EPR-PROTECTION STRATEGY

2020

EMERGENCY PREPAREDNESS AND RESPONSE

Considerations in the Development of a Protection Strategy for a Nuclear or Radiological Emergency

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

https://www.iaea.org/resources/safety-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.

CONSIDERATIONS IN THE DEVELOPMENT OF A PROTECTION STRATEGY FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

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

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ANTIGUA AND BARBUDA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BARBADOS
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
COMOROS
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
ESWATINI
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GRENADA
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
NORTH MACEDONIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAINT LUCIA
SAINT VINCENT AND THE GRENADINES
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
TURKMENISTAN
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VANUATU
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''.

EPR-PROTECTION STRATEGY (2020)

CONSIDERATIONS IN THE DEVELOPMENT OF A PROTECTION STRATEGY FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2021

COPYRIGHT NOTICE

For further information on this publication, please contact:

Incident and Emergency Centre
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
Email: Official.Mail@iaea.org

CONSIDERATIONS IN THE DEVELOPMENT OF A PROTECTION STRATEGY FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY
IAEA, VIENNA, 2021
EPR-Protection Strategy (2020)
ISSN 2518–685X

Printed by the IAEA in Austria
April 2021

FOREWORD

In March 2015, the IAEA's Board of Governors approved IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency, which was jointly sponsored by 13 international organizations. GSR Part 7 establishes requirements for an adequate level of preparedness for and response to a nuclear or radiological emergency, irrespective of the initiator of the emergency. As part of these safety requirements, governments are required to ensure that *"*protection strategies are developed, justified and optimized at the preparedness stage for taking protective actions and other response actions effectively in a nuclear or radiological emergency*"*, which is also a requirement of the IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards.

In line with these requirements, the IAEA General Conference in 2018, in resolution GC(62)/RES/6, encouraged Member States *"*to ensure that radiation protection strategies are developed, justified and optimized to enable effective protective actions to be taken in a timely manner, during a nuclear or radiological emergency*"*. Moreover, it requested the Secretariat to provide assistance, upon request, to Member States in this regard.

This publication within the Emergency Preparedness and Response Series is intended to assist Member States in the application of Requirement 5 of GSR Part 7 and Requirement 44 of GSR Part 3. It provides practical guidance on and a stepwise approach to the development, justification and optimization of a protection strategy for a nuclear or radiological emergency, the implementation of the concepts of reference levels and generic criteria in the strategy, and the implementation of the strategy during an emergency response. It also elaborates on the planning basis necessary to support the development of a justified and optimized protection strategy as well as on the processes of justification and optimization to be applied by responsible authorities in a State. Finally, this publication provides a template outline of a protection strategy that can be used by States when developing their protection strategy and an example of a protection strategy for postulated nuclear or radiological emergencies.

The IAEA officer responsible for this publication was S. Nestoroska Madjunarova of the Incident and Emergency Centre.

EDITORIAL NOTE

This publication has been prepared from the original material as submitted by the contributors and has not been edited by the editorial staff of the IAEA. The views expressed remain the responsibility of the contributors and do not necessarily represent the views of the IAEA or its Member States.

Neither the IAEA nor its Member States assume any responsibility for consequences which may arise from the use of this publication. This publication does not address questions of responsibility, legal or otherwise, for acts or omissions on the part of any person.

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

The authors are responsible for having obtained the necessary permission for the IAEA to reproduce, translate or use material from sources already protected by copyrights.

The IAEA has no responsibility for the persistence or accuracy of URLs for external or third party Internet web sites referred to in this publication and does not guarantee that any content on such web sites is, or will remain, accurate or appropriate.

CONTENTS

1. INTRODUCTION

1.1. Background

IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [1], and No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [2], require Member States to *"ensure that protection strategies are developed, justified and optimized, at the preparedness stage, for taking protective actions and other response actions effectively in a nuclear or radiological emergency"*.

The concept of the protection strategy, comprising a suite of justified and optimized protective actions and other response actions, has evolved from the previously recommended approach in which interventions, in terms of individual protective actions primarily, were separately justified on the basis of the radiation dose (hereinafter referred to as the dose) that is avertable by that action, using the concept of intervention levels. The concept of protection strategy involves consideration of protective actions and other response actions, individually and in combination, on the basis of the reference level and generic criteria, expressed in terms of residual and projected or received doses, respectively.

The abovementioned safety standards provide for the development of a justified and optimized protection strategy and the application of reference levels and generic criteria on radiation protection grounds. However, these safety standards recognize the need for national authorities to consider a range of factors and different impacts at the national level (possible impacts on health as well as societal, economic, environmental and other impacts) to ensure that emergency response actions are justified and optimized, taking account of radiation protection considerations as well as a range of non-radiological factors and impacts.

The factors and impacts that are to be considered, and how responsible authorities can arrive at a justified and optimized protection strategy, has not yet been addressed in detail.

Given that the combined use of reference levels and generic criteria within a protection strategy is relatively new, Member States requested the IAEA to develop technical guidance on the protection strategy and on the implementation of the reference levels and generic criteria within the protection strategy, taking into account societal, economic and environmental impacts as well as other factors and impacts.

These factors and impacts are expected to influence the final decision to be made by each State on the values to be chosen for the reference level aimed to guide the optimization process, and also on the national generic criteria aimed to guide the initiation of specific protective actions and other response actions, taking into account those values recommended in the IAEA safety standards on radiation protection grounds. These considerations have their importance for both the preparedness stage and the emergency response and will impact the final decisions on how best to approach the protection of populations in a nuclear or radiological emergency.

1.2. Objective

This publication provides Member States with practical guidance and a stepwise approach for the development, justification and optimization of a protection strategy for a nuclear or radiological emergency, for the application of reference levels and generic criteria within the protection strategy as well as on the implementation of the strategy during an emergency response.

This publication also elaborates in more detail on the planning basis necessary to support the development of a justified and optimized protection strategy as well as on the processes of justification and optimization to be applied by responsible authorities in a State.

In addition, this publication provides a template outline of a protection strategy that can be used by States when developing their protection strategy and examples of protection strategies for postulated nuclear or radiological emergencies associated with facilities, activities and sources in the five emergency preparedness categories (EPCs) described in the GSR Part 7 [2].

1.3. Scope

This publication is applicable to any nuclear or radiological emergency that could occur in relation to a facility, an activity or a source, irrespective of the cause (i.e. be it nuclear safety or nuclear security related).

The target audiences for this publication are decision makers (emergency managers), emergency planners (at the facility, local, regional and national level), emergency response coordinators, qualified experts/radiation protection officers (radiological assessors, technical advisers to decision makers) and relevant staff of different response organizations at all levels with roles and responsibilities in preparedness and response for a nuclear or radiological emergency.

Terms are used in this publication as defined in GSR Part 7 [2] and the IAEA Safety Glossary [3].

1.4. Structure

This publication comprises of six sections. Section 2 elaborates on the concept of a protection strategy for a nuclear or radiological emergency and the elements of the protection strategy. Section 3 describes the basis for the development of a protection strategy while Section 4 provides a step-by-step approach for developing the strategy. Section 4 includes also considerations for the implementation of the protection strategy to be considered during the development of the strategy. Section 5 elaborates processes for justification and optimization of the protection strategy. Section 6 addresses the consultation with the public and interested parties in the context of development and implementation of the protection strategy. Appendices provide discussion on the reference level and generic criteria and their application within the protection strategy, template outline of a protection strategy, and an overview of key protective actions and other response actions. Annexes provide example protection strategy for postulated nuclear or radiological emergencies and list example factors and considerations that are relevant for the processes of justification and optimization.

2. CONCEPT OF THE PROTECTION STRATEGY FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

2.1. Background

Requirement 5 of GSR Part 7 [2] states: *"Governments shall ensure that protection strategies are developed, justified and optimized at the preparedness stage for taking protective actions and other response actions effectively in a nuclear or radiological emergency."*

The protection strategy is required to be developed on the basis of the hazards identified and the potential consequences of a nuclear or radiological emergency such that protective actions and other response actions can be taken to achieve the goals of the emergency response (stipulated in para. 3.2 of GSR Part 7 [2]) in an effective manner.

Paragraph 4.28 of GSR Part 7 [2] requires that the development of a protection strategy includes, but is not limited to, the following:

1) *"Consideration shall be given to actions to be taken to avoid or to minimize severe deterministic effects and to reduce the risk of stochastic effects. Deterministic effects shall be evaluated on the basis of relative biological effectiveness (RBE) weighted absorbed dose to a tissue or organ. Stochastic effects in a tissue or organ shall be evaluated on the basis of equivalent dose to the tissue or organ. The detriment associated with the occurrence of stochastic effects in individuals in an exposed population shall be evaluated on the basis of the effective dose.*
2) *A reference level expressed in terms of residual dose shall be set, typically as an effective dose in the range 20–100 mSv, acute or annual, that includes dose contributions via all exposure pathways. This reference level shall be used in conjunction with the goals of emergency response (...) and the specific time frame in which particular goals are to be achieved.*
3) *On the basis of the outcome of the justification and optimization of the protection strategy, national generic criteria for taking protective actions and other response actions, expressed in terms of projected dose or of dose that has been received, shall be developed with account taken of the generic criteria in Appendix II [of GSR Part 7]. If the national generic criteria for projected dose or received dose are exceeded, protective actions and other response actions either individually or in combination, shall be implemented.*
4) *Once the protection strategy has been justified and optimized and a set of national criteria has been developed, pre-established operational criteria (conditions on the site, emergency action levels (EALs) and operational intervention levels (OILs)) for initiating the different parts of an emergency plan and for taking protective actions and other response actions shall be derived from the generic criteria. Arrangements shall be established in advance to revise these operational criteria, as appropriate, in the course of a nuclear or radiological emergency, with account taken of the prevailing conditions as they evolve."*

Paragraph 4.31 of GSR Part 7 [2] further requires that the protection strategy is implemented safely and effectively in an emergency response through the implementation of emergency arrangements. Such implementation of pre-established arrangements is related, but not limited to, taking various protective actions and other response actions with the aim to avoid or minimize severe deterministic effects and to reduce the risk of stochastic effects among individuals as well as to mitigate non-radiological consequences. In addition, it relates to activities taken to:

- Assess the effectiveness of the implemented protective actions and other response actions and adjusting them as appropriate on the basis of prevailing conditions and available information as well as the reference level expressed in terms of residual dose;
- Revise the protection strategy as necessary and its further implementation;
- Discontinue protective actions and other response actions when they are no longer justified.

The various requirements mentioned imply that the protection strategy describes how the objectives of an emergency response are achieved through the implementation of a justified and optimized set of protective actions and other response actions on the basis of thoughtfully defined dosimetric criteria that allow for effective protection and safety. The protection strategy is developed at the preparedness stage and then implemented safely and effectively, in response to an emergency, through the execution of pre-established emergency arrangements (such as emergency plans and procedures). This concept of the protection strategy, comprising a suite of justified and optimized protective actions and other response actions, has evolved from the previously recommended approach [4, 5] in which interventions (i.e. individual protective actions) were individually justified on the basis of the dose that is avertable by that action, using the concept of intervention levels on the basis of the ICRP recommendations valid at that time [6, 7]. Discussion on the reference level, generic criteria and their application within the protection strategy, in line with the latest requirements and recommendations, is provided in Appendix I.

However, currently there is no clarity to what the protection strategy actually is from a practical point of view to assist States in identifying suitable means to apply these requirements in their national emergency preparedness and response (EPR) framework and to develop an adequate protection strategy. The situation is further complicated by the fact that the term ‘protection strategy’ is commonly used to refer to both a framework and its documentation, i.e. the same term is applied to:

- A framework under which the justified and optimized set of protective actions and other response actions in an emergency response are implemented (through execution of pre-established emergency arrangements); and
- A document (or set of documents) that describes the goals to be achieved, the decision making basis, and the set of justified and optimized emergency response actions that comprise or set the framework.

This publication provides practical guidance to help States develop a suitable protection strategy as a documentation that can serve as a framework under which the emergency response is undertaken in a nuclear or radiological emergency. This section aims to bring clarity to a concept of the protection strategy.

2.2. Concept of the protection strategy

The protection strategy is, in general terms, an outline of the national approach to a nuclear and radiological emergency response to achieve the goals of emergency response. The concept of protection strategy involves consideration of protective actions and other response actions, individually and in combination, based on the reference level and generic criteria, expressed in terms of residual and projected doses or received doses, respectively. Such actions are further justified and optimized taking account of a range of non-radiological considerations as well and are taken based on directly measurable or observable criteria (i.e. operational criteria). As such, the protection strategy describes, in a comprehensive manner, what needs to be achieved in response to a nuclear or radiological emergency in all its phases (i.e. from the time the emergency is declared by the time the emergency is terminated) and

how the set objective or goals will be achieved through ensuring a justified and optimized set of protective actions and other response actions are taken [8]. For large-scale emergencies, the protection strategy may extend into the longer term, within the framework of an existing exposure situation.

Most States already have emergency plans and other arrangements in place, most of which were developed on the basis of the previous concepts contained in Refs [4–7]. They were intended to allow for an effective emergency response at the time and as such, elements of a protection strategy are already in existence at national levels but spread out over a range of various documentation (such as legislation, regulations, emergency plans at various levels, procedures, processes in established management systems, checklists and technical assessments). Such elements relate, but are not limited to, clearly set objectives to be met during the emergency response, the basis upon which the decisions for emergency response actions are taken, pre-planned set of emergency response actions for particular type of a nuclear or radiological emergency and the means for adjusting the emergency response actions to meet the prevailing circumstances.

The development of a protection strategy, as required in GSR Part 3 [1] and GSR Part 7 [2] and suggested in this publication provides opportunity for States to collate, at one place, all relevant information that relates to ensuring justified and optimized protection and safety during an emergency for the benefit mostly of those whose advise and decisions in an emergency response are the most needed, while bringing them up to date with the latest standards and recommendations given in Refs [1, 2, 9, 10]. It will also help identifying elements needed to be further elaborated at the national level, improving consistency and increasing the transparency among all concerned parties. Finally, it will support engagement and building trust with the public and other interested parties through open sharing of the relevant information that underpins their protection and safety in a nuclear or radiological emergency.

To apply the new concept of protection strategy as required in GSR Part 3 [1] and GSR Part 7 [2], States need to carefully review all necessary information so that informed decisions are made on how the new concept of protection strategy that considers applying the dose concepts of projected dose, received dose and residual dose impact current arrangements, on the best way to implement these concepts and on how consistency is ensured across various arrangements and documentation. Thus, the process of development of the protection strategy entails taking account of information and data already available (e.g. from existing emergency arrangements), compiling additional information or developing additional aspects that are of relevance and applying it within the context of the protection strategy in a coherent manner. Such a process calls for collaboration with all relevant response organizations with responsibilities at all levels. Their engagement is essential and enables issues such as the acceptability, feasibility and any practicalities associated with the protection strategy to be identified, discussed and resolved in a timely manner.

The developed protection strategy then forms the basis for revision of the existing emergency arrangements (e.g. emergency plans at national and local levels) and/or development of additional arrangements (e.g. specific procedures) among all response organizations. It is with the execution of these arrangements in an emergency response, that the protection strategy is implemented in a nuclear or radiological emergency.

2.2.1. Documentation of the protection strategy at the preparedness stage

How the protection strategy is documented at the national level is strongly influenced by the established national EPR framework. Based on experience, three options for documenting the protection strategy can be identified as follows:

- Protection strategy as a standalone document issued at national level;
- Protection strategy as a section in, or part of, the national emergency response plan;
- Elements of a protection strategy included in various documents, such as policy documents, regulations, guidance and emergency plans.

Any of these options has advantages and disadvantages from a practical point of view. The first of the listed options has the advantage of having all relevant information underpinning a justified and optimized protection and safety in an emergency response at one place while promoting consistency and ensuring transparency. A national protection strategy document is subject to approval at a high governmental level, giving the contents of the protection strategy a high degree of enforceability. Such a document necessarily contains primarily high level statements of the protection policies, goals and the means of achieving them. It does not contain operational details but provides a firm basis for ensuring such details are included in a coherent and consistent manner in the various emergency arrangements such as emergency plans at different levels. Such an option allows for a more stable document that is not dependent on frequent revisions. However, the level of details to be covered in such a national document is again driven by the national EPR framework and as a result, they may differ among States. Moreover, some State would need to embark on changing the legislation to allow for developing a protection strategy as a new policy document before they can develop the strategy as a standalone document.

The second of the listed options brings the advantage of preventing possible repetitions and inconsistencies between the protection strategy and the national emergency response plan and, hopefully, with other associated policies, plans and procedures. As with the first option, this option also has the advantage of having all relevant information underpinning a justified and optimized protection and safety in an emergency response at one place while promoting consistency and ensuring transparency. However, the review cycle of the national emergency response plan (driven primarily by the various operational arrangements being elaborated therein) might lead to unnecessarily frequent revision of the protection strategy. Furthermore, while in some States this approach might appear to be more easily implemented, the administrative arrangements in other States might make this arrangement inappropriate, e.g. in some federal States where elements of the protection strategy and the emergency plan might be administered by bodies at different federal or national levels.

The third option, of distributing the components or elements of the protection strategy among various documents, as a current practice in most States, poses a major challenge to even those whose advice or decision is essential in an emergency response in relation to finding and using all the relevant information to be considered in an emergency response. Keeping all these components or elements consistent and up to date would be particularly difficult under these circumstances considering the number of various documents impacted by a change occurring at one, for example, policy document. Bringing all documents up to date and consistent in such case takes a lot of time and practically may not be possible to have all of them consistent and up to date all at the same time. Finally, it is difficult to ensure transparency and effective and meaningful cooperation on the entire basis underpinning the protection and safety in a nuclear or radiological emergency (which extends beyond just radiation protection considerations) as different documents are developed with different groups of concerned parties and used for consulting with different groups of interested parties. Thus, such an option is not further considered in this publication and is not advised.

The practical guidance provided in this publication focuses on a single national protection strategy, irrespective whether the strategy would be issued as a separate document or as part of the national emergency response plan. In case the latter option is pursued, the generic

contents of the protection strategy might be reconsidered to avoid overlaps with the contents of the national emergency response plan.

In the context of the first and the second option of documentation of the protection strategy, development of a single national strategy helps to achieve a higher level of oversight and coordination than the development of multiple protection strategies. Having multiple protection strategies imposes additional operational level details to be elaborated, which are generally already captured either partially or fully in existing emergency plans, procedures and other arrangements and continue to be part of such operational arrangements. Nevertheless, States might decide to develop multiple protection strategies, for example for different types of a nuclear or radiological emergency or for particular sites, if this is determined to be helpful. Still, the practical guidance provided in this publication is equally relevant in cases governments decide for multiple strategies.

2.2.2. Implementation of the protection strategy in response

The national protection strategy (as a document) is not intended to change during the response to an emergency. It is expected to be maintained as a framework for implementing emergency response as the emergency evolves. The national protection strategy has to allow for different options to be implemented in the response to a range of emergencies, and only those options that are best suited for the actual circumstances need to be implemented through execution of the pre-established emergency arrangements.

The protection strategy implemented in the response (referred to as the adapted protection strategy) needs to be continually reassessed as the emergency evolves and modified, as appropriate, to address the prevailing conditions. A flexibility to allow doing so would need to be embedded in the national protection strategy when developed at the preparedness stage so that the emergency arrangements be designed accordingly. Figure 1 illustrates the differences between the national protection strategy, developed at the preparedness stage, and the adapted protection strategy that is implemented in the emergency response.

While the national protection strategy itself is not modified during an emergency response, it may be reviewed considering operational experience and lessons learned following an emergency, as well as from exercises and events occurring within the country or other countries abroad. The results of such reviews are then used to decide on any revision needed to the protection strategy itself or to relevant emergency arrangements through which it is implemented.

Phase	Protection strategy
Preparedness	National protection strategy
	• Describes what needs to be achieved in an emergency response, the basis upon which decisions are made, justified and optimized protective actions, means of assessing effectiveness and means for consultation on the adapted protection strategy • Expected to be a formal document at the national level with high level approval • Not modified in the course of the emergency response • Improved (if needed) based on lessons learned
Response	Adapted protection strategy
	• Adapted based on available information and prevailing conditions at the time of emergency • Includes set of actions, processes and operational arrangements • Not expected to be a formal document

FIG. 1. The differences between the protection strategy at the preparedness stage and during response.

2.3. Place of the protection strategy among other relevant documents

The protection strategy supports and is supported by the necessary legislation, regulations, emergency plans, procedures and other emergency arrangements, which may be updated more frequently. While the relevant legislation, regulations and other legally binding instruments, including international standards and best practice, provide a basis for the development of the protection strategy itself and various elements contained therein, the emergency arrangements will significantly more details on the operational arrangements and the mechanisms for coordination through which the protection strategy is implemented. A schematic diagram of the relationship between the protection strategy, should it be part of the national emergency response plan or a separate document, and relevant standards, legislation, regulations, emergency plans, procedures and other emergency arrangements is provided in Fig. 2.

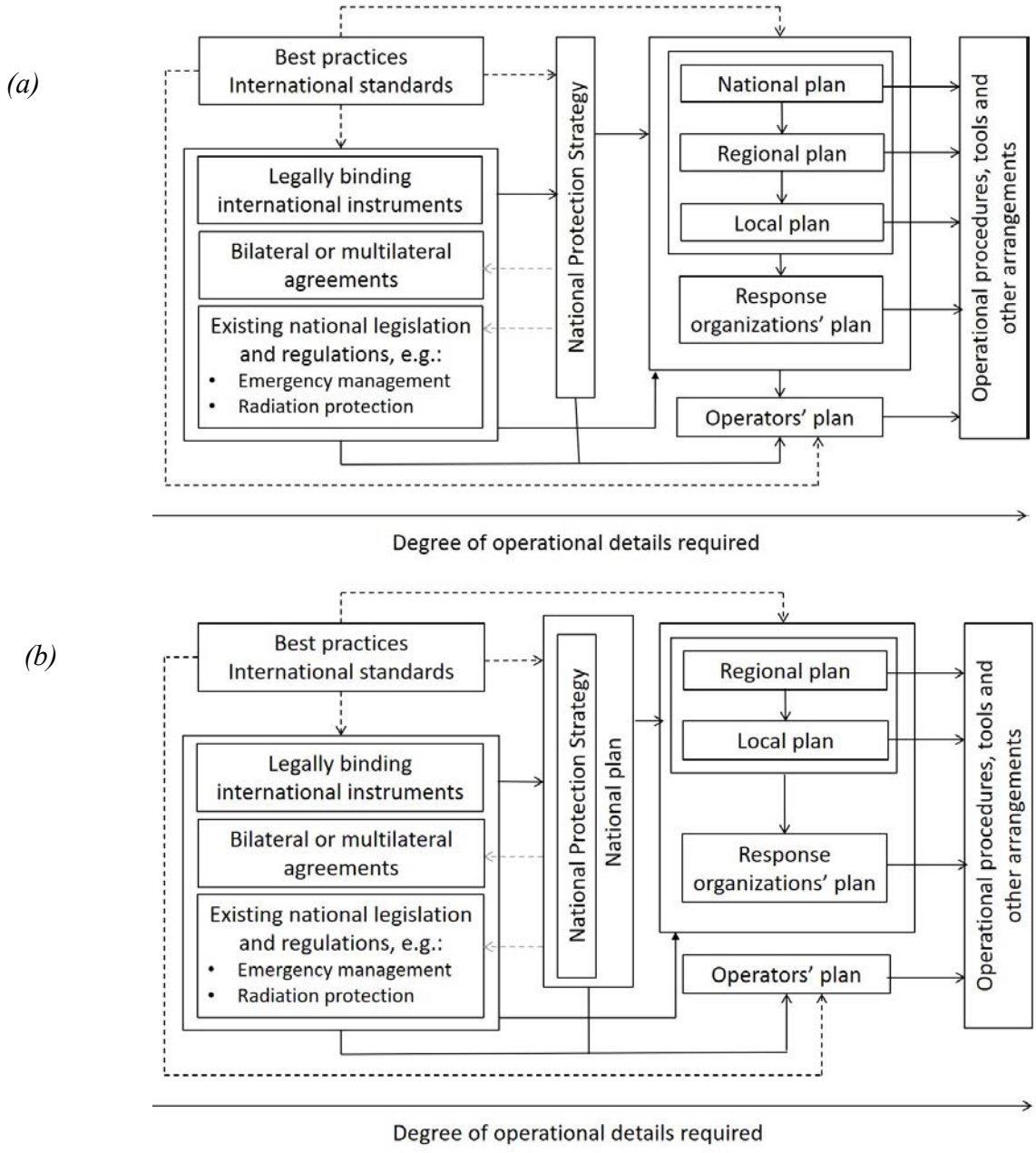


FIG. 2. A schematic diagram showing the place of the protection strategy with other supporting documentation and emergency arrangements should the protection strategy be a separate document (a) or part of the national emergency response plan (b).

2.4. Elements of the protection strategy

In line with Requirement 5 of GSR Part 7 [2] and Requirement 44 of GSR Part 3 0, the protection strategy needs to elaborate on the dosimetric criteria that provide a basis, on radiation protection grounds primarily, for justified and optimized protective actions and other response actions. However, the protection strategy is not limited to this element only. While the expectations for what the exact elements of the protection strategy are may vary from State to State, from organization to organization, and even from expert to expert, an effort was made in this publication to derive a reasonable content of the protection strategy comprising decision making criteria as well as other elements. These elements of the protection strategy are expected to clearly specify the following:

- What does the protection strategy aim to achieve?
    - This aspect includes, for example, discussion of the goals that the protection strategy and the response aim to achieve; it serves the purpose of having common view among all concerned parties of the end objective they all contribute to.
- What does it apply to?
    - This aspect includes, for example, discussion on the scope of the protection strategy and it aims to bring clarity to all concerned parties regarding the range of emergency scenarios it applies to.
- The basis upon which decisions are made;
    - This includes the decision making criteria and tools (to be) applied as well as means to assess the situation against the selected criteria. For example, generic and operational criteria for taking and lifting protective actions, use of any prediction models to facilitate optimal use of available resources without jeopardizing the effective implementation of the protection strategy, and use of radiation monitoring results.
- The justified and optimized protective actions considered and means for their adjustment including lifting;
    - This includes a description of the suite of protective actions and other response actions that are to be taken to achieve the goals set up in the protection strategy and how they are adapted and lifted as the emergency evolves.
- Any relevant considerations to address the prevailing conditions at the time of the emergency that may impact the selection of specific options;
    - This includes discussion on the aspects to be considered at the time of the emergency with the aim to ensure safe implementation of the pre-planned actions in the protection strategy. For example, severe weather conditions may render the planned evacuation unsafe and call for a different set of actions to be invoked.
- Means of assessing the effectiveness of the protection strategy and for its adjustment as the emergency evolves;
    - This includes discussion on the means for dose assessment and assessment of compliance, use of reference level and how this is done.
- Means for consultation on the adapted protection strategy in the course of the emergency response;

- This includes discussion on how the interested parties are consulted, on what aspects of the adaptation, time available to do so and how their voice is factored into the decision making during the emergency response.

The protection strategy needs to address the necessary relation to the strategy to regain control on the site and on how emergency workers and helpers in an emergency are always protected. Moreover, the protection strategy itself may impose specific considerations and even priorities for the development of other strategies, for example related to radiation monitoring and assessment, waste management, public communication as well as considerations for nuclear security system and measures. For example, if the decision has been made for implementing evacuation in the urgent protective action planning zone (UPZ) around a nuclear power plant (NPP) based on radiation monitoring results, then the monitoring strategy needs to address radiation monitoring of the respective area within the UPZ as a priority to allow for effective implementation of the protection strategy as such. This also impacts the necessary information and instruction to be provided to the public living in the area and, thus, sets priority for public communication strategy as well.

