IAEA SAFETY STANDARDS SERIES

Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants

SAFETY GUIDE

No. NS-G-3.2

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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Information on the IAEA's safety standards programme (including editions in languages other than English) is available at the IAEA Internet site

www.iaea.org/ns/coordinet

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DISPERSION OF RADIOACTIVE MATERIAL IN AIR AND WATER AND CONSIDERATION OF POPULATION DISTRIBUTION IN SITE EVALUATION FOR NUCLEAR POWER PLANTS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

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FOREWORD

by Mohamed ElBaradei
Director General

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following bodies oversee the development of safety standards: the Commission for Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail; obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA. Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfil their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by individual States.

The attention of States is drawn to the fact that the safety standards of the IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfil all of their international obligations effectively.

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

The English version of the text is the authoritative version.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. The IAEA issues Safety Requirements and Safety Guides pertaining to nuclear power plants and activities in the field of nuclear energy, on the basis of its Safety Fundamentals publication on The Safety of Nuclear Installations [1]. The present Safety Guide, which supplements the Code on the Safety of Nuclear Power Plants: Siting [2][1], concerns the effects of a nuclear power plant on the surrounding region and the consideration of population distribution in the siting of a plant.

1.2. This Safety Guide makes recommendations on how to meet the requirements of the Code on the Safety of Nuclear Power Plants: Siting, on the basis of knowledge of the mechanisms for the dispersion of effluents discharged into the atmosphere and into surface water and groundwater. Relevant site characteristics and safety considerations are discussed. Population distribution, the projected population growth rate, particular geographical features, the capabilities of local transport networks and communications networks, industry and agriculture in the region, and recreational and institutional activities in the region should be considered in assessing the feasibility of developing an emergency response plan.

1.3. In the selection of a site for a facility using radioactive material, such as a nuclear power plant, account should be taken of any local features that might be affected by the facility and of the feasibility of off-site intervention, including emergency response and protective actions (see the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [3], Appendices IV and V). This is in addition to the evaluation of any features of the site itself that might affect the safety of the facility. This Safety Guide recommends methods for the assessment of regional and local characteristics.

1.4. This Safety Guide supersedes four earlier IAEA Safety Guides, namely: Atmospheric Dispersion in Nuclear Power Plant Siting (Safety Series No. 50-SG-S3 (1980)); Site Selection and Evaluation for Nuclear Power Plants with Respect to Population Distribution (Safety Series No. 50-SG-S4 (1980)); Hydrological Dispersion of Radioactive Material in Relation to Nuclear Power Plant Siting (Safety Series No. 50-SG-S6 (1985)); and Nuclear Power Plant Siting: Hydrogeological Aspects (Safety Series No. 50-SG-S7 (1984)).

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[1] To be superseded by a Safety Requirements publication on Safety of Nuclear Power Plants: Site Evaluation, in the Safety Standards Series.

OBJECTIVE

1.5. Radioactive materials discharged from a nuclear power plant might reach the public and might contaminate the environment in the region by way of both direct and indirect pathways. The objective of this Safety Guide is to provide guidance on the studies and investigations necessary for assessing the impact of a nuclear power plant on humans and the environment. It also provides guidance on the feasibility of an effective emergency response plan, in consideration of all the relevant site features.

1.6. This Safety Guide provides guidance on investigations relating to population distribution, and on the dispersion of effluents in air, surface water and groundwater. The guidance is intended to help determine whether the site selected for a nuclear power plant satisfies national requirements and whether possible radiological exposure and hazards to the population and to the environment are controlled within the limits set by the regulatory body, with account taken of international recommendations.

SCOPE

1.7. This Safety Guide provides guidance for the site evaluation stage of a facility, specifically on:

- the development of meteorological, hydrological and hydrogeological descriptions of a plant site;
- programmes to collect meteorological and hydrological data (for surface water and groundwater);
- programmes to collect data on the distribution of the surrounding population in order to demonstrate the feasibility of an effective emergency plan.

1.8. The effects of the proposed plant on the uses of land and water in the region of the site have to be investigated and are covered by this Safety Guide. This is also an aspect that should be considered in the preparation of an emergency plan and in the environmental impact assessment.

1.9. This Safety Guide does not give guidance on dose assessment in relation to the siting of a nuclear power plant. Specific guidance on the calculation of doses and for the identification of characteristics of the site that are relevant to the local and regional radiological impact of a nuclear power plant is given in Refs [4, 5].

1.10. This Safety Guide does not give detailed information on specific methods or mathematical models. Methods for calculating the concentrations and rates of deposition of radioactive material due to the dispersion of effluents in air or water are presented in Ref. [4]. Attention should be paid to the use of environmental data in conjunction with calculational models to ensure that the type of data is appropriate for the regulatory objective.

STRUCTURE

1.11. Sections 2 and 3 provide guidance on the collection of data on the dispersion of radioactive material in air and water. Sections 4 and 5 provide guidance relating to uses of land and water and to the distribution of the population in the region. Guidance on the site related information necessary for the establishment of an emergency plan is given in Section 6. Guidance on quality assurance considerations is provided in Section 7.

2. TRANSPORT AND DIFFUSION OF EFFLUENTS DISCHARGED INTO THE ATMOSPHERE

GENERAL CONSIDERATIONS

2.1. The atmosphere is a major exposure pathway by which radioactive materials that are either routinely discharged under authorization or accidentally released from a nuclear power plant could be dispersed in the environment and transported to locations where they may reach the public.

2.2. The evaluation of the transport in the atmosphere of radioactive materials discharged from a nuclear power plant under normal operational or accidental conditions is a requirement of design and licensing (Ref. [2], para. 503). A meteorological investigation should be carried out to evaluate regional and site specific meteorological parameters. These data should be collected from appropriate elevations above ground in order to obtain realistic dispersion parameters.

