IAEA Safety Standards

for protecting people and the environment

Site Survey and Site Selection for Nuclear Installations

Specific Safety Guide

No. SSG-35

IAEA

International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

SITE SURVEY AND
SITE SELECTION FOR
NUCLEAR INSTALLATIONS

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA, PLURINATIONAL STATE OF
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DJIBOUTI
DOMINICA
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
GUYANA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA, BOLIVARIAN REPUBLIC OF
VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

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".

IAEA SAFETY STANDARDS SERIES No. SSG-35

SITE SURVEY AND SITE SELECTION FOR NUCLEAR INSTALLATIONS

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2015

COPYRIGHT NOTICE

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
July 2015
STI/PUB/1690

IAEA Library Cataloguing in Publication Data

Site survey and site selection for nuclear installations. — Vienna : International Atomic Energy Agency, 2015.
p. ; 24 cm. — (IAEA safety standards series, ISSN 1020–525X ; no. SSG-35)
STI/PUB/1690
ISBN 978–92–0–102415–2
Includes bibliographical references.

1. Nuclear facilities — Location. 2. Nuclear power plants — Location. 3. Nuclear facilities — Safety measures. I. International Atomic Energy Agency. II. Series.

IAEAL 15–00971

FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to "establish or adopt… standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

---

[1] See also publications issued in the IAEA Nuclear Security Series.

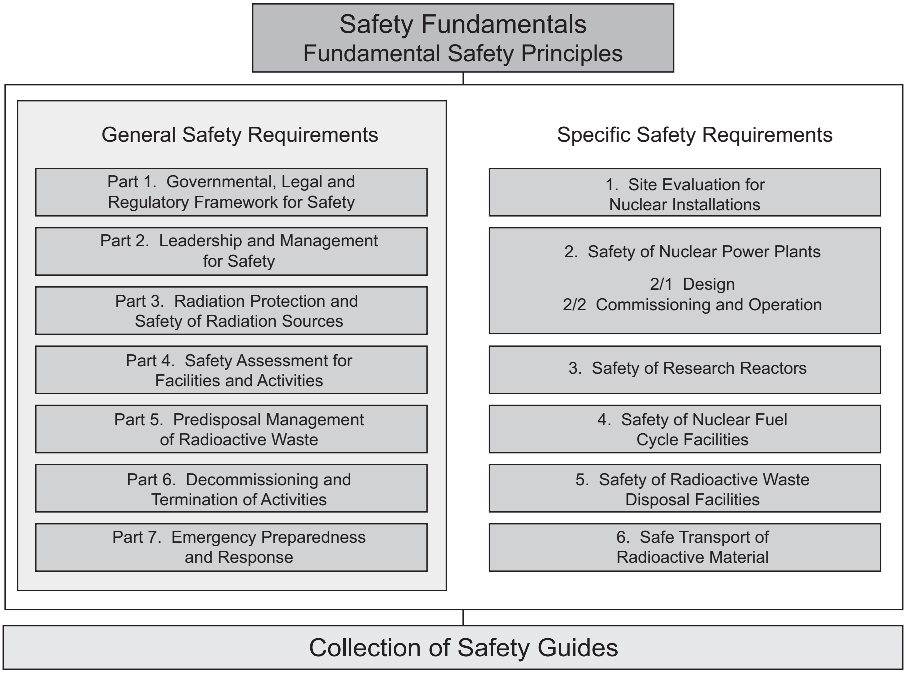

FIG. 1. The long term structure of the IAEA Safety Standards Series.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and

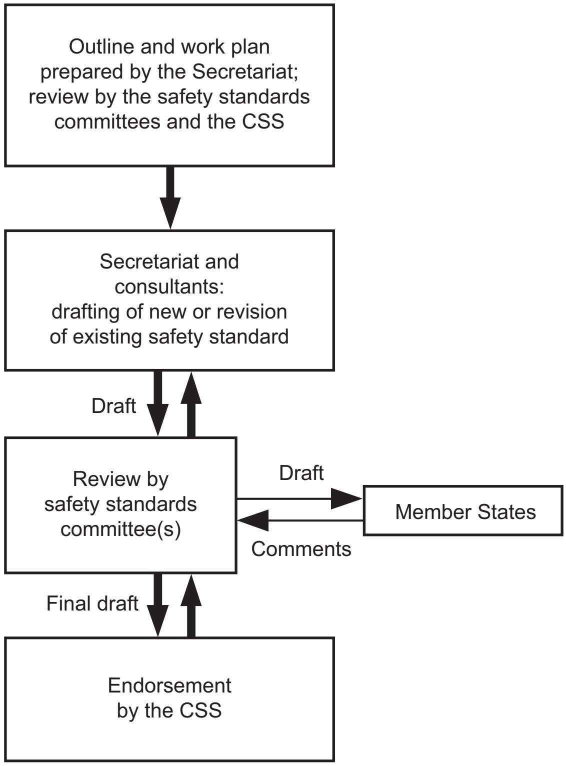

FIG. 2. The process for developing a new safety standard or revising an existing standard.

includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see http://www-ns.iaea.org/standards/safety-glossary.htm). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's programme for safety standards. It supplements and provides recommendations on meeting the requirements for nuclear installations established in the Safety Requirements publication on Site Evaluation for Nuclear Installations (NS-R-3) [1] with respect to the safety aspects to be considered during the stages of the selection process for a site for a nuclear installation. The effects of external events occurring in the region of a particular site and the characteristics of the site and of its environment are factors that could influence the transfer to persons and to the environment of radionuclides that might be released over the operating lifetime of the nuclear installation. This Safety Guide complements other safety guides that deal with all safety considerations in site evaluation with regard to such factors. This Safety Guide also deals with the population density and population distribution and other characteristics of the external zone, in so far as they may affect the feasibility of taking emergency actions over the expected operating lifetime of the installation.

1.2. The IAEA Safety Fundamentals publication, Fundamental Safety Principles (SF-1) [2], establishes that "The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation" (para. 2.1). Principle 8 of SF-1 [2] on prevention of accidents states that "All practical efforts must be made to prevent and mitigate nuclear or radiation accidents." SF-1 [2] also establishes that "The primary means of preventing and mitigating the consequences of accidents is 'defence in depth'" (para. 3.31). Defence in depth is provided by an appropriate combination of specified systems and measures, one of which is "Adequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy" (SF-1 [2], para. 3.32). To apply this principle, it is required (NS-R-3 [1], para. 2.1) that the suitability of a site for a nuclear installation be evaluated with regard to the following:

"(a) The effects of external events occurring in the region of the particular site (these events could be of natural origin or human induced);

"(b) The characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released;

“(c) The population density and population distribution and other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures and the need to evaluate the risks to individuals and the population.”

1.3. The selection and the evaluation of a site suitable for a nuclear installation are crucial. These processes can significantly affect the costs, public acceptance and safety of the installation over its operating lifetime. The outcome of this process may even affect the success of the nuclear power project. Poor planning and execution, lack of information and lack of knowledge of international safety standards and recognized good practices could lead to faulty decision making and could cause major delays, either at the construction stage or at the operational stage of a nuclear installation. Faulty decisions made at the site selection stage might necessitate major resource commitments at a much later phase of the project. If the site related design parameters are changed during the operational stage, re-evaluation of and upgrades to the installation during operation may consequently be necessary, possibly necessitating extended shutdown periods and causing considerable costs.

1.4. The selection process for a suitable site, termed ‘siting’, for a nuclear installation is a multifaceted process that includes safety considerations. With regard to accident prevention, siting is intended to prevent accidents arising from external hazards associated with external events. Siting involves a comprehensive process of screening out sites for which external hazards are significant or could become significant. Siting also involves screening out sites for which the additional safety measures in the design that would be necessary to address such hazards would be excessively demanding, or sites where knowledge is not sufficient to define these measures with a sufficient degree of confidence. With regard to mitigating the consequences of accidents, siting is intended to reduce the possible impacts of an accident on people and on the environment. It involves the selection of a site with favourable dispersion characteristics for radionuclides in the air, in surface water and subsurface water, and also with a terrain, population distribution and infrastructure that would facilitate the implementation of an emergency plan.

1.5. The siting process, from the beginning, has to be guided by a clearly established set of criteria consistent with the relevant regulatory requirements. Such criteria are of particular importance for those factors for which sites can be excluded. A balance has to be established between the characteristics of a site and specific design features, site protection measures and administrative procedures.

1.6. The Safety Requirements publication NS-R-3 [1] was published in 2003 (under revision). That safety standard deals with the requirements for the full characterization of the site for a nuclear installation from the safety point of view, covering the entire process of the site evaluation, from the site selection stage to site characterization and the pre-operational and operational stages. Thus, NS-R-3 [1] does not cover the initial stage of the siting process, the site survey, which is when studies and investigations are performed at the regional level to identify potential sites, from which candidate sites are chosen.

1.7. The previous IAEA Safety Guide on Site Survey for Nuclear Power Plants (50-SG-S9), was published in 1984[1]. This revision was necessary to update the recommendations and guidance and to bring the Safety Guide into consistency with the existing safety requirements established in NS-R-3 [1], particularly as they relate to exclusionary criteria, and with other Safety Guides that provide recommendations relevant to the early stages of site evaluation, especially Refs [3–9].

1.8. The approach in this Safety Guide ensures that issues associated with site safety are considered early in the process and that alternative sites are available in the event that the selected site does not meet the requirements on the basis of the detailed site characterization. It is important that external hazards are identified early to allow for adequate consideration of protective measures that may be necessary to provide sufficient defence in depth.

1.9. Terms in this publication are to be understood as defined and explained in the IAEA Safety Glossary [10], unless otherwise stated.

OBJECTIVE

1.10. The objective of this Safety Guide is to provide recommendations and guidance on meeting the requirements [1] for the consideration of safety in the siting process for a nuclear installation in order to meet the fundamental safety objective of SF-1 [2]. Recommendations are provided for criteria and approaches for identifying suitable sites for nuclear installations that comply with established safety requirements. The Safety Guide provides recommendations and guidance on establishing a systematic process for site survey and site selection for

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Survey for Nuclear Power Plants, Safety Series No. 50-SG-S9, IAEA, Vienna (1984).

a number of preferred candidate sites, from which one could be selected for the construction and operation of a nuclear installation.

1.11. This Safety Guide is intended for use by organizations with an interest in the siting process, including government bodies, future licensees (generally the operating organizations) and their contractors. This Safety Guide also has an informative role for the regulatory body as, in most States, siting is a non-regulated process and does not require regulatory actions.

SCOPE

1.12. This Safety Guide addresses the consideration of safety in the siting process for a nuclear installation. It is recognized that there are other important factors in the siting process, possibly regarding both safety and non-safety issues, such as nuclear security considerations, technology, economics, land use planning, availability of cooling water, non-radiological environmental impacts and socioeconomic impacts, among them the opinion of interested parties, including the public. As the siting process progresses, more and more sites are screened out. For the few potential sites that remain, safety considerations will become more pronounced.

1.13. The difference between the investigation processes of site survey and site evaluation may not be very distinct and will depend on the methodology and technology used. There is a transition between these two stages of assessment. This Safety Guide covers the process that eventually terminates in the site selection for one or more nuclear installations. It covers site evaluation only to the extent necessary for understanding the context.

1.14. As well as providing recommendations and guidance on the siting of a nuclear installation at a new site, this Safety Guide also provides recommendations with regard to the location of a new installation at an existing site.

1.15. This Safety Guide addresses a range of types of nuclear installation[2]. The methodologies recommended for nuclear power plants can be applied to other nuclear installations through a graded approach. The recommendations can be tailored to meet requirements for different types of nuclear installation in accordance with the potential radiological consequences of accidents. The recommended direction of grading is to start with attributes relating to nuclear power plants and, if possible, to grade down to installations with which lesser radiological consequences are associated.[3] If no grading is performed, the recommendations relating to nuclear power plants (Sections 2–5) are applicable to other types of nuclear installation.

1.16. This Safety Guide does not provide recommendations and guidance on site characterization and does not establish an assessment of site hazards for use in a design evaluation for licensing purposes. The guidelines for final site characterization or re-evaluation as part of a periodic safety review are given in Refs [4–9].

1.17. This Safety Guide refers to but does not provide guidance on considerations relating to nuclear security. Nuclear security is covered in the IAEA Nuclear Security Series of publications.

