantitative methods and criteria (some MSs)
Public individual	Quantitative methods and criteria	Quantitative methods and criteria (but little international consensus)
Public societal	Quantitative methods and criteria (little international consensus) (some MSs)	Quantitative methods and criteria (little international consensus) (some MSs)
Fauna & Flora	Quantitative methods and criteria available (up to MSs)	Qualitative and judgement (if at all) (up to MSs)
Cultural assets	Qualitative and judgement (if at all) (other non–radiological impacts would be considered)	Qualitative and judgement (if at all) (up to MSs)

General Considerations

Considerations in determining what could be significant for a particular site/installation combination

SSR-1: Graded approach



4. GENERAL REQUIREMENTS FOR SITE EVALUATION

Requirement 3: Scope of the site evaluation for nuclear installations

The scope of the site evaluation shall encompass factors relating to the site and factors relating to the interaction between the site and the installation, for all operational states and accident conditions, including accidents that could warrant emergency response actions.

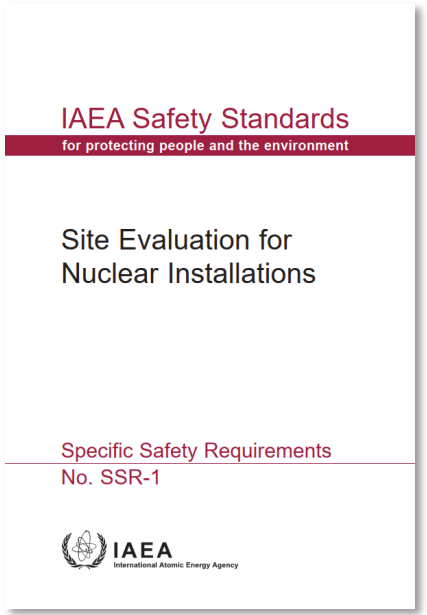
4.1. The scope of the site evaluation shall cover all external hazards, monitoring activities and site specific parameters relevant for the safety of the nuclear installation. In determining the scope of the site evaluation, a graded approach shall be applied commensurate with the radiation risk posed to people and the environment.

4.2. The application of the safety requirements for site evaluation for nuclear installations shall be commensurate with the potential hazards associated with the nuclear installation.

4.3. The level of detail needed in the evaluation of a site for a nuclear installation shall be commensurate with the risk associated with the nuclear installation and the site and will differ depending on the type of nuclear installation.

4.4. The scope and level of detail of the site evaluation process necessary to support the safety demonstration for the nuclear installation shall be determined in accordance with a graded approach.

SSR-1: Site Suitability



Requirement 4: Site suitability

The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation.

4.6. In the assessment of the suitability of a site for a nuclear installation, the following aspects shall be addressed at an early stage of the site evaluation:

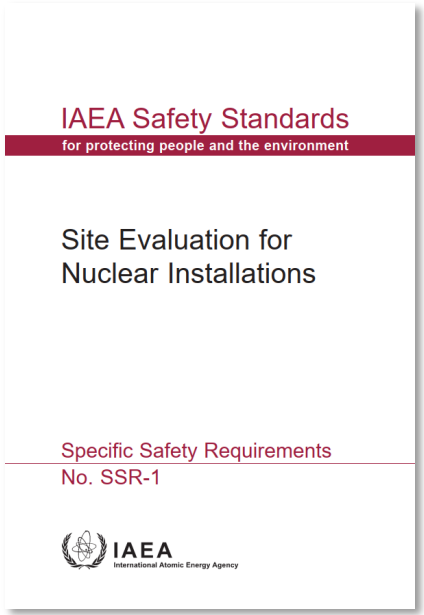
(a) The effects of natural and human induced external events occurring in the region that might affect the site;

(b) The characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and to the environment;

(c) The population density, population distribution and other characteristics of the external zone, in so far as these could affect the feasibility of planning effective emergency response actions [9], and the need to evaluate the risk to individuals and to the population.

4.7. The site shall be deemed unsuitable for a nuclear installation if one or more of the three aspects listed in para. 4.6 indicates that the site is unacceptable and the deficiencies cannot be compensated for by means of a combination of measures for site protection, design features of the nuclear installation and administrative procedures.