2.3. Contamination in the air, on the ground and in water over short and long time periods should be described in the atmospheric dispersion models, with account taken of diffusion conditions in the region. Orographic elevations having significant slopes should be considered in the models.

2.4. The type and extent of acquired and stored meteorological data should allow for reliable statistical analyses to determine the distribution of radiation exposures.

2.5. The effects and consequences for the public and the environment of short term or long term radioactive discharges should be assessed on the basis of meteorological information and site specific conditions relating to land and water uses, population distribution, infrastructure in the vicinity of the site and relevant radiological parameters.

2.6. A detailed meteorological investigation should be carried out in the region. The calculations of the dispersion and concentrations of radioactive materials should show whether the radiological consequences of routine discharges and potential accidental releases of radioactive materials into the atmosphere are acceptable. The results of these calculations may be used to establish authorized limits for radioactive discharges from the plant into the atmosphere (see Ref. [5]).

2.7. The results of the meteorological investigation should be used to confirm the suitability of a site; to provide a baseline for site evaluation; to determine whether local meteorological characteristics have altered since the site evaluation was made and before operation of the plant commences; to select appropriate dispersion models for the site; to establish limits for radioactive discharges into the atmosphere; to establish limits for design performance (for example, containment leak rates and control room habitability); and to assist in demonstrating the feasibility of an emergency plan.

RADIOACTIVE SOURCE PARAMETERS FOR NORMAL AND ACCIDENTAL DISCHARGES IN AIR

2.8. The following properties and parameters should be estimated for radioactive sources:

(a) Radioactivity:
  — the rate of discharge of each important nuclide and the total activity of each important nuclide released in a specified period;
  — variation of the rate of discharge of each important nuclide;
(b) Chemical characteristics of the material released;
(c) Physical properties of the material released;
(d) Geometry and mechanics of the discharge.

2.9. Information should be collected on the background levels of activity in air due to natural and artificial sources.

PROGRAMME FOR METEOROLOGICAL INVESTIGATION

2.10. A programme for meteorological investigation should be designed to collect and evaluate data continuously also on the following parameters during normal operation of a nuclear power plant:

— Site specific meteorological parameters relating to calculations of atmospheric dispersion and statistical analyses;
— Site specific meteorological parameters as specified in the emergency plan; and
— Site specific meteorological parameters relating to safe operation and confirmation of the design bases for the plant (see Refs [6, 7]).

2.11. The programme of meteorological measurements should provide data for an adequate time period (at least one full year) that are representative of the site before the start of plant construction, and should continue for the lifetime of the plant. In addition, the data should be compared with data collected after the plant is constructed, but before operation, to determine whether changes are necessary to the design bases or to assumptions made in the calculational model.

METEOROLOGICAL DATA NECESSARY FOR THE PROGRAMME

2.12. The meteorological data collected should be compatible in terms of their nature, scope and precision with the methods and models in which they will be used in evaluating the radiation exposure of the public and the radiological impact on the environment for assessment against each regulatory objective.

2.13. Meteorological measurements are often affected by terrain, and local features such as vegetation and ground cover, orographic features and plant structures (such as cooling towers and masts supporting meteorological sensors) as well as building wake effects may influence the representativeness of the data obtained. In collecting meteorological data, care should be taken to prevent local effects from unduly altering the values of the parameters to be measured.

2.14. In order to provide a description of the meteorological conditions, data on the following should be obtained concurrently:

— wind vectors (i.e. wind directions and speeds),
— specific indicators of atmospheric turbulence,
— precipitation,
— air temperatures,

— humidity,
— air pressure.

COLLECTION OF DATA

2.15. It should be ensured that the data collected adequately represent local meteorological conditions. Activities should be undertaken in accordance with accepted international standards. Data for at least one representative year should be presented. Information should be given to indicate the extent to which these data represent the long term meteorological characteristics of the site. This information may be obtained by comparing the local data with concurrent and long term data from synoptic meteorological stations in the surrounding area.

Siting of the meteorological measurement system

2.16. Meteorological equipment should be installed in such a way as to obtain data representing the dispersion conditions at release points. Examination of the terrain in the range of several kilometres around a nuclear power plant site is necessary. Topographical features of interest include valleys, principal ridges and coastlines. Isolated hills, wooded and forested areas and large artificial structures should be noted. Shallow valleys (less than 100 m deep and 5–10 km wide) should be considered because they can affect lower level winds. Equipment should be properly exposed and should be positioned far enough from any obstacles to minimize their effects on measurements. Ground cover and vegetation should be managed for the duration of the investigation programme, to avoid local influences.

2.17. When the site is near an international border and it is necessary to locate meteorological equipment on the territory of the neighbouring country, an agreement should be concluded for the installation and maintenance of the equipment and for the collection of data.

Wind characteristics

2.18. To gain a better understanding of atmospheric conditions at the site, the positions and settings of equipment should be selected for maximum exposure. In addition, instruments should be capable of obtaining data representing the entire profile of the wind at least up to the height of potential releases.

2.19. If the wind speed or direction does not vary significantly across the region, then the wind speed and direction at a single location representative of the site may be measured in order to obtain wind data continuously at the following levels:

- — At an elevation of 10 m, for purposes of comparing and correlating wind data from the site with wind data from the synoptic network of meteorological stations; and
- — At the point representing the effective height of discharge[2] (to be evaluated on the basis of preliminary information).

2.20. In other cases, measurements should be made at more than one location. For example, where the effect of sea breezes is important, data from an additional meteorological station further inland should be used in order to evaluate characteristics of the diffusion regime for the sea breeze over land.

2.21. Meteorological data should be obtained at least hourly. The averaging time and the sampling time for the data should be in accordance with the regulatory objective. Instruments should be provided for continuous recording in order to ensure that the data collected can be made readily available at the appropriate locations where they are used.

2.22. Measurements of wind parameters at additional stations should be made concurrently with measurements of other parameters.

