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The Radioactive Waste Safety Standards (RADWASS) programme follows the hierarchical categorization scheme used in the publications of IAEA Safety Series, as shown below:

Safety Fundamentals (silver cover)

Basic objectives, concepts and principles to ensure safety.

Safety Standards (red cover)

Basic requirements which must be satisfied to ensure safety for particular activities or applications areas.

Safety Guides (green cover)

Recommendations, on the basis of international experience, relating to the fulfillment of basic requirements.

Safety Practices (blue cover)

Practical examples and detailed methods which can be used for the application of Safety Standards or Safety Guides.

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An additional category, Safety Reports (purple cover), comprises independent reports of expert groups on safety matters, including the development of new principles, advanced concepts and major issues and events. These reports are issued under the authority of the Director General of the IAEA.

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The RADWASS reports are published within the IAEA Safety Series under No. 111. The report numbers are composed of the following elements:

— The Safety Series number (111).
— Identification within a subject area by a serial number.

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SITING OF NEAR SURFACE DISPOSAL FACILITIES
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SITING OF NEAR SURFACE DISPOSAL FACILITIES

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1994
FOREWORD

Radioactive waste is generated from the production of nuclear energy and from the use of radioactive materials in industrial applications, research and medicine. The importance of safe management of radioactive waste for the protection of human health and the environment has long been recognized and considerable experience has been gained in this field. The Radioactive Waste Safety Standards (RADWASS) programme is the IAEA’s contribution to establishing and promoting, in a coherent and comprehensive manner, the basic safety philosophy for radioactive waste management and the steps necessary to ensure its implementation.

The RADWASS publications will (a) reflect the existing international consensus in the approaches and methodologies for safe radioactive waste management, including disposal, and provide mechanisms to establish consensus where it does not yet exist and (b) provide Member States with a comprehensive series of internationally agreed documents to assist in the derivation of and to complement national criteria, standards and practices.

In keeping with the IAEA’s Safety Series structure, the RADWASS publications are organized in four hierarchical levels. The leading publication in this series is the Safety Fundamentals. This publication lays down the basic objectives and fundamental principles for the management of radioactive waste.

In addition to the Safety Fundamentals, six Safety Standards cover the following subjects:

- Planning
- Predisposal
- Near surface disposal
- Geological disposal
- Uranium/thorium mining and milling
- Decommissioning/environmental restoration.

As the programme develops, other subjects may be added to this list.

The Safety Standards are supplemented by a number of Safety Guides and Safety Practices.

This Safety Guide defines the site selection process and criteria for identifying suitable near surface disposal facilities. Management of the siting process and data needed to apply the criteria are also specified. The Safety Guide has been prepared through two consultants meetings and a Technical Committee meeting. The list of contributors to drafting and review of the Safety Guide along with their affiliations is given at the end of the report. The IAEA wishes to acknowledge the contributions made by the experts in the preparation of the Safety Guide, especially D.E. Billington, who chaired the Technical Committee meeting. Z. Dlouhy, M. Bell and K.W. Han of the Division of Nuclear Fuel Cycle and Waste Management were the responsible officers of the IAEA.
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1. INTRODUCTION

BACKGROUND

101. The objective of radioactive waste disposal is to isolate waste so that it does not result in undue radiation exposure to humans and the environment. The required degree of isolation can be obtained by implementing various disposal methods, of which near surface disposal represents an option commonly used and demonstrated in several countries. In near surface disposal, the disposal facility is located on or below the ground surface, where the protective covering is generally a few metres thick. In some cases, the covering goes up to a few tens of metres for rock cavern type facilities. These facilities are intended to contain low and intermediate level wastes without appreciable quantities of long lived radionuclides.

102. Near surface disposal has been practised for some decades, with a wide variation in sites, types and amounts of wastes, and facility designs employed. Experience has shown that the effective and safe isolation of waste depends on the performance of the overall disposal system, which is formed by three major components or barriers: the site, the disposal facility and the waste form. Near surface disposal can also rely on active institutional controls, such as monitoring and maintenance.

103. For the suitability assessment of a given disposal system, underlying safety principles are used. These principles are based on national regulations as well as international recommendations. In establishing and implementing these principles, the specific characteristics of the proposed facility design and the intended waste form and packaging are taken into account. General guidelines by which the acceptability can be judged and subsidiary site selection criteria also need to be established.

104. The safety and environmental impact assessment of near surface disposal facilities involves consideration of radiological impacts during both the operational and post-closure periods. Potential radiological impacts following closure of the repository arise from natural processes leading to the gradual release of radionuclides to the biosphere and from discrete events which may have adverse impacts on the facility such as human intrusion. The suitability of a site will depend largely on its capacity to confine radioactive wastes for required periods of time, and to limit release rates of radionuclides, and on its capability to limit potential adverse impacts of the disposal system on humans and the environment.
OBJECTIVE

105. The objective of this publication is to provide guidance on the site selection process and guidelines for identifying suitable near surface disposal sites. The information contained here should help the personnel involved in the siting of near surface disposal facilities to choose a proper site using a method that would best suit the specific conditions of the country, the waste type intended for disposal, and the performance requirements of the regulatory body. This document provides basic guidance for site selection and information for managing related regulatory activities. It may also be used by the regulatory body for the development of more specific requirements and specifications.