SSR-1: Identification of exposure pathways



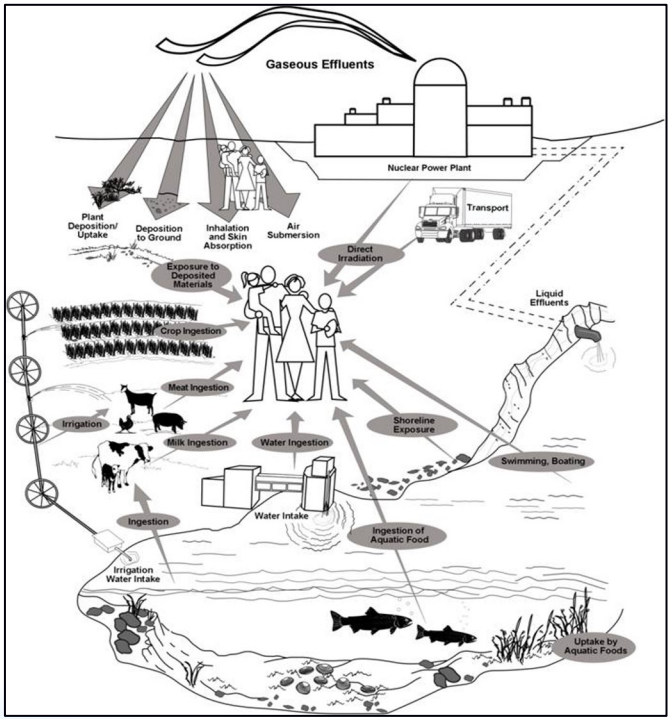
Requirement 12: Potential effects of the nuclear installation on people and the environment

In determining the potential radiological impact of the nuclear installation on the region for operational states and accident conditions, including accidents that could warrant emergency response actions, appropriate estimates shall be made of the potential releases of radioactive material, with account taken of the design of the nuclear installation and its safety features.

4.38. The potential effects of the nuclear installation on people and the environment shall be estimated by considering the postulated accident scenarios (including the resulting source terms) and taking into account the feasibility of planning effective emergency response actions at the site and in the external zone. These estimates shall be confirmed when the design of the nuclear installation and its safety features has been established.

4.39. The direct and indirect pathways by which radioactive releases from the nuclear installation could potentially affect the public and the environment shall be identified and evaluated. In this evaluation, specific regional and site characteristics, including the population distribution in the region, shall be taken into account, with special attention paid to the transport and accumulation of radionuclides in the biosphere.

Identification of Exposure Pathways

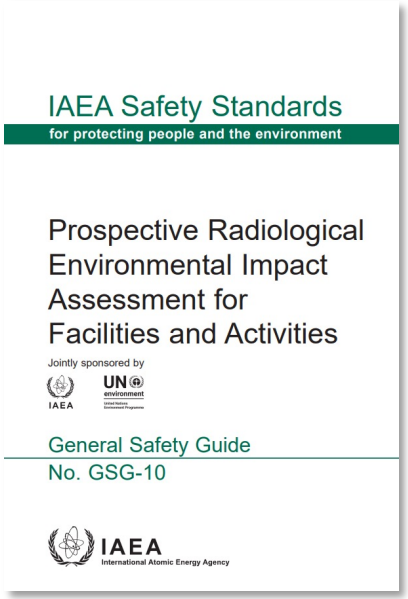


Environment around site needs to be characterized so that impact of radiological releases can be characterized

These are pathways to humans – also may need to consider

- Impact on fauna and flora
- Impact on environmental in general – e.g. cultural assets – as part of the Environmental Impact Assessment for the project

Identification of Exposure Pathways



List of pathways from GSG-10 para. 5.27:

(a) Inhalation of airborne material in an atmospheric plume (gases, vapours, aerosols);

(b) Inhalation of resuspended material;

(c) Ingestion of crops;

(d) Ingestion of animal food products (milk, meat, eggs);

(e) Ingestion of drinking water;

(f) Ingestion of aquatic food (freshwater or seawater fish, crustaceans, molluscs);

(g) Ingestion of forest food (wild mushrooms, wild berries, game);

(h) Ingestion of breast milk or locally prepared food for infants;

(i) Inadvertent ingestion of soil and sediments;

(j) External exposure from radionuclides in an atmospheric plume (cloud shine);

(k) External exposure from radionuclides deposited on the ground (ground shine) and on surfaces;

(l) External exposure from radionuclides in water and sediments (i.e. from activities on shores, swimming and fishing)

Also exposure from direct radiation from site

Identification of Exposure Pathways

Not all pathways will be equally significant

Relative significance may vary for release scenarios

- Planned releases
- Unplanned: spectrum from AOOs to severe accidents
  - Different source terms
  - Different release locations
  - Releases to different environmental media