Moreover, effective implementation of the protection strategy calls for an adequate record keeping system (for example, records of the location of the affected members of the population, before and after implementation of protective actions, dates of movement from one location to another, time of iodine thyroid blocking (ITB) administration, activities while sheltering, dose records, measures taken in each area, radiation monitoring results, economic data). Transboundary coordination and feedback from consultation with interested parties are also relevant. Although such aspects might not be included in detail in the protection strategy, they impact both the emergency management system and the quality management programmes that need to be such to allow availability of necessary data and information to those in need. These aspects may need to be addressed in the protection strategy so as to provide a basis for development of other strategies and other aspects of the emergency response in a transparent and consistent manner so as to allow for effective implementation of the protection strategy.

The protection strategy may contain an executive summary written in a simple and understandable language that targets non-technical community and the public in general. Its aim would be to bring the protection strategy closely to these groups by explaining plainly what the strategy is and how it provides for radiation protection, safety and the well-being of affected populations in a nuclear or radiological emergency.

Finally, the level of details to be provided in the protection strategy is also driven by the national context. In any case, the protection strategy may not provide all necessary details but need to include sufficient information to support effective decision making and to enable development of appropriate emergency plans, procedures and other emergency arrangements.

A template for the protection strategy, which provides an overview of its expected contents in more details, is provided in Appendix II. In case the protection strategy is developed as part of the national emergency response plan, its proposed contents might need to be closely assessed against the contents of the national emergency response plan to avoid overlaps and duplication. States may use the template as proposed in this publication or may follow another format, provided it contains all relevant information as given in the template in Appendix II. An example protection strategy developed on the basis of IAEA safety standards and technical guidance is provided in Annex I.

3. BASIS FOR THE DEVELOPMENT OF A PROTECTION STRATEGY

This section provides details of the drivers for developing the protection strategy (i.e. the goals of emergency response or objectives to be met in the response), the components of the planning basis and its application in the hazard assessment for the purpose of emergency preparedness and response. Practical guidance on hazard assessment and application of its results in the development of a protection strategy is also provided.

3.1. Goals of emergency response

Nuclear or radiological emergency can have a wide range of consequences and an effective emergency response has to address them as a whole. Although the initial priority is focused on those efforts that aim to protect the public against the harmful health effects due to exposure to radiation, other consequences also need to be addressed in a timely manner. Namely, nuclear or radiological emergency can have adverse non-radiological consequences (economic, social and psychological) that can overcome the radiological consequences and warrant adequate response to ensure that they are minimized. To help designing a robust EPR framework that addresses the various consequences of the emergency as well as of the emergency response, para. 3.2 of GSR Part 7 [2] defines the goals of emergency response as follows:

"(a) To regain control of the situation and to mitigate consequences;

(b) To save lives;

(c) To avoid or to minimize severe deterministic effects;

(d) To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries;

(e) To reduce the risk of stochastic effects;

(f) To keep the public informed and to maintain public trust;

(g) To mitigate, to the extent practicable, non-radiological consequences;

(h) To protect, to the extent practicable, property and the environment;

(i) To prepare, to the extent practicable, for the resumption of normal social and economic activity."

These goals represent an international consensus of what needs to be achieved in the response to a nuclear or radiological emergency for the response to be effective. While the first goal relates to efforts to be done on the source itself to mitigate the consequences (through preventing further escalation or delaying it to allow for effective protection of the public), the rest of the goals relate to efforts to be made to deal with the range of radiological and non-radiological consequences until the situation allows preparations to be made to resume normal social and economic activity. These goals are expected to be the driving force for the development of the protection strategy and the establishment of various emergency arrangements including emergency plans and procedures. Therefore, the set of goals to be achieved in an emergency response needs to be agreed at the national level and stated at the beginning of the protection strategy. Each of the agreed goals will need to be considered in the protection strategy in terms of the timeframe in which it can be achieved, and the actions needed to achieve that goal. This helps all concerned parties to have a common understanding on objectives they aim to achieve when undertaking the agreed response functions they are responsible for.

Examples of how each of these goals may be achieved and of the bodies responsible are provided in Table 1.

3.2. Planning basis

The planning basis brings together the relevant data and information at national, regional and local levels and, where appropriate, at the international level, needed as an input to the assessment of hazards for EPR purposes and to the development of the protection strategy and of associated emergency arrangements.

Much of the data and information referred to in the planning basis is likely to have been gathered in preparing the existing emergency arrangements in a State. Depending on the type and level of data and information gathered earlier, that data and information may be used directly or may need to be updated, as appropriate, for the purposes of developing the protection strategy. Where such information is not available, States will need to compile all the necessary data and information before they can embark on developing the protection strategy and associated emergency arrangements. The level of detail of the information gathered need to be sufficient to provide the basis for an appropriately detailed hazard assessment and for an effective protection strategy. The level of detail for various aspects (such as potentially affected areas and population groups, available infrastructure or meteorological data) need to be sufficient to support the needs of a national, largely generic, assessment for particular types of source or facility. This information may be generalized from more localized, site-specific information or derived by other means. In any case, more extensive and detailed planning basis information is needed for a site-specific hazard assessment and for the development, justification and optimization of a site-specific protection strategy.

The planning basis includes data and information obtained from various organizations at national, regional and local levels as well as from the regulatory body and operating organizations. It may also necessitate cooperation with representatives or organizations in neighbouring States to provide mutual support in gathering relevant data and information where there is a potential for transboundary emergencies. It is therefore important that various organizations with relevant responsibilities (e.g. operating organizations, the regulatory body and relevant off-site response organizations) as well as other institutions that are holder of relevant information and data (e.g. research institutes, statistics agencies) are consulted on the data and information they hold and can provide, conditions under which they can provide the data and information, conditions under which the data and information can be used thereafter and on any associated practicalities involved in compiling the planning basis. The importance of gathering this data and information for the purpose of developing an effective protection strategy needs to be well explained to all and the way it is intended to be used and shared (or made known to others) needs to be well established.

TABLE 1. MEANS FOR ACHIEVING GOALS OF EMERGENCY RESPONSE

Goal of emergency response	**Means of achieving the goal**
To regain control of the situation and to mitigate consequences	Taking measures and actions to prevent, delay and/or reduce the release of radioactive material and exposure of individuals which is primary responsibility of the operating organizations. In the case of dangerous source being found (EPC IV) with no operating organization to be account responsible for, this goal remains under the responsibility of the first responders who need to secure the source and prevent further exposures of individuals from being in contact with the source.
To save lives	Taking actions to save the life of individuals involved in the emergency and provision of prompt medical care to those in need by either operating organization or response organizations.
To avoid or to minimize severe deterministic effects	Taking urgent protective actions and other response actions to keep the dose below the threshold for severe deterministic effects. In many cases, these protective actions are most effective when taken before, or shortly after, a significant release of radioactive material from a facility or before, or shortly after, an exposure. This goal is primarily the responsibility of operators and the off-site response organizations.
To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries	Ensuring that the first to arrive at the site are qualified to immediately provide first aid. Later, very specialized treatment of radiation-induced injuries may be provided by medical specialists. Its effectiveness is dependent on: recognition of the need for specialized treatment, the training of medical personnel in radiological response and basic radiation protection principles, and on timely identification of when international assistance might be needed in providing the necessary specialized treatment and in dose assessment. This goal is the responsibility of operator and off-site organizations (primarily first responders and health services).
To reduce the risk of stochastic effects	Taking protective actions and other response actions effectively to reduce the risk for stochastic effects below the levels at which incidence of radiation induced cancers among population is discernible as a priority and thereafter, keeping the doses as low as reasonably achievable, provided justified and optimized actions are available. This and subsequent goals have shared responsibility among operators and off-site response organizations.

Goal of emergency response	Means of achieving the goal
To keep the public informed and to maintain public trust	Providing the public with timely, useful, truthful, consistent and coordinated information about the emergency and emergency response actions while using simple and easily understandable language. It is important that the communication is maintained in both directions, so that authorities can maintain an understanding of public concerns and provide further information as needed. It is also important to ensure that sensitive nuclear security information is appropriately protected from unauthorized disclosure.
To mitigate, to the extent practicable, non-radiological consequences	Implementing proper public communication strategy, provision of social support and considering these consequences in overall justification and optimization processes for the protection strategy. Addressing conflicting and non-informative materials from official sources and the technical community is important for achieving this goal.
To protect, to the extent practicable, property and the environment	Taking measures to limit the spread of contamination and ensuring that any remedial actions taken to reduce the environmental impact (e.g. decontamination) do more good than harm.
To prepare, to the extent practicable, for the resumption of normal social and economic activity	Taking various actions and activities that provide for appropriate radiation protection to the public as well as for normal living conditions (including promoting resumption of social and economic activity and rebuilding necessary infrastructure). These actions and activities relate to the prerequisites stipulated in Section 3 of GSG-11 [8].

The planning basis encompasses a wide range of data and information that can be grouped as related to:

- The governmental, legal and regulatory framework in a State;
- The characteristics of the facilities, activities and sources that can give rise to an emergency;
- The characteristics of the areas that can be potentially affected by the consequences of an emergency and locations where emergency response actions might be warranted as well as characteristics of the potentially affected populations;
- Resources and infrastructure available to support the implementation of the protection strategy;
- Experience.

Examples of the type of data and information necessary to form the planning basis in each of these five groups are considered in Sections 3.2.1 to 3.2.5.

The level of detail of the data and information gathered is normally enough to provide the basis for the development of the national protection strategy. Depending on the needs, the details of various aspects (such as potentially affected areas and population groups, available infrastructure or meteorological data) may need to be expanded during the hazard assessment, during the development, justification and optimization of the protection strategy or during the development of associated emergency arrangements.

3.2.1. The governmental, legal and regulatory framework

Before the development of the protection strategy can be initiated, the existing governmental, legal and regulatory framework within a State needs to be well understood. This covers at least the areas of emergency preparedness and response, crisis management and civil protection, radiation protection, nuclear and radiation safety, nuclear security and public security in general, public health and safety of members of the public and workers, and environmental protection. Some of these areas may also be governed by international legal instruments (e.g. Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [11], Convention on Nuclear Safety [12], International Health Regulations [13], ILO Radiation Protection Convention [14]), to which the State has become a party. In addition, there may also be bilateral or multilateral arrangements and agreements in place, for example related to emergency preparedness and response where there is an NPP located in a neighbouring State. Such agreements may also impose certain aspects to be adhered to when developing the protection strategy or associated emergency arrangements with the aim of better harmonization at regional level.

The existing governmental, legal and regulatory framework imposes ways in which the protection strategy and associated emergency arrangements are formulated and could already have resulted in specific arrangements put in place. It is therefore essential to better understand, as part of the planning basis, the circumstances within which the protection strategy can be formulated and any associated limitations and practicalities related to current practice in the State. Without sharing common understanding on this, the development of the protection strategy is a difficult and very challenging process. Compiling of this information also allows to identify responsibilities for developing the protection strategy and for consultation with interested parties and to recognize those concerned parties that are to be

involved in the overall process. It also helps utilizing the all-hazard approach for the sake of optimal use of available resources and structures.

Furthermore, international safety standards and technical guidance need to be used when compiling the planning basis to provide foundation for developing a harmonized protection strategy in line with most current international requirements and recommendations. While the governmental, legal and regulatory framework might have been in place for many years, this exercise is an opportunity to reconsider its update to better align it with the latest international requirements and recommendations (such as those contained in GSR Part 7 [2] and ICRP 103 [10]). Should this revision be estimated to be a lengthy process, interim solutions have to be drawn (e.g. a decision issued by the government) and agreed to allow development of the protection strategy without delays while new laws or regulations are adopted.

3.2.2. Characteristics of facilities, activities and sources

With the aim to enable characterization of facilities, activities and sources for which it is possible that situations may arise warranting an emergency response on the State's territory (and thus, protection strategy to be prepared for) and assessment of associated hazards, it is necessary to prepare an inventory of the type, location and other characteristics of the various facilities, activities and sources in the State and, where appropriate, beyond borders. This is expected to include compiling and analysing the information regarding relevant transport activities and common routes when transporting nuclear or radioactive material, as well as information regarding non-radiation related hazards (e.g. physical, chemical, biological) associated with the facility, activity and sources that may have an impact on the way the protection strategy can be formulated and associated emergency arrangements developed. It is assumed that these facilities, activities and sources are already under stringent regulatory control in the State. An inventory of them and associated data and information is expected to be in place at the national level and usually it is maintained by the regulatory body of a State.[1] It is also likely that, for them, some form of risk or safety analysis have already been performed for various purposes (as required in IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), Safety Assessment for Facilities and Activities [15]) as well as hazard assessment for the purpose of establishing adequate on-site emergency arrangements (as required in GSR Part 7 [2]) primarily. Such a documentation provides a useful starting point for the characterization of facilities and activities and for the hazard assessment which provides the basis for developing the national protection strategy. It is assumed that such documentation owned by the operating organization is already available for the regulatory body as well[2] and is included in the planning basis.

In addition, results of a threat assessment performed[3] for nuclear security purposes, as recommended in Ref [16], will contain useful insights on the credibility of certain criminal or intentional unauthorized acts involving or directed at these facilities, activities and sources which have relevance for emergency preparedness and response in general, as well as for the hazard assessment in particular. For this reason, the result of the threat assessment is normally part of the planning basis. However, such threat assessment results may have more stringent rules on what information can be shared, in what form and to whom can be made known. This

[1] If this is not the case, this may call for arranging such information be collected directly from users and for establishing a database.

[2] Usually, it is required that such documentation forms part of the licensing documentation.

[3] Threat assessment is a process of evaluating the nuclear security threats, based on available intelligence, law enforcement and open source information that describes the motivations, intentions and capabilities of these threats, where threat refers to a person or group of persons with motivation, intention and capability to commit a malicious act.

highlights the necessity for close cooperation with nuclear security specialists who are responsible for the provision of the necessary nuclear security information and, where relevant, the competent authorities for nuclear security, so that relevant information in appropriate form is included in the planning basis and considered in the hazard assessment, development of the protection strategy and associated emergency arrangements.

Technical resources that aid the development of the protection strategy and provide inputs to the hazard assessment also include statistics (or other relevant information) from manufacturers and vendors on equipment and sources used at specific facilities or in specific activities, as appropriate.

3.2.3. Characteristics of the potentially affected areas, locations and populations

Characterization of the potentially affected areas, locations and populations is a necessary part of the planning basis. The exact radiological and non-radiological impacts of the emergency will differ depending on the characteristics of the surrounding area, for example whether it is agricultural or industrial land, and on the form of agriculture and industry present. Furthermore, the type and density of housing and the habits and behaviour of the population influence exposure scenarios and pathways and the level of dose to be received, the protective actions that might be appropriate and their effectiveness. For example, factors such as the typical housing, and the shielding factors associated with it, determine the doses received indoors and the effectiveness of sheltering as a protective action. The characterization of the population and areas helps to align the protection strategy and associated plans to the location and emergency scenarios, particularly in site-specific planning. This information may also be included in the generic national information, which provides a basis for a national protection strategy.

The locations and characteristics of special facilities such as hospitals, chemical plants, prisons, water supply systems in the potentially affected areas also need to be identified. Such facilities cannot be simply closed or abandoned if the surrounding area is evacuated and suitable alternative actions have to be considered in the protection strategy. Facilities such as chemical plants and water supply systems either need to be shut down in a safe condition, which may take some time to achieve, or continue to operate under modified conditions, depending on the situation. All such factors need to be considered in the protection strategy as well as in the associated arrangements. Relevant information therefore needs to be collated as part of the planning basis.

Other forms of data from previous assessments may also be useful inputs particularly to the hazard assessment, such as historical meteorological data from the facility and its vicinity, which support the selection of appropriate meteorological data for assessing potential consequences and, thus, for developing an adequate protection strategy.

The level of detail on which this information and data is collected varies depending on its use; it needs to be commensurate with the purpose of developing the national protection strategy. This is less detailed than would be necessary for establishing comprehensive operational arrangements. However, as indicated above, this more detailed information may be used to develop the generic information needed for a national protection strategy, for example for particular types of facility.

3.2.4. Infrastructure and resources

In preparing the protection strategy and associated emergency plans, it is clearly important to identify the infrastructure and the human, technical, and financial resources available to support the implementation of the protection strategy. The relevant information is wide-

ranging and needs to be collated from a variety of sources. It is therefore necessary to involve many organizations and interested parties in the specification, collection and application of this category of planning basis information.

The state of the existing transport infrastructure (e.g. road and rail networks) is a key consideration given that it is influences the speed with which response organizations can reach the site of the emergency to help mitigating its consequences on-site or to support protective actions for members of the public. Such considerations also affect the amount of time necessary to undertake protective actions such as evacuation. Information on the transport system is therefore an essential part of the planning basis.

Other features of infrastructure that need to be considered in planning and response are those necessary to support protective actions for special facilities such as hospitals, chemical plants, prisons, water supply systems in the potentially affected areas. For example, if it becomes necessary to evacuate patients and staff from a hospital, it is necessary to ensure that patients are moved to an appropriate facility and that they receive continuing care during and after transfer. Appropriate supervision of and accommodation for prisoners are also prerequisites of any evacuation of prison populations.

The development of the protection strategy and associated emergency plans requires a detailed understanding of the human resources necessary and available in an emergency, including the number of responders, their qualifications and training (and associated training needs). The technical resources may involve many types of equipment with a range of general and specific purposes, from fire engines to radiation monitoring equipment. The financial resources available under different circumstances and the mechanisms for making them available also need to be identified.

Paragraph 4.8 of GSR Part 7 [2] states: *"The government shall ensure that response organizations, operating organizations and the regulatory body have the necessary human, financial and other resources, in view of their expected roles and responsibilities and the assessed hazards, to prepare for and to deal with both radiological and non-radiological consequences of a nuclear or radiological emergency, whether the emergency occurs within or beyond national borders."*

The adequacy of the resources available to response organizations, operating organizations, the regulatory body and others to fulfill their allocated responsibilities needs to be determined at the preparedness stage, in order to plan for appropriate and efficient deployment during an emergency. This in turn has an impact on how the protection strategy may look like. Collection of relevant information is therefore an important element of the planning basis.

3.2.5. Experience

Records from operating experience and from past emergencies (both nuclear and radiological emergencies, and conventional emergencies) may provide very useful input to the development of a feasible protection strategy. Therefore, such information needs to be compiled as part of the planning basis. This includes results from the analysis of mishaps, near misses and similar events as well as past emergencies, associated lessons learned and any corrective actions taken. In case that information involves aspects of sensitive information, these aspects should be managed adequately to prevent inappropriate disclosure. This also helps providing a better view on how the protection strategy may be developed under the umbrella of the all-hazards approach.

3.3. Hazard assessment

Requirement 4 of GSR Part 7 [2] states: *"The government shall ensure that a hazard assessment is performed to provide a basis for a graded approach in preparedness and response for a nuclear radiological emergency."*

In this context, the term 'hazard assessment' means an *"assessment of hazards associated with facilities, activities or sources within or beyond the borders of a State in order to identify:*

(a) Those events and the associated areas for which protective actions and other response actions may be required within the State;

(b) Actions that would be effective in mitigating the consequences of such events." [3]

Hazard assessment provides the basis for making adequate arrangements for the emergency preparedness and response that are *"commensurate with the hazards identified and the potential consequences of an emergency"* (para 4.18 of GSR Part 7 [2]). The results of the assessment, together with other elements of the planning basis, enable the development of the protection strategy, its justification and optimization.

States may pursue different approaches and methodologies to perform the hazard assessment for emergency preparedness and response, including various models and tools for consequence and dose assessments. These approaches and models may necessitate different information and data which may influence the results and their interpretation and may impose different range of uncertainties. For example, methods or models may be designed to be simple and conservative or more detailed and realistic. The approach chosen has implications for the amount of information that needs to be collected and on the way in which the results are interpreted. It is therefore important that the approach adopted is agreed among all of the parties involved before the hazard assessment is performed, and that all involved understand the implications of the choice and associated uncertainties for the development of the strategy and its associated emergency arrangements. How these uncertainties would then be considered in the protection strategy and associated emergency arrangements, and the flexibility they allow in an actual emergency response, need also to be discussed and agreed among all parties involved.

Irrespective of the approach and methodology used, the hazard assessment involves the application of the data and information gathered as part of the planning basis, particularly related to the identification of emergency situations that might arise for the identified facilities, activities and sources in order to assess the potential consequences that could arise, and to identify the range of protective and other actions that might be warranted. In addition, the safety or risk assessment performed for any another purpose (e.g. as required in GSR Part 4 (Rev. 1) [15]), may provide a useful starting point for performing the hazard assessment.

3.3.1. Hazard assessment process

The hazard assessment process needs to comprise of the following six main stages:

1. Characterization of postulated emergency situations;
2. Evaluation of the inventory or releases (including the radionuclide mix and the nature of any chemical or other hazards);
3. Assessment of the distribution of radioactive and any other materials released (including dispersion and deposition processes), when appropriate;
4. Assessment of the radiological consequences associated with the release or exposures;

5. Assessment of the non-radiological consequences;
6. Assessment of the effectiveness of possible protective actions.

Each stage of the hazard assessment process is described in Sections 3.3.1.1 to 3.3.1.6.

Performing the hazard assessment involves a range of expertise in its different stages beyond just the EPR community, for example radiation protection experts, nuclear and radiation safety specialists, researchers in various areas of safety and radiation protection and in the performance of specific facilities or activities, and nuclear security specialists. They all may provide essential inputs that would support and contribute to the hazard assessment although they not necessarily have the expertise and knowledge in emergency preparedness and response in general and in the development of the protection strategy. What the necessary expertise is, who can provide it and what the associated inputs are, needs to be identified when compiling the planning basis and before the hazard assessment is started, taking account of the six stages and the work expected to be accomplished in each stage.

3.3.1.1. Characterization of postulated emergency situations

The first stage in the hazard assessment is to identify and characterize an appropriate range of postulated emergencies for each type of facility, activity and source that may warrant prompt action to mitigate the consequences in the State. This includes determination of credible events (including those that may result in the failure of some or all safety systems as a result of a safety-related unintentional event or a malicious act), their dynamics and evolution. The type of events to be considered in the hazard assessment are listed in para 4.20 of GSR Part 7 [2] and include the following:

- Events of very low probability but with high consequences and events not considered in the design (i.e. events that are beyond the design basis and conditions that are beyond design extension conditions) which may also be criminal or intentional in nature;
- Events involving a combination of a nuclear or radiological emergency with a conventional emergency (which may be the cause of the nuclear or radiological emergency but not necessarily) such as a nuclear or radiological emergency following an earthquake, a volcanic eruption, a tropical cyclone, severe weather, a tsunami, an aircraft crash or civil disturbances that may affect wide areas and/or impair capabilities to provide support in the emergency response;
- Events that could affect several facilities and activities concurrently and the interactions among the facilities and activities affected (e.g. in terms of resources to be deployed for an effective emergency response); and
- Events at facilities in other States or events involving activities in other States (i.e. past events in facilities or affecting activities such as those present in the State which resulted in an emergency warranting a prompt action).

Example events that would need to be considered for NPPs, research reactors and nuclear fuel cycle facilities include the loss of reactor core cooling resulting in fuel damage, damage to spent fuel pools, and criticality events. The range of postulated and observed fuel damage scenarios considered for an NPP need to include different forms of core damage leading to releases to the containment and beyond. Such postulated events may range from the failure of fuel pins and the release of gaseous fission products to the containment (gap release phase) to a situation in which molten core debris (including reactor fuel) melts through the reactor vessel and onto concrete structures below (ex-vessel melt release), which results in the release of less volatile nuclides due to interaction with concrete and vaporization of radionuclides

deposited on surfaces within the reactor system during an earlier phase (in-vessel melt release phase) [17].

Large fires and explosions are examples of the type of events that need to be considered for a range of facilities and activities including radiopharmaceutical and source manufacturing. Events that could affect storage facilities, or that could lead to sources becoming uncontrolled (due to being lost, stolen or abandoned) and unshielded are also typical of the type of events that would need to be considered in the hazard assessment. The hazard assessment would need to take account of events such as loss of a radioactive source and subsequent removal of the source from its shielding, resulting in exposures among members of the public who may not have been aware of the associated hazard. The malfunctioning of the shielding mechanism around a radiotherapy source or failures in the treatment planning and delivering software resulting in the overexposure of patients are another relevant example of events that could lead to an emergency warranting prompt action for consideration in the hazard assessment.

A range of nuclear security events which may lead to failure of nuclear security measures and of all safety systems at a facility, or events involving the malicious use of radioactive sources causing wide dispersal of radioactive material in the public domain and/or exposures to members of the public need to be considered in the hazard assessment. Events which are unintentional, intentional or criminal, and which take place at strategic locations, such as ports or crossing border points, also need to be considered. Results of the national threat assessment performed for nuclear security purposes (completed in line with Refs [16, 18, 19]) will inform decision for the types of event and strategic location[4] to be considered in the hazard assessment.

Finally, experience arising from operational events, incidents and emergencies, including near misses, also need to be taken into account when identifying all relevant events that may lead to an emergency warranting a prompt action.

3.3.1.2. Evaluation of inventory of release and the mix of radionuclides

This stage in the hazard assessment process involves an assessment of the inventory of the release or source, including its chemical composition and total activity, and the projected release (e.g. proportion of the inventory and the radionuclide composition) that could arise under defined emergency conditions. This is specialized information that depends upon the nature of the event and of the facility, activity or source. It is associated with the impact the postulated (at the initial stage) emergency scenarios are expected to have. It may necessitate research into fundamental chemical and physical processes and, thus, it involves interaction with experts outside the EPR community. It involves the consideration of radionuclides present or released from the source which, as appropriate, includes decay products (i.e. fission products and activation products), and of chemical and other hazards. In making this evaluation, the magnitude and mix of radionuclides released during past emergencies need to be considered. This certainly contributes to the evaluation of a potential release under postulated emergency conditions.

When evaluating the inventory of release and the radionuclide mix, consideration has to be given to account not only those mixes or radionuclides which may have meaningful contribution to the dose of the public, but also those with signification contribution to the instrument response.

[4] A location of high security interest in the State which is a potential target for terrorist attacks using nuclear material or other radioactive material.

Many factors influence the amount and mix of radionuclides released in an emergency at an NPP, notably the extent and type of damage to the reactor fuel [17]. The release of radionuclides to the environment is affected by the conditions within the plant (e.g. sprays and plate-out). It also depends on the extent to which the fuel is cooled. For example, the release of radionuclides from spent fuel may be postulated in circumstances where the fuel is not being cooled and, thus, heats up by its own decay heat, resulting in a self-sustained zirconium oxidation reaction once the zirconium ignition temperature is reached [17]. This is further discussed at the next stage of the hazard assessment.

Evaluation of the release in case of an emergency involving a radioactive source also depends on the type of events considered in the hazard assessment. A publication within the EPR Series, EPR-D-Values 2006 [20], considers various types of event and exposure scenario for the sake of determining the hazards associated with radioactive sources, taking account of the amount of the material present, its physical and chemical form, and the quantities of radioactive material that may be dangerous[5]. The assumptions made in Ref. [20] (e.g. on release fraction in case of dispersal of radioactive materials) can provide a good basis for evaluation of the releases or exposures in case of an emergency involving a radioactive source at the facility or activity level as well as at the national level.

In case of emergency situations in which there is a possibility for concurrent events to happen, it is important to consider the impact the concurring events may have on the level of release and the radionuclide mix.

3.3.1.3. Assessment of the distribution of radioactive and any other materials released

Once the radioactive material expected to be released under postulated emergency conditions has been determined, it is necessary to consider the impact on the release during the "transport" from the source (that is the emergency site) to the individual. In the analysis, the "transport" may be divided into the following steps:

- Transport from the source to the environment (e.g. atmosphere, water, objects) eventually through a facility/source specific structure (e.g. containment of an NPP or housing of an irradiator); and
- Transport from the environment to an individual (e.g. atmospheric dispersion and deposition, movement of water to the public).

In the first step of this analysis, direct and indirect transport from the source to the environment need to be considered. Direct transport would encompass cases in which the radionuclide mixes determined at the previous stage would not change significantly (e.g. direct containment bypass in an NPP or breach of a sealed radioactive source) while indirect transport would encompass cases in which the radionuclide mix is affected by a facility/source specific structure before being released to the environment.