SCOPE

106. The scope of this publication covers siting of a near surface repository for the disposal of low and intermediate level solid waste. It does not encompass selection of sites for disposal of uranium mill tailings, nor does it deal with siting of sanitary landfill facilities for disposal of exempt waste. The siting of deep geological disposal facilities is dealt with in a companion Safety Guide [1]. This document is concerned with the selection of sites so as to achieve compliance with safety requirements; it provides no detailed information on other factors such as economic and social impacts which may influence site selection.

STRUCTURE

107. Guidelines contained in this publication include the general approach to siting relevant to near surface disposal and a description of the siting process (Section 2), the management of the siting process (Section 3), and an overview of site selection guidelines and necessary data to be collected during the siting process (Section 4).

108. In this Guide, the word ‘shall’ is used to denote a firm requirement, the word ‘should’ denotes a desirable option, and the word ‘may’ denotes permission (neither a requirement nor a desirable option).
2. APPROACH TO SITING

GENERAL

201. Siting of radioactive waste disposal facilities is an important step in developing a waste disposal system that would best suit the needs for accommodation of wastes from a national nuclear programme and simultaneously satisfy all relevant safety, technical and environmental requirements set out in various national and international guidelines. When properly implemented, a near surface disposal system should provide adequate isolation of radionuclides from the biosphere for periods of time necessary to allow their decay to safe levels. Development and issuance of guidance on the objectives and/or guidelines to be applied in selecting suitable sites will help ensure that near surface disposal facilities provide adequate isolation.

202. The purpose of siting is to locate a site which, along with a proper design, waste form, type and quantity of waste packages, other engineered barriers and institutional controls, will provide radiological protection in compliance with requirements established by the regulatory body. IAEA standards [2] and existing international recommendations and guidance should be taken into account.

203. A suitable disposal site may be chosen either by narrowing the field of candidates from a number of sites or by objectively evaluating a single designated potential site. For either method it is not essential to locate the best possible site, but to provide a waste disposal system which can be convincingly shown to comply with the safety, technical and environmental requirements. Thus, the approach to evaluating a site in both methods is similar.

204. It has to be recognized that in near surface disposal systems, the wastes are limited in both concentrations of long lived radionuclides and total inventory [3]. Site stability should be assessed for the period of time over which the activity of waste decays to safe levels. Institutional control periods in the range fifty to a few hundred years have been adopted by some Member States. Shortcomings in some site characteristics may be compensated for by engineered barriers, which should take into consideration the isolation and confinement ability of the entire disposal system.

BASIC OBJECTIVE

205. The basic objective of the siting process is to select a suitable site for disposal and to demonstrate that this site has characteristics which, when combined with the facility design and waste package, provide adequate isolation of radionuclides from
the biosphere for desired periods of time. Sites generally serve as a principal barrier, but engineering measures can enhance site performance and improve overall safety and environmental protection. To keep releases within acceptable limits, the disposal system should be developed such that the design of the facility and the type and amount of wastes intended for emplacement are in concert with the characteristics of the site and the surrounding natural media.

STAGES OF THE SITING PROCESS

206. If there are no pre-existing constraints, it is possible to follow a systematic process of narrowing the range of choices from large regions to specific sites. One systematic siting process for a near surface disposal facility may be considered to consist of four stages:

— conceptual and planning stage
— area survey stage
— site characterization stage
— site confirmation stage.

The transition from one stage to the next may not always be clear owing to the overlap of siting activities. Further phases of work within each stage may be considered. In each stage, procedures are implemented with the aim of collecting and analysing relevant data. The amount of data required and the complexity and sophistication of the procedures should increase as the overall siting process progresses towards its goal of confirming a site.

207. Specific sites may be designated for consideration by a local or national authority. Existing nuclear sites or land adjoining existing nuclear facilities may be identified as worthy of special consideration because of the potential benefits of co-location, particularly in relation to reducing the potential burden of public acceptance and waste transport requirements. Additionally, it might be possible to solicit volunteer sites from communities or land owners. In this case, the second stage in the process described may be omitted. However, the conceptual and planning, site characterization and site confirmation stages are still needed.

208. This staged approach requires a high level of technical effort and intensive accompanying work to ensure full public information, and thus places large strains on human and financial resources. The staged approach nevertheless has important advantages in the form of serious, well documented scientific investigations and specific knowledge which will support the ultimate choice of a site. In examining the range of possible options, confidence may increase if studies are as complete as
possible; however, the clear aim must remain to find an acceptable solution with sufficient safety reserves rather than a single 'best' solution.

209. Although the staged screening approach is used in most countries, specific needs or conditions in a Member State may result in the choice of a different approach or a combination of approaches. Consideration should be given to the choice of an adequate approach or its possible variation in the course of general planning at the start of the siting process.

CONCEPTUAL AND PLANNING STAGE

210. The purpose of the conceptual and planning stage is to develop an overall plan for the site selection process, to establish the siting principles and to identify desirable site features which can be used as a basis for the area survey stage.

211. The human and financial resources, materials, equipment and time requirements should be estimated to the extent practicable, and responsibilities for the siting studies defined. Approval to proceed according to a plan, which is likely to require periodic updating, should be obtained from the regulatory body. This is also an appropriate time to consider public involvement in the siting process.