STRUCTURE

1.18. Section 2 addresses the siting and site evaluation processes. Section 3 provides general recommendations for site selection for a nuclear installation. Section 4 describes the classification of criteria for the siting process. Section 5 provides recommendations and guidance with regard to investigations necessary for the different stages of the site survey and site selection process (for the compilation of a database). Section 6 deals with the site survey and site selection process for a nuclear installation other than

---

[2] The term ‘nuclear installation’ includes: nuclear power plants; research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities; spent fuel storage facilities; 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.

[3] For sites at which nuclear installations of different types are collocated, particular consideration should be given to the use of a graded approach so that siting evaluation is commensurate with the approach needed for the most potentially hazardous nuclear installations.

a nuclear power plant and recommends a graded approach for dealing with such installations. Section 7 provides recommendations for the management system. The Appendix provides recommendations for the database for the siting process. Annex I presents tables to be used in the siting process, including criteria for screening and ranking. Annex II provides example criteria for the siting process for nuclear power plants. The numerical values provided in the annexes are only examples of those used in some States.

2. GENERAL DESCRIPTION OF THE SITING PROCESS AND THE SITE EVALUATION PROCESS

2.1. There are two processes relating to the safety considerations for the site of a nuclear installation — the siting process and the site evaluation process. These two processes are further split into five stages:

— Site survey stage;
— Site selection stage;
— Site characterization stage (site verification and site confirmation);
— Pre-operational stage;
— Operational stage.

The framework for the site survey stage and the site evaluation stage is elaborated in the schematic representation shown in Fig. 1.

2.2. Siting is the process of surveying and selecting a suitable site for a nuclear installation. The selection of a suitable site is one of the elements of the concept of defence in depth for preventing accidents as stated in Principle 8 of SF-1 [2].

2.3. The siting process and the site evaluation process include five different stages. The siting process for a nuclear installation consists of the first two stages of these five, i.e. site survey and site selection (see Fig. 1). In the site survey stage, large regions are investigated to find potential sites and to identify one or more candidate sites. The second stage of the siting process is site selection, in which unsuitable sites are rejected and the remaining candidate sites are assessed by screening and comparing them on the basis of safety and other considerations to arrive at the preferred candidate sites.

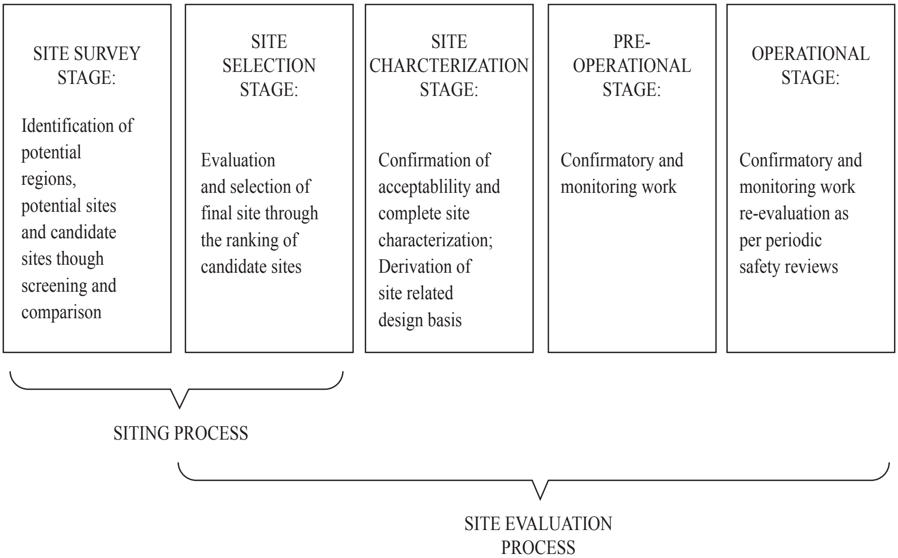

FIG. 1. Stages in the siting process and site evaluation process in the operating lifetime of a nuclear installation.

2.4. Site evaluation[4] is the process that extends from: (a) the last stage of the siting process (i.e. the stage of evaluation of the candidate sites in order to arrive at the preferred candidate site(s)); to (b) the detailed site characterization stage for the selected site to confirm its suitability, its characterization and derivation of the site related design basis for the nuclear installation; to (c) the confirmation and completion of the assessment at the pre-operational stage for the installation (i.e. during the design, construction, assembly and commissioning stages); and finally to (d) the operational stage of the installation included within the framework of periodic safety review (see paras 1.8 and 1.14 of NS-R-3 [1], and Ref. [10]). Thus, site evaluation continues throughout the operating lifetime of the installation, with appropriate components covered in the final safety analysis report, to take into account changes in site characteristics, the availability

---

[4] Site evaluation is defined as the analysis of factors at a site that could affect the safety of a facility or activity on that site. This includes site characterization and consideration of factors that could affect safety features of the facility or activity so as to result in a release of radioactive material and/or could affect the dispersion of such material in the environment, as well as population and access issues relevant to safety (e.g. feasibility of evacuation, location of people and resources) [10].

of data and information, operational records, regulatory approaches, evaluation methodologies and safety standards [1, 4–9].

2.5. The second stage of the siting process, site selection, includes part of the site evaluation process and is the overlapping stage between the siting process and the site evaluation process (see Figs 1 and 2). After the site selection stage, the suitability of the site is confirmed and a complete site characterization[5] is performed, together with finalizing the derivation of the design basis due to external events during the site characterization stage. This process eventually leads to the preparation of the site evaluation report as a basis for the 'site' section of the preliminary safety analysis report[6] for the nuclear installation. All the site related activities involving confirmatory and monitoring work are taken up in the pre-operational stage[7]. Following the approval of the final safety analysis report for the nuclear installation, the site evaluation at the operational stage[8] starts. This includes all confirmatory, monitoring and re-evaluation work conducted throughout the operational stage, and especially during periodic safety reviews of the installation. This work is generally reported in periodic safety review reports. Outcomes in comparison with those for the stages of the siting process and the site evaluation process are shown in Fig. 2.

2.6. In most States, siting is a non-regulated activity and no licence is required. Siting and site evaluation processes should be consistent with the licensing process as specified by the regulatory body and should also be consistent with the applicable IAEA safety standards [11, 12].

---

[5] The site characterization stage is further subdivided into: site verification, in which the suitability of the site to host a nuclear installation is verified mainly according to predefined site exclusion criteria, and site confirmation, in which the characteristics of the site necessary for the purposes of analysis and detailed design are determined [10].

[6] Other terms are used in some States, e.g. preliminary safety case.

[7] In the pre-operational stage, studies and investigations begun in the previous stages are continued after the start of construction and before the start of operation of the nuclear installation, to complete and refine the assessment of site characteristics. The site data obtained allow a final assessment of the simulation models used in the final design.

[8] At the operational stage, appropriate safety related site evaluation activities are carried out over the operating lifetime of the nuclear installation, mainly by means of monitoring and periodic safety review.

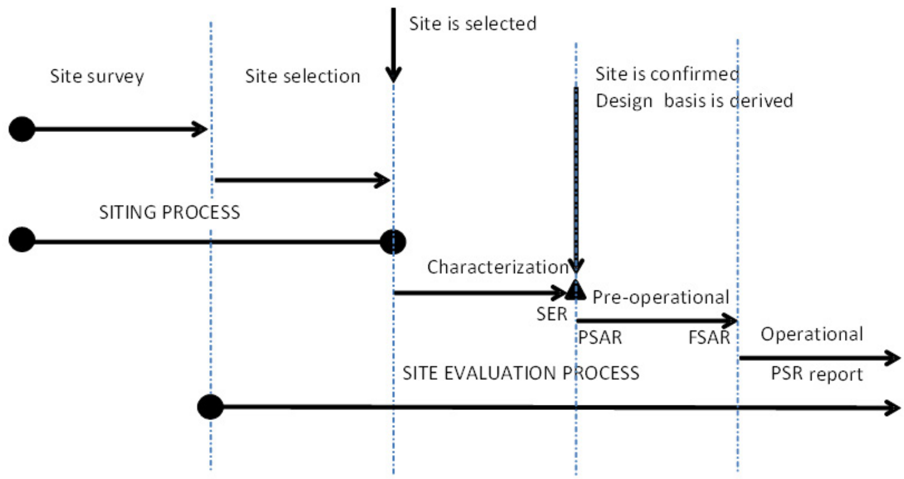

FIG. 2. Outcome of the siting process and site evaluation process for a nuclear installation. FSAR: final safety analysis report; PSAR: preliminary safety analysis report; PSR: periodic safety review; SER: site evaluation report.

2.7. There are three important steps that should receive input from site survey, site selection and the site evaluation process before construction starts. These are:

(a) The decision regarding the suitability of the preferred site, i.e. confirmation that the site has no characteristics that would preclude the safe operation of a nuclear installation;
(b) The definition of the site related design basis parameters on the basis of the site evaluation report;
(c) The preparation of the preliminary safety analysis report or preliminary safety case which, among other things, demonstrates that the site related design basis parameters have been appropriately taken into account, in particular through the design features of the nuclear installation and the measures to be taken for site protection.

2.8. The site should be deemed unsuitable for the purposes of the licensing of the proposed installation if it is concluded during characterization of external hazards that no engineering solutions exist to design protective measures against those hazards that challenge the safety of the nuclear installation, or there are no adequate measures to protect people against unacceptable radiological risks.

2.9. The future operator of the proposed installation on the site should have an early role to play in reviewing and accepting work done during siting, even if the future operator does not have a direct role in selecting the site.

3. GENERAL RECOMMENDATIONS FOR THE SITING PROCESS

SITING PROCESS

3.1. The siting process is intended to select suitable locations for the envisaged nuclear installation such that its characteristics are compatible with available engineering protective measures for all natural and human induced hazards arising from external events, so that the necessary level of safety can be achieved. Furthermore, the surrounding demographic setting and dispersion characteristics should be such as to limit the exposure of the population for any plant state to as low as reasonably achievable, and to allow the implementation of measures for mitigating the consequences of any accidental release of radionuclides over the operating lifetime of the installation.

3.2. The siting process consists of a series of related activities with the objective of selecting suitable sites for a new nuclear installation. The process should systematically and successively apply a number of screening criteria to screen out those sites with attributes which contribute unfavourably to the safety of the installation. A flow chart of the siting process for a nuclear installation is given in Fig. 3.

3.3. The siting process has three distinct steps starting with the region(s) of interest as given.

(1) *Regional analysis:* This is the first step, in which region(s) of interest are analysed to identify potential sites. All potential sites in a region should be taken to the next step (screening) unless their exclusion can be appropriately justified.
(2) *Screening:* In the second step, the potential sites are screened to choose the candidate sites. The principal objective of this step is to exclude unfavourable sites on the basis of both safety related considerations and non-safety-related considerations.

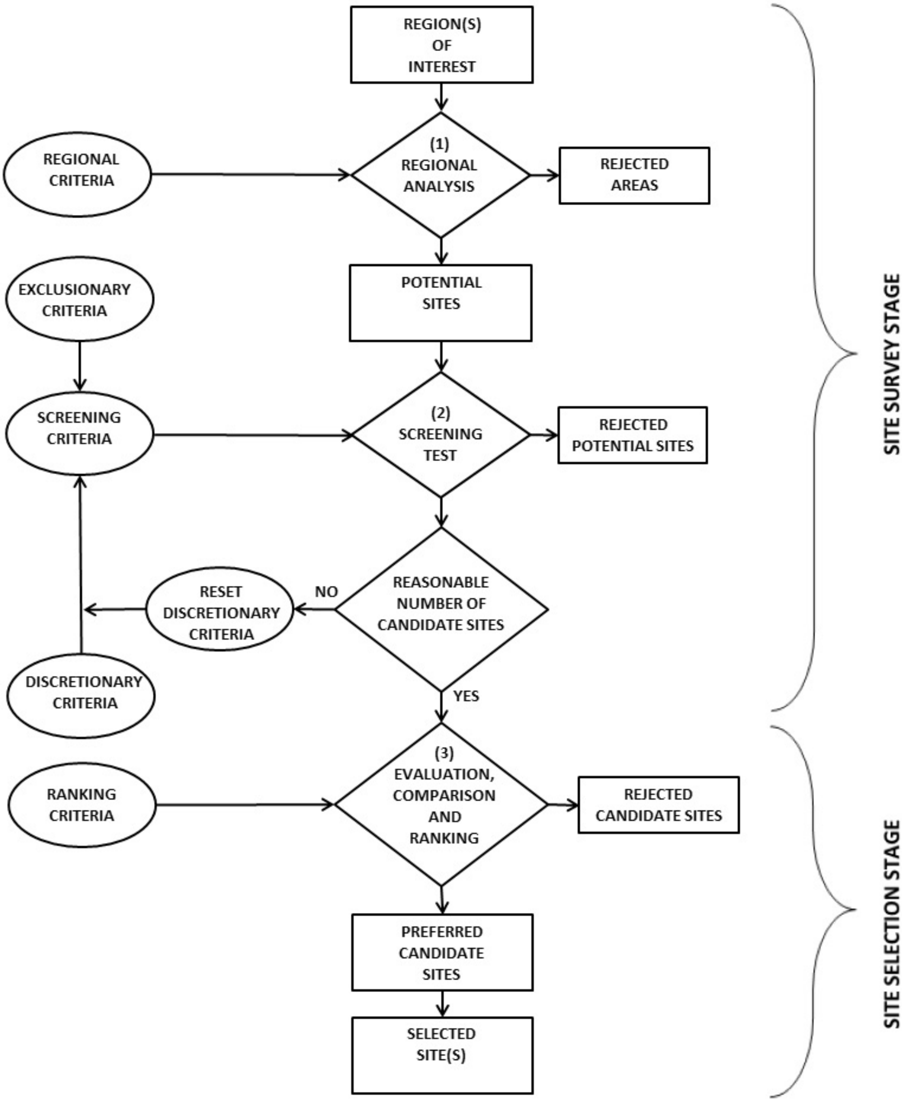

FIG. 3. Flow chart for the siting process for a nuclear installation.