Turbulence in the atmosphere

2.23. Fluctuations in meteorological conditions are direct indicators of atmospheric turbulence. Depending upon the model, turbulence should be indicated by the use of data relating to one or more of the following:

- — Fluctuations in wind direction (sigma–theta method);
- — Air temperature and temperature lapse rate (delta T method);
- — Wind speed and solar radiation levels or sky cover during the daytime, and sky cover or net radiation levels at night-time (insulation method); and
- — Wind speed at different heights.

2.24. For the purpose of meeting certain regulatory objectives (notably those relating to site evaluation and design), dispersion characteristics of an atmospheric layer may need to be determined by the temperature variation with height between at least two

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[2] The effective height of discharge will depend on the buoyancy of the plume and on building wake effects.

measurement levels. These levels should include the level at which the wind is measured.

2.25. The frequency, duration and time of the measurements of temperature variation with height should be concomitant with the wind data. For complex meteorological situations, for example in relation to orography, measurements of turbulence indicators made at the site alone may not be sufficient. Depending on the particular characteristics of the region, it may be necessary to make additional measurements of wind and turbulence indicators a few kilometres from the site. In certain cases, normal discharges of effluents or experimental discharges of tracers are used for the development of a local diffusion model, which is often a general model with adjustments derived from air concentration values measured at the site and in the region.

2.26. In developing site specific diffusion models, sufficient information should be acquired on the space and time distributions of wind and temperature to be able to understand and determine the trajectory of effluents. Such information should be obtained by way of a programme of field measurements. This programme should be planned to be conducted in various seasons and at various times of the day in order to be representative of meteorological conditions over at least one year.

2.27. If atmospheric turbulence is determined by visual observations of sky cover at various times of the day (the insulation method), then the observations of the amount of sky cover and of the height of clouds should be combined with wind data measured concurrently at the site.

Precipitation and humidity

2.28. Precipitation should be reported at least hourly. Measurements of the intensity of precipitation and total precipitation as well as details of the type of precipitation should be used to evaluate the impact of precipitation on airborne concentrations of contaminants and on ground contamination. Data on humidity may also help to determine any effects of cooling towers (for example, icing or fogging on roadways and bridges, and effects of salt drift on vegetation). Air humidity can modify the dispersion of aerosols, as it can increase the coalescence of particulates.

INSTRUMENTATION

2.29. Meteorological instrumentation and systems should be shielded, maintained, serviced and calibrated on a regular basis in order to mitigate harmful environmental effects such as those of sun, lightning, ice, sandstorms and corrosive agents.

2.30. In assessing the accuracy of instrumentation, allowance should be made for errors due to cabling, signal conditioning, recording, solar radiation and the effects of fluctuations in environmental temperature. The accuracy and reliability of equipment should be ensured by means of a quality assurance programme including regular maintenance and inspection.

2.31. When Doppler–SODAR instrumentation is used in lieu of a tall mast to characterize wind vector measurements, a measurement system should still be maintained to record the conditions at the 10 m elevation as well as at other elevations of interest (see para. 2.15).

ANALYSIS AND PRESENTATION OF DATA

2.32. There are two basic steps in the analysis of the data:

(1) Determination of average values of the variables at regular intervals; and
(2) Statistical analysis of these average values.

2.33. The wind vector at different elevations and temperatures should be averaged at least once per hour, while for other variables such as solar radiation levels and precipitation levels the period of integration should be one hour. Wind direction should be averaged as a vector and wind speed as a scalar over the prescribed time period.

2.34. For purposes of site evaluation and design, statistical analyses should be performed to evaluate the effects of both routine discharges and accidental releases.

2.35. Depending on the requirements of the calculational model, analysis for routine discharges may necessitate a joint frequency distribution of wind direction and wind speed for each stability class (three dimensional weather statistics). For effluents subject to washout, account should also be taken of the precipitation class (four dimensional weather statistics).

2.36. Analysis of postulated accidental radioactive releases may involve the probability of occurrence of different sets of meteorological conditions during different periods of time over the duration of the accident, for example, in the first hours of the postulated accident, on the first day, over the first week and over the balance of the duration of the accident.

2.37. The information necessary to perform dose assessments for exposure to radioactive materials includes:

(a) the source term for the discharge of radioactive material to the environment and its variation in time;
(b) atmospheric, physical and physicochemical characteristics governing the transport, diffusion and suspension of radioactive materials;
(c) relevant food-chains leading to humans;
(d) characteristics of resident and transient populations, including their agricultural, industrial, recreational and institutional activities.

MODELLING OF ATMOSPHERIC DISPERSION[3]

2.38. Atmospheric dispersion models should typically be applied in site evaluation and design for nuclear power plants to meet the following objectives:

(1) To derive short term (a few hours) normalized concentrations[4] and deposition values in order to assess the probability of occurrence of high normalized concentrations and contamination levels due to postulated accidents;
(2) To derive longer term (up to one month) time integrated normalized concentrations and deposition values for postulated accidents;
(3) To derive long term (about one year) time integrated normalized concentrations and deposition values for routine operations.

These atmospheric dispersion models serve to calculate concentrations which may be applicable for normal or accidental discharges.

2.39. Once a radioactive gas or aerosol becomes airborne, it travels and disperses in a manner governed by its own physical properties and those of the ambient atmosphere into which it is discharged. The effluent enters the atmosphere with a certain velocity and temperature which are generally different from those of the ambient atmosphere. The effluent motion has a vertical component owing to the effects of vertical velocity and differences in temperature, as long as these continue. This upward rise of the effluent, termed ‘plume rise’, changes the effective height of the discharge point. The path of the effluent is affected by flow modifications near

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[3] If the publications referenced in this Safety Guide are used in the modelling of dispersion, the applicability of the model to a particular site and plant state (normal operation or accident conditions) should be verified, because these references do not directly address issues which may arise in site evaluation for nuclear power plants.