Significance of pathways

What is a significant will depend on:

- the quantities and chemical and physical form of the radionuclides released and other characteristics of release that may affect their subsequent dispersion and behaviour in the environment (the source term)
- the location and medium into which the release is made
- the characteristics of the environment and population around the site

The first two items will vary from planned releases through the spectrum of unplanned releases

- Frequency of the event for unplanned releases is important in determining its overall significance or risk

Identifying significant pathways

The pathways listed earlier will include the most significant in most circumstances

- However, it is possible that there may be other unusual pathways
- It should be confirmed that all significant pathways have been identified especially if there is something unusual about:
  - the installation design
  - its operation
  - the site
  - land-use around the site e.g. farming practices
  - the surrounding location
- For example, the presence of desalination plants producing water for drinking or irrigation either at or close to the discharge outlets

Sources of radioactivity in a nuclear installation

Corrosion products

- e.g. Co-58, Co-60
- remain in coolant during normal operation but can be released to environment in loss of coolant accidents (LOCAs)

Fission products and actinides

- formed by fission or activation of uranium in fuel
- e.g. noble gases (Kr-85, Xe-138), I-131, Cs-137, Sr-90, Pu-238, Np-239
- prevented from release in normal operation by many barriers
  - fuel matrix, fuel cladding, coolant circuit, containment
- volatiles can be released into coolant through small pin failures or by tramp uranium and therefore can be released when coolant is released or by off-gassing
- in severe accidents when fuel fails all the above barriers may be breached to a greater or lesser extent

Activation products

- e.g. tritium, C-14, Ar-41
- formed by activation of water (in water-cooled reactors) so can be released when coolant is released or by off-gassing

Activity can also be released during fuel handling faults, radioactive waste handling faults, or accidents involving waste storage for example

Factors determining the radiological significance of a given radionuclide

- Large inventory
- Easily released (gas or volatile)
- Half-life long enough not to decay significantly before exposing people and short enough to have high activity (several hours to tens of years)
- High energy gamma decay (or alpha-emitter)
- Easily assimilated and retained in the body
- Concentrated in environmental media or foodstuffs

Summary of relative significance of main pathways for accidental releases

Adapted from Tables in revised NS-G-3.2

Pathway: Inhalation

Short-term (days) versus longer-term (weeks to years) impact	Very high in the short-term for people exposed but no impact later - exposure occurs only during passage of the plume Most nuclides apart from noble gases: short-lived nuclides of volatile elements like I-131 etc. can be particularly significant if present
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Very high for people exposed All people under passage of plume Atmospheric dispersion usually reduces impact with increasing distance from the release
Countermeasures and their effectiveness	Sheltering, evacuation, Stable iodine
Usual overall significance and situation where it might become significant	Very high Likely to be the dominant pathway for an atmospheric release in the short-term unless release is predominantly noble gas
Site characterization data needed	Meteorological data, topographic data, population and habit data

Pathway: Inhalation of resuspended material

Short-term (days) versus longer-term (weeks to years) impact	Low to zero Insignificant when compared with direct inhalation A small fraction of plume deposits and a small fraction of that resuspends Can lead to longer-term exposures but probably still insignificant
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Probably insignificant in the near-field Can lead to exposure in areas unaffected by the initial deposit
Countermeasures and their effectiveness	Relocation
Usual overall significance and situation where it might become significant	Low Could be relatively more important in the longer-term for longer lived nuclides released as particulate particularly alpha and in areas unaffected by the initial deposit
Site characterization data needed	Land-use data and surface types could be used but probably not worthwhile considering low relative significance

Pathway: Ingestion of crops

Short-term (days) versus longer-term (weeks to years) impact	None in the short term as unlikely that harvest would occur before countermeasures implemented Can lead to impact when food harvested if no food bans applied Can also lead to longer-term exposure if land contaminated and crop production continues
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Could be significant for people not exposed to the plume directly Can lead to significant collective doses as will affect any farm under the plume passage but assessment would require aggregating very small doses over large numbers of people which is not recommended
Countermeasures and their effectiveness	Food bans effective if implemented
Usual overall significance and situation where it might become significant	Medium Possibly important if societal effects considered
Site characterization data needed	Data on agricultural practices in the local area and habit (food consumption) data in the local population and the population in general

Pathway: Ingestion of animal food products (milk, meat, eggs)