(3) *Evaluation, comparison and ranking:* The purpose of the third step is twofold: (i) to evaluate the sites in order to ensure that there are no features (at the sites or in their surrounding areas) that would preclude the construction and operation of the nuclear installation, and (ii) to compare the candidate sites and to rank them in order of their attractiveness as possible sites for a nuclear installation.

3.4. Detailed examination later, at the site characterization stage, may lead to a candidate site being found unsuitable and thus excluded. In order to cater for such situations, candidate sites should therefore be placed in an order of preference to allow the selection of a potentially suitable alternative site.

3.5. The siting process is completed once the site on which the nuclear installation will be located has been selected from the list of preferred candidate sites. The final selection is generally made by the government or operating organization (future licensee) for the nuclear installation, with input from all the relevant stakeholders. The operating organization, the future licensee, should be involved from the outset of the siting process.

SITING CRITERIA

3.6. Siting criteria provide the basis on which decisions are made in consideration of the site attributes in the different steps of the siting process. Siting criteria are used to evaluate specific site related issues, events, phenomena, hazards and other considerations after the site has been investigated and analysed. As is shown in Fig. 3, there should be three categories of siting criteria: regional criteria, screening criteria and ranking criteria.

3.7. The regional analysis should be carried out to identify potential sites using well established regional criteria. Regional criteria are generally related to national domestic policy, national economic policy, national and international environmental protection or other related policies of the State. Technical constraints and the availability of resources (e.g. infrastructural constraints, availability of water) on a regional basis should also be important considerations for regional analysis. The regional criteria should identify all possible potential sites and no site should be discarded without appropriate justification.

3.8. The screening of potential sites should be conducted using screening criteria of two types:

— *Exclusion criteria*: The exclusion criteria are used to discard sites that are unacceptable on the basis of attributes relating to issues, events, phenomena or hazards for which there are no generally practicable engineering solutions.

— *Discretionary criteria*: The discretionary criteria are associated with those attributes relating to issues, events, phenomena, hazards, or other considerations, for which protective engineering solutions are available. These criteria, listed in Table I–1 of Annex I, are used to facilitate the selection process through iterative screening to eliminate less favourable sites when there are a large number of possible candidate sites.

3.9. The resulting candidate sites should then be placed in an order of preference through an exercise of comparison and ranking using suitable ranking criteria.

3.10. The screening criteria and ranking criteria consist of both safety related and non-safety-related criteria. Screening criteria and ranking criteria are further elaborated in Table I–1 of Annex I.

GENERAL BASIS FOR SCREENING CRITERIA

3.11. Exclusion criteria should be established and used as part of the screening at the site survey stage. Screening by exclusion criteria enables sites with unfavourable characteristics to be excluded from further consideration.

3.12. Exclusion criteria should be selected for the negative attribute of a site characteristic, or for any site related issue, event, phenomenon or hazard for which engineering, site protection or administrative measures are not available or are excessively demanding.

3.13. Exclusion criteria encompass not only inherent weaknesses in a site's characteristics, but also the feasibility of engineering solutions to compensate for such weaknesses, either through design or through site protection measures. Therefore, the existence of a certain hazard or even the high likelihood of its occurrence should not constitute the sole basis upon which an exclusion criterion is based. Screening out on the basis of an arbitrary criterion may lead to the discarding of a site with otherwise favourable qualities for safety and may finally result in the choice of a site that is less safe than the site that has been discarded.

3.14. Discretionary criteria should be established:

— To decrease the number of possible candidate sites if their number is too large to conduct the exercise of comparison and ranking;

— To increase the number of candidate sites if their number is too small or if there are none.

This is generally an iterative process in which criteria may be made more or less strict depending on the desired number of potential sites for further consideration. Attributes relating to these criteria are also used for the preliminary evaluation of a site in the site selection stage of the siting process.

3.15. As a result of the iterative screening of potential sites, a number of candidate sites are identified. If candidate sites are distributed in two or more regions with different attributes, this would preclude the possibility of the elimination of all the candidate sites on the basis of common regional shortcomings; e.g. for two candidate sites that are geographically widely separated, the seismic hazard may differ widely at the two sites, which reduces the risk of both sites being eliminated later in the siting process owing to concerns over the seismic safety of the proposed nuclear installation(s).

3.16. The siting process for a nuclear installation is expected to be completed using existing data. However, at an early stage, especially during the site survey stage, it may not always be possible to collect a sufficient amount of good quality data on which such a decision could be based with adequate certainty. In such a case, additional data should be collected to confirm the suitability of the site in the subsequent site selection stage. Some preliminary field investigation, if required, should also be conducted at this stage.

3.17. Data collection in relation to potential and candidate sites should focus in particular on attributes of the sites that are relevant to the exclusion criteria.

SPECIFIC SCREENING CRITERIA

3.18. The site safety requirements cited in NS-R-3 [1] are the primary source for establishing the screening criteria. They are reproduced in the following:

> “2.27. In relation to the characteristics and distribution of the population, the combined effects of the site and the installation shall be such that:
>
> “(a) For operational states of the installation the radiological exposure of the population remains as low as reasonably achievable and in any case is in compliance with national requirements, with account taken of international recommendations;

“(b) The radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken, is acceptably low.

“2.28. If, after thorough evaluation, it is shown that no appropriate measures can be developed to meet the above mentioned requirements, the site shall be deemed unsuitable for the location of a nuclear installation of the type proposed.

“2.29. The external zone for a proposed site shall be established with account taken of the potential for radiological consequences for people and the feasibility of implementing emergency plans, and of any external events or phenomena that may hinder their implementation. Before construction of the plant is started, it shall be confirmed that there will be no insurmountable difficulties in establishing an emergency plan for the external zone before the start of operation of the plant.

…….

“3.7. Where reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation, an alternative site shall be considered.

…….

“3.35. Geological maps and other appropriate information for the region shall be examined for the existence of natural features such as caverns, karstic formations and human made features such as mines, water wells and oil wells. The potential for collapse, subsidence or uplift of the site surface shall be evaluated.

“3.36. If the evaluation shows that there is a potential for collapse, subsidence or uplift of the surface that could affect the safety of the nuclear installation, practicable engineering solutions shall be provided or otherwise the site shall be deemed unsuitable.

…….

“3.38. The potential for liquefaction of the subsurface materials of the proposed site shall be evaluated by using parameters and values for the site specific ground motion.

…….

“3.40. If the potential for soil liquefaction is found to be unacceptable, the site shall be deemed unsuitable unless practicable engineering solutions are demonstrated to be available.

…….

“3.44. The potential for aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of characteristics of future air traffic and aircraft.

“3.45. If the assessment shows that there is a potential for an aircraft crash on the site that could affect the safety of the installation, then an assessment of the hazards shall be made.

“3.46. The hazards associated with an aircraft crash to be considered shall include impact, fire and explosions.

“3.47. If the assessment indicates that the hazards are unacceptable and if no practicable solutions are available, then the site shall be deemed unsuitable.

…….

“3.49. Hazards associated with chemical explosions shall be expressed in terms of overpressure and toxicity (if applicable), with account taken of the effect of distance.

“3.50. A site shall be considered unsuitable if such activities take place in its vicinity and there are no practicable solutions available.

…….

“3.51. The region shall be investigated for installations (including installations within the site boundary) in which flammable, explosive, asphyxiant, toxic, corrosive or radioactive materials are stored, processed, transported and otherwise dealt with that, if released under normal or accident conditions, could jeopardize the safety of the installation....

If the effects of such phenomena and occurrences would produce an unacceptable hazard and if no practicable solution is available, the site shall be deemed unsuitable.

…….

“3.54. Potential natural and human induced events that could cause a loss of function of systems required for the long term removal of heat from the core shall be identified, such as the blockage or diversion of a river, the depletion of a reservoir, an excessive amount of marine organisms, the blockage of a reservoir or cooling tower by freezing or the formation of ice, ship collisions, oil spills and fires. If the probabilities and consequences of such events cannot be reduced to acceptable levels, then the hazards for the nuclear installation associated with such events shall be established.”

BASIS FOR RANKING CRITERIA

3.19. Ranking criteria are necessary to provide bases for comparison between the candidate sites so as to arrive at a list of preferred candidate sites. For safety related issues, comparison within topical areas is generally quite straightforward. For example, sites with a higher seismic hazard would be penalized in comparison with those in more geologically stable areas. What is more difficult is comparison between topics, in other words to compare a site with a higher seismic hazard but lower flood hazard with another site that has a higher flood hazard but lower seismic hazard.

3.20. Ranking criteria are generally developed by using considerations relating to discretionary criteria together with relevant non-safety-related considerations.

3.21. A sufficient amount of data should be collected before a comparison based on a particular criterion is made between two (or more) sites. To the extent possible, the amount and quality of the data upon which the comparison is to be based should be similar for the regions or possible sites being compared.

3.22. The candidate sites should be ranked in order to determine the preferred candidate site or several preferred candidate sites. Ranking involves cross comparison of sites with respect to all their attributes, both safety related attributes and non-safety-related attributes. This may involve the weighting of various attributes in a matrix form. It is also possible to quantify the differences of each site with regard to a reference combination of site and installation. For many of the attributes to be considered, more than one quantification parameter (e.g. the differential cost or cost–benefit estimation with respect to a reference combination of site and installation) is the basis for comparison and ranking.

3.23. One criterion for ranking candidate sites may be the likelihood that the specific site parameters are within the standard plant parameter envelope of potential suppliers for nuclear installations. Suppliers of technologies for nuclear installations typically offer non-site-specific generic design information for consideration when bounding envelopes are being used in siting process. This generic design information identifies some of the design bases for withstanding particular site related loads. Such information should be used either to screen out candidate sites or to decide where design changes may be necessary to bring the design parameters within the site bounding envelope.

SITING OF NEW NUCLEAR INSTALLATIONS AT EXISTING SITES

3.24. The siting process, as discussed above, is for the construction and operation of a new nuclear installation at a new site. A similar process should be used for the siting of a new installation at an existing site with certain special considerations. The presence of an existing nuclear installation should not warrant the assumption that the site is suitable for a new nuclear installation. The site evaluation process should be conducted with the same level of rigour as for a new site and it should depend on the implications of the new installation for safety.

3.25. There are several issues that should be given special attention, such as:

- When a site that was selected in the context of an earlier project for a nuclear installation is to be reassessed to confirm that it meets safety requirements;
- When a site that had been discarded in the context of an earlier project for a nuclear installation is to be considered for a new project for a nuclear installation.

Such issues include the completion of data, considerations for new regulations and standards, considerations for new methods of analysis and lessons to be learned from recent external events, if relevant.