Determining the impact on the radionuclide mix resulting from an indirect release is heavily dependent on the type of source, the type of facility/source specific structure, and the conditions during the event. The following factors need to be considered:

- The behaviour of the source within the facility/source specific structure during the emergency progression (e.g. in- or ex-vessel melt, core/concrete interactions);
- The retention of any released mixes in the containment/source specific structure (e.g. plate out, revaporisation);

[5] A dangerous quantity is that which, if uncontrolled, could result in the death of an exposed individual or a permanent injury that decreases that person's quality of life 0.

- Mitigatory actions implemented within the facility/source specific structure (e.g. water sprays, passive autocatalytic recombiners, chemical reactors);
- Release pathways within the facility/source specific structure (e.g. release through filters or water pools);
- Other facility/source specific effects (e.g. self-sustained zirconium oxidation reaction in a spent fuel pool, criticality accidents in a uranium reprocessing facility or fires in any facility).

For determining the exact impact on the radionuclide mix, detailed and extensive physical, chemical and engineering research and analysis are necessary, lying far outside the scope of this publication and the expertise of the EPR community. Refs [21–27] provide detailed examples of such an analysis.

This process involves considering the dispersion and deposition of radionuclides during the process of release and once released into the environment. This process therefore involves consideration of dispersion and deposition arising:

- At the facility (e.g. plate-out);
- On the release pathway from the facility (e.g. spent fuel pools);
- In the atmosphere, terrestrial environment or water body into which material is released;
- Environmental migration of materials from the ground or surfaces on which they are deposited.

At a nuclear facility, for example, the processes of plate-out may influence the profile of radionuclides that remain within the facility and that are released to the environment. Furthermore, the pathway through which the radionuclides are released affects the nature and chemical composition of the release. Many of these factors are dependent not only on the postulated emergency (e.g. a release from a spent fuel pool), but also on the site. Therefore, generic assumptions need to be made in developing the hazard assessment.

The nature of the environment into which radionuclides are released also influences the further distribution of activity. Materials released to the atmosphere are dispersed in air in a manner that depends on many factors including the speed of the wind and the topography of the local area. The deposition of this activity on surfaces, including the ground, soils, agricultural produce, surface water bodies and buildings, depends on the characteristics of the radionuclides, the nature of the surfaces present and the pattern of any rainfall. Materials released to water bodies (e.g. lake, river or marine systems) are dispersed in the water body, and the extent and speed of dispersion depend upon the nature of the water body (e.g. water turbulence) and the speed of the stream. The distribution of activity between the water and suspended and deposited particles depends upon the nature of the water body and the radionuclides involved.

Radionuclides deposited on surfaces are further distributed among the various environmental media by a range of processes, including migration through the soil and washout by the action of rainfall, leading to further deposition on underlying surfaces and transfer to water bodies. These processes affect both the dose rates at and above the surface and the activity incorporated in environmental components such as foods. The uptake of radionuclides depends on the nature of the soil, the radionuclides and, for foods, the position in the food chain. For example, activity in milk is the result of transfer from soil, vegetation and through the animal behavior.

A radiological emergency may or may not include the dispersion of radionuclides in the environment. Some sources (i.e. dangerous sources) represent a dangerous hazard in an undispersed form as well, as indicated above. The relevant assumptions and approaches to make an analysis in such situations, depending on the type of event and exposure scenarios, can be found in Ref. [20]. The corresponding stage in the assessment process in such situations is the establishment of whether the quantity exceeds the relevant D-value and the establishment of the state and location of the source. However, in any case, where the source has been removed from its housing and is dispersed, it is necessary to consider the mechanisms by which the radioactive material may be distributed by natural or human activities. The radiological emergency in Goiania, Brazil [28] is an example of such a situation. Due to the large number of assumptions and uncertainties taken into account in this type of analysis, the results cannot be considered as an exact value, but rather as a very rough estimate, calling for a reasonably conservative approach to ensure an effective protection of the public.

In performing the analysis, experience from past emergencies need to be considered, such as the estimated releases and depositions from the Chernobyl or the Fukushima Daiichi accidents [29–32] as well as from past radiological emergencies [28, 33–36].

3.3.1.4. Assessment of the radiological consequences associated with the release or exposures

This stage of the hazard assessment involves undertaking an assessment of the radiological consequences of the range of postulated emergencies associated with the identified facilities, activities and sources being considered. This may take various forms, depending upon the amount of information available and the purpose of the assessment, and encompasses the following steps:

- Determining the relevant exposure scenarios and associated exposure pathways;
- Identifying the characteristics of the representative person;
- Performing relevant dose calculations.

Exposure scenario relates to *"a postulated set of conditions, circumstances, events and behaviour of the public that characterizes the exposure situation."* [17]. It will help determining who might be exposed in the emergency considered and how. Thus, identifying relevant exposure scenarios will provide a basis for determining the characteristics of the representative person and the relevant exposure pathways (i.e. the routes by which radiation or radionuclides can reach an individual resulting in radiation exposure). Although developed for a specific purpose, examples of relevant exposure scenarios (i.e. ground, food pre-analysis, skin and food post-analysis scenarios) and associated exposure pathways associated with a severe reactor emergency are described in Ref. [17]. Examples of exposure scenarios for emergencies involving radioactive sources, taking into account sealed sources as well as their dispersal in the environment (e.g. pocket, room, inhalation, ingestion, contamination and immersion scenarios) due to various causes, including unintentional and malicious acts, are provided in Ref. [20]. A rigorous assessment will involve characterization of the temporal and spatial distribution of any material released and the exposure scenarios and pathways associated with each postulated emergency. The projected doses to people on-site and off-site (as appropriate) may then be assessed (in the absence of protective actions) using information from the planning basis on the characterization of both the area and population.

An assessment of the exposure of the public involves identification of the pathways by which people may be exposed. The main relevant exposure pathways need to be determined on the basis of the exposure scenario and, as appropriate, consider:

- External exposure from:
  - The source;
  - Activity in the plume (often referred to as cloud shine);
  - Deposition on surfaces (e.g. the ground, often referred to as ground shine); and
  - Resuspension of deposited radioactive material (often referred to as air shine).
- Internal exposure due to:
  - Inhalation of material from the radioactive plume;
  - Inhalation of deposited material that has been resuspended in the air (e.g. from the ground or clothing);
  - Ingestion of food, milk and drinking water and foods contaminated with radionuclides; and
  - Inadvertent ingestion of dust or deposited materials (e.g. from dirt on the hands).

The relative importance of these pathways depends upon many factors, including the radionuclides released, the characteristics of the area, the age and habits of the population (considered within the exposure scenario).

Any dose calculations as part of the hazard assessment need to be performed for a representative person. The concept of representative person is established by the International Commission on Radiation Protection (ICRP) for the purpose of radiological protection of the public in any situation of exposure [10, 37] and it represents *"an individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population"* 0. For the purposes of the hazard assessment (and for emergency preparedness and response area in general), the representative person is a hypothetical construct that ensures that it is characteristic of the most highly exposed individual under the assumed circumstances. It aggregates the dose models for the internal and external exposure of ICRP reference persons of different age groups together with relevant exposure scenario providing the highest dose estimate for any exposure pathway of postulated emergency [17]. In doing so, those members of the public that are most vulnerable regarding radiation exposure, i.e. children and pregnant women, need to be considered.

How the construct of the representative person is done for the purpose of calculating OILs taking account of the specific exposure scenario can be found in Ref. [17]. However, in determining the representative person at the facility or national level, consideration needs to be given to the realistic habits of the representative person associated for example with food consumption and consumption rate, breathing rate and other local and site-specific characteristics. While some extreme habits may also need to be considered, they are not expected to define the characteristics of the representative person. To account for these realistic habits to be associated with the representative person, information and data collected as part the planning basis need to be used. This dictates the needed level of details to be gathered as part of the planning basis as discussed earlier in this section.

Determining the relevant exposure scenarios and associated exposure pathways and constructing the representative person allows for necessary dose calculations to be performed using appropriate age dependent physiological parameters and appropriate dose coefficients. In addition, care needs to be given that appropriate dose quantities are used within the hazard assessment to evaluate radiation induced health effects or the detriment associated with occurrence of stochastic effects in an exposed population. Namely, relative biological effectiveness (RBE) weighted absorbed dose in an organ or tissue, equivalent dose to an organ

or tissue and the effective dose need to be calculated, as appropriate, when projecting doses that might be received under the considered emergency conditions if no protective actions are taken (i.e. projected doses). These calculations are used to identify where protective actions may need to be taken (individually or in combination) in order to prevent severe deterministic effects to occur and to reduce the risk of stochastic effects. Following identifying the range of possible effective public protective actions (to be further discussed below), the doses that are expected to be received if these actions are taken (i.e. residual doses) need to be also calculated. The residual doses in this case help identifying the optimal combination of protective actions to be pursued in the protection strategy with account taken on the pre-set reference level (discussed in Appendix I).

The prompt implementation of protective actions depends on the existence of operational criteria, primarily OILs of interest in this context, that allow for decisions on necessary protective actions be made without need for further assessment. Thus, further calculations will need to be made to develop default OILs along with the dose calculations discussed in this section although this could be done at later stage as well. The methodology for the derivation of such levels is elaborated in Refs. [17, 38]. In order to ensure that all age groups of the population are sufficiently protected, three age groups are usually considered in such assessments comprising infants (aged 1 year), child (aged 10 years) and adults (over 17 years of age). Projected doses can be calculated for each exposure pathway at appropriate locations, taking account of the distribution of radionuclides in the environment and the habits and physiological characteristics of each age group. In this way, the group receiving the highest effective or equivalent dose from a given exposure scenario can be identified to provide the basis for considering the projected doses and the consequent need for protective actions. The various estimations may provide information on a range of consequences that are specific for a facility, activity or sources, as well as and areas and locations affected. This in turn, may necessitate several strategies and plans to be developed for each specific situation and different emergency preparedness approach to be adopted for them for particular sites, facilities or locations. Further details are provided in Ref. [17].

3.3.1.5. Identifying possible non-radiological consequences

The efficiency of the efforts taken to protect the public in a nuclear or radiological emergency does not only depend on how the radiological consequences are addressed but also on how it is dealt with the adverse non-radiological (i.e. psychological, societal and economic) consequences of the emergency and the response thereof. Experience has shown that, in many cases, these non-radiological consequences could overcome the radiological ones and cause more harm. Thus, in the hazard assessment care needs to be given to identify the range of non-radiological consequences that might be expected under the considered emergency conditions, so as to provide a basis for identifying suitable response actions to accompany the protective actions in ensuring such consequences be minimized.

In contrast to radiological consequences, assessing possible non-radiological consequences cannot be exact science. However, lessons learned from past nuclear and radiological emergencies and other conventional emergencies can help identifying non-radiological consequences that range from the economic impact on businesses, industry, tourism to adverse psychosocial consequences associated with fear, lack of trust in authorities and lack of information resulting in unwarranted actions being taken by the public (such as unwarranted voluntary abortions, taking inappropriate drugs, shunning of individuals and products from an effected area) in the belief that they provide for theirs and their families protection and safety [28–36].

At this stage, it is equally important to consider possible impacts of the emergency on any critical functions for the emergency response (for example available infrastructure or equipment), and the consequences associated with losing them. This allows later for the protection strategy and associated emergency arrangements to be aligned to deal with a greater range of situations and thus be more resilient to a wide range of circumstances.

Relevant information and data gathered from the planning basis (e.g. characteristics of the affected areas and populations, businesses and industries that might be affected, goods in routine import/export and other trade) can help identifying possible non-radiological consequences. This again highlights the need for careful consideration be given on the type and the level of information and data to be collected as part of the planning basis.

3.3.1.6. Assessment of the effectiveness of possible protective actions

Assessment of the radiological and non-radiological consequences will help identifying what protective actions and other response actions may be warranted in order to prevent severe deterministic effects, to reduce the risk of stochastic effects, to mitigate non-radiological consequences and to prepare for the resumption of normal social and economic activity as well as where and for whom they may apply. In turn, identifying these actions will also help determining conditions in which such actions may need to be implemented, indicating the necessary protection to be provided to the emergency workers. In this context, para. 4.23 of GSR Part 7 [2] states: *"In the hazard assessment, facilities and activities, on-site areas, off-site areas and locations shall be identified for which a nuclear or radiological emergency could — with account taken of the uncertainties in and limitations of the information available — warrant any of the following:*

(a) Precautionary urgent protective actions to avoid or to minimize severe deterministic effects by keeping doses below levels approaching the generic criteria at which urgent protective actions and other response actions are required to be undertaken under any circumstances, with account taken of Appendix II [of GSR Part 7];

(b) Urgent protective actions and other response actions to avoid or to minimize severe deterministic effects and to reduce the risk of stochastic effects, with account taken of Appendix II;

(c) Early protective actions and other response actions, with account taken of Appendix II;

(d) Other emergency response actions such as longer term medical actions, with account taken of Appendix II, and emergency response actions aimed at enabling the termination of the emergency (see Requirement 18); or

(e) Protection of emergency workers in accordance with Requirement 11 and with account taken of Appendix I [of GSR Part 7]."

Thus, at the last stage of the hazard assessment process, actions that are effective in mitigating the consequences need to be identified. Options for actions to be implemented individually or in combination are at varying degree of efficiency and the final selection of what options are considered in the protection strategy needs to go through thorough justification and optimization process as discussed in Section 5. This ensures that the actions envisaged do more good than harm, are feasible and are optimized resulting in residual doses below the reference level (discussed in Appendix I).

Examples of assessment of the effectiveness of various protective actions as a function of the distance from the release point in case of severe reactor emergency can be found in Ref. [39].

An example of showing the effectiveness of various protective actions in keeping doses below 2 Gy weighted absorbed dose to the red bone marrow is presented in Fig. 3.

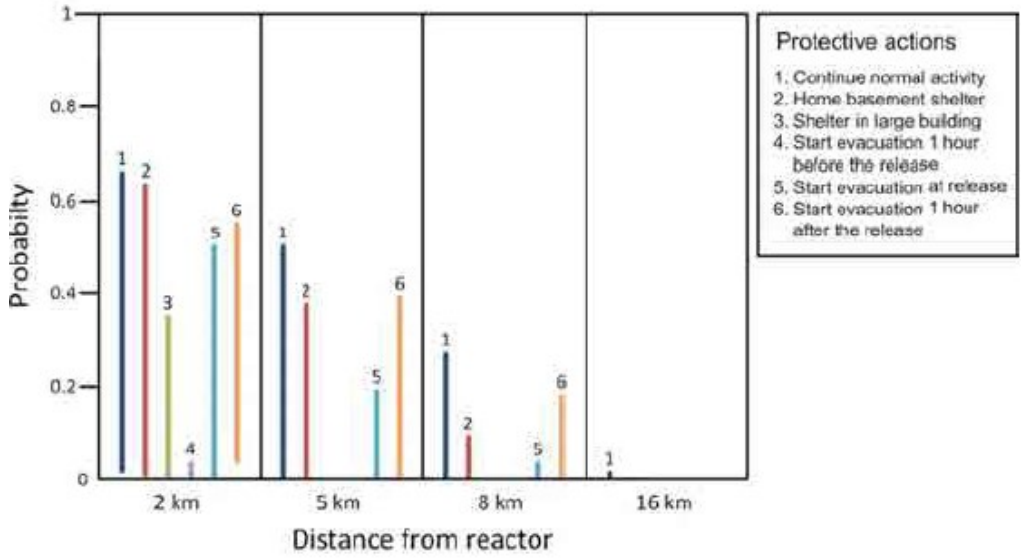


FIG. 3. Probability of exceeding 2.0 Gy weighted absorbed dose to the red marrow for various protective actions assuming core melt and an early containment failure for a nuclear power plant of about 3000 MW(th) [39].

Going through thorough justification and optimization when analysing the findings from such an analysis will indicate the best options for protective actions to be included in the protection strategy. These options are not necessarily those with lowest doses but those that provide the best protection under the prevailing circumstances.

The consequences of the timing of the emergency progression and its implications on the time available for decision making on specific protective actions and other response actions and their implementation have to be assessed at this stage. This, in turn, also indicate the necessary emergency arrangements to be put in place at the preparedness stage to allow for effective protection of the public once an emergency occurs (e.g. pre-distribution of stable iodine for efficient iodine thyroid blocking within specific areas).

The timeframes over which actions allow for effective protection of the public and for resumption of normal social and economic activity are among the key factors in decision making on the best choice of protection and safety. In addition, the following elements also need to be considered when assessing the effectiveness of available protective actions:

- The need for protective actions and their efficiency will vary spatially and temporally;
- Dependency between actions (e.g. sheltering in case of a severe reactor emergency involving the release of radioactive iodine will invoke the need for iodine thyroid blocking simultaneously) and the need to accompany specific protective actions with other response actions that provide for public reassurance (e.g. provision of medical care and psychosocial counselling to evacuees when evacuation is considered);
- Other non-radiological hazards associated with the emergency or with the protective actions, for example, presence of chemicals and other toxic hazards, possibilities for fires or explosions, as they will have an impact on the exact protective actions to be taken into account.

Appendix III provides an overview of the key protective actions and other response actions highlighting their strengths, weaknesses and limitations as well as other aspects associated with their implementation which impact the need for further considerations when developing the protection strategy.

Regarding situations where there are concurrent events, it is important to consider not only the impacts on the potential of concurrent events on the level of release, but also on the effectiveness of protective actions, under such circumstances. In undertaking and using the results of such assessments, it is necessary to consider the nature and extent of uncertainties associated with them. The impact of these uncertainties needs to be considered when analysing the options and deciding on the best options to be considered in the protection strategy.

3.3.2. Identifying areas where emergency response actions may be warranted

The radiological consequences and doses to members of the public need to be assessed in the hazard assessment as a function of distance to identify the appropriate extent of protective actions. This helps to determine, through the hazard assessment, areas where emergency response actions may be warranted as well as protective actions that may be effective in dealing with the assessed consequences within these areas. This ensures effective implementation of precautionary, urgent and early protective actions and other response actions even when very limited information is available, and the uncertainties are large. Such areas include the four emergency planning zones and distances and the inner cordoned-off areas defined in GSR Part 7 [2]. The four emergency planning zones and distances are applicable to facilities in EPCs I and II and are:

- A precautionary action zone (PAZ) for the area in which the focus is on taking precautionary protective actions to avoid or minimize severe deterministic effects and associated arrangements;
- An urgent protective action planning zone (UPZ) for the area in which the focus is on taking urgent protective actions to reduce the risk of stochastic effects and associated arrangements;
- An extended planning distance (EPD) for the area in which the focus is on taking early protective actions to reduce the risk of stochastic effects and associated arrangements which include those for conducting timely radiation monitoring and assessment;
- An ingestion and commodities planning distance (ICPD) for the area in which the focus is on taking actions for ensuring food and commodities safety and associated arrangements.

The level of planning and response for these areas is determined on the basis of the doses that are expected to be incurred by the affected population in absence of any protective action, and the urgency associated with implementation of effective public protective actions to ensure no radiation induced health effects occur and the radiological consequences are mitigated. Their implementation in the protection strategy has to ensure that a staggered emergency response can be applied, focusing firstly on those in danger of sustaining deterministic effects and then on those in danger of an increased risk for radiation induced cancers with planning that is more specific and detailed (as reflected in emergency plans, procedures, exercises) in the same line of priorities. More deliberate assessments and informed decisions are then foreseen to lead to justified and optimized actions for the rest of affected population, if needed at all, and arrangements that are more flexible are expected to accomplish this.

A similar approach is adopted for radiological emergencies with the establishment of an inner cordoned off area which allows priority to be given to actions for those that may be exposed to doses at which radiation induced health effects that could be attributed to radiation exposure either as an individual outcome or as a collective outcome, could be observed.

Thus, for ensuring that effective protection strategy can be developed, it is important that the hazard assessment studies the impact of the emergency as a function of distance, so that it provides effective protection without delaying any efforts needed for those that are in most risk. Methodology for performing such assessment and for deriving the radii for emergency planning zones and distances for severe reactor emergencies is given in Ref. [39]. IAEA safety standards [9, 40] and technical guidance [39] suggest generically derived and justified and optimized radii for the emergency planning zones and distances and for the inner cordoned off areas.

3.3.3. Application of EPCs

States need to perform a thorough hazard assessment and identification of areas where emergency response actions may be warranted, as discussed above for the purpose of developing the protection strategy as well as for establishing overall emergency arrangements.

The results of the hazard assessment assist States in applying a graded approach to both emergency planning and response. However, this may be a lengthy process, necessitating a range for expertise and knowledge. Therefore, it might be too challenging for those States that lack such expertise and knowledge as well as face time limitations for establishing an effective EPR framework. In such circumstances, the EPCs and generically derived and justified suggested radii for emergency planning zones and distances and for inner cordoned-off areas in the IAEA safety standards [2, 9, 40] and technical guidance [39] can be used instead. This can be done only after they have been considered within the national, local and site-specific context.

Namely, the five EPCs defined in Requirement 4 of GSR Part 7 [2] establish the basis for a graded approach to the application of the requirements and for developing generically justified and optimized arrangements for preparedness and response for a nuclear or radiological emergency. Thus, using the data and information compiled as part of the planning basis (see Section 3.2.2) and the criteria provided in Table 4 of GS-G-2.1 [40], States can determine the EPC applicable to the specific facilities, activities and sources of interest and apply appropriate planning to them. For those facilities of EPCs I and II, a protection strategy that considers the emergency planning zones and distances as required in GSR Part 7 [2] has to be established to manage the off-site consequences. In selecting the sizes of the zones, the suggested generic radii in GS-G-2.1 [40] and Ref [39] can also be used; however, it is necessary that thorough processes of justification and optimization taking account of various non-radiological factors (discussed in Section 5) are performed within the national context when determining the exact radii of the areas and their boundaries and determining the best strategy for protection and safety within these areas. The end result in terms of the protection strategy is expected to be the same as after going through all stages of the hazard assessment process.

4. DEVELOPMENT OF A PROTECTION STRATEGY

Once the planning basis has been compiled and the hazards associated with potential consequences for a range of postulated nuclear or radiological emergencies assessed, the protection strategy development can be initiated. The process to develop a protection strategy needs to be defined and agreed among all concerned parties before the development is initiated. It may include a timeline with actions to be completed, assignment of responsibilities and associated milestones. Resources to be invested in the development also need to be allocated.

4.1 Step-by-step approach for development of a protection strategy

A step-by-step approach for development of a protection strategy is proposed in this publication to assist States in establishing protection strategy at the preparedness stage. An overview of the steps is shown in Fig. 4.

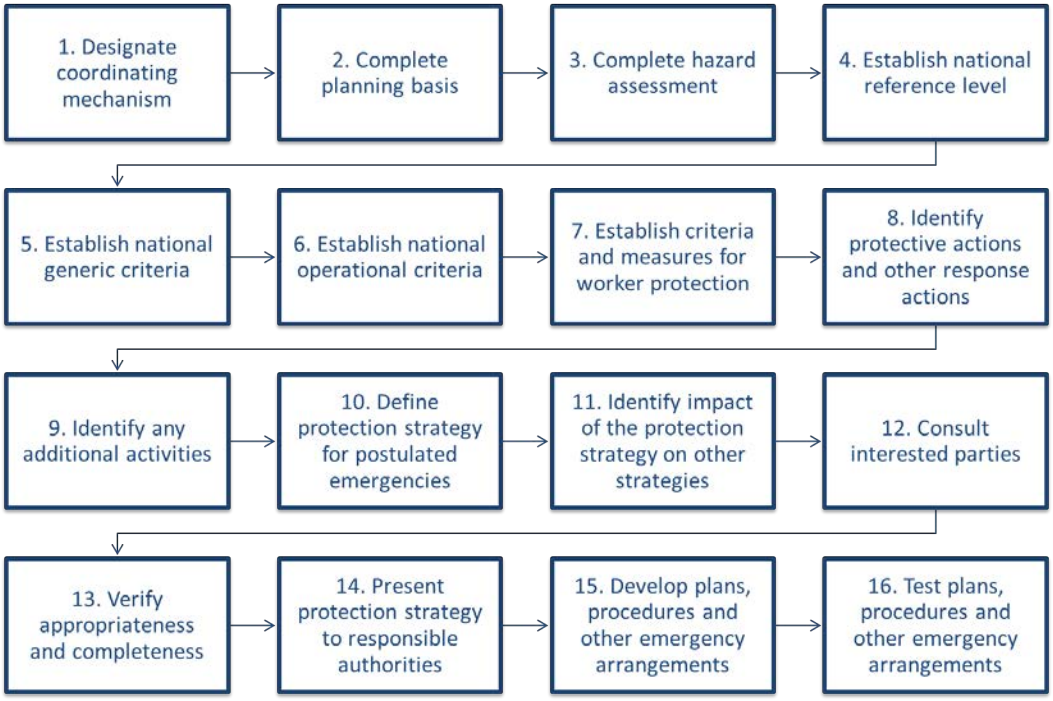


FIG. 4. An overview of the steps involved in developing a protection strategy.

The approach was developed under the assumption that no emergency arrangements as required in the IAEA safety standards exist in a State at the time with the intention that it may be useful for those State which are currently embarking on developing effective EPR framework. In addition, this approach may serve as a reminder to any State, including those with a mature EPR framework, on all necessary aspects they need to consider when developing or updating their protection strategy in line with the latest international requirements.

It is recognized that some of these steps may already have been fully or partially completed, as part of the development of the existing emergency arrangements at national level. For example, selection of the reference level and other criteria, and features of the planning basis and hazard assessment, may already have been established and continue to be relevant or relevant emergency plans and procedures may already have been put in place. In these cases, the associated steps may be modified to constitute a review for consistency with the aim to

identify need for revision to bring selected levels and criteria in consistency with the latest international requirements. Some the steps in this process may take place sequentially, while others may take place in parallel, in a different order, or as part of an iterative process, depending upon the needs and decisions taken by the State.

Once the protection strategy has been developed, it will be necessary to establish emergency arrangements (emergency plans, procedures and other arrangements), or to update those already in place (in case they had existed before the protection strategy was developed), to allow for effective implementation of the protection strategy. In case the State considers the protection strategy as part of the national emergency response plan, once agreement has been achieved on the protection strategy, other elements of the national emergency response plan may need to be revisited to ensure that they are consistent with the protection strategy but also that there are no overlaps. Emergency arrangements will then need to be tested in exercises. However, before resources are allocated to do this, the protection strategy is expected to be verified as complete and effective in achieving the goals of emergency response. The interaction with interested parties through consultation is also necessary at different stages of the development process.

Step 1: Designate the national coordinating mechanism to run the development process

A significant number of bodies or organizations may be involved in the response to a nuclear or radiological emergency (e.g. operating organizations, response organizations and regulatory body). It is therefore necessary to establish a coordinating mechanism at the preparedness stage to oversee the consistent and coordinated development of the protection strategy and its implementation. The coordinating mechanism needs to be a clearly defined national agreement with well documented responsibilities, authorities and functions. Consideration will also need to be given to possible emergencies with transboundary impacts and the way in which relevant information can be obtained by neighbouring States and the way in which they need to be involved in the development of the protection strategy to help provide, to the extent possible, for a coordinated and consistent approach across borders.

The coordinating mechanism is expected to include representatives from each of the bodies or organizations involved in the preparedness and response to a nuclear or radiological emergency. In addition, as relevant, at times it may include additional organizations and institutions that may hold information relevant to the planning basis, hazard assessment or justification and optimization. Such organizations may be identified at the stage when the need for specific information, which is available in certain organizations, is recognized, as discussed in Sections 3 and 5, respectively. The coordinating mechanism can therefore be established in different ways, including:

- An existing body or organization may be assigned to carry out coordination; lead coordinator is designated within that organization; and representatives of other organizations are assigned as representatives in different working groups (for example, the working groups may be formed by elements of the protection strategy or different postulated emergencies or any other way);
- An inter-ministerial/organizational body comprising representatives from all relevant organizations, established as a committee, with a lead coordinator designated from among them to oversee the overall process.