Short-term (days) versus longer-term (weeks to years) impact	Produce in continuous production such as milk can lead to exposure almost immediately and peaking within a few days.
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Could be significant for people not exposed to the plume directly Can lead to significant collective doses as will affect any farm under the plume passage but assessment would require aggregating very small doses over large numbers of people which is not recommended
Countermeasures and their effectiveness	Food bans effective if implemented
Usual overall significance and situation where it might become significant	Medium to High Possibly faster route to exposure than with crops. Deposition on pasture and then through cows to milk and human consumption can be a significant pathway
Site characterization data needed	Data on agricultural practices in the local area and habit (food consumption) data in the local population and the population in general

Pathway: Ingestion of drinking water

Short-term (days) versus longer-term (weeks to years) impact	Unlikely to be important in the short-term unless water source very close to the release Can lead to longer-term exposure for longer-lived nuclides
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Unlikely to be a significant contributor to individual dose as significant dilution may occur Could be significant for collective dose for a large water source
Countermeasures and their effectiveness	Food bans effective if implemented
Usual overall significance and situation where it might become significant	Low Counter-measures very likely to be effective for large drinking water sources
Site characterization data needed	Local water sources such as reservoirs Local habit data

Pathway: Ingestion of aquatic food (freshwater or seawater fish, crustaceans, molluscs)

Short-term (days) versus longer-term (weeks to years) impact	Unlikely to be important in the short-term Possible that nuclides could be concentrated in sediments and/or by aquatic organisms Iodine can be concentrated in seaweed and then eaten by some people
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Could be important wherever food is consumed
Countermeasures and their effectiveness	Food bans effective if implemented
Usual overall significance and situation where it might become significant	Low High dilution and easy to implement food-bans. Possibly relatively more important where activity is concentrated or where fishing consumption less amenable to control
Site characterization data needed	Data on water transport, concentration factors for sediments and organisms, habit data for consumers

Pathway: Ingestion of forest food (wild mushrooms, wild berries, game)

Short-term (days) versus longer-term (weeks to years) impact	Could be important in short or long term
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Will be most significant where contamination is highest
Countermeasures and their effectiveness	Interdiction of land but less likely to be as effective as bans on commercially produced food
Usual overall significance and situation where it might become significant	Low Could be relatively more significant where foraging occurs close to a site as this type of food consumption is less amenable to control Exposure by this pathway could also be combined with exposure by ground shine during collection of food
Site characterization data needed	Data on location and type of food, habit data (consumption and foraging)

Pathway: Ingestion of breast milk or locally prepared food for infants

Short-term (days) versus longer-term (weeks to years) impact	Could be important in short or long term
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	
Countermeasures and their effectiveness	
Usual overall significance and situation where it might become significant	Can be relatively more important for some specific nuclides
Site characterization data needed	

Pathway: Inadvertent ingestion of soil and sediments

Short-term (days) versus longer-term (weeks to years) impact	Could be important in short or long term
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Will be most significant where contamination is highest
Countermeasures and their effectiveness	
Usual overall significance and situation where it might become significant	Low Pica (e.g. ingestion of soil) could be important for infants and small children as less amenable to control
Site characterization data needed	

Pathway: External exposure from radionuclides in an atmospheric plume (cloud shine)

Short-term (days) versus longer-term (weeks to years) impact	Only occurs during initial passage of the plume Since exposure is determined largely by the concentration of radionuclide in the plume exposure by this pathway will occur at the same time as inhalation and inhalation will usually be the dominant pathway for most nuclides other than noble gases
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	As for inhalation above
Countermeasures and their effectiveness	Sheltering, evacuation
Usual overall significance and situation where it might become significant	Medium Important if the releases are predominantly noble gas. For releases with other nuclides, inhalation is likely to dominate
Site characterization data needed	As for inhalation above

Pathway: External exposure from radionuclides deposited on the ground (ground shine) and on surfaces

Short-term (days) versus longer-term (weeks to years) impact	Probably less significant than inhalation in the very short term but can be very important in the longer-term
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Will be most significant where deposition of activity is highest
Countermeasures and their effectiveness	Sheltering, evacuation
Usual overall significance and situation where it might become significant	High Relatively more important for longer-lived nuclides such as Cs-134, Cs-137 for long integration times
Site characterization data needed	As for inhalation above

Pathway: Exposure from direct deposition on skin

Short-term (days) versus longer-term (weeks to years) impact	More significant in the shorter term as activity can be removed or washed off
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	Will be most significant where deposition of activity is highest
Countermeasures and their effectiveness	Washing is an effective countermeasure
Usual overall significance and situation where it might become significant	Low Could be relatively more important for radionuclides with high energy beta decay
Site characterization data needed	As above for inhalation