3.26. If a new site under consideration is close to or adjacent to the site of an existing nuclear installation, the effects of the existing site on the new site and the effects of the new site on the existing site should be considered. In certain cases, owing to age, technology and design, for example, plants on the same site could have different licensing requirements. The effects of a new installation on or near to an existing site should be assessed on the basis of the following considerations:

(a) Any design, construction or operational restrictions arising from the way in which the existing installation is operated. For example, the heat sink requirements for the operation of existing installations may have significant bearing on the design of the heat sink system for a new installation.
(b) The nuclear or radiological hazards arising from accidents at the existing installations or new installations involving the release of radioactive material, direct radiation shine or both.
(c) Conventional hazards arising from accidents on the existing site, such as the release of toxic chemicals, explosions, missiles or flooding.
(d) Interactions between the emergency arrangements for new sites and for existing sites.
(e) Relevant hazardous events, such as loss of power supply from the electricity grid, and most external hazards, can initiate common cause failures on several or all of the nuclear installations on the site, and the effects of such common cause faults should be accounted for.
(f) Hazards arising from accidents at both the new installation and the existing installation, and consequential impacts.
(g) Compliance with dose constraints and risk constraints from the combined sites in both operational states (normal operation and anticipated operational occurrences) and accident conditions:
    (i) Where the new installation forms part of an existing site, the net effects of both installations in terms of safety should be considered with regard to:
        — *Exposure of members of the public and environmental impacts in normal operation:* It is to be expected that radiological consequences in operational states for members of the public may increase since the new installation will have an additional source term. It should be established whether this additional source term necessitates additional protection over and above what would be expected if the new installation were on an isolated site.

— *Exposures and risks in accident conditions:* The new installation provides a contribution to exposure of and risks to members of the public in accident conditions. Where there are independent accidents at each installation, the increase in risk is likely to be small. The net combined contribution to risk should be determined, however. Where the accident initiator is a common cause event (e.g. a flood), then both exposure of and risks to members of the public should be assessed. It should be taken into consideration that all installations at the site may be simultaneously challenged by a common cause event and that consequences may be higher for the combined site. This may warrant additional safety measures being applied to the new nuclear installation or to both installations to meet dose constraints and risk constraints, and in order to keep exposures and risks as low as reasonably achievable.

(ii) Where the new installation occupies a separate site immediately adjacent to, or very close to, an existing site, it is to be expected that exposures and risks for people outside both sites will be similar to those mentioned in (i) above. Additional safety measures may still be necessary at one or both sites to keep exposure and risks as low as reasonably achievable.

3.27. If different, the operating organization for the new site should provide the operating organization for the existing site with information on the issues mentioned above. It is therefore beneficial for both operating organizations to establish a good working relationship early on, so that relevant information can be made available to either operating organization as and when it is necessary.

4. CLASSIFICATION OF SITING CRITERIA

4.1. Criteria used in the siting process for a nuclear installation are classified as follows:

— Safety related criteria;
— Criteria relating to nuclear security;
— Non-safety-related criteria.

Such criteria may be screening criteria (i.e. exclusionary or discretionary criteria) or ranking criteria.

SAFETY RELATED CRITERIA

4.2. Safety related criteria to be considered in the siting process should be consistent with the requirements established in NS-R-3 [1] and with the associated Safety Guides relating to site evaluation for nuclear installations. From a thematic perspective, these criteria are classified into four sets.

4.3. The first set of criteria is related to the potential impact of natural hazards on the safety of the nuclear installation. In this context, the following natural hazards should be considered:

(a) Capable faults (i.e. faults that may cause surface displacement near the nuclear installation);
(b) Vibratory ground motion due to earthquakes;
(c) Volcanic hazards;
(d) Coastal flooding or low water intake level (including inundation as well as receding water levels due to wave action, storm surges, seiches or tsunamis);
(e) River flooding (overtopping of banks due to failure of water retaining structures such as dykes or dams) or low water intake level due to low river flow or drought;
(f) Blockage of intake channels (e.g. due to marine organisms, ice, debris, ship collisions, oil spills or fires);
(g) Combinations of coastal and river flooding (e.g. in estuaries), and flash floods due to intense precipitation or downbursts;
(h) High winds — both straight winds such as hurricanes and tropical storms and rotational winds such as tornadoes;
(i) Local phenomena such as sand storms and dust storms;
(j) Other extreme meteorological events such as droughts, extreme precipitation, including snow pack, extreme hail, lightning and extreme temperatures, including the temperature of the source of cooling water;
(k) Geotechnical hazards such as slope instability, soil liquefaction, landslides, rock fall, avalanche, permafrost, erosion processes, subsidence, uplift and collapse;
(l) Forest fires;
(m) Credible combinations of events (i.e. combinations of both dependent and independent events that potentially could lead to more severe consequences than for a single hazard, such as a seismic event together with flooding, or wind together with snow).

4.4. The second set of criteria is related to the potential impacts of human induced events and nuclear security events on the safety of the nuclear installation. In this context and in accordance with the recommendations of NS-G-3.1 [4], the following origins of potential human induced hazards should be considered:

(a) Stationary sources:
   (i) Other nuclear installations, oil and gas operations, chemical plants, processing of hazardous materials such as commercial facilities for manufacturing or storing munitions, broadcasting and communication networks, mining or quarrying operations, high energy rotating equipment and hydraulic engineering structures;
   (ii) Military facilities (permanent or temporary), especially shooting ranges and arsenals.
(b) Mobile sources:
   (i) Surface transportation (e.g. railways and roads, and oil, gas and other pipelines);
   (ii) Airport zones and harbour zones (military and civilian);
   (iii) Air traffic corridors and flight path zones (military and civilian).
(c) Electromagnetic interference.

4.5. The third set of criteria is related to the characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and the environment. In this context and in accordance with the recommendations of NS-G-3.2 [5], the following phenomena should be considered:

(a) Atmospheric dispersion of radioactive material;
(b) Dispersion of radioactive material in surface water;
(c) Dispersion of radioactive material in groundwater;
(d) Population density and population distribution and distance to centres of population, including projections for the operating lifetime of the nuclear installation.

4.6. The fourth set of criteria is linked to the third set but it relates mainly to the demonstration of the feasibility of implementation of the emergency plan for the nuclear installation. In this context, the following phenomena should be considered:

(a) Physical characteristics of the site that could hinder implementation of the emergency plan (in particular, geographical features such as islands, mountains and rivers);

(b) Infrastructural characteristics relating to the implementation of the emergency plan (especially local transport infrastructure and communications networks);
(c) Considerations of populations (e.g. special population groups with regard to protective actions in the event of a nuclear or radiological emergency, such as elderly and disabled persons and hospital patients and prisoners), and land and water use considerations;
(d) Specific requirements of the regulatory body for special zones, such as emergency planning zones and distances;
(e) Industrial facilities that could involve potentially hazardous activities;
(f) Impacts of concurrent external hazards on infrastructure.

4.7. Examples of criteria for the siting process are presented in Annex II.

CRITERIA RELATING TO NUCLEAR SECURITY

4.8. Nuclear security aspects should also be considered in siting nuclear installations, taking account of the guidance provided in the IAEA Nuclear Security Series (see Refs [13–15]) and involving relevant national competent authorities. Typically, this includes consideration of site characteristics that could affect the ability to implement physical protection measures and the capability to deter, detect, delay and respond to nuclear security events.

NON-SAFETY-RELATED CRITERIA

4.9. In the site survey and site selection process, another set of criteria are concerned with considerations that are not directly related to nuclear safety (e.g. availability of cooling water, topography, access to electrical grid, non-radiological environmental impacts, socioeconomic impacts). Such non-safety-related criteria should be considered together with the considerations relating to nuclear safety, especially in the ranking of the candidate sites [16].

5. DATA NECESSARY AT DIFFERENT STAGES OF THE SITING PROCESS

5.1. Site selection should make use of an increasingly detailed process of data collection and evaluation. In particular, the site survey stage should be based on information and data collected principally from existing sources such as available records, satellite images, topographic sheets and information available from local authorities and other institutions. It may be that a potential site could not satisfy all the screening criteria on the basis of information collected at the site survey stage, but that it is likely to be able to satisfy these screening criteria with the help of additional study and investigation. In this case, such additional study and investigation and the related screening test should be initiated as soon as possible so that the results are available in the next stage, i.e. the site selection stage. The input information and data collected during the site survey are important and should be considered for all site related activities prior to construction.

5.2. The siting process for a nuclear installation starts on a regional basis and each step is focused on selecting potential sites and candidate sites. The data acquisition and processing for these stages should be in line with this purpose. Accordingly, these stages should generally start with the consideration of regional data presented on a large scale (coarser data; data of low resolution) and should proceed to the consideration of local data presented on a smaller scale (finer data; data of higher resolution).

5.3. For each topic under consideration, the data should be collected in a coordinated manner, with consideration of interfaces with other topics. The level of detail of the different sets of data should be consistent with the aims for the specific steps of the siting process.

5.4. In the analyses performed on the basis of the data collected, the operating lifetime of the nuclear installation should be considered. Appropriate projections should be made, especially in relation to parameters that may show significant variation with time. Data that may change gradually should also be considered. In this context, the potential impact of climate change on site related hazards should be considered, as recommended in SSG-18 [7], especially in terms of the possibility of increased incidence and intensity of extreme meteorological and hydrological phenomena. Uncertainties associated with these phenomena should be taken into account.

5.5. The general approach to site survey and site selection should be directed towards reducing the uncertainties at various steps of the siting process in order to obtain reliable results based on the data. Experience shows that the most effective way of achieving this is to collect a sufficient amount of reliable and relevant data. There is generally a trade-off between the time and effort necessary to compile a detailed, reliable and relevant database and the degree of uncertainty that the analyst should take into consideration at each step of the process.

5.6. The acquisition and processing of data to be used in relation to siting criteria should be performed subject to the requirements for quality management, as recommended in Section 7.

5.7. All data on the site should be collected in a systematic, transparent, retrievable and traceable manner. The use of tools such as a geographical information system should be considered, especially for the data collected in relation to the preferred candidate sites.

5.8. A site specific database should be developed, containing all relevant site characteristics as established in the siting process. This database should include the following categories of data, which are further elaborated in detail in the Appendix:

(a) Geological data;
(b) Hydrogeological data;
(c) Seismological data;
(d) Data relating to fault displacement;
(e) Volcanological data;
(f) Geotechnical data;
(g) Data on coastal flooding including tsunamis;
(h) Data on river flooding;
(i) Data on meteorological events;
(j) Data on human induced events;
(k) Data on population, land use, water use and environmental impacts.

5.9. For the screening and ranking criteria, the site characteristics should be used as a basis for the decision on whether a site should be kept or screened out, and if a site is kept, how it should be ranked with respect to other candidate sites. The decision for keeping or screening out a site could be based on conclusions drawn from one category of the site characteristics or more, as it is not always necessary to consider all categories for every criterion. Each of the categories of site characteristics is described in the Appendix, and criteria associated with the data are listed in Table I–1 of Annex I.

5.10. A two stage process for siting is recommended in Sections 2 and 3. It is intended that a graded approach to data collection be adopted for this process. In the initial site survey stage, readily available data[9] should be collected from relevant national and local authorities and other organizations. Such data could include contextual maps for undertaking a qualitative desktop study in order to establish relatively quickly whether the site can be screened with respect to exclusionary criteria, and the likely impacts of discretionary screening and ranking criteria on such contextual site maps.

5.11. In the second stage (site selection), it is intended to conduct a more detailed examination of how the site fares against the ranking criteria. The objective at this stage is to provide sufficient information and analysis to enable confident judgements to be made using the ranking criteria. It is anticipated that at the end of this stage, a firm decision on site selection should be made by the site owner, operating organization or both with the reasoning for it recorded.

5.12. To enable the activities at the second stage to be conducted, it is anticipated that more data will be required. Data should be collected and analytical work should be undertaken. For example, comprehensive surveys of the relevant literature and, in some cases, specific fieldwork will be required (e.g. to identify local sub-map-scale topographical features of significance or to confirm geological features from local rock exposures).

5.13. Although the data on some external hazards are likely to be limited and of variable quality, it is anticipated that some analyses will be required and should be undertaken, such as the following:

(a) Analysis of hazards associated with accidental aircraft crashes;
(b) Analysis of effects of nearby industrial facilities on the proposed site, for example, impacts of fires and chemical explosions and effects of dispersion for hazardous airborne releases that could affect the site;
(c) More detailed analysis of local fault displacement capability;
(d) Estimation of the seismically induced soil liquefaction potential at the site;

[9] The necessary extent of data collection and analysis cannot be specified in this Safety Guide since they are likely to be specific to the State and to the site concerned.

(e) Generation of a set of hazard curves for extreme meteorological and flooding events, e.g. in relation to wind, precipitation, temperature, and sea and river flooding, covering return periods appropriate to the nuclear installation in question.

5.14. The judgements made at this stage should be sufficiently robust to provide a high degree of confidence that they will not be called into question by further data collected or by further analysis in the site evaluation process.