Whatever form the coordinating mechanism takes, its first priority is to prepare an action plan for developing the protection strategy in accordance with steps given here, including: (a) identifying which steps have already been fully or partially completed; (b) the timeframes for

completion of the various steps (including specific activities within each step); (c) possible interactions and iterations of the process that may be necessary; and (d) the responsibility for completing each step. The responsibility for supervising the implementation of the protection strategy in various operational arrangements and for enforcing its implementation also needs to be clearly stated and assigned.

In establishing the coordinating mechanism and its functions, it is recommended that States take into account the experience they have with such mechanism being in place for establishing their national emergency response plan or for whatever other EPR matter so as to allow for the efficient work of the mechanism. This is of particular importance in the case when the protection strategy is developed as part of the national emergency response plan.

Step 2: Complete the planning basis

The completion of the planning basis entails gathering various types of data and information that support the development of the protection strategy, the identification of the hazards as well as the development of overall emergency arrangements. It includes the data and information discussed in Section 3.

Steps 1 and 2 need to be completed before any further steps can be taken. Step 2 may have been undertaken for the purpose of developing existing emergency arrangements. If so, it is expected that the planning basis are reviewed and completed, as necessary, to allow for the development of the protection strategy in line with latest requirements and suitable documentation of the process.

Step 3: Complete the hazard assessment

The hazard assessment consists of the identification of events that may lead to an emergency associated with a facility, an activity or a source within the State, or affecting the State, and of associated hazards with the aim of identifying the actions that may be effective in mitigating these hazards and associated consequences. It includes characterizing various postulated emergencies, assessing potential radiological and non-radiological consequences, identifying areas and locations where emergency response actions may be warranted and assessing the effectiveness and impacts of implementing various protective actions, in isolation or in combination with others. The hazard assessment process and its outcomes are discussed in detail in Section 3.

The most efficient manner of performing Step 3 is in parallel with the process of establishing national criteria for implementing protective actions and other response actions and for selecting the reference levels. However, it is recognized that some of the elements of these processes may already have been completed and the various dosimetric criteria (see Steps 4 to 6) may already be part of established legislation and regulations or the national emergency response plan. The same is valid for the criteria and measures for the protection of emergency workers and helpers (see Step 7). Where dosimetric criteria already exist, it is necessary to record their values, the basis on which they were established, and the process through which they are to be applied within the protection strategy, in order to identify effective protective actions and other response actions. In doing this, it is necessary to review the various criteria to verify their consistency against results of the hazard assessment (see Section 3) taking into account the fact that they might have been introduced at different times and providing for any necessary revisions. In such cases, once this is completed and consistency confirmed, Step 3 would be followed by Step 8. In cases this exercise reveals a need for their revision and update, the next steps have to be followed.

Step 4: Establish national reference level

This step involves setting the reference level for residual doses, considering the recommended range in Requirement 5 of GSR Part 7 [2] and Requirement 44 of GSR Part 3 [1], respectively. The concept of reference level, the way it is intended to be used within the protection strategy and factors to be considered when selecting the national value for the reference level are discussed in Appendix I. The way in which reasonable values can be drawn at the national level, is discussed in Section 3 as part of the hazard assessment.

Step 5: Establish national generic criteria

This step involves developing national generic criteria in terms of projected doses and doses that have been received for implementing specific protective and other response actions, considering those recommended in Appendix II to GSR Part 7 [2]. The national generic criteria need to be selected to allow for a staggered emergency response so that priority is given to those at risk of sustaining radiation induced health effects in line with the UNSCEAR 2012 report [41]. They need to include generic criteria for doses

- For which protective actions and other response actions are expected to be undertaken under any circumstances in a nuclear or radiological emergency to avoid or to minimize severe deterministic effects;
- For which protective actions and other response actions are expected to be taken, if they can be taken safely, in a nuclear or radiological emergency to reasonably reduce the risk of stochastic effects;
- For which restriction of international trade is warranted in a nuclear or radiological emergency, with due consideration of non-radiological consequences;
- To be used as a target dose for the transition to an existing exposure situation.

Discussion on generic criteria, what they present, how they are intended to be used within the protection strategy, and their relationship with the reference level is provided in Appendix I.

Step 6: Establish the national operational criteria

Once national generic criteria have been established, it is necessary to develop operational criteria to trigger emergency response actions as indicators that generic criteria might be exceeded. Such operational criteria usually comprise of EALs associated with observable conditions at a facility or an activity, OILs associated with directly measurable quantities using radiation monitoring, and observable conditions at any site. Further discussion on operational criteria is provided in Appendix I. Example EALs for light water reactors (LWRs) are given in GSG-2 [9]. Methodology for deriving OILs and default OILs values are provided in GSG-2 [9], GSG-11 [8] and Refs17, 38]. During this step, it is necessary to elaborate and document the methodology used to calculate the default OILs as they may need to be recalculated to take account of the specific conditions of the emergency, as it evolves. The compelling reasons to recalculate OILs have to be determined and the process for recalculation agreed among all concerned parties.

Step 7: Establish criteria and measures for protecting emergency workers and helpers

This step involves defining specific criteria and measures to be taken to protect the emergency workers and helpers in an emergency. These measures and criteria might differ depending on the assigned tasks. In determining different tasks to be assigned to emergency workers and helpers, consideration has to be given to the protection strategy expected to be carried out and

arrangements to be put in place. It is noted that measures and criteria to be used for protecting emergency workers and helpers assigned to different tasks might differ and this needs to be well explained to all concerned parties. GSG-2 [9], GSG-7 [42] and GSG-11 [8] provide guidance on protecting emergency workers and helpers in an emergency.

Step 8: Identify protective actions and other response actions that may be warranted

This step involves identifying which protective actions and other response actions may be effective, either individually or in combination, in mitigating the range of expected radiological as well as non-radiological consequences for each postulated emergency. This is done using the results of the hazard assessment as discussed in Section 3. It will include considerations of possible options that can effectively address expected consequences. However, it goes further in identifying what additional action might need to accompany the selected options. Namely, Appendix III provides details on the most common protective actions, their applicability, strengths and weaknesses, and gives information concerning the implication one particular action might have on the overall protection strategy.

Aspects of the protective actions and other response actions that have to be considered in this step include the following:

- Which protective actions and other response actions would be appropriate to mitigate the specific hazards identified and associated consequences, and the time frames for decision making and for their effective implementation;
- The positive and negative impacts of implementing applicable protective actions and/or other response actions as well as any limitations associated with their implementation (see Appendix III for further information);
- The potential impact of protective actions taken earlier in the emergency on subsequent actions;
- The need for justifying and optimizing protective actions to take account of the prevailing conditions as the emergency evolves;
- The need for any differences among effective protective options appropriate for various sites/areas, emergency scenarios and in different timeframes;
- The means to be used to adapt protective actions and conditions necessary to lift applicable protective actions;
- The decision making process to be used to decide on specific protective actions and other response actions to be taken;
- Means to assess the situation so that the effectiveness of actions and the strategy can be judged, and further options can be pursuit.

Selecting best options for the protection strategy would need to consider justification and optimization, with account taken of radiological as well as non-radiological factors. The processes of justification and optimization need to be applied in an iterative process within other steps as well. Justification and optimization are further discussed in Section 5.

Step 9: Identify any additional activities that may be required during the emergency response

This step involves identifying various activities that may be warranted to support the resumption of normal social and economic activity and concern the return to the new normality and the well-being of affected populations. A comprehensive list of such activities can be found in the prerequisites given in Section 3 of GSG-11 [8]. Example activities might

include: ensuring that the infrastructure and the public services are in place, establishing public support centres, and restoring workplaces.

Step 10: Define the protection strategy for postulated emergencies

This step involves compiling and drafting the protection strategy comprising the identified protection options, that have been justified and optimized, including defining the decision making mechanism and the mechanism for its adjustment based on previous steps (in particular Steps 3 and 8). The template provided in Appendix II can be used for this purpose.

Step 11: Identify how the justified and optimized protection strategy may impact other related strategies

This step involves investigating what needs to be implemented during the response to enable effective implementation of the protection strategy. It relates to identifying priorities associated with various aspects of the emergency response, such as those related to radiation monitoring and assessment, emergency management, public communication, waste management and nuclear security, that will feed into related strategies or operational arrangements. The results of this analysis need to be used to ensure that information required for efficient decision making and public protection is collected in an effective manner during the response. This ensures consistency, transparency and feasibility of the effective implementation of the protection strategy.

Step 12: Consult various interested parties

This step involves consulting interested parties, including the public, on the protection strategy to ensure that their feedback is considered and reflected in the strategy and to help ensuring that the proposed strategy is acceptable and feasible. As with justification and optimization, consultation happens at different stages and at different steps, depending on the needs and not necessarily once protective options in the draft protection strategy have already been proposed. In this way, others' opinion can be timely factored into the draft protection strategy.

The interested parties involved extend beyond the bodies and organizations taking part in the coordinating mechanism. This process needs to be appropriate for the situation and to allow for a suitable level of engagement. It includes providing interested parties with a rationale for the options considered in the development of the protection strategy as well as the consequences and limitations associated with the implementation of different protective actions. In addition, interested parties need to be informed that, while the goal of developing the protection strategy is to define a justified and optimised strategy for emergency response, the protection strategy needs to be sufficiently flexible to be adapted to take account of the specific conditions that exist in an emergency. Outlining the processes for making such adaptations is an important component of the protection strategy. Further discussion on consultation is provided in Section 6.

Step 13: Verify the appropriateness and completeness of the protection strategy and finalize it

In order to finalize the developed protection strategy, its appropriateness and completeness as well as its feasibility and practicability, the strategy needs to be verified. Such verification activities could include comparison of the protection strategy with international recommendations and with strategies that are recognized to reflect best practice. It may also involve conducting tabletop exercises or workshops with participation from organizations

indicated in the protection strategy. These fora may consider testing the application of the protection strategy against several example emergency scenarios (as identified in the hazard assessment). This step includes addressing the lessons learned from the verification activities and finalizing the protection strategy. Finalization may encompass its adoption at high levels of the government for ensuring its enforceability. If the protection strategy is part of the national emergency response plan, then this finalization will take place with the adoption of the national emergency response plan. In this case, parallel to the development of the protection strategy, revision of respective elements of the national emergency response plan needs to be undertaken to ensure consistency and to avoid delays in the adoption of the strategy.

Step 14: Present the final protection strategy to responsible authorities

Before starting to develop various arrangements to support the implementation of the protection strategy, it is necessary to present the strategy to all those authorities responsible for implementation of the protection strategy in the form of operational arrangements. This process may include response organizations at national, regional and local levels as well as operating organizations. It also includes decision makers and others who will have been involved in some or all the steps of developing the protection strategy. The aim of this step is to achieve a common understanding of the strategy and to facilitate the coordinated and consistent implementation of the protection strategy in their respective operational arrangements (e.g. emergency plans, procedures). It also provides an opportunity to clarify and test the distribution of responsibilities and their practicability. Such presentation may take form of a training activity or a workshop, and may utilize leaflets and other promotional and information materials aimed at the staff of those organizations with relevant responsibilities in the implementation of the protection strategy.

Step 15: Develop or update emergency plans, procedures and other emergency arrangements at the national, regional, local levels and at operator's level (as appropriate) to implement the protection strategy

This step involves developing the emergency response capability at the preparedness stage. As many States have had operational arrangements in place for many years, this step also includes the revision of such arrangements to bring them in line with the final protection strategy. It is important that this is done in a coordinated and consistent manner so that it will not jeopardize the effectiveness of the protection strategy when implemented. If the protection strategy is part of the national emergency response plan, then this step relays to other related emergency plans, procedures and operational arrangements at different levels through which the strategy is implemented.

Step 16: Test the emergency plans, procedures and other emergency arrangements

This step involves conducting various types of exercise against pre-set objectives to test established arrangements that implement the final protection strategy and to identify improvements needed. Such exercises have to be performed on a regular basis and to allow testing of all critical functions within a specific timeframe (e.g. in five years). It also includes ensuring revisions are made to adjust the emergency plans, procedures and other arrangements, as necessary, to address findings from those exercises.

4.2. Considerations for developing the protection strategy implied from implementation

In an emergency, the relevant aspects of the pre-established protection strategy are implemented through the pre-established emergency arrangements. However, recognizing that an emergency is unlikely to be identical to any of the scenarios considered at the preparedness stage, a capacity for flexibility and adjustment needs to be incorporated into the protection strategy at the preparedness stage. This includes consideration of arrangements for: (a) assessment, including the establishment of the relevant priorities for gathering information to support decision making; (b) revision and application of criteria; and (c) processes for adjusting or lifting protective actions or other restrictions. The level of flexibility, which is provided in the protection strategy and, thus, in the associated emergency plans, procedures and other arrangements, will strongly depend upon the time after the emergency onset, i.e. the phase of the emergency response (see Fig. 5).

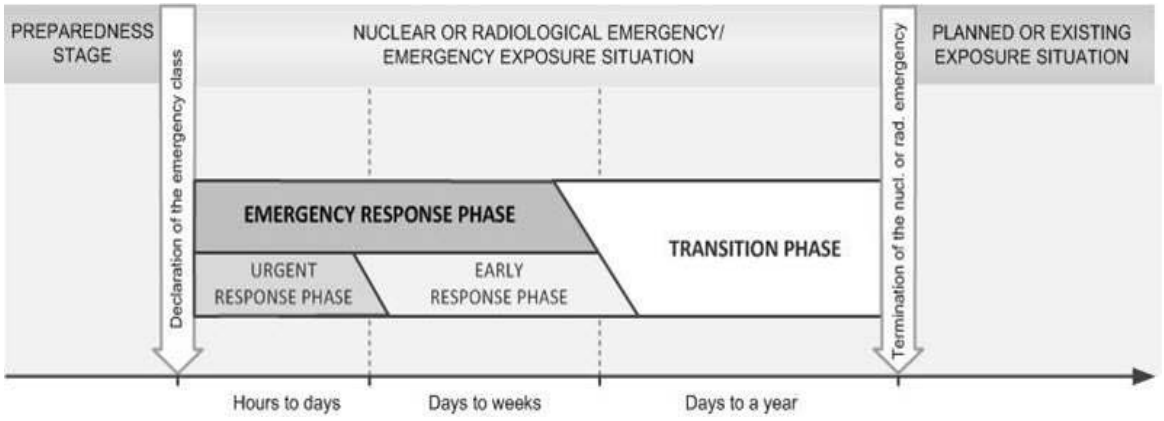


FIG. 5. Emergency response phases [8].

In addition, the protection strategy needs to be continually adapted during the response as the emergency evolves (the adapted protection strategy, see Section 2), depending on the scale and phase of the emergency and on the amount and type of information available. Means and processes to be used for this adaptation are an important part of the strategy.

A range of temporal and spatial aspects needs to be considered when implementing the protection strategy which may have an impact on the development of the strategy at the preparedness stage as well. For large or prolonged releases, the impact of the emergency differs from one area to another, potentially resulting in different exposure pathways dominating in different areas (e.g. deposition, resuspension, ingestion) and different dominant radionuclides. The range of received, projected and residual doses varies spatially, hence it is to be expected that the optimum protective actions vary from area to area and with time, and the protection strategy needs to reflect this. The protection strategy for implementation needs to include a planned timescale for actions, broken down if necessary and where appropriate by areas which are similar in contamination and/or dose.

In conjunction with considerations about the non-homogeneous spread of contamination, it is possible that the pre-emergency demographic, economic, land usage and other factors will vary with area, again potentially leading to different protective actions. Furthermore, protective actions may be adjusted to take account of non-radiological factors (for example, to avoid dividing a population group or a community, decision makers may prompt evacuation over a wider area than what is expected based on the radiation monitoring results). It is necessary to determine the likely impact of actions in one area on another area. This will

indicate whether it is necessary to implement actions in a particular order to reduce adverse consequences in other areas. Issues such as discussed above might be faced in a response when the protection strategy needs to be implemented and, thus, they need to be considered in the development of the strategy and its justification and optimization.

4.2.1. Considerations for the urgent response phase

As soon as the emergency has been declared, prompt implementation of the protection strategy is of paramount importance to provide the best level of protection under the prevailing circumstances, even if very little information is available and uncertainties are large. During this phase, the protection strategy needs to be implemented according to the detailed emergency plans, procedures and other arrangements developed and agreed upon at the preparedness stage and corresponding to the protection strategy. The focus needs to be on the protection of those at highest risk for radiation induced health effects.

Urgent protective actions ideally are triggered by plant conditions (i.e. EALs) or other observable conditions. The protection strategy for the urgent response phase needs to be planned in detail at the preparedness stage to ensure its effectiveness, considering that during this phase there is insufficient time for data gathering, consultation and adaptation and limited information is available. Thus, it is essential that decisions related to the urgent response phase are made at the preparedness stage and consider what is to be undertaken, when, where and how.

However, it is recognised that specific conditions prevailing at the time during the urgent response phase may require flexibility in the protection strategy to enable its safe implementation. For example, severe weather conditions may render planned evacuation unsafe. Thus, it is important to consider such factors at the preparedness stage and include in the protection strategy in order to avoid the necessity of making unplanned adjustments in an emergency. Example conditions that may require adaptation of the pre-planned protection strategy during the urgent response phase include, but are not limited to:

- Destroyed infrastructure (e.g. by a serious natural event);
- Severe adverse weather conditions; and
- Unavailability of resources due to prior deployment for other purposes.

4.2.2. Considerations for the early response phase

As the emergency evolves and progresses into the early response phase, more information on the circumstances leading to the emergency and its consequences become available. In this phase, there is less urgency than in the urgent response phase, so improving the understanding of the situation comes also in focus with the implementation of the public protective actions. Moreover, the urgent protective actions taken need to be reconsidered at this stage to determine whether the actions are appropriate and sufficient, and to adjust them as necessary. It is at this time possible to begin to consider revising, justifying and optimizing the protective actions, and the adapted protection strategy, taking into account:

- How the potential or actual situation varies from the most similar scenario assumed in the basis for the protection strategy developed during the preparedness stage;
- How the situation may continue to evolve; and
- Whether protective actions and other response actions need to be adjusted or lifted (e.g. if no longer justified).

The situation needs to be continually assessed in order to make informed adjustments about the extent to which the protection strategy continues to be appropriate for the hazards posed

by the prevailing circumstances. Any adaptation of the protection strategy needs to be based on an iterative process of justification and optimization that takes account of a range of radiological and other relevant factors, discussed in Section 5. The objective needs to be to ensure that the adapted protection strategy continues to do more good than harm and be the best under the prevailing circumstances. The reference level may need to start playing a role in this phase as a tool to guide further efforts and to help judging effectiveness of the protection strategy implemented by that time. However, even during the early response phase, there is likely to be limited time for comprehensive justification and optimisation, assessment of effectiveness and consultation (see Sections 5 and 6) and, thus, more detailed planning for the protection strategy might be appropriate for this phase as well. Still, some practical aspects may call for attention at certain point of time during the early response phase. Examples of such aspects are provided in Table 2.

TABLE 2. EXAMPLES OF PRACTICAL ASPECTS TO CONSIDER WHEN ADJUSTING THE PRE-ESTABLISHED PROTECTION STRATEGY DURING THE EARLY RESPONSE PHASE

Types of consideration	**Examples of necessary information, when and if available**
The current radiological or non-radiological situation	− Whether any individuals at immediate risk due to radiological or non-radiological hazards. − The current picture of the local region and infrastructure and how has this changed from the emergency plan as a consequence of the emergency. − Estimates of projected and residual dose. − The position with regard to agriculture and water supplies. − The adequacy of the food and water supplies in areas where restrictions are necessary and where people are present.
The actual conditions of the emergency	− Prognosis of the future development (for example termination of the release). − Estimates of the activity/source term, in terms of current releases and projected releases. − Meteorology during any release of radionuclides and current weather conditions and future weather predictions.
The protective actions that have already been implemented	− The effectiveness of the implemented and planned protective actions at reducing exposures in this emergency. − The uptake of the protective actions by the population. − The potential for negative impacts from continuation of the protective actions.
Whether or not the protective actions that have been implemented can be lifted or modified	− Whether or not the protective actions are still effective. − Whether or not the protective actions are still justified. − Whether any other required activities to facilitate lifting of the protective actions have been undertaken.

Types of consideration	Examples of necessary information, when and if available
Whether any protective actions within the protection strategy are not yet implemented and should be implemented imminently	− Whether the required resources are available (human, technical, financial) and on what timescale? − Whether any past protective actions preclude taking additional protective actions. − Positive and negative effects and other limitations associated with the proposed protective actions (see Appendix III). − For this particular emergency, what is the likely effectiveness of actions in dose reduction (if the effectiveness of an action is unclear, a pilot study may be needed to determine whether it is appropriate for use on a larger scale).
What protective actions are under consideration for the later phases of the emergency and need consideration and planning during the early response phase	− Preparations required for these (e.g. movement of equipment and/or personnel). − Optimum initiation timings of proposed protective actions, relative timings and priorities in regard to the implementation of each and also to existing protective actions, applicability and priorities in each affected area. − Collation of information on data for input to decisions on recovery and decontamination (these are given elsewhere but include resources available, estimated areas affected, prioritisation of areas, estimated waste arisings and disposal routes).
Other circumstances that may be impacting the pre-determined protection strategy and/or arrangements	− Destroyed infrastructure due to a natural disaster. − Severe and adverse weather conditions. − Unavailability of resources due to their prior deployment for other purposes.

Other considerations need also to be included in the justification and optimization processes, such as (a) feasibility; (b) acceptability and public trust; (c) possible adverse psychological and sociological consequences, as discussed in more detail in Section 5. The level at which all these considerations are tackled during this phase will increase with time.

Throughout the early response phase, the protection strategy needs to be continuously reassessed and adapted on the basis of the prevailing conditions, as the time allows for effective protection of the public. The reassessment of the situation based on actual circumstances may lead to decisions to lift protective actions that are no longer justified and/or to implement new justified actions. The rationale for each adapted protection strategy needs to be transparent, documented and communicated with relevant authorities and interested parties. It is necessary to specify relevant criteria and to explain and justify changes from the earlier protection strategy with reference to the conditions considered (including radiological and other factors).

Any limitation to what and when can be done at this stage needs to be well thought and reflected in the protection strategy for this phase.

4.2.3. Considerations for the transition phase

As the emergency progresses, there is a progressively greater understanding of the precise nature of the emergency and the circumstances surrounding it. Therefore, decision making needs to be based on actual conditions rather than pre-planned response, to a progressively greater extent. It is expected that, before or during the transition phase, the emergency situation is brought under control and that the radiological situation is characterized in detail. This information may then be used to further adapt the protection strategy, as appropriate. At this stage, it is possible to apply the justification and optimization processes more rigorously, including consultation with interested parties. For large emergencies, there need to be an increasing focus on activities to allow social and economic activity to resume.

All aspects for consideration in adapting the protection strategy outlined for the early response phase also apply to the transition phase with the aspect of having more time to shape the response better to the actual situation using all necessary means. Additional considerations in the transition phase that need further consideration in the protection strategy include:

- Primary objective and prerequisites to enable the emergency to be terminated and allow social and economic activity to be resumed as appropriate to the circumstances;
- The change in what acceptable reference level is to enable the transition to an existing exposure situation.

As in the early response phase, it is important to ensure that any adaptations to the protection strategy in the transition phase are transparent, documented and communicated with relevant authorities and relevant interested parties, following agreed processes in the strategy at the preparedness stage. As indicated above, it is necessary to specify the relevant criteria and conditions considered (both radiological and non-radiological) in this process. Also, as for the early response phase, various actions (individually or in combination) need to be appropriate in the transition phase, and it may be anticipated that the adopted protection strategy needs to be further developed in detail for different areas and with a clear timescale for each area rather than this to be done in the strategy at the preparedness stage. It is important to ensure that the reasons for changes in the protection strategy over time, for the circumstances of the particular emergency, are clear and appropriately explained. Further guidance on factors to consider in the protection strategy for the transition phase is provided in GSG-11 [8]. The general and specific prerequisites provided in Section 3 of GSG-11 [8] help in identifying possible actions and activities to be considered in the protection strategy for this phase.

There is less urgency associated with the transition phase than either the urgent or early response phases. Therefore, the level of planning in preparedness for the transition phase is less detailed than for the earlier phases, since there is more time available to adapt the protection strategy to the particular circumstances. During the preparedness stage, it is therefore important to establish a flexible general framework for decision making that may be applied in the transition phase, taking account of the following priorities for this stage:

- Full characterization of the radiological and non-radiological situation;
- Adaptation of the protection strategy by means of comprehensive justification and optimization processes, including consultation with interested parties;
- Facilitation of the resumption of social and economic activity with care given to the well-being of those affected.

5. JUSTIFICATION AND OPTIMIZATION OF PROTECTION AND SAFETY

The principles of justification and optimization are easily understood in their essence and there appears to be a consensus on the considerations involved in justifying and optimizing the protection strategy. However, there is less agreement and clarity on the processes deployed at national levels to derive justified and optimized protective actions. States generally apply informal processes during which emergency or crisis management organizations tend to demonstrate a greater ability to consider non-radiological factors and practical aspects in optimization than radiological protection professionals. This is linked to their experience associated with the more frequent conventional emergencies for which they are responsible for managing.

This Section aims to help States apply more formal processes for justification and optimization and identify the information that needs to be gathered, the way this information needs to be used, and the organizations to be involved for providing adequate input to support informed decisions.

5.1. Introduction

Justification and optimization are important processes in both the development and implementation of the protection strategy. In the context of an emergency or existing exposure situation, these terms are defined in GSR Part 3 [1] and GSR Part 7 [2] as follows:

- Justification is *"the process of determining ... whether a proposed protective action or remedial action is likely, overall, to be beneficial; i.e. whether the expected benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the protective action or remedial action outweigh the cost of such action and any harm or damage caused by the action."* [1, 2].
- Optimization (of protection and safety) is *"the process of determining what level of protection and safety would result in the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure being as low as reasonably achievable, economic and social factors being taken into account (ALARA)."* [2].

The process of justification is thus applied in deciding whether actions taken to reduce exposures are likely to do more good than harm, taking account of both the disadvantages (e.g. disruption) and the advantages (e.g. reduction in radiation risk) associated with their implementation. Optimization is then applied to justified actions to ensure that the best is achieved, under the prevailing (or assumed) circumstances, taking account of economic and social factors associated with different means of implementing the justified actions. In other words, while justification and optimization both involve taking account of the costs (or harm) and benefits associated with implementing actions, justification requires that a net benefit is achieved, while optimization further requires that the various components of cost and benefit are balanced to achieve the best (or optimum) result, which may not necessarily be the one with the lowest dose.

As mentioned in Section 2, the concept of the protection strategy, comprising a suite of justified and optimized protective actions and other response actions, has evolved from the previously recommended approach, outlined in GS-R-2 [5] and based on ICRP Publications No. 60 [6] and 63 [7], in which interventions (i.e. individual protective actions) were individually justified and optimized on the basis of the dose that is avertable by that action, using the concept of intervention levels. In GSR Part 7 [2], taking into account the recommendations in ICRP Publication No. 103 [10], the focus for justification and

optimization has been modified to encompass not only individual protective actions but the overall protection strategy as well. Namely, justification has to be applied for individual protective actions themselves as well as to the overall protection strategy (i.e. the combination of protective actions) with the aim to ensure that the net benefit when combining individual actions is not compromised. Justified actions and justified combinations of actions then need to be optimized and incorporated within a protection strategy. Depending on the relation among various actions considered, optimization may to some extent be possible for some protective actions in isolation from other actions considered in the strategy, while in other cases it has to be ensured that all actions in combination would result in the best outcome.

Justification and optimization are complex processes that involve taking account of a range of considerations that call for inputs from various organizations or bodies. They therefore require close collaboration among all the organizations with relevant responsibilities (including operators, regulators and response organizations at different levels) that may own knowledge, information or data on various aspects to be considered in these processes. Examples of the factors that need to be taken into account in the processes of justification and optimization are presented in Annex II to provide, among other things, a basis for identifying the organizations and interested parties that need to be involved in providing relevant inputs to support making an educated guess regarding the justified and optimized actions to be considered.