Pathway: External exposure from radionuclides in water and sediments (i.e. from activities on shores, swimming and fishing)

Short-term (days) versus longer-term (weeks to years) impact	Could be important in short or long term
Near field (a few km) individual risks Versus Far field (a few 100 km) societal effects	
Countermeasures and their effectiveness	
Usual overall significance and situation where it might become significant	Low Could be relatively more important for people engaged in these activities if there has been a significant release to these waters
Site characterization data needed	Water transport, sediment behaviour and transfer coefficients form water to sediments Local habit data

IAEA
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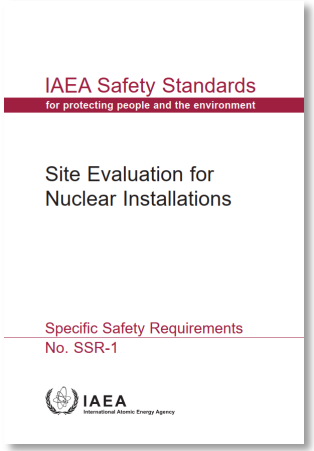
Population distribution and public exposure

SSR-1 Requirement 25:Population Distribution and public exposure



Requirement 26: Population distribution and public exposure

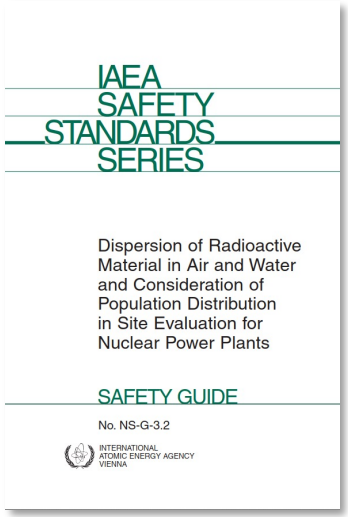
The existing and projected population distribution within the region over the lifetime of the nuclear installation shall be determined and the potential impact of radioactive releases on the public, in both operational states and accident conditions, shall be evaluated and periodically updated.

6.8. Information on the existing and projected population distribution in the region, including resident populations and (to the extent possible) transient populations, shall be collected and kept up to date over the lifetime of the nuclear installation. Special attention shall be paid to vulnerable populations and residential institutions (e.g. schools, hospitals, nursing homes and prisons) when evaluating the potential impact of radioactive releases and considering the feasibility of implementing protective actions.

6.9. The most recent census data for the region, or information obtained by extrapolation of the most recent data on resident populations and transient populations, shall be used in obtaining the population distribution. In the absence of reliable data, a special study shall be carried out.

6.10. The data shall be analysed to obtain the population distribution in terms of the direction and distance from the site. This information shall be used to carry out an evaluation of the potential radiological impact of normal discharges and accidental releases of radioactive material, including reasonable consideration of releases due to severe accidents, with the use of site specific design parameters and models as appropriate.

Population Distribution



5.1. The distribution and characteristics of the regional population should be studied in the site evaluation for a nuclear power plant. The purposes of the studies should be:

— to evaluate the potential radiological impacts of normal radioactive discharges and accidental releases; and
— to assist in the demonstration of the feasibility of the emergency response plan.

Why is population data needed?

Two principal uses of population data

SITE EVALUATION
Population assessment
Habit survey
- local food consumption
- activities

Land use – agriculture
Water use

→ Emergency Plan

→ Risks to individuals and population
- Normal operation
- Accidents

→ Environmental Impact Assessment

Regulatory review

Emergency plan feasible
Site OK ✓

Risks acceptable
Site OK ✓

Environmental impact acceptable
Site OK ✓

Summary of population data requirements

SITE EVALUATION

Population assessment

- Geographical distribution
- Transient populations
- NPP site workers and families
  - Avoid double-counting
- People close to site
- Densely populated regions
- Vulnerable populations
  - schools, hospitals etc.
- Closest populations and large population centres in neighbouring states

Habit survey

Land use - agriculture

→ Develop Emergency Plan
Assess emergency plan

→ Impact assessment and comparison against criteria

↑ Projected growth and changes over lifecycle of the NPP (~100 years)

Summary on population data

Fundamental issues to be addressed concerning population are:

- Are the risks to the population acceptable?
- Is the Emergency Plan feasible?