6. SITING FOR NUCLEAR INSTALLATIONS OTHER THAN NUCLEAR POWER PLANTS

6.1. The graded approach mentioned in para. 1.15 provides guidance for siting (site survey and site selection) for a broad range of nuclear installations other than nuclear power plants. These installations include:

(a) Research reactors and laboratories in which nuclear material is handled.
(b) Installations for storage of spent nuclear fuel (located either with nuclear power plants or with independent installations), including:
    (i) Installations for spent fuel storage for which active cooling is required;
    (ii) Installations for spent fuel storage that require only passive or natural convection cooling.
(c) Installations for processing nuclear material in the nuclear fuel cycle, e.g. conversion facilities, uranium enrichment facilities, fuel fabrication facilities and facilities for the reprocessing of spent fuel.
(d) Installations for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities.

6.2. For the purpose of siting, these installations may be graded on the basis of their potential radiological hazards and non-radiological hazards, e.g. the presence of flammable, explosive, toxic or corrosive materials.

6.3. Prior to categorizing an installation, if adopting a graded approach, a conservative process should be applied to estimate the consequences of a radiological release associated with a maximum hypothetical event (accident). The analysis should use the worst case (maximum) radioactive inventory expected over the operating lifetime of the installation and should not include any mitigating factors associated with siting (e.g. atmospheric dispersion), unless those factors are included in the final site selection acceptance criteria.

6.4. The possibility that an external event will give rise to radiological consequences will depend on characteristics of the nuclear installation (e.g. its purpose, layout, design, construction and operation) and on the external event itself. Such characteristics should include the following factors:

(a) The amount, type, form (e.g. solid, liquid or gas) and status of the radioactive inventory at the site (e.g. whether solid or fluid, processed or only stored);
(b) The intrinsic hazard associated with the physical processes (e.g. nuclear chain reactions) and chemical processes (e.g. those for fuel processing purposes) that take place at the installation;
(c) The thermal power of the nuclear installation, if applicable;
(d) The configuration of the installation for activities of different kinds;
(e) The concentration of radioactive materials in the installation (e.g. for nuclear power plants or research reactors, most of the radioactive inventory will be in the reactor core and the fuel storage pool, whereas in fuel processing facilities and fuel storage facilities it may be distributed throughout the installation);
(f) The changing nature of the configuration and layout for installations designed for experiments (the activities associated with which may be unpredictable);
(g) Characteristics of engineered safety features for the prevention of accidents and for mitigation of the consequences of accidents;
(h) The characteristics of the processes or the safety features that might show a cliff edge effect[10] in the event of an accident;
(i) The characteristics of the site that would be relevant to the consequences of the possible dispersion of radioactive material to the atmosphere and the hydrosphere (e.g. the size and demographics of the region);
(j) The potential for on-site and off-site contamination;
(k) Monitoring instruments, and the response time of control systems and trip systems.

---

[10] A cliff edge effect in a nuclear installation is an instance of severely abnormal system behaviour caused by an abrupt transition from one system status to another following a small deviation in a system parameter, and thus a sudden large variation in system conditions in response to a small variation in an input.

6.5. Some or all of the factors mentioned in para. 6.4 should be considered, depending on national requirements. For example, fuel damage, radioactive releases or exposures may be the conditions or parameters of interest.

6.6. The grading process should be based on the following information:

(a) The generic preliminary safety analysis report for the installation, if one is available, which should be the primary source of information;
(b) The results of a preliminary probabilistic safety assessment, if available;
(c) The characteristics specified in para. 6.4;
(d) National regulatory criteria, if any.

6.7. As a result of this process, three or more categories of installation may be defined on the basis of national practices and criteria. As an example, the following categories may be defined:

(a) The lowest hazard category includes those nuclear installations for which national building codes for conventional facilities (e.g. essential facilities such as hospitals) or for hazardous facilities (e.g. petrochemical plants or chemical plants), as a minimum, should be applied.
(b) The highest hazard category includes installations for which standards and codes should be applied that establish an equivalent level of quality to those used for nuclear power plants.
(c) There may often be one or more intermediate categories of nuclear installation.

6.8. The graded approach should generally be applied to the extent and level of detail of the data to be collected and analysed at each step. These considerations should be taken into account when setting up the screening criteria for nuclear installations other than nuclear power plants.

6.9. It should be taken into consideration that criteria not directly associated with safety (para. 4.9) may be very different for other types of nuclear installation.

7. APPLICATION OF THE MANAGEMENT SYSTEM

GENERAL RECOMMENDATIONS

7.1. The siting process should be addressed in the overall management system for the nuclear installation project. The management system for siting should be established at the earliest possible time consistent with its implementation in the conduct of activities for the site survey and site selection stages of the nuclear installation. See GS-R-3 [17] and GS-G-3.1 [18] for requirements, recommendations and guidance on the management system.

7.2. As a part of the management system, a quality management programme should be established by the operating organization (future licensee), and the contractors that carry out the work for selection of the site for a nuclear installation.

7.3. The management system, in accordance with GS-R-3 [17] and GS-G-3.1 [18], should cover organization, planning, work control, personnel qualification and training, verification and documentation for all the activities concerned to ensure adequate performance of these tasks and adequate reporting.

7.4. The results of the activities for site investigation should be compiled in a report that documents the results of all in situ work, laboratory tests and geotechnical analyses and of more general safety related evaluations.

7.5. The studies and investigations should be documented in sufficient detail to permit their independent review.

7.6. Records should be kept of the work carried out as part of the site selection activities for the nuclear installation.

7.7. In developing the part of the management system dealing with the siting process, the following should be considered:

(a) The intended end uses of the knowledge, information and data that result from the activities in the siting process, in particular in terms of their consequences for safety;
(b) The capability to demonstrate, test or repeat the results;
(c) The scale and technical complexity of the activities in the siting process, whether it is a new or proven concept or a model that is being applied or an extension of a new application;

(d) The managerial complexity of the activity and the involvement and coordination of personnel in multiple disciplines, work units or internal or external organizations, with divided or contingent objectives and responsibilities;
(e) The extent to which other site characterization work, or later work, depends on the results of the siting activities;
(f) The desired use or application of the results.

SPECIFIC RECOMMENDATIONS

7.8. A project work plan should be prepared prior to, and as a basis for, the execution of the project for siting, including site survey and site selection. The work plan should convey the complete set of general requirements for the nuclear installation (such as the total power generation capacity of the nuclear power plant), including applicable regulatory requirements. In addition to specifying general requirements, with reference to the overall management system if relevant, the work plan should delineate the following specific elements: personnel and their responsibilities; work breakdown and project tasks; schedule and milestones; and deliverables and reports.

7.9. A programme should be established, implemented and documented under the management system to cover all activities for data collection and data processing, field and laboratory investigations, analyses and evaluations that are within the scope of this Safety Guide.

7.10. Results of the activities during the site survey and site selection stages should include all outputs indicated in the work plan. The reporting of the site survey and site selection should be specified in sufficient detail in the work plan.

7.11. To make the activities of the site selection process traceable and transparent to the public, users and reviewers, the related documentation should provide the following:

— A description of all elements of the process;
— Identification of the participants in the study and their roles;
— Background material that comprises the documentation of the analysis, including raw and processed data, computer software and input and output files, reference documents, results of intermediate calculations and sensitivity studies.

7.12. This material should be maintained in an accessible, usable and auditable form by the responsible organization. Documentation or references that are readily available elsewhere should be cited where appropriate. All elements of the site survey and site selection should be addressed in the documentation.

7.13. The documentation should identify all sources of information used in the site survey and site selection, including information on where to find important sources of information cited that may be difficult to obtain. Unpublished data that are used in the analysis should be included in the documentation in an appropriately accessible and usable form.

7.14. If earlier studies for site survey and site selection for the same region are available, studies should be made to demonstrate how different approaches or different data affect the earlier conclusions. These should be documented in a way that allows their review.

7.15. In view of the fact that various investigations are carried out (in field, laboratory and office), technical procedures that are specific to the activity concerned should be developed to facilitate the execution and verification of these tasks, and a peer review of the process should be conducted.

7.16. Requirements for the application of a management system should be established by the responsible organizations to ensure that the processes of and inputs from their contractors are appropriate. The responsible organization for siting should identify the quality assurance standards that should be met. Applicable requirements, recommendations and guidance on the management system are provided in GS-R-3 [17] and GS-G-3.1 [18]. Special provisions should be specified to address document control, analysis control, software, validation and verification, procurement and audits, and non-conformance and corrective actions. Work related documents should be prepared to cover all the activities under the programme mentioned in para. 7.9.

Appendix

DATABASE FOR THE SITING PROCESS

A.1. The extent of the work necessary to develop an appropriate database for the siting process will depend on the nature of the site, on how easy it is to meet the siting criteria (especially the exclusion criteria) and on the level of effort necessary for the comparison and ranking between the candidate sites.

A.2. The database for the siting process should be comprehensive and up to date, and should be compiled so as to support the evaluation and judgement of the relevant number of topics as recommended in Section 5.

GEOLOGICAL AND HYDROGEOLOGICAL DATABASE

A.3. The objective for the geological and hydrogeological database is to collect all the data necessary to enable judgements of site suitability to be made confidently on the basis of the siting criteria. The requirements for detailed data (for the final site selection process) are the same as those for nuclear safety purposes and are specified in the relevant IAEA Safety Guides [6–9]. The extent and quality of data collection may vary depending on the stage in the site survey and site selection process for which the data are used. The radius of the relevant region to be studied is typically 150–300 km and depends on the seismotectonic setting of the site, the type of installation and the method or approach of the hazard assessment.

A.4. The following summarizes the data necessary at different stages.

Site survey stage

A.5. Use should be made of existing data available from national and local archives such as the following:

(a) Regional geological maps, including those containing data on stratigraphy, i.e. with appropriate cross-sections;
(b) Tectonic maps;
(c) Hydrogeological maps;
(d) Regional geophysical maps, indicating gravity and magnetic anomalies;
(e) Satellite imagery.

Site selection stage

A.6. At this stage, the data, as already indicated, should be augmented with more detailed information. This may require more detailed and site specific information such as existing borehole logs and geophysical surveys to be obtained and studies of the site to be undertaken, for example by means of geological fieldwork, to confirm its geological and hydrogeological characteristics.

SEISMOLOGICAL DATABASE

A.7. The ground motion to be considered in the siting process should be determined as appropriate for the installation under consideration by postulating a ground motion to occur with a very low probability over its operating lifetime. Geological, seismological and geotechnical characteristics of the potential site and candidate sites should be considered. The requirements for detailed data (for the final site selection process) are the same as those for nuclear safety and are specified in SSG-9 [6].

Site survey stage

A.8. Major earthquakes that may have had significant impacts on the proposed site should be selected by using available earthquake catalogues, with account taken of the characteristics of causative faults. This preliminary information will be used for identification of the seismically active zones and for preliminary estimation of seismicity for the potential sites to be used in the screening process.

Site selection stage

A.9. Available information on prehistorical, historical and instrumentally recorded earthquakes in the region and paleoseismological data if available should be collected and documented. A catalogue should be compiled that includes all information on earthquakes developed for the project covering all these temporal scales. In particular, all available ‘pre-instrumental’ historical data on earthquakes (that is, events for which no instrumental recording was possible) should be collected, extending as far back in time as possible.

DATABASE RELATING TO FAULT DISPLACEMENT

A.10. A fault displacement hazard arises when an earthquake event on a fault close to or beneath safety related structures of a nuclear installation causes displacement to occur that may directly affect the safety of the installation. This hazard is also referred to as a capable fault hazard. A clear definition of a capable fault is given in SSG-9 together with a listing of recommended site investigations in relation to potential capable faults [6].

Site survey stage

A.11. Capable faults should be thoroughly investigated by integrating geomorphological, geological, geodetic and geophysical methods to make clear the locations, shapes, activity and characteristics of the capable faults, while also considering their distance from the proposed site. At this stage, the available site specific data may not be sufficient but a literature survey relating to the suspect features would be a reasonable source of information.

Site selection stage

A.12. An in-depth investigation should be made of the capable faults within the area of the site vicinity (5 km radius) that combines the survey of existing reference materials, tectonic geomorphological investigation, investigation of surface geological features, and geophysical and other investigations.

VOLCANOLOGICAL DATABASE

A.13. Volcanic products such as lava flows, pyroclastic flows, lahars and ash fall (among many others) may affect the safe operation of a nuclear installation. The effects of such products should be evaluated for potential and candidate sites if they are in volcanic regions.

Site survey stage

A.14. The volcanological database should include descriptions of any volcanic products at the site. For Holocene period and younger volcanoes, including those that are known to be currently active, if the volcanic products could have an impact on the safe operation of a nuclear installation under consideration, the entire geological history of the volcano should be investigated.