[4] The term ‘normalized concentration’ as used here means the ratio of the actual concentration to the release rate.

obstacles such as buildings and structures. The model(s) employed should account for these effects.

2.40. The effluent, while undergoing plume rise, transport and diffusion, may also be subject to processes such as the following:

(a) radioactive decay and buildup of daughter products;
(b) wet deposition:
  - rainout and/or snowout (in which vapour or aerosol is scavenged by water droplets or snowflakes in cloud and falls out as precipitation);
  - washout (in which vapour or aerosol is scavenged below the rain cloud by falling precipitation);
  - fogging (in which vapour or aerosol is scavenged by water droplets in fog);
(c) dry deposition:
  - sedimentation of aerosols or gravitational settling (for particulate diameters larger than about 10 μm);
  - impaction of aerosols and adsorption of vapours and gases onto obstacles in the path of the wind;
(d) formation and coalescence of aerosols; and
(e) resuspension of materials deposited on surfaces.

These effects can be expressed mathematically, and they should be considered in the calculational models when this is appropriate for the regulatory objective.

2.41. Calculational models for atmospheric dispersion should be chosen in accordance with the regulatory objective and, to the extent possible, site and/or plant specific characteristics should be taken into account.

2.42. Methods and mathematical equations used in the models for turbulence indicators and for the calculation of atmospheric dispersion, plume rise and effective stack height, and time integrated concentrations, as well as general procedures for evaluating dispersion and techniques for estimating resuspension of deposited materials, are discussed in Refs [4, 5]. They are not discussed in this Safety Guide.

DATA STORAGE AND DOCUMENTATION

2.43. The raw data should be stored until data qualification and statistical analysis have been performed. Hourly mean values derived from the programme for meteorological investigation should be stored for the lifetime of the facility. Data averaged over shorter periods of time (less than one hour) should be stored continuously for purposes of emergency response and recovery, as they can be used to assess the plume dispersion in the event of an accidental release.

2.44. The programme for regional meteorological investigation and all information relating to it should be documented for the purposes of site evaluation and design, and for use in emergency response plans.

3. TRANSPORT AND DIFFUSION OF EFFLUENTS DISCHARGED INTO THE HYDROSPHERE

GENERAL CONSIDERATIONS

3.1. The hydrosphere is a major exposure pathway by which radioactive materials that are routinely discharged under authorization or are accidentally released from a nuclear power plant could be dispersed to the environment and transported to locations where water is used by or for the population in the region of the site. Radionuclides are transported rapidly in some surface waters such as rivers, and very slowly in groundwater. The dispersion of discharged effluents in surface water and groundwater is discussed separately in this Section.

3.2. A detailed investigation of the hydrosphere in the region should be carried out. Calculations of dispersion and concentrations of radionuclides should be made to show whether the radiological consequences of routine discharges and potential accidental releases of radioactive materials into the hydrosphere are acceptable. The results of these calculations may be used to demonstrate compliance with the national authorized limits for discharges of radioactive effluents [5].

3.3. The information necessary to perform dose assessment relating to exposure pathways in the hydrosphere includes:

— the source term for the discharge of radioactive material to the environment;
— hydrological, physical, physicochemical and biological characteristics governing the transport, diffusion and retention of radioactive materials;
— relevant food-chains leading to humans;
— locations and amounts of water used for drinking and for industrial, agricultural and recreational purposes;

— dietary and other relevant habits of the population, including special occupational activities such as the handling of fishing gear and recreational pursuits such as water sports and fishing.

3.4. The results of the hydrospheric investigation should be used for the following purposes: to confirm the suitability of the site; to select and calibrate an appropriate dispersion model for the site; to establish limits for radioactive discharges into water; to assess the radiological consequences of releases; and to assist in demonstrating the feasibility of an emergency plan. They should also be used to develop a monitoring programme and a sampling strategy for use in the event of an accidental radioactive release.

RADIOACTIVE SOURCE PARAMETERS FOR NORMAL OR ACCIDENTAL DISCHARGES TO SURFACE WATER AND GROUNDWATER

3.5. The following properties and parameters should be estimated for radioactive discharges:

(a) Radioactivity:
- — the rate of discharge of each important nuclide, and an estimate of the total activity discharged in a specific period and its fixation capacity on soils;

(b) Chemical properties, including:
- — important anion and cation concentrations, and their oxidation states and complexing states (e.g. Ca^{2+}, K^+, Mg^{2+}, Na^+, NH_4^+, HCO_3^-, Cl^-, SO_4^-, NO_2^-, NO_3^-, PO_4^-);
- — organic content;
- — pH;
- — the concentration of dissolved oxygen, and conductivity and concentrations of associated pollutants;

(c) Physical properties of the liquid effluents discharged, including:
- — temperature;
- — density;
- — loads and granulometry of suspended solids;

(d) Flow rates for continuous discharges, or volume and frequency for batch discharges;

(e) The variation of the source term over the duration of the discharge, which is necessary to evaluate the concentrations due to long term releases;

(f) The geometry and mechanics of discharges.

3.6. Any airborne radioactive material deposited on the ground surface or on surface water may be transmitted by infiltration processes into groundwater. The potential for indirect contamination in surface water and possible contamination of groundwater from the surface should be assessed.

MONITORING PROGRAMME FOR SURFACE WATER AND GROUNDWATER

3.7. A monitoring programme should be established for both surface water and groundwater. The purpose of such a programme is to provide a baseline for site evaluation and to determine whether the hydrological characteristics of the region have altered since the site evaluation and before the commencement of plant operation.

3.8. The monitoring programme for groundwater should be initiated about two years before the start of plant construction. The site area should be monitored before the foundation work is begun in order to verify possible changes in the groundwater regime, and monitoring should be continued after construction has finished.