212. At the start of the conceptual and planning stage, the types of wastes to be disposed of should be defined and characterized, including the projected waste volumes and radionuclide contents. On the basis of this information, generic facility design concepts should be developed.

213. The likely waste acceptance criteria should be identified and the overall performance criteria for the facility developed, in conformity with national requirements. From these criteria and the design concepts developed, screening criteria should be established for selecting potential areas or sites and later for selecting the preferred site(s).

214. Available methodologies for safety analysis should be reviewed and basic methods and models selected. Subsequently, a generic safety assessment should be performed according to the national regulatory requirements or international recommendations. This generic safety assessment would give confidence that the proposed facility is capable, basically, of meeting the regulatory requirements for the anticipated waste.

215. The generic design and safety studies may suggest the need to modify the waste characteristics and quantities proposed for disposal or to re-evaluate the conceptual
design. On the basis of these conceptual studies various desirable features, such as land area, geology and hydrogeology, could be identified as a basis for the area survey stage.

AREA SURVEY STAGE

216. The purpose of the area survey stage is to identify one or more potential sites. This is often accomplished by the systematic screening of a region of interest, which results in the selection of potentially suitable areas. During this stage, it is necessary to take into account engineering, operational, socioeconomic and environmental constraints.

217. The area survey stage generally involves two phases:

- regional mapping to identify areas with potentially suitable sites
- screening to select potential sites for further evaluation.

(a) Regional mapping phase

218. A typical sequence starts with defining the region of interest. This may be the whole territory of a State, a region defined by natural or political boundaries, or an area adjacent to major waste producers in a country. In defining the region of interest, due consideration should be given to significant features located outside the study area which could affect or be affected by the proposed disposal facility.

219. The parameters to be mapped during the regional mapping phase can be based on factors such as the type of intended disposal facility, the applicability of simple guidelines and the availability of the necessary data. Any specific regulatory requirements and guidance must also be considered. Much of the information needed is likely to be available or easily obtained. In practice, regional mapping should proceed by first considering large areas that contain lands having favourable geological, structural, hydrological, hydrogeological and climatic features. Within these lands, subsequent activities should focus on successively smaller and increasingly more suitable areas.

(b) Screening phase

220. In the screening phase, potential sites are identified within the suitable areas. These potential sites are screened against more detailed guidelines not considered in the regional mapping phase. Some potential sites may be identified at an early stage,
on the basis of characteristics for which sufficient information can be readily obtained. Others may require further and more detailed study.

221. With the application of these more detailed guidelines, the screening process would result in the identification of a few candidate sites that would then be examined in the site characterization stage.

SITE CHARACTERIZATION STAGE

222. The site characterization stage involves the investigation of one or more candidate sites to demonstrate that they meet safety and environmental requirements. Specific site related design bases should also be determined at this stage.

223. The site characterization stage requires site specific information to establish the characteristics and the ranges of parameters of a site with respect to the location of the intended disposal facility. This will require on-site investigation and laboratory studies to obtain data on geological, geochemical and hydrogeological conditions.

224. A preliminary safety assessment should be performed for each candidate site to determine that each one is potentially suitable for accommodating a disposal facility.

225. Using appropriate guidelines and analysis techniques, a reasonable comparative evaluation may be made among sites on the basis of their ability to meet safety requirements and of their suitability for construction of the disposal facility. Economic, social and political considerations should be taken into account at this stage.

226. At the conclusion of the site characterization stage, a preferred site or sites should be identified, taking into account the relevant economic, environmental, social and political considerations. A report on the entire process should be prepared, with complete documentation of all data and analytical work.

SITE CONFIRMATION STAGE

227. The purpose of the site confirmation stage is to conduct detailed site investigations at the preferred site(s) to:

— support or confirm the selection;
— provide additional site specific information required for detailed design, safety and environmental impact assessment and licensing.
228. The site confirmation stage consists of detailed laboratory studies and field investigation of the preferred site(s) and its (their) surroundings prior to the start of construction. From the results of this work, detailed specifications of the site(s) should be established to allow final detailed design. Radiological, radionuclide transport and ecological evaluations should be carried out in detail.

229. Safety analysis data and models should be updated for the specific site(s), and a detailed safety and environmental impact analysis should be performed using all the detailed information available. Extensive laboratory studies and in situ testing should be conducted. In situ tests, together with results of laboratory studies, should provide site specific data for radionuclide transport modelling.

230. A final safety and environmental impact assessment based on all the investigations and evaluations should be prepared, summarizing all the relevant data, evaluations and conclusions derived from all site characterization and confirmation activities. Careful comparisons with criteria should be made to ensure that the site(s) will perform as required. Upon confirmation of the suitability of the site(s), the regulatory body should be provided with sufficient information to permit decisions to be made on authorization for construction and operation, taking into account closure and post-closure considerations.

231. Although not a direct part of the siting process, additional studies may be continued during construction and operation of the facility. These studies will provide specific information that may allow improvement in the validity of previous safety and environmental impact assessments for the facility.

232. At closure of a near surface facility, although not a direct part of the siting process, an update of the safety and environmental impact assessment may be performed to reflect any new data developed through site studies conducted during the operating period, taking into account the actual wastes disposed of at the facility.