During the preparedness stage, the justification and optimization processes are applied to develop a protection strategy for a range of postulated emergencies, resulting in a range of potential consequences. This is a generic process, associated with significant uncertainties, for example, in estimating the impact of an emergency. However, during the emergency response, the justification and optimization processes are applied in an actual emergency. In the urgent response phase, priority needs to be given to the implementation of a pre-planned set of justified and optimized precautionary and urgent protective actions. When the emergency progresses into the later phases, there is less urgency associated with implementation of effective emergency response actions and an increasing amount of information becomes available regarding the emergency and its impact. Only at this time, it is possible and reasonable to review how effective the response by that time is, and to explore through thorough justification and optimization processes what else can be done.

The process of evaluation, justification and optimization within the overall process of developing and implementing the protection strategy is illustrated in Fig. 6.

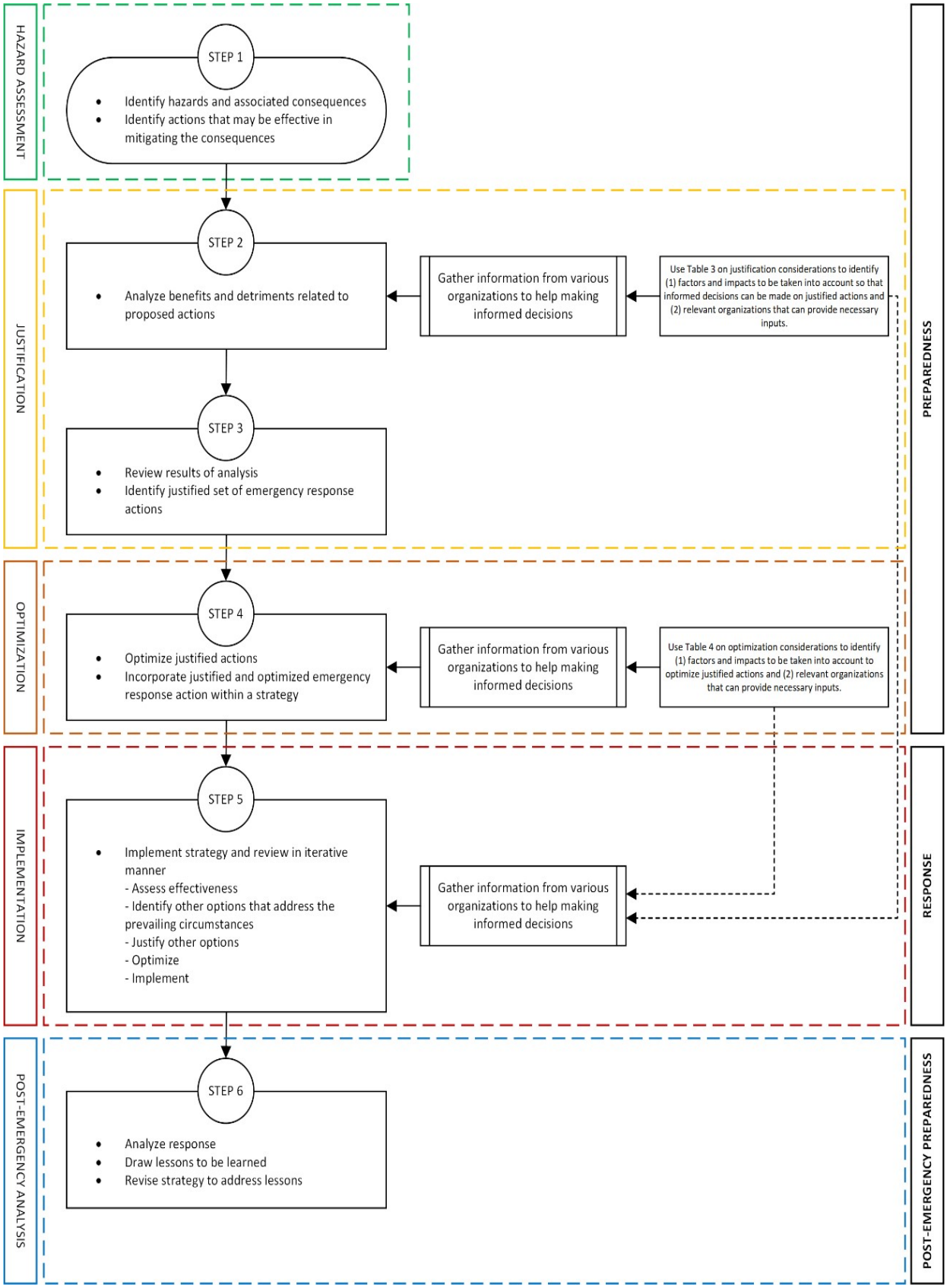


FIG. 6. Illustration of the process of justification and optimization in developing and implementing the protection strategy.

Figure 6 also illustrates the stages at which it is necessary to obtain information from various organizations to make informed decisions. Step 1 was described in Section 3. The present Section provides practical guidance on undertaking Steps 2 to 5 of this process. The factors and considerations presented in Annex I have been expanded in the form of questions and considerations related to the processes of justification and optimization in Tables 3 and 4, referred to in Fig. 6 and elaborated in details in the relevant Sections below.

Figure 7 presents the process of justification and optimization in a simplified way, highlighting its forward looking and iterative features for examining available options for protection and safety and for adjusting the actions to obtain the best outcome.

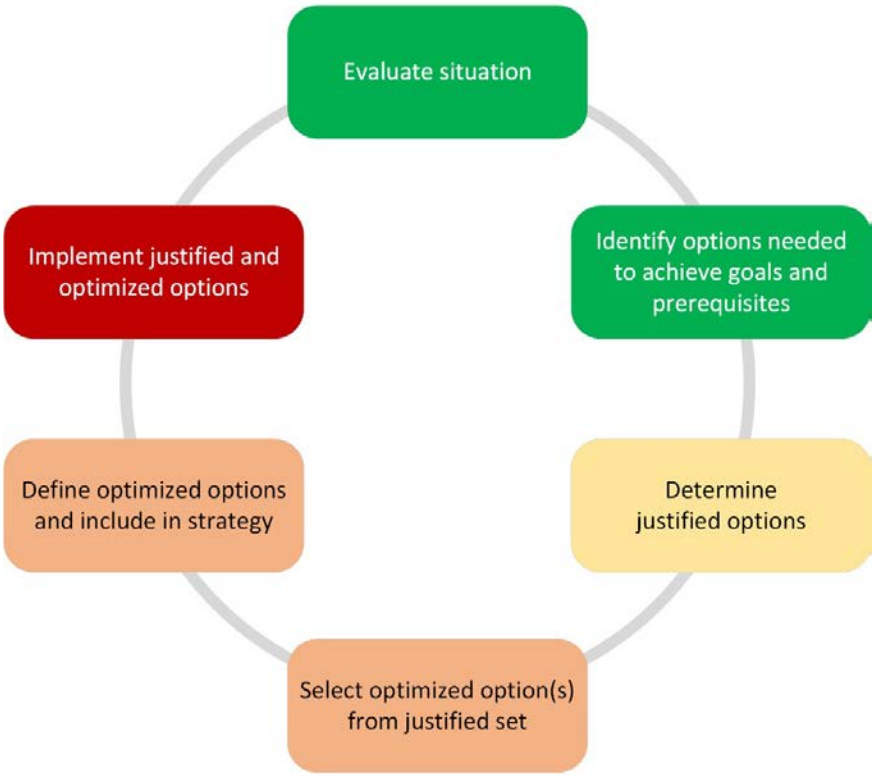


FIG. 7. Iterative process of justification and optimization of protection and safety in a nuclear or radiological emergency.

The processes of justification and optimization at the preparedness phase and during response are explained in further details in Sections 5.2 to 5.4.

5.2. Justification at the preparedness stage

Paragraph 4.29 of GSR Part 7 [2] states: *"Each protective action, in the context of the protection strategy, and the protection strategy itself shall be demonstrated to be justified (i.e. to do more good than harm), with account taken not only of those detriments that are associated with radiation exposure but also of those detriments associated with impacts of the actions taken on public health, the economy, society and the environment."*

Thus, the development of the protection strategy will involve ensuring that the protection strategy as a whole is justified, taking account of the impacts of the individual protective actions, which have themselves been justified for the range of possible emergency scenarios,

derived from the hazard assessment. When doing so, the justification needs to involve an analysis of the benefit associated with the reduction in radiation detriment if the action or protection strategy are introduced against the harm associated with introducing a protective action or the protection strategy as a whole. The comparison between the gross harm and gross benefit will then determine the net result. However, even if the net benefit is confirmed, some circumstances may render some justified protective action impractical or unsafe, and such consideration would form also essential part of the justification process.

In the development of the protection strategy, it is important to consider the way in which individual protective actions can impact the applicability or efficiency of other actions and/or may preclude the use of other actions. Alternatively, some protective actions may be more effective in combination than the sum of the expected benefits for each measure in isolation. For example, the combination of sheltering and iodine thyroid blocking can be useful precursors to evacuation in some circumstances such as the simultaneous occurrence of a natural event leading to widespread disruption of infrastructure.

When considering various justified protective actions that have clear net benefit, those actions which aim at preventing health effects that can be attributed to exposure to ionizing radiation either as an individual outcome (i.e. severe deterministic effects) or as a collective outcome (i.e. increase in the incidence of radiation induced cancers among affected populations) have to be given priority over actions which aim at further reduction of doses that are at levels at which risks can only be inferred [41]. Because of the urgency associated with the implementation of such priority justified actions, the precautionary and urgent protective actions have to be well planned and optimized during the preparedness stage so that they can be readily implemented safely and effectively during an emergency. In circumstances involving high doses and high dose rates (e.g. above thresholds for severe deterministic effects), protective actions and other response actions clearly bring benefit and, therefore, are justified even if they can be disruptive.

At low doses and low dose rates, at which risks due to exposure to ionizing radiation can only be inferred [41], the adverse consequences associated with the protective actions and the protection strategy on the economy, society and the environment are likely to have a relatively greater weight in the justification process then the benefit of reducing further the risk of stochastic effects. Thus, making decisions on protective actions and the protection strategy in situations involving low doses and low dose rates need to include considerations of a complex range of factors and impacts to ensure that they do more good than harm.

Examples of adverse impacts associated with specific protective actions and the protection strategy that need to be considered in the justification process may include: possible reduced life expectancy due to stress associated with resettlement; possible effects of inadequate care arrangements for the sick and vulnerable; costs associated with the loss of critical infrastructures; loss of productivity of industrial facilities; costs associated with compensation payments to those impacted; societal impact owing to the loss of places of great cultural or historical importance; and costs to society and its economy associated with loss of businesses or with the management of the radioactive waste generated.

In most, if not all practical situations, protective actions and the protection strategy will be aimed at protecting a group of people. The protection strategy will be then considered to be justified if it is expected to do more good than harm for most of the group.

An overview of some of the key factors and relevant considerations in the justification process that States are advised to use in establishing formal approaches to justification are presented in Table 3.

TABLE 3: FACTORS AND CONSIDERATIONS IN THE PROCESS OF JUSTIFICATION

Factors	**Examples of relevant questions**	**Examples of relevant considerations**
Goals of emergency response	• Why is the action in question being considered? • Will this action prevent individuals from being subjected to a serious risk of death, severe deterministic effect or long term health impact due to radiation exposure? • Will this action help mitigating non-radiological consequences and/or facilitate protection of property and the environment?	• Specific actions identified in the hazard assessment as potentially or actually effective in achieving the emergency response goals to mitigate adverse consequences (see Appendix II to GSR Part 7 [2]). Such actions may be indicated by: o Whether doses are projected to exceed generic criteria at which protective and other response actions need to be taken to avoid or minimize severe deterministic effects and to reduce the risk of stochastic effects; o Non-radiological consequences (e.g. adverse economic and psychosocial consequences) that may require action.
Radiation protection	• Will this action result in the reduction of doses below levels at which severe deterministic effects and/or a significant increase in the incidence of cancer among affected populations might be expected? • Will this action reduce the radiation detriment to affected populations? How relevant is this reduction? • What will be the impact of implementation of this action on the doses incurred by emergency workers?	• In situations involving high doses and high dose rates, at which health effects might be attributed to radiation exposures, the benefit of taking protective actions will almost always outweigh the adverse impacts from taking the action even if such actions are disruptive. • However, in situations involving low doses and low dose rates at which radiation risks can only be inferred, careful consideration is needed to ensure that adverse impacts from taking protective actions are outweighed by any benefit from further reducing the doses. • Under some circumstances involving high doses, protective actions may not be justified owing to fact that they cannot be safely implemented at the time and thus, potentially causing more harm than good. • In order to assess the effectiveness of the action at providing protection against harmful effects of ionizing radiation to members of the public while taking account impact on emergency workers, appropriate methods of assessment need to be in place.
Timing	• Are there timing constraints on decision making for the action and on its implementation? • How does the evolution of the emergency affect timing of	• The timescale over which doses will be and/or are received need to be considered so that any urgency in the decision-making process, and any need for timely implementation of the action, may be

TABLE 3: FACTORS AND CONSIDERATIONS IN THE PROCESS OF JUSTIFICATION

Factors	Examples of relevant questions	Examples of relevant considerations
	implementation of the action?	identified and associated practicalities recognized. Relevant considerations include: o The stage at which the action needs to be taken in order to be effective; o The length of time it will take to implement this action and how this timing relates to the timescale over which doses are received.
Efficiency/Feasibility	• Can the action being considered be practically achieved? • Will the proposed action affect other aspects of the response to the emergency?	• The action may be desirable and most effective one, but it may not be possible for it to be implemented in sufficient time to achieve the expected benefits. This could be due to limitations in resources and equipment or the deficiencies in infrastructure needed to carry out the action being considered. This may also be due to the impact this action has on other aspects of emergency response jeopardizing the protection and safety of those who needed the most.
Environmental aspects	What are the likely direct or indirect impacts of the emergency response on the environment?	• Actions may, or may not, have an impact on the environment. For example: o Evacuating an area for an extended period might result in a facility critical to protection of the environment shutting down or becoming less efficient, resulting in a detrimental impact on the environment (indirect impact); o Remediation involving topsoil removal over large areas will have a detrimental impact on the overall environment (direct impact).
Economic aspects	• What the costs associated with implementing the action be taking account of both direct and indirect costs? • How the proposed actions affect the economy (either due to its implementation or the decision not to implement it)? • Will there be any associated economic disruption and, if	• Each action to be implemented will bear some costs which may be associated for example with resources utilized to take the action or with further activities needed to manage the impacts of the action. o Such impacts may relate to the local and broader economy, and may include, for example, whether the market for products unique to the region is permanently

TABLE 3: FACTORS AND CONSIDERATIONS IN THE PROCESS OF JUSTIFICATION

Factors	Examples of relevant questions	Examples of relevant considerations
	so, how significant would this be?	affected. Any impact on critical national or international infrastructure or other economic or industrial activities need to be analysed.
Social and ethical aspects	• Will this action have an impact on the overall lifestyle of individuals? What would be the scale of disruption? • Will the proposed action have unintended individual or societal consequences? • Does the action provide socially acceptable solution?	• The length of time the proposed action is likely to be in place and the associated impact it may have on the lifestyle of individuals and on communities. Examples of further considerations include: o Whether the action will prevent people from going to work, attending schools, undertaking hobbies and pastimes, undertaking normal social activities and so on for an extended period; o If the action will have associated psychological impacts by, for example, requiring people to sleep in temporary shared accommodation for extended periods, where they are unable to take part in hobbies and pastimes, or to have access to the internet and so be able to function normally; Whether reduced life expectancy owing to stress with resettlement is to be expected; o Any social impact owing to the loss of places of great cultural or historical importance. • The acceptability of the proposed action among members of the public and other interested parties may influence the relative effectiveness of different options. For example: o Decontamination of food products will only be worthwhile if such measures are likely to be accepted and the products will subsequently be purchased. However, it is important to note that decision-making remains the responsibility of the authorities and that social acceptability ought not to be the main driver in such decisions since this may lead to taking unjustified actions, which may cause even greater harm in the longer term.
Cross-border	• Do the actions and/or associated criteria take account of	• Consistent response across borders, in case of transboundary

TABLE 3: FACTORS AND CONSIDERATIONS IN THE PROCESS OF JUSTIFICATION

Factors	Examples of relevant questions	Examples of relevant considerations
coordination	possible cross-border agreements or commitments?	emergency in particular may need to be considered for the same of building trust and avoiding public concerns regarding level of protection they are afforded.
Waste	• Will any wastes be generated and, if so, what volume and what characteristics of waste might be anticipated? • Are there any foreseen locations for the storage and/or disposal of radioactive and other wastes arising from a nuclear or radiological emergency?	• The generation, management storage and disposal of radioactive waste may also impact communities than those directly affected by the consequence of the emergency and future generations as well. The waste management will lead to extra costs which can be significant impact on the economy. What wastes are likely to be produced because of the action and how will they be treated and disposed of will need to be analysed to help make informed decisions for justified actions.
OVERALL QUESTION		
Taking the responses to all of the questions above into account, does the proposed action do more good than harm?		• Whether the expected benefits from taking the action or protection strategy are significant and sufficient to outweigh all the adverse impacts. *NOTE:* *If this is not the case, or if the net benefit is only marginal, it is necessary to consider whether any other action may be more appropriate, in the context of the overall protection strategy, which would result in a lower overall adverse impact.*

5.3. Optimization at the preparedness stage

Once justified, the protection strategy has to be optimized. Optimization is intended to ensure that the best strategy under the prevailing circumstances is selected, i.e. maximizing the margin between benefits and harm, taking into account the situation and associated constraints. Optimization is the means by which the doses are reduced to a level that can be considered 'as low as reasonably achievable' (ALARA) and this may not necessarily be the level with lowest doses.

Optimization of protective actions and the protection strategy involves the evaluation and balancing of a wide range of complex information and data, collated as a result of the planning basis (relating to e.g. available infrastructure, demography, weather data) and from the hazard assessment, for a range of likely consequences of an emergency associated with a number of sites, facilities and sources. Optimization involves the consideration of the factors and consequences associated with implementing a range of options for given protective actions that thus includes more detailed practical considerations than justification. For example, it may be determined that evacuation is justified, under certain circumstances. Optimization involves considering the best way to implement evacuation, in the prevailing conditions with the resources being available.

Optimization may mean that, while it may be possible to consider introducing disruptive, high cost protective actions (for example evacuation) for a relatively small number of people, an emergency affecting a much larger population might focus on a different combination of protective actions, in view of the feasibility of undertaking such actions for large numbers of people and the far greater level of disruption and cost involved. Any such consideration need not to jeopardize the protection and safety of those to be or being exposed at levels at which radiation induced health effects (severe deterministic effects or increase in the incidence of radiation induced cancers among affected populations) can be observed.

Like justification, optimization involves a wide range of factors and considerations that are presented in Table 4. It is worth noting that some factors are difficult to quantify in units that allow a detailed quantitative cost benefit analysis. It is therefore necessary to express the both quantitative and non-quantitative factors in a way that allows decision makers to address them appropriately in formulating decisions. The priorities assigned to different factors can markedly differ according to the region and the societal contexts, such that the outcomes of optimization processes undertaken in different areas, regions or states, or at different phases of the emergency, may differ. Table 4 can be used to identify the authorities that can bring relevant inputs to these considerations to inform decisions on optimal options or approaches.

Features of the emergency that have a significant influence on the optimization process include:

- Dominant exposure pathways as they help determining the types of justified protective action to be considered individually and in combination so that all exposure pathways are targeted at the same time;
- Timescales over which components of dose are likely to be received as this guides informed decisions about the timeframes available to decide on and implement protective actions;
- Factors impacting the effectiveness of individual protective actions and the protection strategy need for combining various protective actions to allow for their effectiveness and the associated resource implications;

- Social and economic impacts associated with the emergency itself as well as with emergency response.

Whilst both individual and collective factors are considered in the optimization process, the relative weight accorded to collective and individual factors varies depending on the magnitude of the individual risk; when the expected individual risks are high, the importance accorded to collective factors is reduced. In addition, when considering the impact of collective doses in cases that exposures occur over large populations, large geographical areas, or long periods of time, an ICRP recommendation needs to be considered that states that in such circumstances *"...the total collective effective dose is not a useful tool for making decisions because it may aggregate information inappropriately and could be misleading for selecting protective actions. To overcome the limitations associated with collective effective dose, each relevant exposure situation must be carefully analyzed to identify the individual characteristics and exposure parameters that best describe the exposure distribution among the concerned population for the particular circumstance."* [43].

When optimizing the protection strategy, it is necessary to consider the possible protective and other actions across all phases of an emergency response to ensure that the protection strategy provides confidence that all the goals of emergency response continue to be achieved, notably that:

- Doses that may result in severe deterministic effects are avoided;
- The risk of stochastic effects is reduced below levels at which an increased incidence of radiation induced health effects would be observed; and
- The residual doses are kept 'as low as reasonably achievable' (ALARA), social and economic factors taken into account.

The reference level was first introduced by ICRP [10, 43] as a tool for optimization of protection and safety that applies also for emergency exposure situation. The reference level is the level of dose above which it is not appropriate to allow exposures to occur and below which optimization of protection and safety would continue to be implemented [1, 2]. The reference level is to be used as a boundary condition for optimization of protection and safety. In this context the term 'constraint optimization' is used [1, 10]. This would mean that, while first priority is always given to actions that prevent or reduce doses that may lead to health effects that can be attributed to exposure to ionizing radiation, at the next stage resource allocation is such that priorities are then given to reducing exposures that are above the reference level, to optimized levels (which are usually expected to fall below the reference level), using justified response actions. Optimization will need to be applied at doses below the reference levels as well, provided that justified actions to do so have been identified.

Finally, the process of optimization is aimed at achieving the most overall benefit, and not an equal level of protection for every individual or community. This may lead to differences in planning and implementation that may be difficult to explain.

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
Legislation and regulations	• How does any relevant legislation and regulations affect the implementation of the actions? • Which options result in reducing exposure below a pre-set reference level and gives rise to the greatest benefit? • Are the criteria flexible enough to accommodate unexpected events or developments?	• Legislation and regulations including any international legal instruments, bilateral or multicultural agreements associated with radiation protection, safety and with other areas, e.g. crisis management to determine whether and how they might affect implementation of various options and decision-making on these options. • The residual doses associated with the options and comparison with the relevant reference level to identify the options that provide the best protection under the prevailing circumstances. • How any deviation from pre-planned options might be undertaken to meet actual circumstances.
Nature of the emergency	• How does the extent and nature of the release affect implementation of actions? • How does the size of the impacted area and/or the number of people affected influence implementation of the actions? • How does the implementation of actions interact with other actions being taken?	• The effect of the following characteristics of the release on the implementation of actions including the possibility for them to be known, with sufficient accuracy, at the time of an emergency: o Release start, effective height and duration; o Source term involved. • Prevailing conditions at the time of emergency. For example, frequently occurring conditions or those that have been present in past emergencies need to be considered to allow for flexibility in the operational arrangements. Once an emergency has occurred, the actual conditions drive the optimization process, with due consideration of the limited information available. • The areas impacted, number of people affected, available resources to implement the actions and time needed to do so. For example, where a large number of people are involved, an optimized approach may suggest that phased implementation and/or a combination of actions may be necessary to achieve the goals of emergency response (e.g. by placing initial priority on those receiving the highest doses to ensure that severe deterministic effects are avoided, to the extent possible). • The combination of protective actions that may be necessary; delaying or bringing forward some actions or implementing actions in

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
		parallel may optimize the overall effect of response (e.g. by enhanced effectiveness or by reducing the overall detriment associated with implementing the actions).
Radiation protection	• Which implementation option leads to the best protection under the prevailing conditions?	• An assessment of the exposure scenarios and dominant exposure pathways (to the public and workers) associated with each option and identification of options that result in the best protection under the prevailing conditions. This involves taking account of: o Levels of radioactivity present in the living environment (dose rates, surface activity concentrations, activity concentrations in samples); o Levels of radioactivity present in food, milk and drinking water; o Levels of radioactivity present in non-food commodities; o Dose to the public (projected doses, received doses, residual doses); and o Dose to the emergency workers and helpers. • The best protection under the prevailing conditions needs to be judged by the ability to keep the number of individuals exposed, the magnitude of doses and the likelihood of exposure ALARA, and not based on the lowest possible dose.
Timing	• How does the expected duration of the action affect its implementation?	• The timescale over which doses may be and/or are received. For example, considering if it is possible to implement some options in a way that will reduce their longer-term impact (e.g. by making arrangements to reduce the level of disruption and discomfort associated with temporary accommodation).
Efficiency	• How do external factors (such as natural events, other relevant events, season of the year and weather conditions) affect the feasibility of implementing any of the options? • What effect do technical, social, environmental, economic	Critical processes or infrastructure may be affected by external factors and the impact and consequences this may have on implementing the action. For example, an earthquake or severe weather conditions might lead to damage or loss of infrastructure needed to access and move people away from the affected area, and therefore affect the

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
	limitations have on the ability to implement each option?	implementation of evacuation and, possibly, the relative effectiveness of evacuation and sheltering. • Some factors, e.g. the weather, cannot be known in advance. These may be considered by providing suitable flexibility in the operational arrangements, by taking account of past experience, aimed at enabling adaptation of the response to the actual circumstances. For example, a severe storm at the time of the nuclear or radiological emergency might render the evacuation unsafe and impractical. • The social acceptability of protective actions may impose limitations on the options (e.g. extended duration of sheltering). There may also be options for implementation that would increase the acceptability of action (e.g. allowing time for making arrangements and moving or sheltering with family members). • Efficiency of actions in reducing residual doses to below a predetermined level or in decreasing the number of individuals affected. Account need to be taken of the efficiency of processes, technologies, etc. supporting the implementation of the action. For example, the efficiency of ITB depends on distribution arrangements and timing for its administration. • The impact of actions on other actions, raising the necessity for other actions and rendering others ineffective etc.
Resources	• What human resources are necessary to implement the options? • What infrastructure is necessary for implementing the options? • What materials and equipment are necessary for implementing the options? • What financial resources are necessary for implementing the options? • What logistical support is necessary for implementing the options?	• The number of people needed to implement the option and the knowledge and skills required and consequent exercise and training needs. • The infrastructure needed to implement the options and the infrastructure that is available, or could be made available, in order to determine the best protection strategy and implementation of each action. For example, transport and temporary accommodation infrastructure will need to be identified, from those existing, for the evacuation of people. While for waste treatment, storage and disposal, facilities are needed that may not be available at the time.

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
		• Materials and equipment necessary for implementing the action and those that are available, or could be made available, in order to determine the best protection strategy and implementation of each action. Examples may include stable iodine tablets for implementation of ITB; specialised equipment, such as suitable devices for radiation monitoring of foods in support of food restrictions); trucks, buses etc. needed to move goods or people to implement evacuation. Chemicals and other means/resources may also be necessary for decontamination and decorporation. • The costs needed to implement each of the options, taking account of the human and technical resources identified above. As an example, the costs include the salaries of workers, the costs associated with the purchase or use of the necessary facilities, equipment and materials. • The forms of logistical support required to implement each of the options. For example, logistics needed to support communications between emergency centres and the workers implementing the actions, logistics needed to support the well-being of evacuees.
Environmental aspects	• How does the nature of the local environment affect or how would it be affected by the available options?	• The characteristics of the local environment determine the impact each option might have on the environment and the potential effect the environment may have on the implementation of the options. (e.g. on restrictions on local produce). • The characteristics of the local environment may also affect the efficiency with which some actions may be implemented. Namely, the type of affected area (e.g. urban, recreational, industrial, agricultural, forest, etc.) influence the use people make of the area and potential exposure pathways, which, in turn, have an effect on the implementation of actions (e.g. the length or type of food restrictions may depend on the proportion of agricultural land and forest in the local area; the latter may be a source of semi-natural produce that may retain higher levels of radioactivity and may therefore warrant

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
		specific actions). • The geographical location of area and associated characteristics need to be considered as they affect the implementation of options. For example, the inaccessibility of mountain areas might affect the movement of people e.g. during evacuation, and the proximity of the sea in coastal areas might result in shipping or other restrictions becoming necessary. The geology of the area (groundwater characteristics, soil type, etc.) affects, among other things, agricultural practices and the balance of exposure pathways and the implementation of protective actions, e.g. food restrictions.
Economic aspects	• What are the direct costs associated with implementing the options? • What are the indirect costs associated with implementing the options? • What compensation costs are associated with each option?	• The direct costs are those directly associated with the implementation of the option. This is related to the identification of resources (noted above). Depending on the option under consideration, these costs may include: salaries of workers, costs associated with equipment and additional use of infrastructure, consumables (fuel, food, heating etc.), ongoing sampling and measurement costs, waste management costs. • The indirect costs are those that are indirectly associated with the implementation of the option. These may include: the loss of revenue from businesses in affected areas (for example during evacuation); losses of use of other facilities (e.g. tourist sites arising during any access restrictions); and costs associated with loss of confidence in goods, e.g. foods subject to restrictions, and the consequent drop in sales. The evaluation of these costs requires consideration of the expected market response and its evolution with time. • Indirect costs may also arise from interruptions in international trade. This may occur if an area associated with major trade routes, such as a major port, is affected. It may be possible to consider implementation of options that reduce the impact on international trade (e.g. by providing alternative routes for supplies) • The basis for compensation costs are likely to be determined by established liability regime.