3.9. Groundwater is monitored by means of samples taken from boreholes and wells. The samples can also be taken from groundwater reaching the surface in springs or in natural depressions. The monitoring programme should be continued throughout the lifetime of the plant. Boreholes and wells should be kept in an operable state for the same period of time.

3.10. The monitoring programme for surface water should also commence well before the start of construction of the plant, and should continue for its lifetime.

3.11. All surface water and groundwater in the site region should be sampled regularly, at intervals that will depend on the half-lives of the radionuclides that could potentially be discharged.

SURFACE WATER

Necessary data

3.12. The data necessary for the surface hydrological analysis for a nuclear power plant site come from different sources. The existing hydrometeorological network usually provides sufficient data. These, however, should be verified before being used.

3.13. The data needs presented herein relate to standard calculational methods. For advanced models, the data needs depend on the model being used to satisfy the relevant regulatory objectives. Specific parameters necessary in the models for assessing the aquatic environmental transfer of radionuclides are discussed in Refs [4, 5].

3.14. Typical water bodies in the vicinity of a nuclear power plant range from rivers, estuaries, open shores of large lakes, seas and oceans to human made impoundments. The collection of hydrological data for sites on different types of water bodies is discussed in the following.

Sites on rivers

3.15. For sites on rivers, the hydrological and other information should cover the following:

(a) The channel geometry, defined by the mean width, the mean cross-sectional area and the mean slope over the river reaches of interest (the water level can be computed from the channel geometry and the river flow rate). If there are important irregularities such as dead zones or hydraulic equipment in the stream which could influence the dispersion of the plume, they should be described. Additional downstream measurements of channel geometry should be made as necessary to assess the dispersion process over the river reaches of interest.
(b) The river flow rate, presented as monthly averages of the inverse of daily flows. The inverse rate of flow is used since the fully mixed concentration is proportional to the reciprocal of the flow rate if sediment sorption effects are not considered. The flow rates of other relevant and important water bodies (such as downstream tributaries of the river) should be measured if they affect dispersion.
(c) Extremes in the flow rate evaluated from available historical data.
(d) Temporal variation of the water level over the reaches of interest.
(e) Tidal variations in water level and flow rate in the case of a tidal river.
(f) Data to describe possible interactions between river water and groundwater, and the identification of those reaches of the channel where the river may gain water from or lose water to groundwater.
(g) River temperature, measured at a representative location over at least an entire year and expressed as monthly averages of daily temperatures.
(h) The thickness of the top layer if thermal stratification of water in the river occurs.
(i) Extreme temperatures evaluated from available historical data.
(j) The concentrations of suspended matter measured:
    — at locations downstream of sections where the river is slowed, depleted or fed by tributaries;

— on discrete samples at appropriate intervals (such as every two months for at least an entire year);
— over a sufficient range of flows to establish curves of flow versus sedimentation and/or erosion rate;

(k) The characteristics of deposited sediments, including mineral and/or organic compositions and size classification;
(l) The distribution coefficients for sediments and for suspended matter for the various radionuclides that may be discharged;
(m) The background levels of activity in water, sediment and aquatic food due to natural and artificial sources;
(n) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass;
(o) Spawning periods and feeding cycles of major fish species.

Sites on estuaries

3.16. For sites on estuaries, the following information should be collected:

(a) The salinity distribution determined along several verticals covering different cross-sections of the salinity intrusion zone. The data should be sufficient to delineate the flow pattern, which is directed towards the estuary mouth in the upper layer and towards the inner reaches in the lower layer of a fully or partially mixed estuary.
(b) Evaluations of sediment displacements, the load of suspended matter, the rate of buildup of deposited sediment layers and the movement of these sediments with the tide.
(c) Channel characteristics sufficiently upstream of the site to model the maximum upstream travel of radioactive effluents if applicable.
(d) The distribution coefficients for sediments and for suspended matter for the various radionuclides that may be discharged.
(e) The background levels of activity in water, sediment and aquatic food due to natural and artificial sources.
(f) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(g) Spawning periods and feeding cycles of major fish species.

3.17. Measurements of water temperature, salinity and other relevant water quality parameters in estuaries should be made at appropriate depths, distances and times, depending on the river flow, tidal levels and the configuration of the water body in different seasons.

Sites on the open shores of large lakes, seas and oceans

3.18. For sites located on the shores of large lakes, seas and oceans, the hydrological information should include the following:

(a) The general shore and bottom configuration in the region, and unique features of the shoreline in the vicinity of the discharge. Data on bathymetry out to a distance of several kilometres, and data on the amount and character of sediments in the shallow shelf waters.
(b) Speeds, temperatures and directions of any near shore currents that could affect the dispersion of discharged radioactive material. Measurements should be made at appropriate depths and distances, depending on the bottom profile and the location of the point of discharge.
(c) The duration of stagnation and characteristics of current reversals. After a stagnation, a reversal in current usually leads to a large scale mass exchange between inshore and offshore waters that effectively removes pollutants from the shore zone.
(d) The thermal stratification of water layers and its variation with time, including the position of the thermocline and its seasonal changes.
(e) The load of suspended matter, sedimentation rates and sediment distribution coefficients, including data on sediment movements characterized by defining at least the areas of high rates of sediment accumulation.
(f) The background levels of activity in water, sediment and aquatic food due to natural and artificial sources.
(g) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(h) Spawning periods and feeding cycles of major fish species.

Sites on human made impoundments

3.19. For sites on impoundments, the hydrological information should include the following:

(a) Parameters of the impoundment geometry, including length, width and depth at different locations;
(b) Rates of inflow and outflow;
(c) Expected fluctuations in water level on a monthly basis;
(d) The water quality at inflows, including temperature and suspended solids;
(e) Data on thermal stratification and its seasonal variation for relevant water bodies;
(f) Interaction with groundwater;

(g) Characteristics of bottom sediments (type and quantity);
(h) The distribution coefficients for sediments and for suspended matter for the various radionuclides that may be discharged;
(i) The rate of sediment deposition;
(j) The background levels of activity in water, sediment and aquatic food due to natural and artificial sources;
(k) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass;
(l) Spawning periods and feeding cycles of major fish species.