3. MANAGEMENT OF THE SITING PROCESS

GENERAL

301. Selection of suitable sites for radioactive waste disposal facilities involves integration of site investigative studies involving a number of disciplines. These include many branches of natural and earth sciences, engineering, safety analysis, health physics and social sciences. The overall siting process encompasses
theoretical, laboratory and field activities carried out in stages such as those outlined in para. 206 but with significant interaction between stages. The process should start with identification of the need for a disposal facility and conclude with selection of a site that is confirmed as meeting all safety and other requirements.

302. Engineering design studies, together with waste acceptance considerations, provide important interactions with site selection criteria. At each stage of the siting process, societal, ecological and legal issues shall be evaluated and dealt with according to national policies. At relevant stages of the process, the regulatory body should be consulted and kept informed and involved in decisions.

303. A plan should be developed at the beginning of each stage of the siting process. It should include:

- description of general tasks to be performed
- sequence diagrams of various tasks
- the guidelines adopted
- an outline of procedures for applying these guidelines
- a comprehensive schedule
- quality assurance and control programme
- cost estimates.

304. The selection of the preferred site(s) should be accompanied by a safety and environmental impact assessment as specified by the regulatory body. Each assessment should reflect the decision process and should contain the evidence that supports such decisions. In general, the assessment should include not only an evaluation of the possible effects of the proposed disposal facility on human health and the environment for present and future generations but also the effects of the environment on the disposal facility. Furthermore, it should include a discussion of how to avoid or mitigate these effects as well as how to avoid or mitigate other local or regional impacts of locating the disposal facility at the site.

305. Public acceptance may be crucial in siting a disposal facility; therefore plans for the siting process should take into account activities to provide the local as well as general public with appropriate information, consultation and compensation as needed.

ROLE OF THE REGULATORY BODY

306. An important role of the regulatory body is to set or approve the site selection guidelines. During the area survey stage, informal consultation may take place between the operator and the regulatory body. In the regional analysis and in the
subsequent screening of potential sites, many national laws and regulations have to be considered such as those relating to groundwater resources, national parks and historical monuments. These are generally clearly defined and, therefore, no specific regulatory actions may be necessary.

307. In the site characterization stage, in which the operator performs a preliminary safety assessment, the regulatory body may review the assessment and provide guidance to the operator on site selection guidelines and planned site studies. The extent of informal consultations between the regulatory body and the operator should be balanced so as to preserve the independence of the regulatory body while providing adequate guidance to the operator.

308. In the site confirmation stage, a safety and environmental impact assessment should be performed by the operator. The regulatory body should review the assessment and results of site confirmation studies, and possibly conduct on-site inspections. After review of all information, including that on closure and post-closure, the regulatory body should, if appropriate, issue authorizations for construction and operation.

INFORMATION COLLECTION AND MANAGEMENT

309. The siting process involves collection and management of information on various site characteristics which are needed for application of guidelines to identify suitable sites. Some of the data required at various stages of the process may be readily available from different sources; other data should be obtained through field investigation studies and laboratory tests. The siting process should be designed to provide the necessary data at various stages to facilitate a series of increasingly accurate estimates of the likelihood of compliance with the safety requirements.

310. The suitability or unsuitability of a site should be determined as quickly as possible with the use of minimum resources. Thus, easily obtainable data are generally gathered first. Also, factors which might result in the disqualification of a site should be investigated early, even if investigations of such factors are not among the most easily conducted. Therefore, an optimization of the data gathering sequence will be necessary to facilitate an efficient process of iterative evaluation of the potential of the site for compliance with the safety requirements.

311. The conceptual and planning stage is performed and organized in such a way that all the relevant information is collected and scrutinized to determine its quality and completeness for safety purposes. Effective organization can facilitate the efficient collection of local information, which might be available from sources known only to local experts.
312. During the area survey stage, the data collected previously as well as new data should be evaluated and assessed with respect to guidelines for the selection of sites for further characterization.

313. In the characterization and confirmation stages, progressively more detailed and more accurate estimates are made as the investigation of the site(s) progresses. Initially, highly qualitative comparisons to factors and guidelines are made on the basis of available information. For multiple sites, these comparisons will be used to select a site or sites for more detailed investigation. For a single site, these comparisons will be used to decide whether to continue site investigations. As more data become available, increasingly analytical and detailed estimates of the likelihood of consistency with siting guidelines, and of compliance with safety requirements, are undertaken. Such investigations will include use of pre-existing data, laboratory studies, on-site studies and study of any relevant analogues.

314. Data should be presented and classified in a suitably standardized fashion. Where standards and formats do not exist locally, they should be established and used throughout the study. Data should be compiled in a format that facilitates examination and comparison and the fullest possible usability. The organization of data should allow for prompt identification of gaps in information. Where significant gaps exist, steps should be identified to gather the necessary information.

315. To manage the data properly, standard formats and maps of standard scale should be used. The scale of the maps should be such that all the needed details can be shown. The type of data to be collected in the siting process is indicated in Section 4.