Different Member States satisfy IAEA Requirements and Guidance in different ways

Different Member States may adopt different population criteria for siting

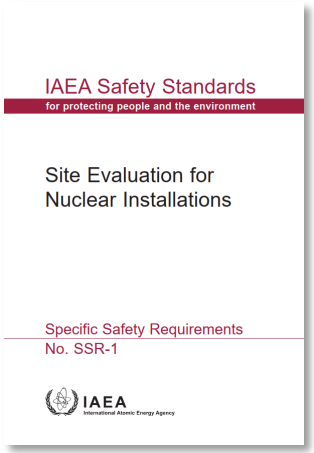
For each individual Member State the following factors – *inter alia* – will need to be balanced in adopting siting criteria or selecting sites:

- Risks to the local population
- Sites available (e.g. some Member States may have more land available and can afford to have more stringent criteria – other States may have a more limited choice)
- Infra-structure available
- Proximity to power demand

For the future, new types of reactors such as SMRs (Small Modular Reactors) may require a different balance – risks may be lower and many more sites may be needed

Uses of land and water in the region

SSR-1 Requirement 25: Uses of land and water in the region

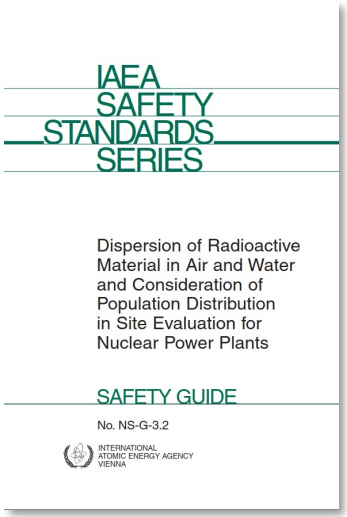


Requirement 27: Uses of land and water in the region

The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation on the region.

6.11. The characterization of the uses of land and water shall include investigations of the land and surface water and groundwater resources that might be used by the population or that serve as a habitat for organisms in the food chain.

Uses of land and Water in the Region of the Site



4.2. The investigations should cover:

(a) land devoted to agricultural uses, its extent, and the main crops and their yields;
(b) land devoted to dairy farming, its extent and yields;
(c) land devoted to industrial, institutional and recreational purposes, its extent and the characteristics of its use;
(d) bodies of water used for commercial, individual and recreational fishing, including details of the aquatic species fished, their abundance and yield;
(e) bodies of water used for commercial purposes, including navigation, community water supply, irrigation, and recreational purposes such as bathing and sailing;
(f) land and bodies of water supporting wildlife and livestock;
(g) direct and indirect pathways for potential radioactive contamination of the food-chain;
(h) products imported to or exported from the region which may form part of the food-chain;
(i) free foods such as mushrooms, berries and seaweed.

Habit data for the local population

The need to identify a Representative Person

A value for individual risk needs to be calculated

- Representative person for potential exposures may be different from that for normal operation

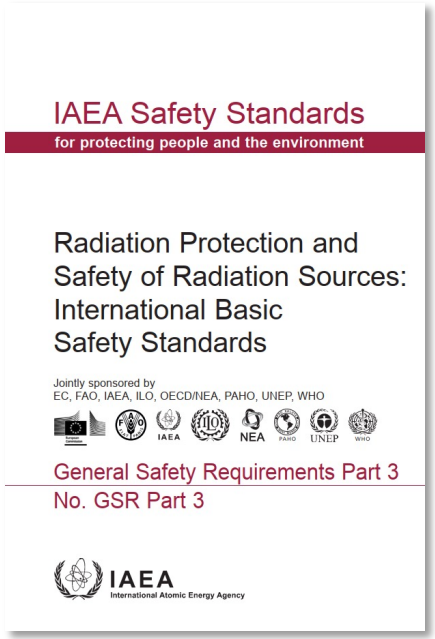
Cannot calculate risk to every individual who might be exposed

Therefore need to identify a hypothetical person who is representative of the group of people most exposed

- Representative in terms of age and habits, e.g.
  - Where they live
  - Where they go
  - What they eat
  - Time spent outdoors
  - Other activities that might lead to exposure
    - *It is important that individual habits (e.g. consumption of foodstuffs, breathing rate, location, use of local resources) used in the deterministic approach are average habits of a small number of individuals who are representative of those more highly exposed, and not the extreme habits of a single member of the population* (ICRP-101)
    - *In selecting habit data for the representative person, reasonableness, sustainability, and homogeneity must be considered* (ICRP-101)

If risk to the Representative Person is acceptable then the population as a whole should be protected

Representative person (critical group)



GSR Part 3 defines the representative person as “an individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population”