Modelling of radionuclide dispersion in surface water

3.20. Many models are available to calculate the dispersion in surface waters of material originating from routine discharges and accidental releases [4, 5]. Advanced models should be used for particularly complex conditions (see footnote 3).

3.21. The three basic groups of models are the following:

(1) Advanced calculational models transform the basic equations of radionuclide dispersion into finite difference or finite element form. Such models permit most of the relevant physical phenomena to be taken into account in the analysis.
(2) Box type models treat the entire body of water, or sections thereof, as composed of homogeneous compartments. In this type of model, average concentrations are computed for each compartment and transfer constants are set up to relate the variables for one compartment to those in adjacent compartments. Most models dealing with the interactions between radionuclides and sediment are of this type.
(3) Calculational models solve the basic equations describing radionuclide transport with major simplifications made for the geometry of the water body and the dispersion coefficients. This group of models is the one most frequently used in surface hydrological analysis.

In addition, Monte Carlo methods may be used to model water body geometry and to simulate particles.

3.22. Standard calculational models drawn from groups 2 and 3 above are commonly used in the site evaluation for a nuclear power plant. The selection of a model should be based on the type of discharge (surface or submerged), the type of water body (river, estuary, impoundment, large lake or ocean) and the use being made of the water. The magnitude of the source term under normal operation and potential accident conditions, the required accuracy and the type of water affected should be considered in the selection of the model.

3.23. The results from a calculational model should be compared with laboratory data or field data for a specific site. Such validation usually has a limited range of applicability, which should be determined with a full understanding of the model.

GROUNDWATER

General considerations

3.24. A discharge of radioactive material from a nuclear power plant may contaminate the groundwater system in the region either directly or indirectly, via earth, atmosphere or surface water, in the following three ways:

(1) Indirect discharge to the groundwater through seepage and infiltration of surface water that has been contaminated by radioactive material discharged from the nuclear power plant;
(2) Infiltration into the groundwater of radioactive liquids from a storage tank or reservoir;
(3) Direct release from a nuclear power plant; an accident at the plant might induce such an event, and radioactive material could penetrate into the groundwater system. The protection of aquifers from such events should be considered in the safety analysis for postulated accident conditions, and a geological barrier to provide protection should be considered.

3.25. The evaluation of hydrogeological characteristics should determine the following:

- the estimated concentration of radioactive material in groundwater at the nearest point in the region where groundwater is drawn for human consumption;
- the transport paths and travel times for radioactive material to reach the source of consumption from the point of release;
- the transport capacity of the surface flow, interflow and groundwater recharge;
- the susceptibility to contamination of the aquifers at different levels; and
- time and space distributions of the concentrations in the groundwater of radioactive material resulting from accidental releases from the plant.

DATA NECESSARY FOR INVESTIGATIONS OF GROUNDWATER

3.26. Hydrogeological investigation in the framework of site evaluation for a nuclear power plant involves regional and local investigations using comparatively standard surface geophysical surveys and programmes for drilling boreholes for geophysical and tracer studies.

Regional and local hydrogeological information

3.27. Both local and regional information should be collected to identify the hydrogeological system and the preferential flow paths. The information to be collected should include:

— climatological data;
— initial concentrations of radionuclides;
— major hydrogeological units, their hydrodynamic parameters and the ages or mean turnover times of groundwater;
— recharge and discharge relationships;
— data on surface hydrology.

Climatological data

3.28. In regions where rainfall makes a substantial contribution to groundwater, hydrometeorological data on seasonal and annual rainfall and on evapotranspiration that have been systematically collected should be analysed for as long a period as they are available. From meteorological (precipitation) data, groundwater recharge should be calculated. Alternatively, tracers (chemical or isotopic) of the water cycle could be introduced to calculate groundwater recharge.

Major hydrogeological units

3.29. Data should be obtained on the types of the various geological formations in the region and their stratigraphic distribution in order to characterize the regional system and its relationship with the local hydrogeological units.

3.30. The geology and surface hydrology of the site area should be studied in sufficient detail to indicate potential pathways of contamination to surface water or groundwater. Any surface drainage system or standing water body accessible from a potential release point in an accident should be identified. Areas from which contaminated surface water can directly enter an aquifer should be determined. The relevant hydrogeological information for surface or near surface discharges includes information on soil moisture properties, infiltration rates, configuration of unsaturated zones and chemical retention properties under unsaturated conditions.

3.31. For consideration of the transport potential of seepage and groundwater in the region of the site (a few tens of kilometres in radius), data on types of aquifers, aquitards and aquicludes, their interconnections and the flow velocities and mean turnover times should be investigated. Such data will permit the regional flow pattern and its relation to the local flow pattern of seepage and groundwater to be characterized. This investigation should include the following data:

— Geological data: lithology, thickness, extent, degree of homogeneity and degree of surface weathering of the geological units;
— Hydrogeological data: hydraulic functions of the unsaturated zone, and hydraulic conductivities and transmissivities, specific yield and storage coefficients, dispersion parameters, and hydraulic gradients of the saturated zone for each geological unit;
— Depth related water ages and mean turnover times;
— Interconnections between aquifers and aquitards without and with groundwater usage;
— The chemical composition of groundwater from the respective aquifers and aquitards in comparison with their lithology;
— Physical properties of the groundwater, especially temperatures, gas contents and density;
— Variations of water levels in wells and mining shafts and in the discharges of springs and rivers;
— Locations of active and potential sink holes in the region.