TABLE 4: FACTORS AND CONSIDERATIONS IN THE PROCESS OF OPTIMIZATION

Factors	Examples of relevant questions	Examples of relevant considerations
Social and ethical aspects	• What level of social disruption is associated with implementing the options? • How does feedback from interested parties influence the choice of options? • How can we compare and optimize factors such as economic costs, dose reduction and social disruption?	• The level of disruption in the lifestyle and living conditions, of individuals and communities, resulting from the options. Very disruptive options (e.g. large-scale evacuation) are likely to lead to stress or psychosocial reactions, although it may be possible to implement options in a way that reduces such outcomes. • The outcome of any consultation with interested parties on the implementation of protective actions and their perspectives on the relative acceptability of different options. However, it is important to note that decision-making remains the responsibility of the authorities and that social acceptability ought not to be the main driver in such decisions since this may lead to taking unjustified actions, which may lead to cause long term damage. • Socioeconomic aspects, including implementation of options to help promote maintenance of public trust and credibility of authorities, (e.g. related to the development of suitable communication strategies associated with some actions and options). • Ensuring available medical care and other public services to allow for the well-being of affected populations.
Waste	• What are the quantities and types of radioactive waste related to the implementation of the options? What effect does the availability of waste disposal routes have on the implementation of the options?	• The volume and characteristics of different types of waste arising from the implementation of different options in order to determine whether there are significant differences that may influence the choice of option. • The practical constraints associated with different options arising from characterization; pre-disposal management and for minimization of the amount of waste; and the availability of waste management facilities.

5.4. Justification and optimization in response

The approach to justification and optimization of protection and safety is likely to differ between the emergency response phases and transition phase of an emergency, as well as between the emergency response stage and the preparedness stage. The different approaches are driven not only by the assumptions made at the preparedness stage (e.g. on the possible evolution of the emergency) in contrast to the actual circumstances of a given emergency, but also by considerations of timing to allow effective protection of the public and the amount of information available to support decision making.

During the emergency response, doses incurred by individuals after the protection strategy is implemented are compared against the applicable reference level. The use of reference level in the response provides an opportunity to assess the effectiveness of the implemented protection strategy and the need for its adjustment to address the prevailing circumstances. With this adjustment, further protective actions (including the resources available at the time) can be determined and implemented so that they focus on those groups/individuals whose doses exceed the reference level, i.e. those who need such protective actions the most.

5.4.1. Urgent response phase

The initial priority in the response is to implement precautionary and urgent actions to prevent people receiving high doses and being exposed to high dose rates. Immediately following the declaration of an emergency, the focus needs to be on the implementation of precautionary and urgent protective actions based on observable or plant conditions and in accordance with established emergency plans. These actions are justified and optimized at the preparedness stage, and no further considerations to justification and optimization are expected at this time. However, even in initial implementation, it may become necessary to review the appropriateness of the pre-justified protective action or protection strategy before progressing. For example, an earthquake or severe adverse weather conditions may have destroyed or severely damaged transport infrastructure, making it dangerous to move people as planned and to necessitate alternative protective actions to be taken. Such eventualities need to be considered in the protection strategy at the preparedness stage, to allow for safe and effective implementation in the response and without causing unnecessary delay.

5.4.2. Early response phase

Once the adapted protection strategy (see Section 2) has been implemented, taking account of the specifics of the situation, it is necessary to periodically reassess the situation to determine whether the protective actions and the protection strategy continue to be justified (by doing more good than harm) and to provide the best under the prevailing circumstances, considering any new information that becomes available. Such a reassessment is particularly necessary when there is a marked change in the release or in the information available, e.g. about the pattern of deposition that could lead to a substantial revision of the adapted protection strategy.

Once those most at risk have been identified and appropriate urgent protective actions have been taken, there is a shift in priority from implementing the urgent protective actions to the characterization of the situation and expansion or withdrawal of urgent protective actions and implementation of early protective actions, based on limited justification and optimization processes to account for any major deviation from the assumptions made at the preparedness stage. The decision making process during the early response phase, including the justification and optimization components, is presented in Fig. 8 as an iterative process.

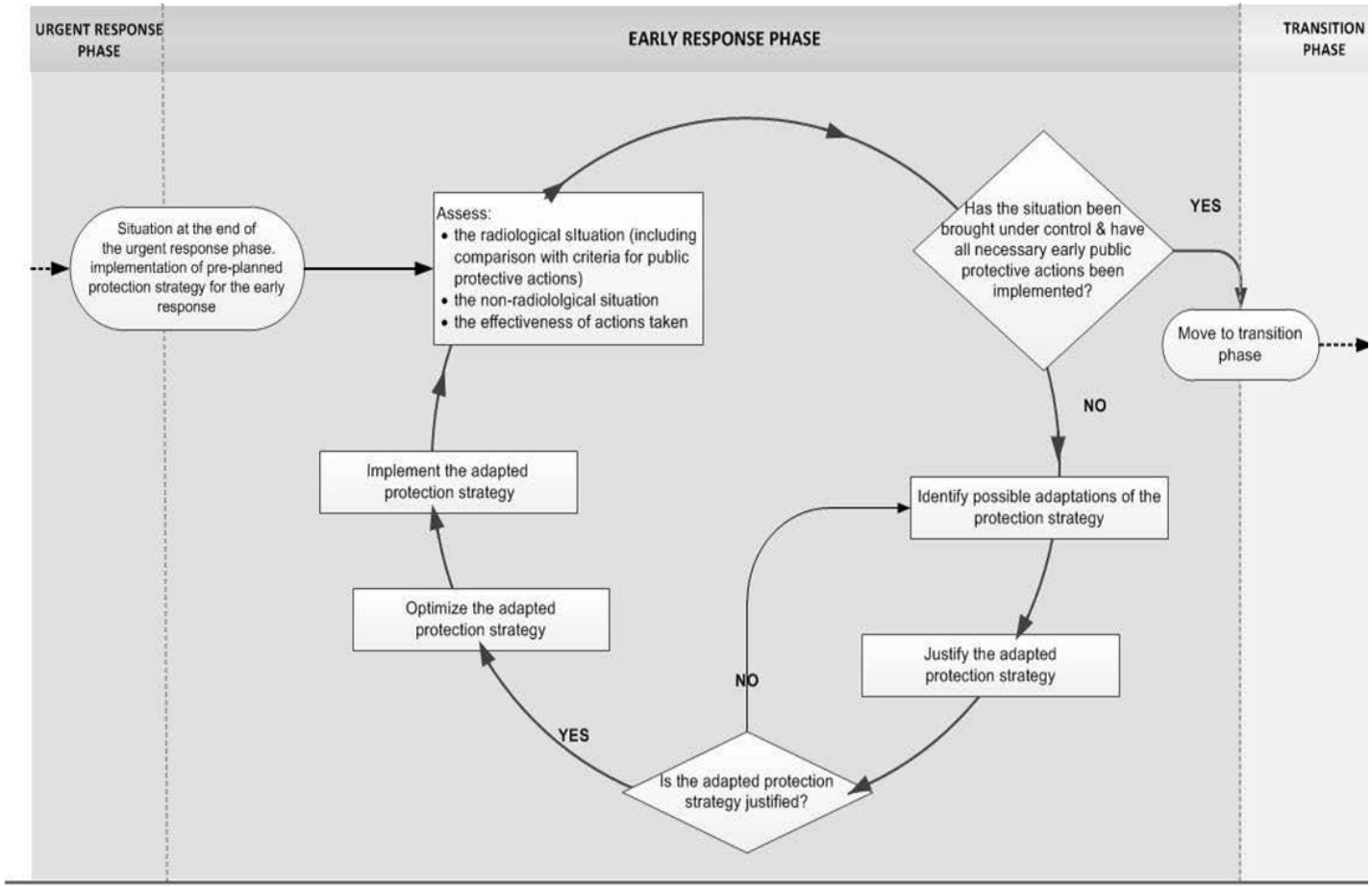


FIG. 8. The iterative assessment process for decision making during the early response phase, including justification and optimization processes.

5.4.3. Transition phase

Once the emergency situation has been stabilized, medium and longer term considerations, such as ensuring the conditions are met to lift protective actions and/or to return to normal social and economic activity, become increasingly in the focus of the emergency response [8]. Activities and actions planned and implemented in this period are likely to be less urgent and subject to consideration of more reliable information that becomes available.

Thus, full justification and optimization are implemented during this time to ensure the protection strategy does more good than harm at any time and provides for the best protection. The process of adapting the protection strategy during the transition phase is illustrated in Fig. 9. During the transition phase, emergency response efforts are increasingly focused on restoring the functionality of communities, therefore requiring an optimization approach that is necessarily emergency- and site-specific.

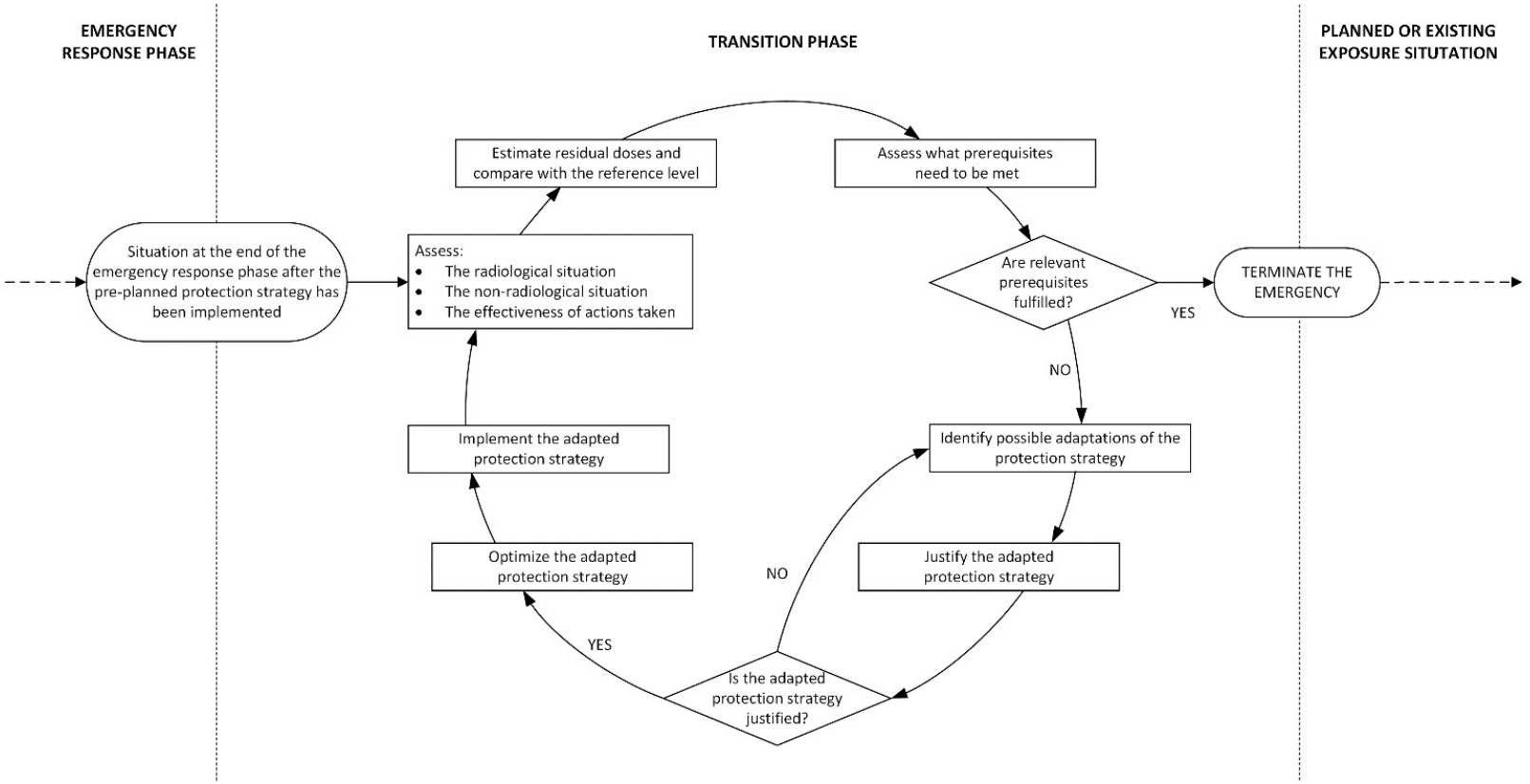


FIG. 9. The iterative assessment process for decision making during the transition phase, including justification and optimization processes.

6. CONSULTATION WITH INTERESTED PARTIES

The success of response to any nuclear or radiological emergency depends not only on the availability of well-prepared, comprehensive emergency arrangements or on the efficiency of the protection strategy to limit the radiological impact and other consequences on the people and the environment. Success also depends on the extent to which the public and emergency workers adhere to these arrangements, which, in turn, depend on their acceptance of the adopted protection strategy, and the arrangements put in place to implement it. The degree of acceptance is enhanced by ensuring that interested parties[6] are suitably informed and consulted about the protection strategy at the preparedness stage and during response, where this is possible without compromising the effectiveness of protective actions and other response actions. The objective of consultation, the people consulted, and applied consultation means depend on the stage or phase in which it occurs, as described in more detail in this Section. Other general considerations, relevant to all forms of consultation are considered, before describing those specific to each stage of consultation.

General considerations

6.1.1. Objectives of consultation

The engagement of interested parties in the development of the protection strategy at the preparedness stage helps to ensure that the protection strategy addresses the concerns of the local community, thus enhancing societal acceptance of the pre-planned protection strategy. Furthermore, effective consultation contributes to building public trust in the credibility of the authorities. It also helps to foster relationships with community leaders and to build and maintain partnerships. Therefore, effective consultation promotes both the state of readiness of emergency workers and enhance the community resilience[7] to deal with a nuclear or radiological emergency.

This highlights the importance of ensuring that, at the preparedness stage, interested parties are sufficiently engaged to develop an understanding of the underlying rationale for the protection strategy and the consequences and limitations associated with different protective actions and other response actions. In the process, they also gain an appreciation of the significance of building flexibility into the protection strategy to allow it to be adapted during the early response phase and the transition phase to the specific conditions that exist at the time of an emergency.

The effectiveness of consultation depends on all parties understanding the objectives of the process and having realistic expectations of the outcomes. Some groups may have unrealistic expectations, for example regarding the acceptable levels of exposure or contamination levels, and the priorities of different groups may conflict with one another such that the available resources might not be sufficient to meet all expectations. Therefore, although the emergency management authorities need to consider the concerns and opinions expressed by interested parties, it is important that their decisions are focused on delivering the highest possible benefit for the community at large.

Active involvement of interested parties in the adaptation of the protection strategy during response is also beneficial in promoting acceptance and empowering local groups to

[6] An interested party is a *"person, company, etc., with a concern or interest in the activities and performance of an organization, business, system, etc."* [1].

[7] Community resilience is the capacity of a community to be able to recover quickly and easily from the consequences of a nuclear or radiological emergency [8].

undertake actions, as appropriate, thus enhancing the perception of autonomy among the affected population. However, it is important to ensure, especially during response, that consultation with interested parties does not unduly delay the process of adapting the protection strategy or taking decisions to enhance the effectiveness of protective actions.

6.1.2. The interested parties

It is assumed that the relevant government departments, response organizations, operating organizations and other authorities with a direct involvement in emergency preparedness and response are involved in the development of the protection strategy. Other interested parties, upon which the effective implementation of the protection strategy depends and who were not directly involved in the early stages of developing the strategy, need to be consulted. Examples of such parties include:

- Representatives of response organizations, which are not directly involved in supporting the national coordinating mechanism or in the development of the protection strategy, for example representatives from ministries or other governmental agencies at all levels;
- Representatives of various response organizations with responsibilities for operational aspects of emergency response or recovery operations (e.g. police department, fire department, civil protection, defense organizations), including employers or representatives of designated emergency workers at all levels (including regional and local authorities that will have the responsibility to implement established emergency plans on a local level);
- Those who are or may be directly affected by an emergency at a particular location, such as specific communities or groups of the population, representatives from industry (e.g. food production sectors) and the population at large;
- Representatives of other States (especially neighbouring States) at national, regional and local levels, that have entered into agreements providing for the exchange of information concerning possible transboundary impacts and whose population might be directly impacted by the transboundary consequences of an emergency;
- Representatives of ministries, other governmental agencies or regulatory bodies in other States concerned with the import or export of certain food products, consumables, materials or technologies.

The precise composition of the groups of consulted interested parties is likely to differ according to the hazards identified in each State and the potential consequences of the postulated emergency scenarios considered in the protection strategy. Moreover, different interested parties may be involved in consultation during the development of the protection strategy and associated arrangements and in their adaptation to reflect actual conditions as they evolve during response. More local and site-specific involvement may therefore be necessary in consultations on arrangements than on the contents of the protection strategy itself. During the emergency response phase, the range of interested parties consulted need to be selected on the basis of the specific characteristics of the situation (i.e. the type and scale of emergency, the range of consequences, and the phase of the emergency response) and the priorities for response.

6.1.3. The timing of consultation

As shown in Fig. 10, the extent of consultation differs markedly between the preparedness stage and throughout the various phases of emergency response.

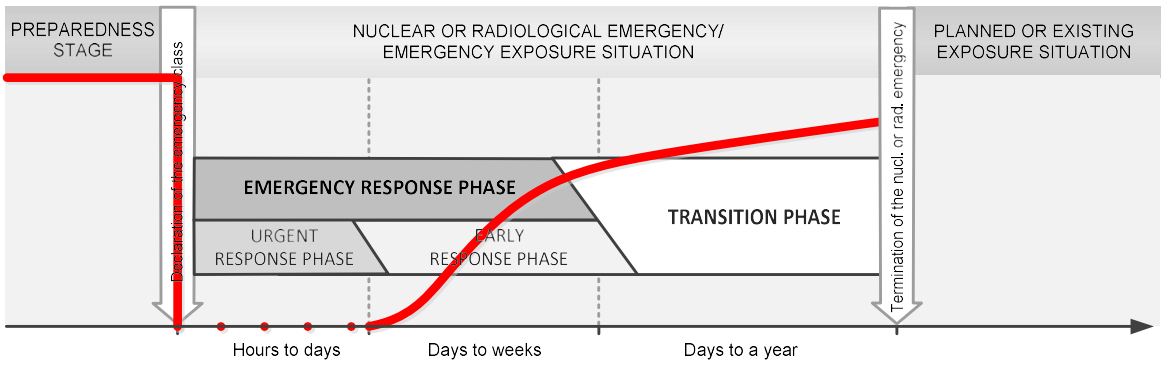


FIG. 10. Involvement of, and consultation with, interested parties during different phases of a nuclear or radiological emergency [8].

During the urgent response phase, the effectiveness of protective actions and other response actions is critically dependent on their urgent implementation such that there is insufficient time to allow consultation to take place. Consultation is thus likely to be limited or non-existent in the urgent response phase but would be expected to increase as the early response phase develops and during the transition phase, as the situation stabilizes (see Fig. 10). It is anticipated that progressively more consultation occurs as time permits, and as more information becomes available for the full characterization of the situation needed for longer term decision making. During the transition phase, it is possible to increase the involvement of interested parties in the adaptation of the protection strategy, while not delaying its optimal implementation.

6.1.4. The process of consultation

Effective consultation with relevant interested parties necessitates the establishment of an appropriate communication mechanism. The processes for consultation need to be based on the principles of transparency and inclusiveness by ensuring that all relevant and necessary information is provided in plain language so that interested parties can form their own informed opinions. Shared accountability and the development of measures (e.g. key performance indicators) that allow the effectiveness of the process to be evaluated are also essential. Finally, processes that allow for feedback to be accommodated in a timely fashion in the overall decision making process also need to be considered in the consultation process. Communication and evaluation issues are described in more detail in Sections 6.1.5 and 6.3, respectively.

At the preparedness stage, while developing the protection strategy, mechanisms to consult with interested parties about the elements that they consider need to be taken into consideration in the formulation of the protection strategy and the associated emergency arrangements (see Section 6.2.1). At this early stage, arrangements to interact with interested parties during response also need to be defined and agreed (see Section 6.2.2) as part of the protection strategy, so that they can be activated during response (see Section 6.2.3).

The different aspects of consultation are necessarily closely related, although their focus differs according to their role within the context of emergency preparedness and response. Furthermore, different consultation mechanisms may need to be established to consult with different groups, at different times at the preparedness stage and during the response. For example, different processes are likely to be appropriate for those potentially or actually impacted by the consequences of the emergency and those with a more general interest.

Consultation mechanisms may take many forms, ranging from formal hearings (involving a limited number of selected representatives) to public meetings (open to all or large target groups). Consultation may also be undertaken on the basis of inputs from working groups comprising representatives of associations, group leaders, or by open consultation utilizing paper or electronic questionnaires. The mechanisms to involve and consult with relevant interested parties from the local community need to be developed to allow for understanding the particular nature of the community, recognizing the community's specific needs, expectations and capabilities.

The mechanisms used for consultation need to be clearly defined in terms of:

- The objectives of the consultation;
  - Examples include obtaining feedback and views on the criteria for public protection during the different phases of the emergency and on the actions that are considered within the protection strategy.
- The targeted interested parties;
  - Depending on the objectives and time of consultation, the targeted interested parties may include a range of parties, such as those identified in Section 6.1.2.
- The applicable legal and regulatory requirements;
  - These may include national legislation, international instruments, standards and guidance based on best practice which call for consultation with interested parties;
  - If relevant legal provisions do not currently exist, they need to be included in future legislation and provisional arrangements need to be established in the interim.
- The timeframes for effective consultation;
  - This includes taking account of the deadlines for successive steps of the development of the protection strategy, the time necessary to collect, analyse and address the comments and to provide the necessary feedback and presentation of a revised protection strategy. The timescale available for the consultation during the preparedness stage is longer than is feasible during the response to an emergency and needs to lay the foundations for consultation and communications in response.
- Relevant documents to be published or otherwise made publicly available;
  - These may include discussion documents describing proposed changes to relevant legal documents, the rationale for the changes; draft regulations strategies and emergency plans.
  - Depending on the nature of documentation, it may be necessary to include an executive summary in plain language to clarify technical content for a general audience.
- Ways in which the interested parties may comment, directly or through representative consultative bodies, on relevant documents;
  - This may include electronically distributed and completed questionnaires with open fields for other comments and papers submissions issues requiring feedback.
  - The appropriate means need to be determined and arrangements for distribution, e.g. by internet or post, need to be arranged.
- Possibilities for communicating with interested parties through appropriate means of consultation;

- This may include public meetings, formal hearings, and interaction with focus groups. The mechanisms appropriate at the preparedness stage may differ from those applicable during the different phases of response.
- During the preparedness stage, it is necessary to identify the most appropriate means for consultation including the range of invitees, the size and facilities for the venue, recruitment of appropriate moderators for meetings or hearings.

– Arrangements for reviewing and assessing the result of the consultation;

- This will include identification of the authorities and expertise that need to be involved in the process, and in the analysis of the feedback received and in proposing appropriate means of addressing it.

– Provisions to consider the result of the consultation in the decision making processes;

- This will include defining final decision making processes to address the received feedback, and providing feedback on how the issues or documents had changed as a result of the inputs received during the course of consultation.

Some examples of the interested parties and the means of consulting them at the preparedness stage and during emergency response are provided in Table 5.

TABLE 5: EXAMPLES OF THE INTERESTED PARTIES LIKELY TO BE CONSULTED AT THE PREPAREDNESS STAGE AND DURING EMERGENCY RESPONSE, AND THE MEANS OF CONSULTATION

WHEN	WHO	HOW
Preparedness stage	Various authorities and/or their representatives not directly involved in the development of the protection strategy	Individual hearings, working groups
	Emergency workers	Working groups involving representatives, web-based or paper questionnaires
	Communities, associations, economic organizations	Working groups with representatives, enquiries, web-based or paper questionnaires
	General public	Enquiries, web-based or paper questionnaires
	Potentially affected populations	Enquiries, web-based or paper questionnaires, public meetings
	Authorities in neighbouring States	Bilateral or multilateral dialogues, meetings or working groups, public hearings, working groups involving representatives
	Authorities in other relevant States	International working groups (for example, led by regional and international organizations)
During response	Communities, associations, trade and industry organizations	Individual or small groups hearings (involving representatives)
	Various authorities or their representatives	Individual or small groups hearings (involving representatives)
	Affected populations	Individual or small groups hearings (involving representatives)
	General public	Monitoring of the media, information requests to call centres, through local authorities
	Authorities in neighbouring States	Audio- and videoconferences, exchange of liaison officers
	Authorities in other relevant States	Audio- and videoconferences, response to enquiries organized on international web platforms, international working groups

6.1.5. Communication

In order to allow interested parties to take a meaningful part in consultation processes, they need to be provided with suitable background information and, where appropriate, be involved in discussion. This could be achieved in advance of consultation, particularly when site-specific arrangements are under consideration. Alternatively, such information may be provided in parallel with the consultation process as plain language background information to explanations regarding suggested solutions for public protection. Examples of the types of information include:

- The nature and characteristics of the local site and the possible consequences which could arise as a result of an emergency, the way in which people and the environment might be impacted and how they would be protected against harmful effects;
- Simplified conclusions from the hazard assessment if available and as appropriate. It is unlikely that sharing detailed technical analysis of the hazard assessment would be appropriate or helpful;
- Relevant aspects of radiation protection and emergency preparedness and response (for example dose, health effects, the means of public protection in an emergency, the goals of emergency preparedness and response, and the emergency arrangements in place), depending on the needs of the targeted parties and the topic on which they are being consulted;
- A description of the most probable protective actions which would be implemented in the event of an emergency, their protection mechanisms, their efficiency and benefits, their costs, drawbacks and limitation and possible alternatives if any;
- The constraints at national, regional and local levels, for example on available means and manner evacuation (e.g. buses, external decontamination facilities);
- The expected contribution of targeted interested parties to the development and effective implementation of the protection strategy, depending on their roles and areas of concern. These would be expected to differ for example among local authorities, rescue teams, teachers, representatives from food, agriculture, fisheries and other forms of local commerce, international trade, tourism, environment. However, the involvement of such parties contributes to ensuring shared accountability for the effective implementation of the agreed suite of protection and safety measures.

It is necessary to take account of the fact that the representatives involved in the consultation process are likely to change with time, and hence memory of previous information and consultation cannot be assumed, and this information may need to be refreshed on an appropriate timescale. Consultation may need to be repeated whenever the protection strategy is revised or when significant changes are made to the associated emergency plans. Additional consultation may also be necessary if there are changes in the structure of the community (e.g. extension of a city, installation or reconversion of industrial plants). Suitable background information needs to be provided in advance and during each consultation process.