QUALITY ASSURANCE

316. A quality assurance programme for all activities during siting shall be established to ensure compliance with relevant standards and guidelines. It is recognized that the nature and extent of quality assurance required will differ from stage to stage and at different steps within a stage. The quality assurance programme should contain provisions for ensuring the identification of, and compliance with, requirements of appropriate codes and regulations, standards, specifications and practices. It should also provide for production of documentary evidence to demonstrate that the required data quality has been achieved.
APPLICATION OF GUIDELINES

317. Application of the siting guidelines presented in Section 4 will ensure that all factors important to the acceptability of a site are considered in the siting process. To evaluate the suitability of a site, the guidelines should be made operational and a method for their application should be established for each guideline.

318. The data quality should be adequate to be utilized in the quantitative approach selected. Different approaches may be used at different stages in the siting process. The uncertainties in data should be evaluated to ensure that screening is reliable. The more sophisticated approaches should permit systematic uncertainty analysis to assess the robustness of the selection.

4. SITING GUIDELINES AND DATA NEEDS

GENERAL

401. This section identifies general guidelines that govern the suitability of sites for near surface disposal facilities mainly from the viewpoint of safety. Other non-safety related considerations are necessary in relation to the establishment of a disposal facility and these include social and economic impacts [4].

402. The relative position of these guidelines within this report does not imply an order of priority since their relevance to the site selection process can vary in specific cases. It is necessary, therefore, that development and implementation of individual guidelines in a siting process be done in accordance with conditions relevant to the region, area or site of concern. The guidelines applied in a specific siting process should be developed in compliance with regulatory requirements and should reflect technical and institutional concerns.

403. Guidelines can be helpful in the decision making process but they are not to be regarded as strict preconditions. To assess whether a disposal system meets its safety requirements, the system should be considered as a whole. Flexibility in the planning stage is important and the possibility of taking advantage of the strength of one component of the overall disposal system by relaxing the demands on another should be retained.

404. An important initial step in the site selection process is to determine at which stage a particular site characteristic should be taken into account. The general
approach is to select, for consideration in the earlier phases of the area survey stage, those site characteristics which may be decisive in the site selection process, and those for which information is most readily available.

405. In the selection of the preferred site(s), it is essential to ensure that all site related characteristics have been taken into account. Any site recommended for detailed study should have the safety related site characteristics and conditions required for the successful development of a disposal facility at the site.

406. For each major stage of the siting process, the collected data, the guidelines used and the results obtained should be reviewed and recorded so as to contribute to the thorough documentation of the entire process. The information should include:

(a) A description of the siting process, based on the plan (see para. 303), including the objectives, legal limitations, and the procedures and guidelines to be considered at each phase of the site selection;
(b) Specification of data to be used and the information required for each site characteristic at each phase of the siting process;
(c) The data collected and the guidelines adopted;
(d) The results obtained in the evaluation of each guideline.

407. Since a number of technical disciplines are involved throughout the siting process, it is necessary that specific technical parameters be addressed within each of the disciplines. The specificity of the data should increase throughout the process. A detailed description of the methods and procedures for data gathering is not given in this publication. The specialized literature on the various topics should be consulted.

GEOLOGY

408. Guideline

The geological setting at the site should contribute to the isolation of waste and the limitation of releases of radionuclides to the biosphere. It should also contribute to the stability of the disposal system and provide sufficient volume and engineering properties favourable for implementing disposal.

409. Preference should be given to sites with a uniform and predictable geology which can be readily characterized through geological investigative techniques.
410. Data needs

In the area survey stage, the geological information should include identification of the approximate geological structure and stratigraphy, possibly with the depth, thickness and lateral extent of the surface formation and surrounding units.

411. In the site characterization stage, information to be collected should include:

- stratigraphy, lithology and mineralogy
- structural characteristics
- geotechnical characteristics.

412. In the site confirmation stage, extensive geological investigations should be undertaken to fully characterize the geology to the level needed for detailed safety assessment, modelling and final facility design.

HYDROGEOLOGY

413. Guideline

The hydrogeological setting of the site should include low groundwater flow and long flow paths in order to restrict the transport of radionuclides.

414. Expected changes in important hydrogeological conditions (e.g. gradient) due to natural events and the disposal should be evaluated. Preference should be given to sites with a simple geological setting that could make characterizing or modelling of the hydrogeological system easy. The dispersion characteristics of the hydrogeological system may also be important and should be evaluated.

415. Data needs

In the area survey stage, hydrogeological characteristics of an area or site may not yet be available in sufficient detail. In situations where hydrogeological maps are lacking, the information analysed should encompass:

- data on existing and projected major water uses
- identification of major discharge and extraction points
- an estimate of groundwater flow velocity and direction.
416. For the site characterization stage, the following information should be considered:

— location, extent and interrelationship of the important hydrogeological units in the region
— average flow rates and prevailing directions of the groundwater flow
— information on recharge and discharge of the major hydrogeological units
— information on regional and local water tables and their seasonal fluctuations.

417. The site confirmation stage may require detailed information on the hydrogeological characteristics of the site selected. The type of data should, in general, express quantitatively the characteristics indicated above, with the aim of defining radionuclide travel times along the likely flow paths from the disposal facility to the biosphere.

GEOCHEMISTRY

418. Guideline

The geochemistry of groundwater and the geological media should contribute to limiting the release of radionuclides from the disposal facility and should not significantly reduce the longevity of engineered barriers.