Water bearing characteristics of the hydrogeological units

3.32. Information on the water bearing characteristics of the main hydrogeological units should be collected, including information on the following properties:

— moisture content;
— porosity and bulk density;
— specific yield for unconfined aquifers and storage coefficients for confined aquifers;
— hydraulic conductivity or permeability;
— transmissivity for fully saturated confined aquifers.

3.33. For the relevant hydrogeological units, information should be collected on the following chemical and physical properties of the groundwater:

— concentrations and oxidation and complexing states of important anions and cations, and their presence in organic compounds;
— contents of organic and biological material;
— pH;
— Eh;
— temperature;
— sorption characteristics.

Interrelationship between groundwater and surface water

3.34. The extent and degree of hydraulic connections between bodies of surface water and groundwater should be identified. Topographic and geological maps should be studied in order to identify lines or areas where such hydraulic connections between surface water and groundwater are present. The amounts of the exchanges should be estimated and their corresponding exchange regimes should be determined.

Modelling of dispersion and retention of radionuclides in groundwater

3.35. Models have been developed to calculate the dispersion and retention of radionuclides released into groundwater. Standard calculational models are generally satisfactory and should be used in most cases. The complexity of the model chosen should reflect the complexity of the hydrogeological system at a particular site.

3.36. Simplified evaluations should be performed with conservative assumptions and data to evaluate the effects of postulated accidental releases of radioactive material to the groundwater. Further, more refined analysis with more realistic assumptions and models should be performed if necessary.

3.37. The direction of groundwater movement and of radionuclide transport is in general orthogonal to the contours at groundwater level. Where this is the case, the standard calculational models should be applied. If aquifers are strongly anisotropic, and water and transported effluents can move over a limited domain through fractures, most calculational models are not valid. Field studies including tracer studies may be necessary and should be considered.

3.38. The analytical models for radionuclide transport in groundwater have several sources of uncertainty. The model used should be validated for each specific application. Validated hydrogeological models that would apply for characteristics similar to those of the site should be considered as a reference for purposes of comparison.

3.39. The documentation generated in a monitoring programme for surface water and groundwater should follow the recommendations made in Section 7.

4. USES OF LAND AND WATER IN THE REGION OF THE SITE

4.1. The operation of a nuclear power plant may affect the population in the surrounding area and the local and regional environment. As part of the environmental impact assessment for the site, the uses of land and water should be investigated. The characteristics of the land and water utilized in the region should also be considered in demonstrating the feasibility of the emergency response plan.

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.

4.3. Present uses of water which could be affected by changes in the water temperature and by radioactive material discharged from a nuclear power plant, together with the location, nature and extent of usage, should be identified. Changes in uses of water in the region, such as for irrigation, fishing and recreational activities, should also be considered.

4.4. Special consideration should be given to any population centres for which drinking water is obtained from water bodies that may be affected by a nuclear power plant. To the extent possible, future water flow and water uses should be projected over the lifetime of the plant. This may lead to a change in the critical group of the population[5].

4.5. For areas where drinking water is obtained from springs, wells or any other source of groundwater, the movement and quality of the groundwater should be studied.

4.6. The data on different water uses should include data on the following:

(a) For water used for drinking by humans and animals, and for municipal and industrial purposes:
   - average and maximum rates of water intake by users;
   - distance of the intake from the potential source of radioactive discharges;
   - mode of water consumption;
   - number of water users.
(b) For water used for irrigation:
   - rate of water use;
   - area of irrigated land;
   - types and yields of agricultural products, and their usual consumers.
(c) For water used for fishing:
   - the aquatic species fished, and their abundance and yields in water used for commercial, individual and recreational fishing.
(d) For water used for recreational purposes:
   - the number of persons engaging in swimming, boating and other recreational uses, and the time spent on these activities.

4.7. These investigations should cover a reasonably large area in the site region. If a nuclear power plant is located on a river bank, users downstream from the site should be identified. If the site is near a lake, all users of the lake should be identified. If a site is on an ocean coast, users of the sea out to a few tens of kilometres in all directions should be identified.

4.8. Information should be collected on levels of background activity for environmentally relevant substances such as soils, and for vegetables and other foodstuffs.

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[5] The critical group is a group of members of the public which is reasonably homogeneous with respect to its exposure for a given radiation source and given exposure pathway and is typical of individuals receiving the highest effective dose or equivalent dose (as applicable) by the given exposure pathway from the given source.

5. 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.

5.2. When a site is near a State's national border, there should be appropriate co-operation with neighbouring countries in the vicinity of the nuclear power plant. Efforts should be made to exchange relevant information. Information relating to the plant should be provided on request to neighbouring countries to permit any potential impacts of the plant on their territory to be evaluated.

5.3. The external zone includes an area immediately surrounding the site of a nuclear power plant in which population distribution, population density, population growth rate, industrial activity, and land and water uses are considered in relation to the feasibility of implementing emergency measures.

5.4. The term 'present population' includes the two categories of permanent population and temporary population. Data on the present population in the external zone should be obtained from local authorities or by means of special field surveys, and these data should be as accurate and as up to date as possible. Similar data should also be collected throughout the region outside the external zone to distances determined in accordance with national practice and regulatory objectives. The data should include the number of people normally present in the area, and the locations of houses, hospitals, prisons and other institutions and recreational facilities such as parks and marinas.

5.5. Information on the permanent population of the region and its distribution should include information on occupation, places of work, means of communication and typical diet of the inhabitants. If a city or town in the region is associated with a major industrial facility, this should be considered.

5.6. The information on the temporary population should cover:

- the short term transient population, such as tourists and nomads; and
- the long term transient population, such as seasonal inhabitants and students.

5.7. The maximum size of the temporary population and its periods of occupancy in the external zone should be estimated. Particular types of institutions such as schools, hospitals, prisons and military bases within the external zone should be identified for the purposes of emergency planning. In the area outside the external zone, estimates of the approximate size of the temporary population together with its periods of occupancy should be made.