- Homogeneous with respect to age, diet, behaviour
- Habits that are sustainable

Some other people maybe exposed to higher doses but most people should be exposed to less dose

May refer to workers for whom the exposures incurred are not considered occupational exposure, and who then are considered as members of the public

Identification of the Representative Person

A representative person (actual or hypothetical individuals likely to be more highly exposed) should be identified

Representative persons for exposures in normal operation or from accident scenarios may be different

For accident scenarios, different exposed population groups may be identified, depending on:

- the characteristics of the accident or event
- the time of day or time of year of the postulated release, in accordance with, for instance, the prevailing meteorological or hydrological conditions, possible temporary occupancy (e.g. different occupancy during day and night, existence of summer campsites and schools, presence of workers near the facility) and seasonal variations in habits and in consumption of food products.

An alternative approach may be to consider average occupancy factors, and habits and food products for each season

Identification of the Representative Person for potential exposures

The end points of the assessment of the potential exposures could differ, depending on the type of assessment and the criteria specified

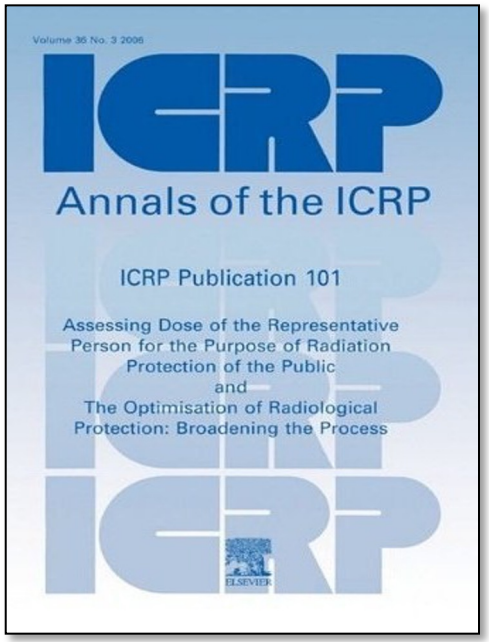
For instance, other possibilities for end points include:

- the dose at a specific location (e.g. the nearest town in the region)
- the dose at a fixed distance (e.g. 1 km, 5 km, 10 km)
- or a distance where a certain relevant projected dose is exceeded (e.g. 100 mSv in the first seven days, if such value is the threshold reference level for protective measures)

In some States, the distribution of doses or risks among larger affected populations is used as an end point

Although there is flexibility in the ways that potential exposures are considered, and different States adopt different approaches, the use of particular end points and criteria should be clearly defined and justified in the relevant regulations or in the assessment, to avoid misunderstanding and misinterpretation of the results.

ICRP 101 – Representative Person



ICRP website: www.icrp.org

Provision of guidance on assessing doses to Representative Person

Choice of an appropriate Representative Person

- Reasonableness
- Sustainability
- Homogeneity

(89) In a prospective probabilistic assessment of dose to individuals, whether from a planned facility or an existing situation, the Commission recommends that the representative person should be defined such that the probability is less than about 5% that a person drawn at random from the population will receive a greater dose.

(74) Care should be exercised to avoid selecting extreme percentile values for every variable to prevent excessive conservatism in the assessment. Such a result could lead to a significant and unrealistic overestimation of the dose to the representative person, and may unduly burden the design of medical or other facilities. Taken together, the selection of parameter values must represent a reasonable and sustainable exposure scenario.

(60) For a time period of about 50 years into the future, it is reasonable to assume that characteristics of individuals can be based on current habit data. The prospective assessment of annual individual dose can therefore be considered valid for a period of this order.

Representative Person

The characteristics of the representative person should be specified by the applicant in accordance with national regulations and in agreement with the regulatory body

- For example, the regulatory body may require the use of more detailed and site specific habit data for assessments carried out for certain types of facilities or at later stages in the authorization process

Habit data should represent habits typical of the population living in the region where the facility is located or in the State at large

Can be obtained from statistics collected at national, regional or international levels or, where possible, from surveys carried out at or near the location where the facility will operate

Representative person

Habit Data include:

- inhalation rates
  - a working farmer will have a higher rate than a normal resident or office worker
- consumption rates of food and drinking water
  - where the representative person obtains food
  - the fraction of the food consumed that is of local or regional origin
- location of person (where they live and where they go)
  - their distance and direction from the point of release of radionuclides
  - the occupancy times at different locations and the fractions of time spent outdoors and indoors
  - can be based on an actual person or group of persons, or on a postulated person or group of persons living at a location selected using cautious assumptions (e.g. close to the site fence or in a region where the highest deposition of radionuclides can be expected)