419. Preference should be given to sites where geochemical conditions promote sorption and precipitation/co-precipitation of radionuclides potentially released from the disposal system and inhibit the formation of easily transportable chemical compounds of radionuclides.

420. In the consideration of the likely chemical interactions within the disposal system, the following processes should be evaluated:

— corrosivity of groundwater towards the engineered barriers
— processes or conditions influencing the solubility and the sorption of radionuclides
— Eh and pH of the groundwater
— processes or conditions involving the presence of natural colloids and organic materials
— potential gas generation by the disposal system.
421. Data needs

Information necessary to estimate the potential for migration of radionuclides to the biosphere should include a description of the geochemical and hydrochemical conditions at the site, the surrounding geological and hydrogeological units, and the paths of potential groundwater flow. This information should include:

- mineralogical and petrographical composition of the groundwater flow system and its geochemical properties
- groundwater chemistry.

422. This information is not likely to be available at the area survey stage for the selection of candidate sites. However, it should be collected as part of the investigation programme carried out during the site characterization and confirmation stages.

TECTONICS AND SEISMICITY

423. Guideline

The site should be located in an area of low tectonic and seismic activity such that the isolation capability of the disposal system will not be endangered.

424. Areas of low tectonic and seismic activity should be selected in the regional analysis. Preference should be given to areas or sites where potential for adverse tectonic, volcanic or seismic events is sufficiently low that it would not affect the ability of the disposal system to meet safety requirements.

425. In the application of site selection criteria, the following conditions should be considered:

- recent or historic evidence of active faulting, tectonic processes or igneous activities;
- historical earthquakes of such magnitude and intensity that, if they recurred, could adversely affect waste isolation;
- potential for natural events such as subsidence or volcanic activity that could change the regional hydrogeological system;
- evidence of soil liquefaction in seismic loads.
426. **Data needs**

The distance of sites from areas with high seismicity or from known or suspected capable faults may be used as a screening factor in the area survey stage for the selection of candidate sites.

427. The design of the disposal facility should take into account tectonic stability and seismic activity of the site that could adversely affect the proposed disposal system. The following information should be analysed at the site confirmation stage:

- historical seismicity at the site;
- occurrence of quaternary faults at the site and the age of latest movement;
- evidence of active tectonic processes, such as volcanism;
- estimate of maximum potential earthquake within the geological setting.

SURFACE PROCESSES

428. **Guideline**

Surface processes such as flooding of the disposal site, landsliding or erosion should not occur with such frequency or intensity that they could affect the ability of the disposal system to meet safety requirements.

429. The disposal site should be generally well drained and free of areas of flooding or frequent ponding. Accumulation of water in upstream drainage areas due to precipitation, snowmelt, failure of water control structures, channel obstruction or landsliding should be evaluated and minimized so as to decrease the amount of runoff which could erode or inundate the facility. Preference should be given to areas or sites with topographical and hydrological features which preclude the potential for flooding.

430. **Data needs**

In the area survey stage, areas and sites subject to flooding should be evaluated. Potential sites can be screened on the basis of the severity of effects of flooding. Surface geological processes such as erosion, landsliding or weathering should be evaluated in regard to their frequency and capacity to affect the safety of the disposal system.
431. In the site characterization and confirmation stages, the following information should be collected:

— topography of the site, showing actual drainage features;
— location of existing and planned surface water bodies;
— definition of areas of landslides and other potentially unstable slopes, and of materials of low bearing strength or high liquefaction potential;
— definition of areas containing poorly drained materials;
— data on the flood history of the region;
— upstream drainage areas.

METEOROLOGY

432. Guideline

The site area meteorology should be characterized such that the effect of unexpected extreme meteorological conditions can be adequately considered in the design and licensing of the disposal facility.

433. The potential for extreme meteorological events should be evaluated. Potential sites may be screened on the basis of the severity of the effects of such events.

434. In the site selection process consideration should be given to the following conditions:

— precipitation (rain and snow);
— dispersion conditions for potential atmospheric releases;
— potential for extreme weather phenomena, such as tropical and extratropical cyclones, tornadoes, severe winter storms and sandstorms.

435. Data needs

In the area survey stage, data on extreme weather conditions which may adversely affect facility safety should be mapped on a national or regional scale.

436. In the site characterization and confirmation stages, the meteorological conditions, as determined from the closest recording station(s), should be known in order to predict potential effects of extreme precipitation on the hydrological and hydrogeological systems at the site, and to evaluate the transport of airborne releases.
during operation of the disposal facility. The types of information should include:

— wind and atmospheric dispersion characteristics
— precipitation characteristics
— extreme weather phenomena.

MAN-INDUCED EVENTS

437. Guideline

The site shall be located such that activities by present or future generations at or near the site will not be likely to affect the isolation capability of the disposal system.

438. Areas in the immediate vicinity of major hazardous facilities, airports or transport routes carrying significant quantities of hazardous materials, should be evaluated. In addition, areas or sites should be evaluated where valuable geological resources or potential future resources, including groundwater suitable for irrigation or drinking, are likely to give rise to interference activities resulting in the release of radionuclides in quantities beyond the acceptable limits. A site should be considered less suitable where previous or future activities could create significant release pathways between the projected facility and the biosphere.