5.8. A projection of the present population in the region should be made for:

- the expected year of commissioning of the plant;
- selected years (e.g. every tenth year) over the lifetime of the plant.

5.9. Projections should be made on the basis of population growth rate, migration trends and plans for possible development in the region. The projected figures for the two categories of permanent population and temporary population should be extrapolated separately if data are available.

5.10. Data should be analysed to give both the current and the projected population distribution in terms of direction and distance from the plant.

5.11. The critical group associated with each nuclear power plant should be identified. Critical groups of the population (see footnote 5) with particular dietary habits and specific locations for particular types of activity in the region should be considered. The persons in the critical group may be located beyond national borders.

5.12. The population data collected should be presented in a suitable format and scale to permit their correlation with other relevant data, such as data on atmospheric dispersion and on uses of land and water. The two categories of permanent population and temporary population should be clearly indicated. In general, population data should be presented either in tabular form, or graphically, using concentric circles and radial segments with the site as the origin. More details should be given for areas closer to the site, especially within the external zone.

Considerations relating to radiological exposure

5.13. The results of the study on the characteristics and distribution of the population, together with results obtained in respect of the dispersion of radioactive material discharged into air, surface water and groundwater, should be used in demonstrating that, for a proposed site and design and for normal operations, the radiological exposure of the population in the region remains as low as reasonably achievable and, in any case, will be within the limits set in the national requirements and those established in the Basic Safety Standards (Ref. [3]), even for the critical groups mentioned in para. 5.11.

5.14. Information similar to that mentioned in para. 5.13 should be used to demonstrate also that, on the selected site, the radiological risk to the population that may result from accident states at the plant, including those which may lead to the implementation of emergency measures, is acceptably low and in accordance with national requirements, account being taken of international recommendations.

5.15. If, after thorough evaluation, it is shown that appropriate measures to comply with the national regulatory requirements cannot be devised, and the engineered safety features of the plant cannot be further improved, the site should be deemed unsuitable for a nuclear power plant of the type proposed.

6. CONSIDERATION OF THE FEASIBILITY OF AN EMERGENCY PLAN

6.1. Before final approval of a nuclear power plant site, the feasibility of an emergency plan should be demonstrated. There should be no adverse site conditions which could hinder the sheltering or evacuation of the population in the region or the ingress or egress of external services needed to deal with an emergency.

6.2. The feasibility of an emergency plan should be demonstrated for the nuclear power plant on the basis of site specific natural and infrastructural conditions in the region. In this context, infrastructure means transport and communications networks, industrial activities and, in general, anything that may influence the rapid and free movement of people and vehicles in the region of the site. Other information on the region, such as information on the availability of sheltering, the systems for the collection and distribution of milk and other agricultural products, special population groups such as those resident in institutions (for example, hospitals and prisons), industrial facilities, and environmental conditions such as the range of weather conditions, should be collected for demonstrating the feasibility of an emergency plan.

6.3. Many site related factors should be taken into account in demonstrating the feasibility of an emergency plan. The most important ones are:

— population density and distribution in the region;

— distance of the site from population centres;
— special groups of the population who are difficult to evacuate or shelter, such as people in hospitals or prisons, or nomadic groups;
— particular geographical features such as islands, mountains and rivers;
— characteristics of local transport and communications networks;
— industrial facilities which may entail potentially hazardous activities;
— agricultural activities that are sensitive to possible discharges of radionuclides; and
— possible concurrent external events.

6.4. The presence of large populations in the region or the proximity of a city to the nuclear power plant site may diminish the effectiveness and viability of an emergency plan. In addition, the specific circumstances of any special groups of the population should be recognized and taken into account. The presence of any residents whose evacuation route would necessarily pass near the nuclear power plant may lead to the rejection of a site if no other emergency measure can overcome this difficulty.

6.5. Disastrous external events or foreseeable natural phenomena such as fog or snow may have consequences that can limit the effectiveness of any response to an accident at a nuclear power plant. For example, an event may result in a problem with the infrastructure or in damage to sheltering facilities. In order to ensure that the population in the region can be sheltered and evacuated effectively, consideration should be given to the provision of backup facilities and alternative routes.

6.6. If, upon evaluating the aforementioned factors and their possible consequences, it is determined that no viable emergency plan can be established, then the proposed site should be considered unacceptable.

6.7. It is possible that conditions assessed for the purposes of approval of the site and design will change over time. The site related factors considered in the emergency plan, such as infrastructural developments, should be reviewed periodically during the operational phase of the plant.

6.8. Detailed guidance on emergency planning is available in other IAEA publications [8–11].

7. QUALITY ASSURANCE PROGRAMME

7.1. A quality assurance (QA) programme should be established to cover all the activities recommended in this Safety Guide.

7.2. The process of site evaluation includes the conduct of scientific and engineering analyses and the exercise of judgement. The data used in the analyses and in making judgements should be as complete and as reliable as possible. Data should be collected in a systematic manner and should be evaluated by technically qualified and experienced personnel. The QA programme for site evaluation is part of the overall QA programme for a nuclear power plant (see Ref. [12], Code and Safety Guide QA1).

7.3. All the investigatory programmes and other studies recommended in this Safety Guide, together with the necessary data and information, should be documented for the purposes of site evaluation.

7.4. In order for data to be collected, recorded and retained throughout the lifetime of the plant, the media for recording and storing data should be checked periodically to verify their compatibility with the technology in use (both hardware and software).

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CONTRIBUTORS TO DRAFTING AND REVIEW

Giuliani, P.	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy
Gürpinar, A.	International Atomic Energy Agency
Seiler, P.	Forschungszentrum für Umwelt und Gesundheit GmbH, Germany
Sjøblom, K.	International Atomic Energy Agency
Tamer, A.	Siemens AG Offenbach, Germany
Vones, V.	Consultant, Canada

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