During the consultation process at the preparedness stage, the results of the consultations need to be communicated to the interested parties and to other groups, as needed. The protection strategy and rationale, on which it has been developed, need to be widely communicated. Communication strategies appropriate for specific groups of interested parties need to be made available, as necessary. Transparent feedback also needs to be provided in a timely fashion regarding the extent to which interested parties' input has been integrated into the protection strategy and the associated rationale.

During the emergency response phase, there is not much time for consultation but it is important to provide information to interested parties on the specifics of the actual emergency and the means to effectively implement the agreed protection strategy and any necessary deviations from planned actions. In particular, it is necessary to provide information about the geographical and temporal differences calling for diverse protective actions and other response actions.

From the transition phase onwards, consultation processes are re-established to provide input to the adaptation of the pre-established protection strategy to take account of the actual circumstances. The rationale for these adaptations needs to be communicated appropriately and in a timely manner. The aim during this period is to increase the level of engagement and consultation with interested parties, while not compromising the effectiveness of response and recovery efforts.

6.2. Consultation on the protection strategy during different phases

Consultation on the protection strategy during different phases is considered in this section, namely:

1. Consultation at the preparedness stage on the protection strategy and on its practical implementation in the development of relevant emergency arrangements (such as emergency plans);
2. Processes for the engagement of and consultation with interested parties during emergency response (primarily during the transition phase);
3. Consultation during emergency response, particularly during the early response phase and the transition phase.

6.2.1. Consultation on the protection strategy at the preparedness stage

As stated in Section 6.1.1, the engagement of the interested parties in the development of the protection strategy at the preparedness stage helps to ensure that the protection strategy addresses their concerns, which fosters trust, credibility and societal acceptability of the pre-planned protection strategy. It also helps to promote acceptance and the perception of empowerment among the affected population and to enhance the community resilience for dealing with a nuclear or radiological emergency. However, it is important to ensure that the process of engagement and consultation does not affect the timely development of the protection strategy.

Consultation on the contents of the protection strategy is likely to take place at a national, federal or state level, while consultation on its implementation in the form of emergency plans, procedures and other arrangements may include more region and site-specific components. Therefore, different processes and people may be involved in these consultation processes.

Consultation on the protection strategy includes representatives of governmental, regulatory, industry and trade and response organizations, in addition to members of the public. The issues of interest to these groups may differ, for example:

– The governmental bodies and other organizations would have an interest in the general objectives of the protection strategy and the possible justified means to meet these objectives and the optimized choice according to pre-identified emergency scenarios, taking account of site-specific and local circumstances. These choices are also be the subject of consultation with other interested parties, by means of an appropriate mechanism.

- Response organizations would have an interest in, among other things, the identification of emergency workers and helpers, their roles and responsibilities and means for their protection, taking into account the available resources in manpower and equipment and the benefits and exposures associated with the assigned responsibilities.
- Trade and industry groups would have an interest in the impacts of the emergency itself and of the protective actions likely to be implemented on their business and the means to minimize the impacts and to recover or compensate losses.
- Members of the public and their representatives would be interested in the means by which they can be protected in an emergency.

The interested parties targeted to take place in consultation depend upon the objective and topic under consideration. Consultation on the protection strategy itself is likely to include the involvement of national or regional representatives of types of organization and public interest groups (e.g. charities, for the protection of children, the elderly, and animals). On the other hand, consultation on the emergency plans and arrangements developed to implement the protection strategy may involve engaging members of the local communities or their representatives, to take account of local conditions and site-specific considerations. For example, the population living in an area within an emergency planning zone around a nuclear facility are likely to be consulted to translate the protection strategy into specific arrangements that are appropriate for the local circumstances. More examples are given in Table 6.

Taking into account the potential for transboundary consequences of emergencies at (a) EPCs I and II facilities, and (b) activities or acts in EPC IV events close to the States' border, it is likely to be necessary to establish bilateral agreements with neighbouring States to foster cross-border coordination and, where possible, harmonization of approaches to emergency preparedness and response. These agreements need to include mechanisms for information exchange and consultation on the protection strategy, and emergency preparedness and response in general, with official representatives at State and local level and with local communities that might be directly impacted by the transboundary consequences of an emergency in the neighbouring State. The consultation is likely to focus on designing a common approach regarding protective actions which be applied on both sides of the border.

Consultations among States engaged in the import or export of foodstuffs and commodities that may be impacted in an emergency are also necessary to define a coherent approach regarding the control of food products and commodities. It is important that such consultations include setting criteria for international trade, and that they build on those consultations already occurring at the international level regarding international standards, guidance and codes of practice.

TABLE 6. EXAMPLES OF THE INTERESTED PARTIES CONSULTED AT THE PREPAREDNESS STAGE, THEIR PRIMARY AREAS OF INTEREST AND MEANS OF CONSULTATION

WHO	PRIMARY INTERESTS	HOW
Various authorities and/or their representatives not directly involved in the development of the protection strategy	The objectives of the protection strategy and the possible justified means of achieving them and optimized choices appropriate for pre-defined scenarios	Individual hearings, working groups
Emergency workers	Identification of emergency workers and their roles and responsibilities and the means employed for their protection in an emergency	Working groups with representatives
Communities, associations, representatives from trade and industry	Potential impacts on specific businesses and the means to minimize these impacts and to recover or compensate from losses	Working groups with representatives, enquiries, web-based or paper questionnaires
General public	How they will be protected in an emergency	Enquiries, web-based or paper questionnaires
Authorities in neighbouring States	Protection strategy, criteria and protective actions that may affect citizens in neighbouring States or that may need to be implemented in neighbouring States	Bilateral or multilateral dialogues, meetings or working groups
Authorities in any State	Criteria and approaches used to control the import and export of foods and commodities that may be impacted by an emergency	International working groups (led by regional and international organizations)

6.2.2. Processes for engagement of and consultation with interested parties

As indicated above, during the early phases of an emergency, the priority is to quickly respond to the situation. The time pressure is such that there is little or no time to interact with interested parties. Thereafter, consultation processes in response are likely to involve those parties that have particular responsibilities for aspects of emergency response or recovery operations or who are directly affected by a specific emergency at a particular location. In preparing for such processes, arrangements need to be made for the full range of emergencies and for different locations.

During the early response phase, limited interaction is likely to take place with representatives of local authorities (regarding adapting or lifting urgent protective actions, and for implementing additional protective actions and other response actions) and with representatives of sectors of the community or industry or trade groups, for example education, hospitals, prisons or industry or trade sectors with limited buffer capacities (e.g. dairy farming).

During the transition phase, the level of interaction with interested parties needs to increase progressively. An increasing number of interested parties are likely to be involved due to the gradual transfer of priorities from public protective actions to activities to promote the resumption of normal social and economic activities in the affected areas.

It is also necessary to consider that following the widespread dispersion of a large release (e.g. from an EPC I facility), the considerations and priorities may vary regionally, according

to the level of impact and the different characteristics of the different affected regions. It may therefore be necessary to consult with different groups in order to prepare to adapt the protection strategy to take account of the specific conditions of different areas.

During response, consultation between States, for example regarding issues such as the control of radioactivity in aircraft, passengers and imported stuffs, needs to focus on adopting a coherent approach facilitated by appropriate communication with interested parties in these States at the preparedness stage.

To be efficient, it is essential that the arrangements for consultation in the early phases of the response (i.e. in the early response phase and in the transition phase) are discussed and agreed at the preparedness stage.

The following components of consultation need to be determined at the preparedness stage, in order to allow for efficient and effective consultation during response:

- Responsibilities for initiating and ensuring consultation;
- Appropriate mechanisms for consultation that allow for progressively greater levels of engagement during the early response and transition phases;
- Issues on which consultation is necessary in the early response and transition phases (e.g. application of criteria the conditions to terminate an emergency);
- Identification of relevant interested parties, according to the expected evolution of priorities and allowing for a balanced representation among relevant parties.

It is also necessary to engage the identified interested parties in a manner that ensures that they agree and share a common understanding and expectations of the nature of consultation during emergency response.

6.2.3. Consultation during emergency response

As indicated earlier, the type and degree of consultation will depend upon the situation and the timescales for the consultation varies with the nature of the process and the phase of emergency response.

In the transition phase, consultation becomes an increasingly important component of the response actions and the consultation plan, established at the preparedness phase, may be activated. However, it may also be necessary to consider whether the specific nature of the emergency means that additional interested parties need to be consulted who had not previously been involved at the preparedness stage.

Typical objectives of undertaking consultation during the transition phase are:

- To review and agree the implementation of conditions and criteria to be met to terminate the emergency situation (following on from consultations at the preparedness stage);
- To facilitate the transition process to the new normality (e.g. by preparing people for return from evacuation and informing them of any restrictions necessary to facilitate return);
- To improve coordination arrangements;
- To ensure sustainability of new arrangements;
- To support normal daily activities in the affected areas;
- To improve acceptance of adjustment of protective actions and other arrangements imposed earlier in the emergency response; and
- To facilitate communication processes.

Examples of the interested parties likely to be consulted and their primary areas of interest are provided below. The means of consultation during the different phases of emergency response are summarized in Table 7.

- Governmental bodies and other organizations would have an interest in reviewing the means used to implement the general objectives of the protection strategy to ensure that they continue to be justified and optimized, taking account of the circumstances of the emergency. A broad group of organizations would also have an interest in the resumption of normal social and economic activities.
- Response organizations would have an interest in the managing the changing roles and responsibilities of emergency workers and the means for their protection, taking into account the exposures received, the resources available, and the evolution of conditions during the various stages of the emergency and following its termination.
- Trade and industry groups would have a particular interest in the re-establishment of normal social and economic activities and the measures taken to facilitate this.
- Members of the public and their representatives would be interested in the means by which they are being protected and their effectiveness, the ways in which they could improve their level of protection, for example by self-help actions, the support measures available to them, including health care and psychological counselling, and the activities to re-establish communities and normal social and economic activities.

TABLE 7. EXAMPLES OF THE INTERESTED PARTIES CONSULTED DURING DIFFERENT PHASES OF THE EMERGENCY, THEIR PRIMARY AREAS OF INTEREST AND MEANS OF CONSULTATION

WHEN	WHO	PRIMARY INTERESTS	HOW
Urgent response phase	Nobody	-	No interaction
Early response phase	Local authorities	Defining and implementing necessary protective actions for appropriate populations and areas	Videoconferences Liaisons officers
	Selected representatives of critical sectors (education, agriculture, hospitals, prisons)	Ensuring that the needs of special groups of the population are addressed in adapting the protection strategy to the specific conditions of the emergency	Through the national or regional authorities in charge of the sector (e.g. ministry of education, agriculture, public health, justice)
Transition phase	Communities, associations, representatives of trade and industry	Identification of activities necessary for the recovery of economic activity	Individual or small group hearings (only representatives)
	Authorities in neighbouring States	Continuing coordination regarding adaptation of protection strategy (e.g. return of evacuees)	Audio- and videoconferences, exchange of liaison officers
	Authorities in any State	Continuing coordination regarding criteria and means used to control the import and export of foods and commodities affected by the emergency	Audio- and videoconferences, response to enquiries organized on international web platforms, international working groups
	General public	Means of protection, including following termination of the emergency	Monitoring of the media, information requests to call centres, through local authorities

Although the opinions of interested parties are useful input to adapting the protection strategy, during the response, the ultimate authority and final decisions remain with the decision making body or bodies. If some contributions to the process are not explicitly retained, for example because of a lack of justification, feasibility, resources or conflicting interests, the inputs and the rationale for not retaining them need to be documented.

6.3. Feedback on the consultation process and further improvement

At the end of the consultation process, it is good practice to consult the interested parties on how successful or otherwise they perceive the process to have been. The results of the consultation process may then be compared with the expectations of the participants at all levels (authorities involved and interested parties). This feedback needs to be reviewed in order to provide lessons for the future and a basis for improving engagement with interested parties and consultation into the long term.

APPENDIX I
REFERENCE LEVEL AND GENERIC CRITERIA AND THEIR APPLICATION WITHIN THE PROTECTION STRATEGY

I.1. Reference level

Reference level in an emergency exposure situation, introduced by ICRP 103 [10] and GSR Part 3 [1], relates to the level of effective dose (a range of 20 to 100 mSv, acute or annual) *"above which it is judged inappropriate to allow exposures to occur as a result of that exposure situation, even though it is not a limit that may not be exceeded"*. Thus, it represents an upper constraint on optimization. Namely, the reference levels are introduced as a tool for optimization so that any *"optimisation of protection shall give priority to exposures above the reference level"* with the possibility for the optimization of protection to continue to be implemented below the reference level as long as this is justified, i.e. does more good than harm. As a tool for optimization, reference levels have their roles in both preparedness and response. However, there are some specifics in these roles. For an emergency response during the urgent phase, there is no time for an optimization due to urgency associated with decision making and implementation of protective actions in an effective manner. Therefore, a justified and optimized protection strategy for the urgent phase needs to be considered and agreed at the preparedness stage. However, as the emergency evolves (particularly towards the transition phase), justification and optimization of protection need to take place and reference levels are used for optimization.

During the emergency response, doses incurred by individuals after the protection strategy is implemented are compared against the applicable reference level, thus providing an opportunity to assess the effectiveness of the implemented protection strategy and the need for its adjustment to address the prevailing circumstances. With this adjustment, further protective actions (including the resources available at the time) can be determined and implemented so that they focus on those groups/individuals whose doses exceed the reference level, i.e. those who need such protective actions the most.

The decision to select specific numerical values for the national reference level remains the responsibility of the relevant national authority [8]. This selection depends on a range of circumstances, including national and local conditions (e.g. the prevailing economic and societal circumstances, and the available national, regional and local resources and capabilities), the phase of the emergency under consideration, the practicality of reducing or preventing exposures, and the availability of options to reduce or prevent exposures. Thus, in selecting the national reference level, it is necessary to consider the following:

- International recommendations and findings, notably the recommendations of the ICRP [10], and IAEA safety standards [1, 2, 8];
- Scientific evidence of harm from ionizing radiation, such as the levels at which no discernible increase in the incidence of radiation induced cancers are expected [41]. This helps in prioritizing actions (i.e. applying a graded approach) to protect the affected populations before optimization can be considered;
- Results of the hazard assessment which help to identify the expected levels of projected doses and residual doses and, therefore, help determining the range of residual doses possible to be achieved with implementing the protection strategy;
- Uncertainties in the assessment of hazards, for example by allowing a sufficient margin in the chosen value for the national reference level;

- Availability of options for reducing exposures below the reference level. The estimated residual doses based on the hazard assessment help identify if there are available protective actions to further decrease residual doses;
- Consistency between the national criteria (generic and operational) for implementing specific protective actions and the national reference level;
- Practicability of further reducing or preventing exposures;
- Recognition of the evolution of the emergency. The residual doses are expected to decrease as pre-planned response is implemented and may allow application of different benchmarks at different times and different areas;
- The level at which reference levels for existing exposure situations are set, to allow for a smooth transition from one exposure situation to another;
- The results of justification and optimization processes, taking account of socio-economic impacts, acceptability and the need for transboundary coordination.

The reference level is expressed in terms of residual dose. This is the effective dose expected to be incurred by an individual after protective actions have been fully implemented or in the absence of protective actions if decided so (e.g. no actions taken or protective actions being terminated). As elaborated in GSG-11 [8], the residual dose expresses the accumulated exposure from the initiation of the event through a specified period of time, with account taken of the implementation of the protection strategy, if any. For emergency exposure situations that may result in exposure over a period of less than one year, the residual dose is the total effective dose from all exposure pathways for the entire duration of the emergency. For a large scale emergency resulting in longer term exposures due to residual radioactive material in the environment, the residual dose encompasses the total effective dose from all exposure pathways over one year from the onset of the emergency. For residual doses to be used during the response, the total residual dose includes the doses received from all exposure pathways (received dose) and the doses expected to be received in future (projected residual dose), with account taken of the implementation of the protection strategy, if any [8].

I.2. Generic and operational criteria

Generic criteria and operational criteria are concepts within the protection strategy that are required to be used to implement protective actions and other response actions in a nuclear or radiological emergency, as described in GSR Part 7 [2], GSG-2 [9] and GSG-11 [8]. If the projected dose or the dose that has been received in an emergency exceed the generic criteria, then protective actions and other response actions, either individually or in combination, are required to be implemented. The concept of generic criteria is superseding the former concept of intervention levels. The generic criteria are expressed in terms of projected dose (i.e. the dose that would be expected to be received if planned protective actions were not taken) and received dose (i.e. the dose that is incurred after protective actions have been fully implemented or a decision has been taken not to implement any protective actions) not only for the effective dose but also for the equivalent dose to an organ or tissue and the RBE weighted absorbed dose to an organ or tissue, considering which of these doses is indicative of the radiation induced health hazard (this is an aspect that is not considered under the concept of reference level).

Appendix II to GSR Part 7 [2] provides a comprehensive set of generic criteria to be considered when developing a justified and optimized protection strategy at the national level, including when establishing the national generic criteria. The generic criteria given in Appendix II to GSR Part 7 [2] are considered to be generically justified and optimized and are intended for application (a) when taking protective actions and other response actions to avoid or minimize severe deterministic effects, to reasonably reduce the risk of stochastic effects, and to mitigate the economic impact of an emergency by providing a basis for the resumption

of international trade, and (b) when guiding actions aimed at enabling the transition to an existing exposure situation. These generic criteria are developed considering the UNSCEAR 2012 Report [41] and are grouped in two sets. The first set of generic criteria is associated with doses received within a short period of time (acute exposures) for which protective actions and other response actions are expected to be undertaken under any circumstances to avoid or minimize severe deterministic effects. The second set of generic criteria is associated with doses at which protective actions and other response actions need to be taken to reduce the risk of stochastic effects.

The generic criteria that aim to avoid or minimize severe deterministic effects are associated with doses that, based on the UNSCEAR 2012 Report [41], can result in deterministic health effects in an individual that could be unequivocally attributed to radiation exposure. Hence, these criteria, provided for RBE weighted absorbed dose to an organ or tissue, represent a basis for taking precautionary protective actions and other response actions within the protection strategy before or shortly after the release or exposures occur, primarily based on observables or plant conditions. Taking effectively such precautionary protective actions ensures that no deterministic effects that could be attributed to radiation exposure are to be observed in any individual. Should doses at this level be assessed to have been received, then they provide a basis for identifying the need for medical examination and screening followed, as required, by medical treatment.

The generic criteria that aim to reduce the risk of stochastic effects are associated with doses that, based on the UNSCEAR 2012 Report [41], can result in an increased incidence of stochastic effects in a population that could be attributed to radiation exposure through epidemiological analysis although radiation induced cancers cannot be unequivocally attributed to radiation exposure on an individual basis. They are provided for effective dose and for the equivalent dose to an organ or tissue. Hence, these criteria provide a basis for taking urgent and early protective actions and other response actions within the protection strategy, either based on observables or plant conditions or based on radiation monitoring results. Taking effectively such urgent and early protective actions ensures that no increase in the incidence of cancers that could be attributed to radiation exposure will be observed in a population. Should doses at this level be assessed to have been received, then they provide a basis for identifying the need for subjecting individuals for health screening and for longer term medical follow-up to detect early and, hence, treat effectively specific radiation induced cancers.

GSR Part 7 [2] and GSG-11 [8] address also protection to be provided at doses lower than the above-discussed internationally agreed generic criteria, i.e. at low doses and low dose rates at which the UNSCEAR Report [41] clearly indicates that increases in the incidence of health effects in populations cannot be attributed reliably to radiation exposure. In this context, GSR Part 7 [2] and GSG-11 [8] emphasize the need for thorough justification and optimization to ensure that (1) the actions taken do more good than harm, social and economic factors being considered, and (2) the protection is the best under the prevailing circumstances which is not necessarily the option with the lowest dose. Should doses at this level be assessed to have been received, there is no need for subjecting individuals to any medical follow-up in relation to early detection and effective treatment of radiation induced cancers.

Operational criteria are associated with directly measurable quantities or observable conditions and are based on the generic criteria. They are derived at the preparedness stage and provide for prompt implementation of protective actions and other response actions within the overall protection strategy without necessity for further assessments. The operational criteria used in the emergency response include observable conditions on the site, EALs and OILs [9]. An OIL is a set level of a measurable quantity that corresponds to a

generic criterion. OILs are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air activity concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples. OILs are used immediately and directly (without further assessment) to determine the appropriate protective actions based on environmental radiation measurements. An EAL is a specific, predetermined criterion for observable conditions used to detect, recognize and determine the emergency class. Example OILs and EALs can be found in GSG-2 [9].

I.3. Dose concepts and their relation

The residual dose, projected dose and received dose, defined in this Appendix, are the three dose concepts used for expression of the reference levels and the generic criteria.

The projected dose and the residual dose considered at the preparedness stage are presented in Fig. 11 for illustration. They are expected to be calculated during the hazard assessment. While the projected dose does not account for any protective action being implemented, the residual dose accounts for the protection strategy in place. In this way, the residual dose allows for planning of what doses might be received in the emergency provided that the protection strategy is implemented effectively. Thus, the residual dose allows for identifying an appropriate numerical value for the reference level to be used in optimization. The difference between the projected and residual dose gives the avertable dose, a concept which was used in the past to justify individual actions through the concept of intervention level [6, 7] but it is not used anymore.

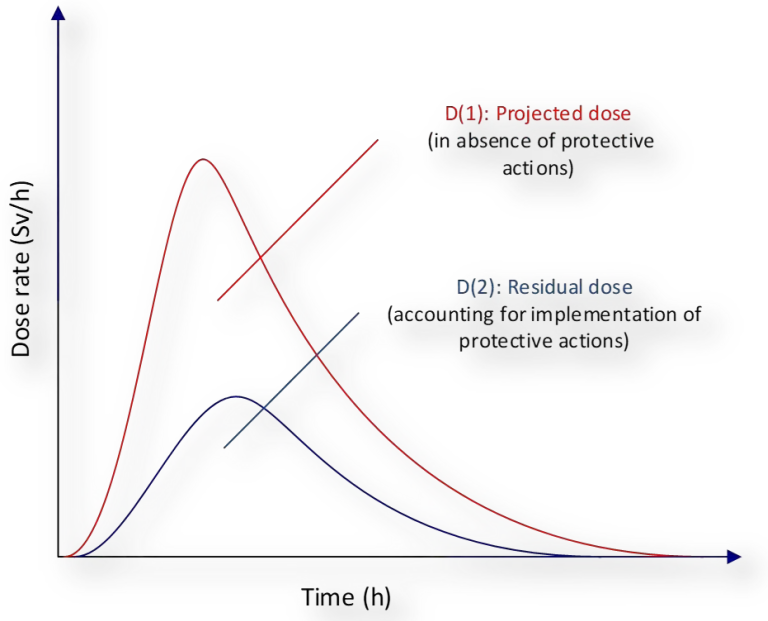


FIG. 11: Assessment of the projected dose and the residual dose at the preparedness stage.

Once in an emergency, the doses that would be incurred after the protection strategy would be implemented can be assessed (see Fig. 12). Should the protection strategy be effectively implemented, the received doses are expected to be below the reference level for the residual dose selected at the preparedness stage. The difference between the projected dose and the received dose in this case provides the averted dose, a concept still in use when assessing the effectiveness of the protection strategy and individual actions.

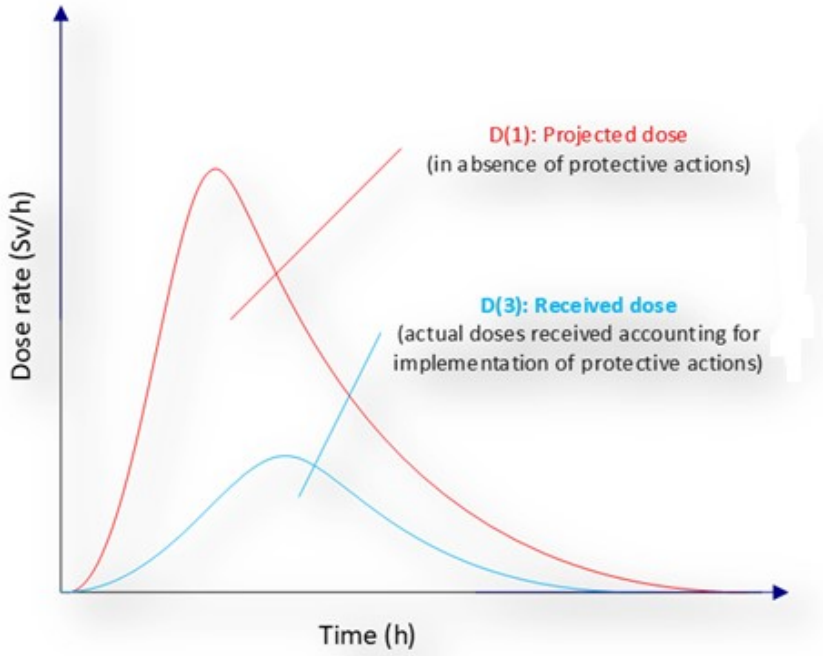


FIG. 12: Assessment of the projected dose and the received dose during the response.

When the protection strategy begins to be adapted and various response actions begin to be considered for adapting and lifting, assessment of the residual doses during the response would need to be used as a tool to assess the effectiveness of the implemented protection strategy, to identify what else needs to be done, and to optimize further options. In such cases, the residual dose would encompass the portion received by the time actions are considered for adapting or lifting, as well as the portion projected to be received after actions are adapted or lifted (see Fig. 13).

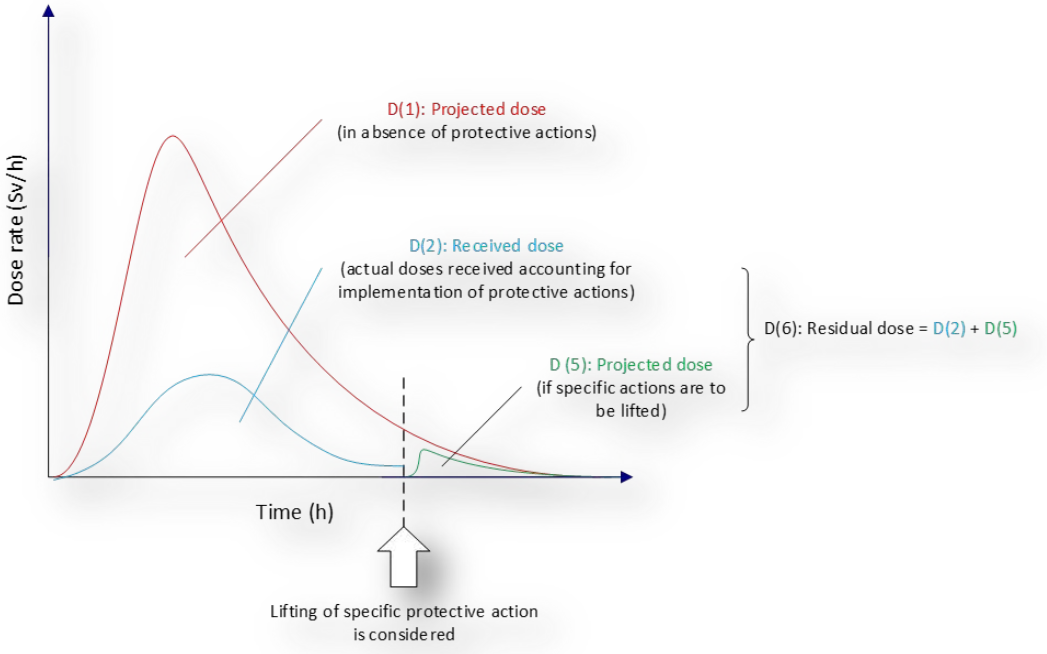


FIG. 13: Assessment of the projected dose, received dose and residual dose during the response.

The goal is that no such doses would be projected to be received in the future that would add to already received doses and result in reaching dose levels at which radiation induced health

effects can be seen. The resulting doses would be planned to be kept below the reference level. However, while the received dose can only be used in relation to identifying need for any medical actions that may be warranted, the optimization further applies to the dose projected to be received in the future.