439. Screening of potential sites should include consideration of the distance from such facilities and the associated impact.

440. Data needs

In the area survey stage, known valuable geological resources, including groundwater, should be mapped as part of the process of defining the region of interest.

441. In the site characterization and confirmation stages, in order to estimate any adverse impact that off-site installations might have on the projected disposal system, the following information should be collected:

— location of nearby hazardous installations, such as oil refineries, chemical plants, storage depots, pipelines and other facilities that could have an impact on the site operations;
— location of airports and important air traffic corridors and flight frequencies;
— location of transportation routes with frequent movement of hazardous material.
442. Also in the site confirmation stage, in order to evaluate whether past or future exploration and recovery of resources could negatively affect the disposal system, the following information should be collected:

— known occurrences of energy and mineral resources, including groundwater, and estimates of their present and projected quality and value and their potential for use;
— records of past and present drilling and mining operations in the vicinity of the site.

TRANSPORTATION OF WASTE

443. Guideline

The site shall be located such that the access routes will allow transportation of waste with a minimal risk to the public.

444. Parameters including cost, radiation exposure and accident potential associated with the transportation of waste to the disposal site should be taken into account.

445. Data needs

To evaluate existing or required access routes, the information to be collected should include:

— description of existing routes in the vicinity of the site and analysis of their adequacy for handling waste shipments;
— anticipated improvements in the existing transportation network;
— estimates of the overall costs and risk of waste transportation;
— analysis of emergency response requirements and capabilities related to transportation.

LAND USE

446. Guideline

Land use and ownership of land should be considered in connection with foreseeable development and regional planning in the area of interest.

447. Future uses of the land in the vicinity of the proposed site should be evaluated for potential impact on the operation and performance of the disposal facility, and vice versa.
448. Jurisdiction over the land, or ownership, may in some countries be a significant factor with respect to economics and public acceptance. Early control or ownership of the site by the operator or government would simplify the site planning and evaluation efforts, shorten the time required for activation of the facility and reduce the problems associated with the withdrawal of land from other uses.

449. *Data needs*

The data should include:

— existing land resources and uses and jurisdiction over them
— foreseeable development of land in the area of interest.

**POPULATION DISTRIBUTION**

450. *Guideline*

The site should be located such that the potential hazard of the disposal system on the current population and projected future population is acceptable.

451. Consideration should be given to avoiding areas of high population density. The selection of candidate sites should be performed on the basis of appropriate suitability factors, taking into account the likelihood of future disturbances and radiation protection aspects of the population potentially affected by the releases of radionuclides from the disposal facility.

452. *Data needs*

At the area survey stage, large scale maps should be prepared showing major population centres and regions with population density as a function of distance.

453. At the site characterization stage, more detailed data should be collected based on the most recent census, extrapolated as appropriate.
PROTECTION OF THE ENVIRONMENT

454. Guideline

The site shall be located such that the environment will be adequately protected during the entire lifetime of the facility and such that potentially adverse impacts can be mitigated to an acceptable degree, taking into account technical, economic, social and environmental factors.

455. Near surface disposal facilities should comply with the requirement to protect the environment. Possible adverse effects which a near surface disposal system may have on the environment include:

- disturbance of the environment due to the construction and operation of the disposal facility
- impact on areas of significant public value
- disturbance of public water supplies
- impact on endangered species.

456. Data needs

To estimate potential impacts on environmental quality, the type of information collected should include:

- location of national parks and areas with historical monuments and archaeological findings;
- existing surface water and groundwater resources and quality;
- existing terrestrial and aquatic vegetation and wildlife, particularly endangered species.
REFERENCES


This publication is no longer valid
Please see http://www-ns.iaea.org/standards/
The IAEA published a Radioactive Waste Management Glossary as TECDOC-264 (1982) and a second edition as TECDOC-447 (1988). Over the years, continuing developments in the field of radioactive waste management made it necessary to update or revise individual terms. New terms also needed to be defined or added to the Glossary. The IAEA recently published the third version of the Radioactive Waste Management Glossary, incorporating such updates, revisions and amendments. The Radioactive Waste Management Glossary serves as a source for the terms included in this Glossary.

area survey. (See survey, area.)

barrier. A physical obstruction that prevents or delays the movement (e.g. migration) of radionuclides or other material between components in a system, e.g. a waste repository. In general, a barrier can be an engineered barrier which is constructed or a natural barrier which is inherent to the environment of the repository.

biosphere. That portion of the Earth's environment normally inhabited by living organisms. It comprises those parts of the atmosphere, the hydrosphere (ocean, seas, inland waters and subsurface waters) and the lithosphere normally related to the human habitat or environment.

criteria. Conditions on which a decision or judgement can be based. They may be qualitative or quantitative and should result from established principles and standards. In radioactive waste management, criteria and requirements are set by a regulatory body and may result from specific application of a more general principle.

disposal. The emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval. Disposal may also include the approved direct discharge of effluents (e.g. liquid and gaseous wastes) into the environment with subsequent dispersion.

disposal facility. (See repository.)

disposal, near surface. Disposal of waste, with or without engineered barriers, on or below the ground surface where the final protective covering is of the order of a few metres thick, or in caverns a few tens of metres below the Earth's surface. Typically short lived, low and intermediate level wastes are disposed of in this manner. This term replaces 'shallow land/ground disposal'.
engineered barrier. (See barrier.)