Site selection stage

A.15. An evaluation of the uncertainty in age determinations should be included in this assessment. For example, the stratigraphy of pyroclastic units is commonly complex and incomplete. Assessment of the completeness of the geological record should be attempted, even if not all volcanic deposits can be mapped. The ages of volcanic deposits should be quantified if possible to describe the history of volcanic activity. Detailed data requirements are similar to those recommended in SSG-21 [8].

DATABASE ON GEOTECHNICAL HAZARDS

A.16. Investigation of the subsurface conditions at the site of a nuclear installation should be carried out at all stages of the site selection and site evaluation processes. The purpose of this investigation is to provide information or basic data for decisions on the nature and suitability of the subsurface materials. At each stage of the process, the investigation programme should be used to provide the necessary data for an appropriate characterization of the subsurface. The specific requirements will vary greatly from stage to stage.

Site survey stage

A.17. The various methods of investigation — that is, the use of current and historical documents, geophysical and geotechnical exploration in situ and laboratory testing — are applicable not only to the site survey stage but also, to varying extents, to all stages of the site evaluation process.

Site selection stage

A.18. The purpose of an investigation at the site selection stage is to determine the suitability of sites and to identify issues that may be used in comparing the site with other potential sites or candidate sites. Subsurface information for this stage is usually obtained from current and historical documents and by means of field reconnaissance, including geological and geomorphological surveys, with a limited amount of site specific field investigations in order to investigate the following:

(a) Unacceptable subsurface conditions;
(b) Classification of sites;

(c) Groundwater regimes;
(d) Foundation conditions.

Detailed data requirements are similar to those recommended in NS-G-3.6 [9].

DATABASE ON COASTAL FLOODING

A.19. The coastal flooding database provides information describing the sea flooding characteristics of the candidate site. The extent and quality of data collection can vary depending on the stage of the site survey and site selection process for which the information is used, as discussed above. This section includes all forms of flooding, including tsunami hazards.

A.20. At both the site survey stage and the site selection stage, the suitability of the site is not determined solely by whether the site is inundated during events of a particular return frequency. In many cases, engineering solutions can be effected as safety measures for the site. The installation could be built at a sufficiently elevated platform level to support the safety related structures and equipment for protection against extreme events of a particular return frequency. The practicality of employing these defensive measures against floods should be considered together with the flood level predictions when deciding whether the coastal flooding is acceptable on the basis of the criteria noted above.

A.21. Similar investigations should be conducted on shore line stability.

Site survey stage

A.22. The potential for flooding due to storm surges, seiches, tides and wind waves should be investigated. To determine the flooding potential for the site in these cases, it is necessary to know the extreme sea levels from storm surges, seiches, tidal waves and wind waves and the topography of the land around the site. At the site survey stage, a good approximation for evaluating flood levels can be made by using tidal data. Tidal data are usually available from national or local authorities or other national or local institutions, or more than one of these. However, these data alone are frequently not sufficient for assessing the highest astronomical tides or the combined effects of storm surge, seiche and wind wave effects. This is because data may be available for a few decades only.

A.23. Once an estimate of extreme sea levels has been made, an approximate flood level at the site can be determined from the local topology of the land in and around the site. It may be possible to screen out the site at this stage if the flood level is too high. However, if the likelihood of coastal flooding is not clear, especially at longer return periods, then more detailed work is required and the judgement of site suitability should be carried to the next stage.

A.24. Consideration should also be given to the potentially detrimental effects of extreme low water levels as well as of other related hazards (such as jellyfish and algae).

A.25. Flooding from tsunami hazards arises because of the effects of earthquakes, volcanic activity or landslides on the ocean floor. Relevant data should be collected from national authorities if they are available. There may also be historical records of large scale flooding in the region that can be associated with one of the initiators mentioned above. SSG-18 [7] provides simple screening criteria that can be employed, for which the data requirements will be only minimal. If the proposed site does not satisfy the conditions for applying the screening criteria in SSG-18 [7], then there may not be enough data for a simple desktop study to be made.

Site selection stage

A.26. The potential for flooding from storm surges, seiches, tidal and wind waves should be investigated. More detailed work is required to provide better estimates for flood levels at the site. A preliminary analytical technique may be used at this stage to determine the extreme sea levels that are appropriate for longer return periods and for the nuclear installation under consideration.

A.27. The potential for flooding from tsunami should be investigated. A preliminary evaluation of the tsunami hazard should be undertaken at this stage. A preliminary analytical technique may be used at this stage to determine the extreme sea levels that are appropriate for longer return periods and for the nuclear installation under consideration. Information provided in SSG-18 [7] will be useful for further work in this area.

DATABASE ON RIVER FLOODING

A.28. The database on river flooding provides information describing the characteristics for river flooding and the characteristics for storm water flash floods of the proposed site, including changes in river courses, changes in the stability of riverbanks and changes in upstream land use. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. The data on flood levels alone are not sufficient for screening a site from further consideration since it may be possible to provide flood defences to protect the site. This should be taken into account when making judgements on site selection.

Site survey stage

A.29. River flooding can arise directly from rivers that have overtopped their banks or flood defences following heavy precipitation and snowmelt upstream of the site or the failure of an upstream dam. The following information and data, normally available from national or local authorities, should be obtained at the site survey stage:

(a) Regional and local maps of watercourses, rivers, lakes, streams, wadis and other waterways and local topographic maps of the site should be obtained. All watercourses that could credibly flood the site should be identified. Characteristics of topographic features such as flood plains, and the locations and sizes of existing flood protection systems such as dykes and levees, should be established.
(b) For major rivers, data on discharge rates versus river level should be obtained. The possibility of ice hazard, including frazil ice, should be considered. Historical data on river levels and on the extent of flooding should be obtained.
(c) Information on water retaining structures, especially upstream of the site, should be collected.
(d) The potentially detrimental effects of low levels of river water should also be considered and relevant information should be collected.

Site selection stage

A.30. For the site selection stage, it may be necessary to undertake preliminary flood hazard analysis to estimate flood water levels at the site and the potential for flood water to interfere with safety related equipment. Simple dam break scenarios should be considered for upstream water retaining structures.

A statistical analysis of flood data to determine flood levels at longer return periods will also be required and this should be made if it is not already available. Recommendations and guidance are provided in SSG-18 [7] for further work in this area.

DATABASE ON EXTREME AND RARE METEOROLOGICAL EVENTS

A.31. The database on meteorological events provides information describing meteorological events that could affect the potential site or candidate sites. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. Meteorological data alone are not sufficient to screen a site out from further consideration since it is often possible to provide defences to protect safety related equipment at the site.

Site survey stage

A.32. Meteorological data are usually collected on a regional basis by national authorities, although local authorities and, in some cases, particular industrial sectors, may collect specific data for special reasons. The following data should be obtained:

(a) Data on the regional and local history of extreme values, both extreme highs and extreme lows, of meteorological parameters relating to temperature, humidity, atmospheric pressure, wind speed, precipitation, icing, ice storms, sand storms, dust storms, and so on. Similar regional and local data on rare meteorological events, such as storms, tornadoes, cyclones and lightning should also be collected.
(b) The site drainage characteristics should be ascertained, e.g. the natural drainage routes for surface water, the height of the water table and the ability of water to flow onto the site. Consideration should be given to the fact that in-ground works of the nuclear installation can have a significant effect on the site drainage characteristics.

Site selection stage

A.33. For the site selection stage, it may be necessary to undertake a preliminary analytical exercise to determine historical meteorological data to establish hazard versus frequency curves for the various meteorological variables. The suitability of the site will also depend on the extent to which measures can be put in place to protect safety related structures, systems and components. In particular, the drainage requirements for the site should be evaluated in detail. The geotechnical features of the site should be determined, at least approximately, and their sensitivity to extremes of precipitation, temperature and drought should be established. Recommendations and guidance provided in SSG-18 [7] will be useful for further work in this area.

DATABASE ON HUMAN INDUCED EVENTS

A.34. The database on human induced events provides information describing the type, severity and frequency of past human induced events in the vicinity of the site and their relationship to the potential site and candidate sites. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. At both the site survey stage and site selection stages, the suitability of the site in relation to human induced events is not determined solely by the site's proximity to human induced events: the credible physical protection measures that can be taken should also be considered. For example, protective barriers can usually be erected to protect safety related equipment against vehicle impacts.

Site survey stage

A.35. To determine the potential of human induced events to affect the site, information about human activities around the site should be collected and it should be analysed how these activities may change over the operating lifetime of the installation. There are a large number of potentially hazardous human activities that could affect a site. Activities in the following general categories should be considered for their hazard potential:

(a) Nuclear installations located on the same site;
(b) Nearby industries, especially industries using quantities of toxic or explosive chemicals, or involving exothermic reactions or high pressure or high temperature processes, and industries that use ionization or strong electromagnetic fields;
(c) Nearby military facilities;
(d) Transport systems, including road, rail, air, shipping and pipeline transport;
(e) Land use activities such as those that influence water courses or the stability of slopes affecting the site, such as upstream dams, major users of river water abstraction and industries that could deposit large amounts of debris into a river upstream of the site.

These potentially hazardous human activities can present a range of hazards and hazardous events, including:

(a) Flooding hazards;
(b) Forest fires and other external fires;
(c) Missiles and impact hazards;
(d) Toxic clouds;
(e) Explosions;
(f) Ground disturbance on or under the proposed site.

Information on local industrial hazards and land use hazards should be available from local government authorities or local planning authorities. Data on the locations and movements of air traffic and other forms of transport should be available from local authorities and from relevant national authorities. Information on military facilities will be available from relevant national government authorities.

A.36. Data on human induced events and potentially hazardous human activities can be used with local and regional maps, showing transport routes and industrial locations and so on, and with local topographical maps to make an initial determination of whether the candidate site should be screened out on the basis of screening distance values for the origins of human induced events. It is anticipated that many of the hazards listed above can be eliminated on the basis that their consequences would be very local to the source and would be unlikely to affect the site directly (such as missiles from small scale pressurized systems), or could easily be protected against (such as impacts from road traffic or rail vehicles). Other hazards might necessitate a more detailed analysis at the next stage before a judgement could be made in respect of site selection.

Site selection stage

A.37. In the site selection stage, more detailed estimates of the severity and the likelihood of human induced events affecting the site or that may affect the site in the future should be provided. For several hazards listed above, a simple analysis made on the basis of site survey data alone might not be sufficient for making a judgement on site selection. For example, it is anticipated that this proviso will apply to the following:

(a) Aircraft traffic (data collected for an aircraft crash of accidental origin can also be used to some extent for the evaluation of the site for an aircraft crash as part of a nuclear security event or other unauthorized act);

(b) Toxic hazards or explosive hazards from nearby industries using or storing very large quantities of toxic or explosive materials, e.g. oil and gas operations, large petrochemical factories, or local quarrying or mining activities under the site.

For such situations, it is likely that an expert analysis will be necessary to determine the severity of the hazard, its likely impact at the site and the frequency associated with the hazard. Further recommendations and guidance on undertaking these analyses are provided in NS-G-3.1 [4].

DATABASE ON POPULATION, LAND USE, WATER USE AND ENVIRONMENTAL IMPACTS

A.38. The criteria for the database on population, land use, water use and environmental impacts should relate to the potential radiological and other impacts of the nuclear installation on workers, the population and the environment due to normal operation and accident conditions. Furthermore, the feasibility of the implementation of emergency plans should also be addressed through this database over the operating lifetime of the installation. Recommendations and guidance provided in NS-G-3.2 [5] will be useful for further work in this area.

Site survey stage

A.39. One of the most common parameters that should be considered at this stage is related to either population density in the site vicinity or the distance of the potential site or candidate sites from population centres (or both). This type of parameter is easy to use because such data are generally readily available. Care should be taken to use reasonable numbers for screening values. It should also be noted that these values are country dependent. The population density projections for the operating lifetime of the installation should also be considered in the assessment of site suitability.

A.40. In relation to protection of the environment, bio-sensitive areas (including protected species), natural reservations, monuments and tourist spots should be identified.

Site selection stage

A.41. Depending on the regulatory requirements of the State, this process for evaluating population, land use, water use and environmental impacts may be more or less involved. Attention should be paid mainly to the feasibility of implementation of the emergency plan.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003) (Revision of this publication in preparation).