Representative person – UK example

NRPB-W41

Generalised Habit Data for Radiological Assessments

K R Smith and A L Jones

ABSTRACT

Members of the public are exposed to radiation, or have the potential for such exposure, because their location or habits bring them into contact with a source of radiation. They may be exposed directly from the source, by direct irradiation or inhalation of released activity, or indirectly due to exposure to contaminated environmental materials, for example, foods. Consequently, habit data are an essential part of dose and risk assessments for members of the public. The habit data used for assessment purposes at NRPB are kept under review and updated as necessary. This report provides a summary of the default habit data which are currently used at NRPB for general radiological assessment purposes for members of the public. The following types of data are discussed: generalised food intake rates; generalised water and air intake rates; indicative habits of coastal communities, eg, aquatic food intake rates; shoreline occupancies, of both coastal communities and the general population; and occupancy data for the time spent indoors and outdoors.

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CONTENTS

http://webarchive.nationalarchives.gov.uk/20140721185223/http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/NRPBWSeriesReports/2003nrpbw041/

Generic habit data (food consumption)

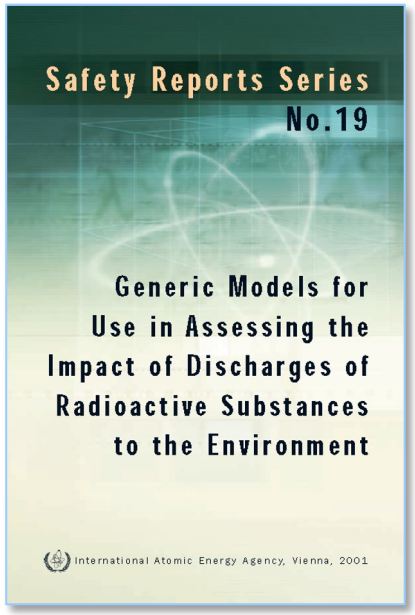

TABLE XVIII. DEFAULT VALUES OF INTAKE PER PERSON FOR VARIOUS CRITICAL GROUPS IN THE WORLD (ADULTS)

	Far East	Near East	Africa	South America	Central America	North America	Europe	Oceania
Water (m^3/a)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Milk (L/a)	65	140	80	135	155	325	250	410
Meat (kg/a)	40	55	35	90	75	205	100	200
Grain, root crops, vegetables and fruits (kg/a)	510	600	380	470	445	535	410	500
Freshwater fish (kg/a)	35	10	15	20	25	25	30	15
Marine fish (kg/a)	60	20	30	35	45	40	50	30
Shellfish (kg/a)	20	5	10	10	15	15	15	10

See also TECDOC-1996 (discussed later)

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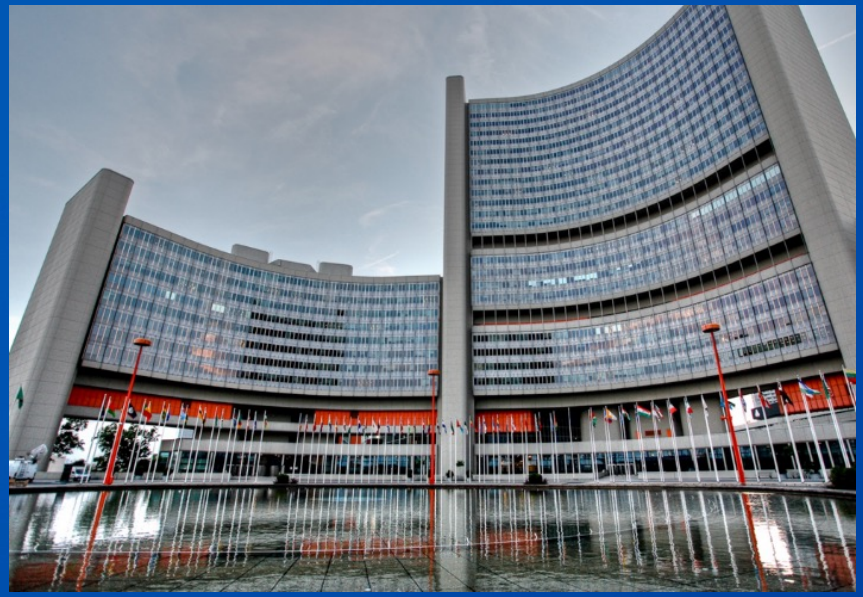

Thank you!
Questions?