Eh. In chemistry, the potential of a half-cell measured against the standard hydrogen half-cell. Eh provides a quantitative measure of reducing/oxidizing conditions existing in groundwater depending on its chemical composition and radionuclide speciation.

institutional control. Control of a waste site (e.g. disposal site, decommissioning site, etc.) by an authority or institution designated under the laws of a country or state. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear facility (e.g. near surface disposal facility).

intermediate level waste. (See waste, low and intermediate level.)

low level waste. (See waste, low and intermediate level.)

migration. The movement of materials (e.g. radionuclides) through various media (e.g. barrier materials or soil) usually by being carried or transported by fluid flow.

near surface disposal. (See disposal, near surface.)

operator (or operating organization). In radioactive waste management, the organization (and its contractors) which performs activities to select and investigate the suitability of a site for a nuclear facility and/or undertakes to design, construct, commission, operate and decommission such a facility.

performance. In radioactive waste management, a measure of how effective a waste disposal system is in isolating waste, and in retarding and dispersing eventual releases of radionuclides in accordance with design specification and requirements. Performance can also refer to the individual parts of a system. For example, the performance of a container may refer to how a waste container remains intact and prevents the release of radionuclides over a period of time.

potential site. Site(s) selected for further investigation following area survey. (See siting.)

preferred site. Site(s) selected for further investigation following site characterization. (See siting.)

regulatory body. An authority or a system of authorities designated by the government of a country or state as having legal authority for conducting the licensing process, for issuing licences and thereby for regulating the siting, design, construction, commissioning, operation, closure, closeout, decommissioning and, if required, subsequent institutional control of the nuclear facilities (e.g. near surface repository) or specific aspects thereof. This authority could be a
body (existing or to be established) in the field of nuclear related health and safety, mining safety, or environmental protection vested and empowered with such legal authority.

repository. A nuclear facility where radioactive waste is emplaced for disposal. Future retrieval of waste from the repository is not intended. (See also disposal.)

risk. The following alternative definitions may be relevant in the field of radioactive waste management:

— In general, risk is the probability or likelihood of a specified event occurring within a specified period or in specified conditions.
— In the safety assessment of radioactive waste repositories, risk may be used as a measure of safety. In this context it is defined as the product of the probability that an individual is exposed to a particular radiation dose and the probability of a health effect arising from that dose.

short lived waste. (See waste, short lived.)

site. The area containing, or under investigation for its suitability to construct, a nuclear facility (e.g. a repository). It is defined by a boundary and is under effective control of the operating organization.

site characterization. Detailed surface and subsurface investigations and activities at candidate disposal sites to obtain information to determine the suitability of and to evaluate long term performance of a waste disposal facility at the site.

site confirmation. The final stage of the site selection process for a nuclear facility (e.g. a repository). Site confirmation is based on detailed investigations on the preferred site which provide site specific information needed for safety assessment. This stage includes the finalization of the repository design and the preparation and submission of a licence application to the regulatory body.

siting. The process of selecting a suitable disposal site. The process is comprised of the following stages:

— concept and planning
— area survey
— site characterization
— site confirmation.

survey, area. One of the stages of siting a waste repository, during which a broad region is examined to eliminate unsuitable areas and to identify other areas which may contain suitable sites. (See also siting.)

waste acceptance criteria. Those criteria relevant to the acceptance of waste packages for handling, storage and disposal.
waste, exempt. In the context of radioactive waste management, waste (from a nuclear facility) that is released from nuclear regulatory control in accordance with clearance levels because the associated radiological hazards are negligible. The designation should be in terms of activity concentration and/or total activity and may include a specification of the type, chemical/physical form, mass or volume of waste.

waste, long lived. Radioactive waste containing long lived radionuclides having sufficient radiotoxicity in quantities and/or concentrations requiring long term isolation from the biosphere. The term ‘long lived radionuclide’ refers to half-lives usually greater than 30 years.

waste, low and intermediate level waste. Radioactive wastes in which the concentration of or quantity of radionuclides is above clearance levels established by the regulatory body, but with a radionuclide content and thermal power below those of high level waste. Low and intermediate level waste is often separated into short lived and long lived wastes. Short lived waste may be disposed of in near surface disposal facilities. Plans call for the disposal of long lived waste in geological repositories.

waste, short lived. Radioactive waste which will decay to a level which is considered to be insignificant from a radiological viewpoint in a time period during which institutional control can be expected to last. Radionuclides in short lived waste will generally have half-lives shorter than 30 years.
CONTRIBUTORS TO DRAFTING AND REVIEW

Consultants Meetings

Vienna, Austria: 26–30 November 1990
Vienna, Austria: 12–16 October 1992

RADWASS Standing Technical Committee
on Disposal of Radioactive Waste

Vienna, Austria: 15–19 April 1991

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111-F. The principles of radioactive waste management

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Note: This is the RADWASS publication plan approved by the International Radioactive Waste Advisory Committee (INWAC) in March 1993. A review of the plan will be undertaken by INWAC in 1995.
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