[2] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing the Safety Infrastructure for a Nuclear Power Programme, IAEA Safety Standards Series No. SSG-16, IAEA, Vienna (2011).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, IAEA, Vienna (2010).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, WORLD METEOROLOGICAL ORGANIZATION, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, IAEA, Vienna (2011).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Volcanic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-21, IAEA, Vienna (2012).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.6, IAEA, Vienna (2004).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary, Terminology Used in Nuclear Safety and Radiation Protection, 2007 Edition, IAEA, Vienna (2007).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1, IAEA, Vienna (2010) (Revision of this publication in preparation).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Licensing Process for Nuclear Installations, IAEA Safety Standards Series No. SSG-12, IAEA, Vienna (2010).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing the Nuclear Security Infrastructure for a Nuclear Power Programme, IAEA Nuclear Security Series No. 19, IAEA, Vienna (2013).
[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Development, Use and Maintenance of the Design Basis Threat, IAEA Nuclear Security Series No. 10, IAEA, Vienna (2009).
[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, IAEA, Vienna (2011).
[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Milestones in the Development of a National Infrastructure for Nuclear Power, Revision 1, IAEA Nuclear Energy Series No. NG-G-3.1 Rev. 1, IAEA, Vienna (2015).
[17] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).
[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Annex I

TABLES TO BE USED IN THE SITING PROCESS

I–1. Table I–1 provides an indication of the type of criteria that are generally associated with various issues relating to the siting process. There may be cases that are not consistent with Table I–1 owing to the specific conditions at certain sites. Table I–1 is therefore to be used as an indication only.

I–2. Table I–2 [I–1 to I–9] cross-references IAEA safety standards that are relevant to the siting related issues that are under consideration in this Safety Guide. Recommendations and guidance provided in the safety standards will be useful for issues relating to the evaluation of candidate sites. In particular cases, explicit guidance may be provided by the safety standards indicated in Table I–2.

TABLE I–1. SCREENING AND RANKING CRITERIA FOR PURPOSES OF SITE SELECTION

Criteria		Category		
		Screening		
Primary	Type	Exclusionary	Discretionary	Ranking
Earthquake	Ground vibration		✓	✓
	Surface rupture	✓		
Geotechnical	Slope instability (massive landslide)	✓		
	Slope instability (minor)		✓	✓
	Subsidence		✓	✓
	Massive liquefaction	✓		
	Liquefaction		✓	✓
	Karst (massive)	✓		

TABLE I–1. SCREENING AND RANKING CRITERIA FOR PURPOSES OF SITE SELECTION (cont.)

Criteria		Category		
		Screening		
Primary	Type	Exclusionary	Discretionary	Ranking
Volcanism	Lava flow	✓		
	Pyroclastic flow	✓		
	Ground deformation	✓		
	Tephra fall		✓	✓
	Volcanic gases		✓	✓
	Lahars (massive)	✓		
Flooding	River		✓	✓
	Dam break		✓	✓
	Coastal (storm surges, waves, etc.)		✓	✓
	Tsunami		✓	✓
Extreme meteorological events	High straight winds		✓	✓
	Tornadoes		✓	✓
	Tropical storms		✓	✓
	Precipitation		✓	✓
	Sand storms and dust storms		✓	✓
Human induced events	Aircraft crashes		✓	✓
	Explosions		✓	✓
	Gas releases		✓	✓
	External fires		✓	✓
	Electromagnetic interference		✓	✓
Nuclear security events			✓	✓
Dispersion	In air and water		✓	✓

TABLE I–1. SCREENING AND RANKING CRITERIA FOR PURPOSES OF SITE SELECTION (cont.)

Criteria		Category		
		Screening		
Primary	Type	Exclusionary	Discretionary	Ranking
Feasibility of implementation of emergency plan		✓		
Implementation of emergency plan			✓	✓
Non-safety	Topography		✓	✓
	Availability of cooling water	✓	✓	✓
	Access to water		✓	✓
	Availability of transport		✓	✓
	Access to national or regional electricity grid		✓	✓
	Non-radiological environmental impacts	✓	✓	✓
	Socioeconomic impacts		✓	✓
	Land use planning		✓	✓

TABLE I–2. SITE SELECTION ISSUES CROSS-REFERENCED TO IAEA SAFETY STANDARDS

Site selection issue		Safety Requirements	Safety Guides relevant to site evaluation						Safety Guides relevant to design	
Primary	Effect	NS-R-3 [I–1]	NS-G-3.1 [I–2]	NS-G-3.2 [I–3]	SSG-9 [I–4]	SSG-18 [I–5]	SSG-21 [I–6]	NS-G-3.6 [I–7]	NS-G-1.5 [I–8]	NS-G-1.6 [I–9]
Earthquake	Ground vibration	✓			✓					✓
	Surface rupture	✓			✓					
Geotechnical	Slope instability	✓						✓		
	Subsidence	✓						✓		
	Soil liquefaction	✓						✓		
	Extensive oil and gas extraction history	✓						✓		
Volcanism		✓					✓			
Flooding	River	✓				✓			✓	
	Dam break	✓				✓			✓	
	Coastal	✓				✓			✓	
	Tsunami	✓				✓			✓	

TABLE I–2. SITE SELECTION ISSUES CROSS-REFERENCED TO IAEA SAFETY STANDARDS (cont.)

Site selection issue		Safety Requirements	Safety Guides relevant to site evaluation						Safety Guides relevant to design	
Primary	Effect	NS-R-3 [I–1]	NS-G-3.1 [I–2]	NS-G-3.2 [I–3]	SSG-9 [I–4]	SSG-18 [I–5]	SSG-21 [I–6]	NS-G-3.6 [I–7]	NS-G-1.5 [I–8]	NS-G-1.6 [I–9]
Extreme meteorological events	High straight winds	✓				✓				
	Tornadoes	✓				✓			✓	
	Precipitation	✓				✓			✓	
Human induced events	Aircraft crashes	✓	✓						✓	
	Explosions	✓	✓						✓	
	Gas releases	✓	✓						✓	
	External fires	✓	✓						✓	
Population	Density	✓		✓						
	Distance from centres	✓		✓						
Dispersion	In air	✓		✓						
	In water	✓		✓						
Feasibility of the emergency plan		✓		✓						

REFERENCES TO ANNEX I

[I–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003) (Revision of this publication in preparation).

[I–2] INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

[I–3] INTERNATIONAL ATOMIC ENERGY AGENCY, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002).

[I–4] INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, IAEA, Vienna (2010).

[I–5] INTERNATIONAL ATOMIC ENERGY AGENCY, WORLD METEOROLOGICAL ORGANIZATION, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, IAEA, Vienna (2011).

[I–6] INTERNATIONAL ATOMIC ENERGY AGENCY, Volcanic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-21, IAEA, Vienna (2012).

[I–7] INTERNATIONAL ATOMIC ENERGY AGENCY, Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.6, IAEA, Vienna (2004).

[I–8] INTERNATIONAL ATOMIC ENERGY AGENCY, External Events Excluding Earthquakes in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.5, IAEA, Vienna (2003).

[I–9] INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Design and Qualification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.6, IAEA, Vienna (2003).

Annex II

EXAMPLES OF CRITERIA FOR THE SITING PROCESS FOR A NUCLEAR POWER PLANT

GENERAL CONSIDERATIONS

II–1. This Annex provides certain information that could serve as examples of attributes and related criteria to be considered in the siting process for a nuclear power plant. The Annex is intended to be used by interested parties associated with the siting process for a nuclear power plant. It was prepared by compiling information on practices in different States and guidance from relevant IAEA safety standards. Examples are given in relation to external natural hazards as well as external human induced events.

II–2. A number of attributes (issues, events, phenomena, hazards and specific considerations) are related to the siting process as well as to general information on the site. These attributes are grouped into thematic sets in Section 4 of this Safety Guide. These sets are:

- External natural hazards;
- External human induced events;
- Radiological impacts on the public and on the environment;
- Emergency planning;
- Considerations not directly related to nuclear safety.

The last set, considerations not directly related to nuclear safety, is considered to have a major bearing on the effectiveness of the siting process.

II–3. This Annex further expands these sets of attributes, providing examples of issues, events, phenomena, hazards and considerations that are to be taken into account in the siting process for a nuclear power plant. Screening values for some of these attributes serve as useful siting criteria. Examples of such screening values are provided. The candidate sites undergo preliminary evaluation, which is useful for comparison and ranking in the second stage of the siting process. Examples of discretionary criteria with respect to some of these issues, events, phenomena and hazards are also provided. Finally, the Annex provides examples of the content of emergency procedures that would serve as useful information for examination of the feasibility of emergency planning.

EXAMPLES OF ATTRIBUTES CONSIDERED IN THE SITING PROCESS

II–4. General site related information:

(a) Maps of site area at a suitable scale:
  (i) Site boundary and emergency planning zones: Typically, these are zones demarcating 5 km, 16 km, 25 km (or more) and 80 km from reactors [II–1 to II–3], although these distances differ between States.
  (ii) Population distribution and location of existing industrial, commercial, institutional, recreational and residential buildings and areas, including projections of relevant developments for the expected operating lifetime of the nuclear power plant.

II–5. External natural hazards:

(a) Geology:
  (i) Properties of subsurface strata, depth and type of bed rock;
  (ii) Characteristics of subsurface material;
  (iii) Groundwater.
(b) Natural events:
  (i) Seismic and geological considerations:
    — Capable faults;
    — Vibratory ground motion due to earthquakes.
  (ii) Volcanism;
  (iii) Meteorological events and variables:
    — High wind events, such as tropical cyclones, tornadoes and water spouts;
    — Precipitation;
    — Storms;
    — Snow;
    — Lightning;
    — Dust storms and sand storms;
    — Hail;
    — Freezing precipitation and frost related phenomena;
    — Air temperature.
  (iv) Coastal flooding:
    — Storm surges;
    — Seiches;
    — Tsunamis;
    — Tides;

— Wave action;
— Combinations of tides: variations and extremes in sea water levels;
— Combination of flooding with relevant meteorological events.

(v) Inland (river) flooding:
— Overtopping of banks;
— Failure of upstream or downstream water control structures such as dykes or dams;
— Blockage of a river or other drainage channel;
— Combination of flooding with relevant meteorological events.

(vi) Combination of coastal and inland flooding for sites on an estuary;

(vii) Geological and geotechnical hazards:
— Slope instability;
— Soil liquefaction;
— Rock fall;
— Permafrost;
— Soil erosion processes;
— Collapse, subsidence;
— Expansion, uplift;
— Karst;
— Avalanches;
— Stability of foundation.

(viii) Shoreline erosion.

(c) Change of hazard with time:

(i) Change due to climatic evolution: regional climatic change with global climatic change;

(ii) Changes in physical geography of a drainage basin, including estuaries, offshore bathymetry, coastal profile, catchment area, etc.;

(iii) Changes in land use and water use.

II–6. External human induced hazards:

(a) Stationary sources:

(i) Oil and gas operations (e.g. refineries);

(ii) Industrial plants and operations and other facilities processing hazardous substances;
— Facilities for the storage of hazardous substances;
— Broadcasting and communication networks (for electromagnetic interference hazards);
— Mining or quarrying operations;

— Other nuclear installations;
— High energy rotating equipment;
— Military facilities (permanent or temporary), especially shooting ranges and arsenals.

(iii) Nuclear installations located on the same site (such as installations for the reprocessing of spent fuel, the storage of fresh fuel and the storage of spent fuel).

(b) Mobile sources:
(i) Railway trains and wagons;
(ii) Road vehicles;
(iii) Ships and barges;
(iv) Pipelines;
(v) Air traffic corridors and flight zones (both civilian and military);
(vi) Transport of fresh fuel and spent fuel and of other nuclear material and other radioactive material.

(c) Other characteristics:
(i) Oil slick;
(ii) Transport of over dimension consignments.

II–7. Radiological impact:

(a) Meteorology:
(i) Wind speed and direction;
(ii) Rain and other precipitation;
(iii) Atmospheric temperature;
(iv) Humidity;
(v) Atmospheric stability;
(vi) Sand storms and dust storms.

(b) Use of land and water;
(c) Population considerations;
(d) Dispersion of radioactive material:
(i) In the atmosphere;
(ii) In subsurface water;
(iii) In surface water.

(e) Management of radioactive waste in operational states:
(i) Radioactive solid waste:
— Characteristics of the waste;
— Quantity;
— Level of activity;
— Management strategy.

(ii) Radioactive liquid waste:
   — Characteristics of the waste:
   — Quantity;
   — Level of activity;
   — Management strategy.
(iii) Discharges of radioactive gases:
   — Characteristics of the waste;
   — Quantity;
   — Level of activity;
   — Management strategy.

(f) Management of radioactive releases in accident conditions;
(g) Ambient radiation;
(h) Monitoring.

II–8. Emergency management:

(a) Physical characteristics and site characteristics that may hinder emergency plans;
(b) Emergency procedures;
(c) Infrastructural characteristics relating to the implementation of emergency plans:
   (i) Evacuation routes and access routes;
   (ii) Sheltering;
   (iii) Transport.
(d) Special requirements prescribed by the regulatory body for special zones, if any, such as the exclusion boundary, low population zones, etc.;
(e) Population considerations within emergency planning zones outside the site area boundary of the nuclear installation;
(f) Additional statutory requirements of:
   (i) The national or federal government;
   (ii) The state, provincial or territorial government;
   (iii) The local government.

II–9. Considerations not directly related to safety:

(a) Topography:
   (i) Salient features;
   (ii) Contour maps for the region up to 30 km.

(b) Accessibility:
   (i) Nearest railway lines;
   (ii) Nearest national highways and major roads;
   (iii) Nearest sea ports.

(c) Availability of industrial infrastructure and construction facilities:
   (i) Construction materials;
   (ii) Construction power;
   (iii) Construction water;
   (iv) Infrastructural facilities.

(d) Proximity to load centres;

(e) Availability of and conditions of access to cooling water:
   (i) Condenser cooling;
   (ii) Fresh water for consumption.

(f) Population centres:
   (i) Locations;
   (ii) Distances from the nuclear power plant site;
   (iii) Expected populations.

(g) Proximity to load centres:
   (i) Lines for the power distribution grid;
   (ii) Locations of major power consuming units, facilities and populations.

(h) Non-radiological environmental impacts, including ecological considerations:
   (i) Heat sinks: water bodies and atmosphere;
   (ii) Presence of bio-sensitive areas adjacent to the site;
   (iii) Natural reserves, monuments or tourist spots;
   (iv) Restrictions by statutory bodies on:
      — Thermal pollution:
         • Temperature differential between the intake and outfall points of the condenser cooling water;
         • Effects on aquatic life of discharges of condenser water.
      — Discharge of chemical pollutants.

(i) Socioeconomic impacts, including public acceptance:
   (i) Type of area adjacent: urban or rural;
   (ii) General source of income for local population: large scale industry, small scale industry, agriculture and agro-industries;
   (iii) General economic conditions of the surrounding population with respect to national averages (e.g. per capita incomes);
   (iv) Level of acceptance of the installation by the public.

EXAMPLE OF SCREENING VALUES

II–10. The screening values of different characteristics of a site could be used as exclusion criteria or discretionary criteria at the site survey stage. Examples of such screening values are given in Table II–1. These are examples of typical values, but values may differ between States. If a site does not satisfy any one or a combination of screening values, it could still be considered acceptable provided that engineering solutions are available, i.e. design features, measures for physical protection of the site or administrative procedures.

TABLE II–1. EXAMPLES OF SCREENING VALUES

No.	Characteristics	Screening values	Remarks
1	Distance from capable fault	8.0 km [II–3]	Exclusion criterion
2	Distances from flight paths approaching an airport	4.0 km [II–4]	Discretionary criterion
3	Distance from airport with attributes of Type 2 event[a]	7.5 km [II–4]	Discretionary criterion
4	Distance from small airports	10.0 km [II–4]	Discretionary criterion
5	Distance from large airport: — for yearly flight operations >500 d^2 — for yearly flight operations >1000 d^2	 < (*d* =)16.0 km > (*d* =)16.0 km [II–4]	Discretionary criterion
6	Distance from military installations or air space usage such as practice, bombing and firing ranges	30.0 km [II–4]	Discretionary criterion
7	Distance from military installations storing ammunition, etc.	8.0 km [II–4]	Discretionary criterion
8	Distance from facilities for storing or handling flammable, toxic, corrosive or explosive material	5.0 km [II–4]	Discretionary criterion

TABLE II–1. EXAMPLES OF SCREENING VALUES (cont.)

No.	Characteristics	Screening values	Remarks
9	Sources of hazardous clouds	8.0 km [II–4]	Discretionary criterion
10	Natural reserves, bio-sensitive regions and forests	Exclusion zone	Exclusion criterion
11	Tsunami	10 km from sea or ocean shoreline or 1 km from lake or fjord shoreline, or 50 m above mean water level [II–5]	Discretionary criteria

Note: *d* = distance.

[a] Accidental aircraft crash at the site such as in a take-off or landing operation at a nearby airport.

REFERENCES TO ANNEX II

[II–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, IAEA, Vienna (2010).

[II–2] INTERNATIONAL ATOMIC ENERGY AGENCY, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002).

[II–3] UNITED STATES NUCLEAR REGULATORY COMMISSION, General Site Suitability Criteria for Nuclear Power Stations, Regulatory Guide 4.7, Rev. 2, USNRC, Washington, DC (1998).

[II–4] INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

[II–5] INTERNATIONAL ATOMIC ENERGY AGENCY, WORLD METEOROLOGICAL ORGANIZATION, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, IAEA, Vienna (2011).

CONTRIBUTORS TO DRAFTING AND REVIEW

Altinyollar, A.	International Atomic Energy Agency
Basu, P.	Consultant, India
Coman, O.	International Atomic Energy Agency
Ford, P.	Health and Safety Executive, United Kingdom
Godoy, A.	Consultant, Argentina
Gürpinar, A.	Consultant, Turkey
Hibino, K.	International Atomic Energy Agency
Hidaka, A.	Nuclear Regulatory Authority, Japan
Mahmood, H.	International Atomic Energy Agency
Samaddar, S.	International Atomic Energy Agency

IAEA
International Atomic Energy Agency

No. 23

ORDERING LOCALLY

In the following countries, IAEA priced publications may be purchased from the sources listed below or from major local booksellers.

Orders for unpriced publications should be made directly to the IAEA. The contact details are given at the end of this list.

AUSTRALIA
DA Information Services
648 Whitehorse Road, Mitcham, VIC 3132, AUSTRALIA
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: books@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy
Avenue du Roi 202, 1190 Brussels, BELGIUM
Telephone: +32 2 5384 308 • Fax: +32 2 5380 841
Email: jean.de.lannoy@euronet.be • Web site: http://www.jean-de-lannoy.be

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road, Ottawa, ON K1J 9J3, CANADA
Telephone: +1 613 745 2665 • Fax: +1 643 745 7660
Email: order@renoufbooks.com • Web site: http://www.renoufbooks.com

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

CZECH REPUBLIC
Suweco CZ, spol. S.r.o.
Klecakova 347, 180 21 Prague 9, CZECH REPUBLIC
Telephone: +420 242 459 202 • Fax: +420 242 459 203
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa
PO Box 128 (Keskuskatu 1), 00101 Helsinki, FINLAND
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit
5 rue Janssen, PO Box 25, 75921 Paris CEDEX, FRANCE
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: fabien.boucard@formedit.fr • Web site: http://www.formedit.fr

Lavoisier SAS
14 rue de Provigny, 94236 Cachan CEDEX, FRANCE
Telephone: +33 1 47 40 67 00 • Fax: +33 1 47 40 67 02
Email: livres@lavoisier.fr • Web site: http://www.lavoisier.fr

L'Appel du livre
99 rue de Charonne, 75011 Paris, FRANCE
Telephone: +33 1 43 07 50 80 • Fax: +33 1 43 07 50 80
Email: livres@appeldulivre.fr • Web site: http://www.appeldulivre.fr

GERMANY
Goethe Buchhandlung Teubig GmbH
Schweitzer Fachinformationen
Willstätterstrasse 15, 40549 Düsseldorf, GERMANY
Telephone: +49 (0) 211 49 8740 • Fax: +49 (0) 211 49 87428
Email: s.dehaan@schweitzer-online.de • Web site: http://www.goethebuch.de

HUNGARY
Librotrade Ltd., Book Import
PF 126, 1656 Budapest, HUNGARY
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472
Email: books@librotrade.hu • Web site: http://www.librotrade.hu

INDIA

Allied Publishers
1st Floor, Dubash House, 15, J.N. Heredi Marg, Ballard Estate, Mumbai 400001, INDIA
Telephone: +91 22 2261 7926/27 • Fax: +91 22 2261 7928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell
3/79 Nirankari, Delhi 110009, INDIA
Telephone: +91 11 2760 1283/4536
Email: bkwell@nde.vsnl.net.in • Web site: http://www.bookwellindia.com

ITALY

Libreria Scientifica "AEIOU"
Via Vincenzo Maria Coronelli 6, 20146 Milan, ITALY
Telephone: +39 02 48 95 45 52 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Web site: http://www.libreriaaeiou.eu

JAPAN

Maruzen Co., Ltd.
1-9-18 Kaigan, Minato-ku, Tokyo 105-0022, JAPAN
Telephone: +81 3 6367 6047 • Fax: +81 3 6367 6160
Email: journal@maruzen.co.jp • Web site: http://maruzen.co.jp

NETHERLANDS

Martinus Nijhoff International
Koraalrood 50, Postbus 1853, 2700 CZ Zoetermeer, NETHERLANDS
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

SLOVENIA

Cankarjeva Zalozba dd
Kopitarjeva 2, 1515 Ljubljana, SLOVENIA
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.mladinska.com/cankarjeva_zalozba

SPAIN

Diaz de Santos, S.A.
Librerias Bookshop • Departamento de pedidos
Calle Albasanz 2, esquina Hermanos Garcia Noblejas 21, 28037 Madrid, SPAIN
Telephone: +34 917 43 48 90 • Fax: +34 917 43 4023
Email: compras@diazdesantos.es • Web site: http://www.diazdesantos.es

UNITED KINGDOM

The Stationery Office Ltd. (TSO)
PO Box 29, Norwich, Norfolk, NR3 1PD, UNITED KINGDOM
Telephone: +44 870 600 5552
Email (orders): books.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

UNITED STATES OF AMERICA

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Co. Ltd.
812 Proctor Avenue, Ogdensburg, NY 13669, USA
Telephone: +1 888 551 7470 • Fax: +1 888 551 7471
Email: orders@renoufbooks.com • Web site: http://www.renoufbooks.com

United Nations
300 East 42nd Street, IN-919J, New York, NY 1001, USA
Telephone: +1 212 963 8302 • Fax: 1 212 963 3489
Email: publications@un.org • Web site: http://www.unp.un.org

Orders for both priced and unpriced publications may be addressed directly to:

IAEA Publishing Section, Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 or 22488 • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

FUNDAMENTAL SAFETY PRINCIPLES
IAEA Safety Standards Series No. SF-1
STI/PUB/1273 (37 pp.; 2006)
ISBN 92–0–110706–4 Price: €25.00

GOVERNMENTAL, LEGAL AND REGULATORY FRAMEWORK FOR SAFETY
IAEA Safety Standards Series No. GSR Part 1
STI/PUB/1465 (63 pp.; 2010)
ISBN 978–92–0–106410–3 Price: €45.00

THE MANAGEMENT SYSTEM FOR FACILITIES AND ACTIVITIES
IAEA Safety Standards Series No. GS-R-3
STI/PUB/1252 (39 pp.; 2006)
ISBN 92–0–106506–X Price: €25.00

RADIATION PROTECTION AND SAFETY OF RADIATION SOURCES: INTERNATIONAL BASIC SAFETY STANDARDS
IAEA Safety Standards Series No. GSR Part 3
STI/PUB/1578 (427 pp.; 2014)
ISBN 978–92–0–135310–8 Price: €68.00

SAFETY ASSESSMENT FOR FACILITIES AND ACTIVITIES
IAEA Safety Standards Series No. GSR Part 4
STI/PUB/1375 (56 pp.; 2009)
ISBN 978–92–0–112808–9 Price: €48.00

PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE
IAEA Safety Standards Series No. GSR Part 5
STI/PUB/1368 (38 pp.; 2009)
ISBN 978–92–0–111508–9 Price: €45.00

DECOMMISSIONING OF FACILITIES
IAEA Safety Standards Series No. GSR Part 6
STI/PUB/1652 (20 pp.; 2014)
ISBN 978–92–0–102614–9 Price: €25.00

REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL, 2012 EDITION
IAEA Safety Standards Series No. SSR-6
STI/PUB/1570 (168 pp.; 2012)
ISBN 978–92–0–133310–0 Price: €44.00

PREPAREDNESS AND RESPONSE FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY
IAEA Safety Standards Series No. GS-R-2
STI/PUB/1133 (72 pp.; 2002)
ISBN 92–0–116702–4 Price: €20.50

Safety through international standards

"Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them."

Yukiya Amano
Director General

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–102415–2
ISSN 1020–525X