I.4. Relationship between the reference level and generic criteria

It is a very common misconception that, in the case a State decides on selecting a national reference level lower than 100 mSv, expressed in terms of residual effective dose annually, this will require scaling down of applied IAEA generic criteria [2, 8]. However, scaling down is not necessary in this case. As previously discussed, the reference level in terms of residual dose accounts for implementation of the protection strategy and its planned adaptation, while generic criteria in terms of projected dose do not consider any actions being taken. The resulting residual dose depends on the efficiency of actions taken on the basis of the projected dose (hence, generic criteria). If these actions are 100% efficient, then they result, theoretically, in 0 mSv residual dose annually among the affected population (see Fig. 14).

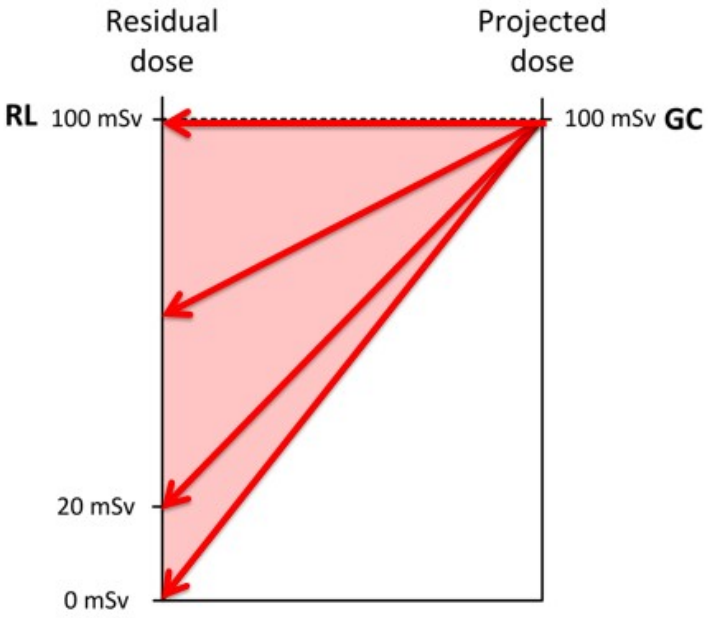


FIG. 14: Residual versus projected dose.

However, in reality, each protection strategy has an efficiency lower than 100% and the efficiency depends on the type of strategy implemented, resources available and other national considerations. Depending on these national considerations, taking actions at levels of projected doses at which IAEA generic criteria are established may result in various residual doses to be achieved. This matter needs to be carefully analyzed during the hazard assessment and development of the protection strategy, before the national reference level is selected. Such analysis helps authorities to identify how effective is the proposed protection strategy and what levels of residual doses could be achieved among affected population in an actual response. Thus, IAEA generic criteria [2, 8] are compatible with the reference level selected at any level of residual dose up to and at 100 mSv, provided that the analysis explained above is performed during the hazard assessment and development of the protection strategy, and that informed decisions are made based on this analysis.

APPENDIX II
OUTLINE OF THE PROTECTION STRATEGY DOCUMENT

TITLE (COVER) PAGE

The cover page needs to include the title of the protection strategy, the approval date, version number and signatures of the responsible authorities at the governmental and other levels who are responsible for preparing and implementing the protection strategy.

CONTENTS

1. INTRODUCTION

If merged with a national emergency response plan, some elements of the protection strategy might be common for the plan and for the strategy, such as the background section and planning basis and hazard assessment. This needs to be acknowledged at the beginning here.

1.1 Background

Describe what the protection strategy is. If necessary, give short description on the process for developing the protection strategy, organizations involved in development and coordination, consultations with interested parties implemented and consensus reached.

1.2 Objective and scope

Describe what the protection strategy aims to achieve, e.g. to provide common understanding of the fundamental bases for emergency preparedness and response, including the principles of protection, goals of emergency response. Define the scope of the protection strategy giving consideration of the range of sites, facilities and sources present in the State and close to borders. Indicate to what situations it is applicable.

1.3 Target audience

Identify the main target audiences. These are expected to include: national, regional and local organizations involved in emergency preparedness and response. It is likely that interested parties, including those from communities in the vicinity of relevant facilities, are also interested and consulted; it is therefore important to present information in a manner that is accessible to all parties.

1.4 Terms used in the protection strategy

Identify key terms used in the protection strategy here or reference to an appendix to the protection strategy.

2. UNDERLYING GOALS AND PRINCIPLES

Elaborate the goals to be achieved by the implementation of the protection strategy and the underlying principles taken into account in the development of the protection strategy. For example, this could include the specification of the goals of the emergency response, elaborated in GSR Part 7 and any additional or alternative goals identified by the Member State; the principles of radiation protection and any other guiding principles such as transparency and inclusiveness. These may be presented in subsections, as follows:

2.1 Goals of emergency response

Describe the goals to be achieved in the emergency response by means of the protection strategy. This should include the goals associated with all the phases of the emergency

response, including the end goals, i.e. prerequisites to be met to enable the termination of the emergency.

2.2 Radiation protection principles

Describe the principles of radiation protection that have been considered in the development of the protection strategy. This is likely to include reference to the principles of justification and optimization.

2.3 Other guiding principles

Describe other guiding principles that have been taken into account in the development of the protection strategy. Examples may include: resilience, continuity and transparency. A brief description of their relevance can also be provided as needed.

3. PLANNING BASIS AND HAZARD ASSESSMENT

Describe briefly what formed the planning basis for the development of the protection strategy. As the planning basis and the hazard assessment need to be documented in detail elsewhere, this is intended to be an overview of the key points that justify the scope and bring clarity to broader audience.

3.1 Planning basis

Describe it briefly and in an easily understandable style; the more detailed documentation of the planning basis can be suitably referenced, as needed.

3.2 Hazard assessment

Briefly describe the results of the hazard assessment. It might shortly describe the emergency scenarios arising from the hazard assessment for which it was deemed appropriate to develop the protection strategy. The results should be expressed in an easily understandable style; the more detailed documentation of the hazard assessment can be suitably referenced.

4. STRATEGY FOR REGAINING CONTROL AND MITIGATING CONSEQUENCES ON THE SITE

The detailed specification of responsibilities, criteria and actions considered for regaining the control at the site and mitigating the consequences in case of facility, activity or source under the responsibility of an operator are beyond the scope of this document. Nevertheless, here short clarification should be given on main actions taken to protect individuals on site, emergency action levels used (without specifying those that are site specific and are part of the operator's arrangements) and emergency classification system as relevant trigger for the off-site response and the protection strategy, as appropriate.

5. PUBLIC PROTECTION STRATEGY

The public protection strategy has its specifics depending on the period of time after the emergency onset it addresses. Thus, the public protection strategy is addressing the emergency response phase and the transition phase separately.

5.1 Description of the emergency phases

Describe the period for which the protection strategy applies starting from when is it assumed to begin (e.g. declaration of an emergency class), through the period when public protective actions are implemented and to end (e.g. when the situation is under control and preparations

to resume normal social and economic activity are made), considering the specific each phase has on the development and implementation of the protection strategy.

5.2 Decision making criteria

Provide an overview of the dosimetric criteria used to make public protection decisions in the emergency response phase, including identifying any differences between those used to initiate urgent and early protective actions, and, as needed, those associated with different postulated emergencies. The issue of making any necessary modifications to decision criteria also need to be described.

5.2.1 Reference Level

Indicate the level of residual dose at which the reference level has been set and provide any additional information, as relevant, regarding its application during the emergency response phase and the transition phase.

5.2.2 Generic criteria

Indicate generic criteria in place for a range of urgent and early protective actions including brief description of their basis and the dose concepts and dosimetric quantities in which they are expressed, as well as numerical values. For example, this description may include application of the generic criteria in IAEA GSR Part 7. Provide any additional information, as relevant, regarding its application during the emergency response phase and transition phase.

5.2.3 Operational criteria

Describe operational criteria in place, emergency action levels, operational intervention levels and observables/indicators, as appropriate, intended to trigger urgent or early protective actions or other response actions. These are expected to be expressed in terms of measurable quantities or observables (e.g. of plant or source condition). Provide numerical values as well as any additional information, as relevant, regarding their application during the emergency response phase and transition phase.

5.2.4 Prerequisites for terminating the nuclear or radiological emergency

Describe prerequisites that need to be fulfilled so that the emergency can be formally declared ended. This may include reference to the primary objective to terminate the emergency, to "facilitate the timely resumption of social and economic activity" and the general and specific prerequisites described in Section 3 of IAEA GSG-11. Provide any additional information, as relevant, regarding their application during the transition phase for different postulated emergencies.

5.3 Process for assessing the situation against decision making criteria and for making the decisions

Provide a brief overview of how decisions are taken and how this changes with time. Describe the approach adopted to aid decision making (e.g. taking precautionary actions based on the emergency class declared by the operator or based on observable conditions by first responders which are then adjusted based on monitoring and assessment using other operational criteria), taking account of decision making criteria and which radiation protection and other factors are taken into account. Describe the process for assessment of the effectiveness of the protection strategy and for its adaptation to meet the prevailing conditions as the emergency evolves.

5.4 Process for adapting or lifting protective actions and other response actions

Describe the process, criteria and any relevant considerations to be used for adapting or lifting protective actions and other response actions to take account of the evolving emergency.

5.5 Protective actions and other response actions to be implemented

Describe the suite of public protective actions and other response actions to be implemented for a range of postulated nuclear and radiological emergencies from the emergency onset by the time the emergency can be terminated; address the radiological consequences assessed as well as the non-radiological consequences addressed and the measures to be taken to mitigate them, as needed. Identify the areas where the protective and other response actions are planned to be implemented, e.g. the predefined emergency planning zones and distances and the time allowing for their effective implementation. Any relevant considerations for effective implementation of planned protective actions and other response actions need also to be given.

5.6 Consultation with the public and other interested parties

Describe the approach and process for consulting with the public and other interested parties in the course of the emergency response in relation to the protection strategy implementation and modification. This needs to be aligned with the communication strategy and to take account of the different priorities of the urgent and early response phase as well as for the transition phase.

6. PROTECTION STRATEGY FOR EMERGENCY WORKERS AND HELPERS

6.1 Emergency workers and helpers

Define these groups of responders to an emergency. Bring briefly clarity on the responsibility for their protection and safety.

6.2 Dose restrictions for emergency workers and helpers

Describe the criteria (such as the guidance values given in IAEA GSR Part 7 and GSR Part 3) to be used to protect emergency workers and helpers in an emergency explaining how they relate to different tasks and their relationship to different phases of response.

6.3 Processes for assessing the situation, decision making and adaptation

Describe the processes by which decisions regarding the protection of emergency workers and helpers are made. Describe the approach adopted to aid decision making (e.g. use of radiation monitoring and assessment data, results of hazard assessment) and which radiation protection and other factors are taken into account. Briefly describe the means used to determine the effectiveness of the actions and measures, for the protection of emergency workers and helpers, and the process for adjusting such actions and measures if necessary.

6.4 Protective actions and measures to be implemented

Provide a brief overview of the protective actions and measures to be implemented for the range of emergency scenarios that consider those for ensuring not only their radiation protection but their well-being as well.

6.5 Communicating risks and doses to emergency workers and helpers

Provide a brief description on how risks and other information is communicated to emergency workers and helpers in the course of the emergency response with a focus on the use of a plain and understandable language.

7. SPECIFIC CONSIDERATIONS

Provide additional specific strategic considerations necessary for the successful implementation of the protection strategy, including links and references to other relevant documentation.

7.1 Management

Describe what are the implications of the protection strategy on the management processes and set priorities. Describe briefly how the emergency management structure intends to support the implementation and modification of the protection strategy, including inter-organizational interfaces for communication, sharing information, cross border coordination, and communication with the international community.

7.2 Radiation monitoring and assessment

Describe what are the implications of the protection strategy on the radiation monitoring strategy. Explain briefly priorities for radiation monitoring to facilitate the effective application of the protection strategy, including the quantities to be measured; the locations (e.g. emergency planning zones, sectors determined based on modelling) at which measurements are necessary and the priorities are set for radiation monitoring. The factors influencing priorities may be described briefly. This description should indicate how the situation evolves with time as the emergency evolves and how radiation monitoring supports effective decision making, as planned above in the protection strategy. Describe what are the implications of the protection strategy on the assessment and prognosis processes and how they are intended to support the effective implementation of the protection strategy.

7.3 Public communication

Describe what are the implications of the protection strategy on the strategy for public communication so the latter can support the effective implementation of the protection strategy. If a public communication strategy is in place, appropriate links and references can be provided.

8. IMPLEMENTING THE PROTECTION STRATEGY IN OPERATIONAL ARRANGEMENTS

Identify the organizations that are responsible for implementing the protection strategy and briefly describe procedures to ensure that emergency plans, procedures, and arrangements are consistent with the protection strategy. Enforcement means can also be given here.

APPENDICES (AS NEEDED)

REFERENCES

ANNEXES (AS NEEDED)

APPENDIX III
OVERVIEW OF KEY PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS

This Appendix gives an overview of the key protective actions and other response actions in a nuclear or radiological emergency. The key protective actions are those recommended to be implemented if the generic criteria in GSR Part 7 [2] are exceeded; they include evacuation, sheltering, iodine thyroid blocking, relocation, restrictions on consumption of food, milk and drinking water, restrictions on use of non-food commodities, contamination control and decontamination, and prevention of inadvertent ingestion.

While this Appendix focuses on the key protective actions, it also covers further considerations for other response actions, including provision of information, advice, psychological counselling and some medical actions.

The purpose of this overview is to help all those involved in developing the protection strategy at the national level to consider relevant aspects in the strategy in relation to: (a) implication of particular protective action on other protective actions and other response actions, which need to be taken together or in sequence; (b) relevant criteria to be used in the protection strategy to support decision making on the key protective actions including the timeframe allowing for effective decision making; and (c) aspects related to expected duration of imposed protective actions and their adaptation or lifting.

The overview also discusses some considerations relevant to the response (as they may have implications for the protection strategy development) and to the preparedness (as they may result in the strategy implications for the operational arrangements to be developed once protection strategy is decided). These considerations are not intended to list all what is relevant to consider but to give the authorities examples of the aspects that need to be taken into account when developing the protection strategy and considering its implications for the operational arrangements. Many other aspects that are local or site specific might also have their relevance, too.

III.1. EVACUATION

III.1.1. Description and objectives

Evacuation is the urgent removal of people from areas where they live and/or work to a safe location in order to reduce the risk from some form of health hazard. In a nuclear or radiological emergency, evacuation is the rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure [3].

By removing people from the location of the immediate hazard in a nuclear or radiological emergency, evacuation protects them from all the exposure pathways. However, it results in people being (compulsorily) moved to temporary accommodation, which is unlikely to be suitable for residence for more than a few days.

Evacuation is a common form of intervention or protective action for public protection and may be implemented on different scales, from a few people to large populations, in response to various natural (e.g. flooding, earthquake, volcanic eruption, forest fire, hurricane, cyclone, typhoon) or human-induced (e.g. fire, explosion) emergencies.

III.1.2. Applicability domain and strengths

Evacuation is an urgent protective action that is expected to be temporary. If evacuation cannot be lifted timely, then it needs to be substituted with relocation so that better living conditions are provided to people.

Evacuation can be taken as a precautionary or urgent action to protect the population by removing them from areas threatened or affected by a radioactive release or the presence of a high activity radiation source. It protects individuals against all exposure pathways and is particularly effective if carried out before any exposure has occurred (e.g. before a radioactive release).

Evacuation may facilitate the implementation of other response actions (e.g. the removal of a dangerous source or remediation) as well as the movement and activities of emergency workers within the affected areas.

III.1.3. Weaknesses and limitations

Evacuation is a very disruptive protective action, typically involving a significant disruption of evacuees' daily lives as well as of the social and economic activity within the evacuated areas. It is also likely to be costly, depending on the number of people evacuated.

It might not always be practical or safe to evacuate people, for example in extremely bad weather conditions particularly when there are a large number of people involved. Furthermore, in tourism areas, the additional population may overwhelm the local means of evacuation at certain periods of year, if not taken into account in planning.

Evacuation might be difficult, or even impossible, to implement for specific groups of people requiring special care or equipment and specific vehicles (e.g. people who are unable to walk, in retirement homes or hospitals, asylums or prisons) unless provisions are made in advance. Evacuation of elderly people and patients in intensive care, for example, could result in physical injury, further ill health or death that could not be counterbalanced by the reduction in radiological risk associated with evacuation.

Planning for implementing this action needs to consider that additional staff, who takes care of the patients or elderly as well as ensures that various parts of the critical infrastructure are in a safe state, have to be designated as emergency workers and adequately protected. The risk to them needs to be considered when justifying and optimizing this action.

If the situation is not appropriately communicated and controlled, anxiety and panic could generate disorderly behaviour among evacuees, leading to traffic congestion and road accidents, additional injuries and death. It may also lead to unwarranted evacuation from areas where it is not recommended by authorities. This highlights the necessity for proper and timely communication and provision of information. Moreover, if the process is significantly delayed, evacuation may lead to people being highly exposed (e.g. during the passage of the plume).

Despite mandatory evacuation orders, some people could refuse to leave their homes. Providing for their care may call for authorities' attention.

III.1.4. Duration

Evacuation is essentially a temporary (few days to a few weeks) protective action and evacuees need to be allowed to return to their home as soon as possible. However, depending on the consequences of the emergency, the level of deposition, the expected evolution of the

contamination deposited over time, and the effectiveness of the protective actions, return of the population may be delayed. If the evacuation cannot be lifted for whatever reason within a reasonable period of time (few weeks), relocation needs to be considered in order to provide the population with better living conditions.

III.1.5. Timeframe for decision taking

To be most effective, the decision on evacuation needs to be taken before any significant release of radioactive materials occurs or shortly after, even as a precaution.

III.1.6. Decision making criteria

Generic criteria

Table II.1 (for RBE weighted absorbed dose in an organ or tissue) and Table II.2 (for effective dose and for equivalent dose in the fetus in the first seven days) in Appendix II to GSR Part 7 [2] provide the generic criteria for evacuation.

Operational criteria

Decisions on evacuation as a precautionary action need to be taken on the basis of observable conditions at a site (i.e. observables) or plant conditions (i.e. EALs). Using such operational criteria, evacuation can be automatically and precautionary taken within pre-set areas (e.g. PAZ and UPZ for a nuclear emergency or inner cordoned off area for a radiological emergency) upon declaration of the emergency class (e.g. general emergency or dispersal of radioactive material in the environment). Examples of observables and EALs can be found in GSG-2 [9].

As an urgent protective action, evacuation can also be taken on the basis of OILs, using OIL1 for a nuclear emergency (see Table 8 of GSG-2 [9]) once radiation monitoring results become available. In case of a radiological emergency, OIL2 [38] (see also Table 8 of GSG-2 [9]) can be used to trigger evacuation, considering that it may be possible to recover the affected area timely without a need to further consider relocation.

III.1.7. Considerations for implementation in response

For implementing evacuation, it is necessary that the authorities organize traffic corridors and transport of people that have no means to evacuate, activate evacuation hubs, contamination control and decontamination centres as well as accommodation/reception centres to be ready to receive the evacuees. A functioning alarm system (e.g. sirens, public address systems, phone calls, short message service (SMS)) to contact the populations concerned needs to be used. Recommendations for evacuation need to be accompanied with any necessary recommendations regarding administration of stable iodine, as appropriate, with instructions to evacuees to collect their identity papers, valuables, medicines necessary for a period of a few days etc. and with clear guidance on the evacuation routes and reception centres to report. It is necessary to pay particular attention to alerting hearing and/or visually impaired people. Decision needs to be made regarding evacuation of children at school, kindergarten or nurseries, under the surveillance of their supervisors or to bring them to their families.

At the evacuation hubs, registration of evacuees need to be organized as well as provision of medical and psychological support. When necessary, evacuees need to be easily redirected towards contamination control and decontamination centres. The accommodation/reception

centres have to provide necessary equipment and stuff for people living there for, at least, a few days. Arrangements for continuous provision of information regarding the event and any next steps concerning their status also have to be in place.

Implementing the evacuation may necessitate putting in place means for coping with self-evacuation (when not planned as such) and shadow-evacuation as unwarranted action.

Personnel of various organizations assisting the evacuation, including those verifying that people have been evacuated, ensuring safe shutdown of critical facilities, controlling the traffic and caring for evacuees, needs to be designated as emergency workers and protected accordingly. If helpers are allowed to assist the evacuation or the provision of care to evacuees, their tasks have to be clearly pre-defined and they have to be protected as well.

Although justified evacuation can be staggered in time and space in combination with sheltering, i.e. when and/or where evacuation is not practicable due to bad weather conditions or by lack of means, authorities may need to delay evacuation and advise sheltering until conditions for a safe evacuation are achieved. For example, depending on the available means, evacuation of a large population may need to be executed gradually, starting with the groups and/or areas most at risk and later extended to groups and/or areas less threatened, and for which sheltering may be recommended instead for a short period of time.

In cases in which evacuation is ordered up to a given distance while sheltering is recommended beyond this distance, especially if evacuation routes pass through areas subject to sheltering, the sheltered population needs to be informed of the rationale for the process, in order to facilitate effectiveness of such approach and to avoid self-evacuation. Depending on the available time and/or transport means, priority may need to be assigned to the movement of infants and children in kindergartens and at school, as the most vulnerable groups.

To ensure that people do not return until it is safe to do so, and to secure the evacuated areas againstcriminal activity, the access to the evacuated areas needs to be controlled by the police and/or the army. However, some re-entry arrangements might be necessary for short periods, when appropriate, e.g. to allow evacuees to collect belongings, documents, medicines, or to attend to the needs of pets and livestock. Check points need to be organized at entry/exit points to register duly authorized person, to inform them about the conditions imposed by the authorities and if needed, to check them for possible contamination. In forest and other similar environments, especially in drought, the area needs surveillance to avoid the occurrence of forest fires.

III.1.8. Considerations for preparedness

Incorporating evacuation in the protection strategy imposes the necessity for a number of arrangements to be made at the preparedness stage within operational arrangements (such as emergency plans, procedures). Some of these arrangements, where appropriate, may include:

- An inventory of the population and communities and the number of people with specific needs, of the available transport means (individual cars, public and private buses);
- Pre-information provided to these population groups about how they are expected to prepare for an evacuation and what to do before leaving their home (disconnect the electricity, gas and water supplies, provide a few days of water and food for pets and cattle, close windows and doors);
- Pre-information on the evacuation routes and destinations;

- Traffic plans taking into account local features (population, road network, accessibility to vehicles) and the possible impact of e.g. poor weather conditions which defines the evacuation routes, the paths to be cleared for rescue workers and check-points for the radiation monitoring at leaving or entering the evacuated area;
- An inventory of the possible locations and infrastructure (e.g. public buildings, sport halls, congress halls) for accommodation and their capacity for each emergency planning zone, identification and arrangements for the installation of evacuation hubs, control and decontamination centres, accommodation centres;
- Operational plans for the organization of these hubs and centres to provide an efficient registration process, administrative, medical and psychological support, supplies of medication, catering, clean clothes, accommodation;
- A robust mechanism to alert and warn the population;
- A clear agreement allowing the unambiguous identification of the buildings from which the persons concerned have been evacuated; and
- A plan to control access to the evacuated area.

A well prepared and controlled evacuation can be performed in a quick way and without road congestion, nervousness or injuries in possible traffic accidents. Good information provision to the population around the nuclear installation in the preparedness phase is expected to minimize the occurrence and likelihood of self-evacuation and associated drawbacks.

For populations located in an emergency planning zone (PAZ or UPZ), each family or individual may be advised to prepare an individual emergency evacuation kit that is available and easily accessible prior to the emergency. An emergency evacuation kit includes a container of food, clothing, water, and other supplies that can be used to sustain the individual(s) until the evacuation shelters are fully functional. During this time, evacuees may suffer fairly simple conditions (e.g. limited clean water, heat, lights, toilet facilities, or shelter), and the evacuation kit can help evacuees to face the experience with dignity and a degree of comfort.

III.1.9. Considerations for adapting or lifting evacuation

Because of the temporary nature of evacuation, priority has to be given to lifting this protective action as soon as possible. If people are allowed to return to an area, their well-being is not endangered and it is possible for them to carry out their routine social and economic activities. However, limited restrictions on normal living habits may still need to be observed and might possibly extend into the longer term. The following considerations are necessary when deciding on lifting evacuation (see GSG-11 [8]):

- In an evacuated area where the radiation monitoring results indicate that the projected doses may exceed the generic criteria for relocation (i.e. the measurement results exceed OIL2 of GSG-2 [9]), evacuation needs to be substituted by relocation to provide better living conditions for evacuees.
- In an evacuated area where the radiation monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [9]), evacuation needs to be lifted if no or only limited restrictions (e.g. restrictions on locally produced food or limited access to certain recreational areas) continue to be necessary for those people living normally in the area. In addition, the following preconditions need to be also fulfilled:

- Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies, telecommunication networks);
- Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning;
- Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning;
- A strategy has been established for the restoration of workplaces and for the provision of social support; and
- Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.

- In an evacuated area where the radiation monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [9]), but limited restrictions are not sufficient for the protection of the people returning to live normally in the area, or the abovementioned preconditions are not fulfilled, evacuation does not need to be lifted until this area can be managed as being under an existing exposure situation, after fulfilment of the prerequisites in Section 3 of GSG-11 [8] and of the abovementioned preconditions. OIL for enabling the transition from an emergency exposure situation to an existing exposure situation needs to be considered in this case as an operational criterion to trigger discussion on lifting the evacuation (see GSG-11 [8]). Example OIL_T for a nuclear emergency at an LWR is given in the Appendix to GSG-11 [8]. OIL_T for a radiological emergency is given in Ref. [38].

The impact the lifting of evacuation might have on the residual doses needs also to be assessed for informed decision making.

When substituting evacuation with relocation, evacuated people may be granted short term access to the evacuated areas in a controlled manner, in order to allow for the preparation of longer term relocation.

III.2. SHELTERING

III.2.1. Description and objectives

Sheltering is the short term use of a structure for protection from an airborne plume and/or deposited radioactive material [3]. Sheltering is an urgent protective action, used to provide shielding against external exposure and to reduce the intake of airborne radionuclides by inhalation. It consists of going inside a suitable building (a private house, a multi-storey building, a commercial mall, a private or public shelter), closing doors, windows and vents, shutting off all ventilation systems, listening to the information and further recommendations and advice provided by the authorities, through the media or other means of communication.

III.2.2. Applicability domain and strengths

Sheltering is considered and applicable during the urgent response phase, as a precautionary or urgent protective action to protect the individuals in areas threatened by the passage of a radioactive plume. In most situations, sheltering is easy to implement and does not involve too much disruption of people's daily lives. It is a relatively prompt and straightforward

action, which can be implemented in large areas and for a large number of people. Iodine thyroid blocking may need to be applied simultaneously if radioactive iodine is expected to be present in the release.

Sheltering can be implemented quicker than evacuation, necessitates fewer resources from emergency response organizations and is easier to implement even in densely populated areas. Sheltering can also provide an alternative to evacuation in cases in which immediate and safe evacuation is not possible (e.g. in highly populated areas, for facilities and critical infrastructure such as telecommunications centres, chemical plants, hospitals or prisons, or whenever conditions make immediate evacuation impractical or hazardous due to e.g. severe weather conditions).

Sheltering the population may aid the implementation of emergency response actions and facilitate the movement and activities of emergency workers within the sheltered area.

Temporary sheltering might also be recommended beyond the urgent response phase while later recovery options (e.g. decontamination) are implemented to facilitate the work of emergency workers and to minimise any enhanced inhalation doses from resuspended material from these activities.

III.2.3. Weaknesses and limitations

Sheltering is not fully effective at preventing exposure: shielding and air tightness efficiency depend on the type of shelter. Moreover, the degree of protection decreases with the duration of the plume passage, the air renewal constant of the shelter, and the progressive contamination of the inside atmosphere.

Prolonged periods of sheltering may cause stress, especially if families are separated or the accommodation is not equipped for residential use. In addition, if sheltering is implemented simultaneously with iodine thyroid blocking, the duration of sheltering might be limited by the time the stable iodine provides protection, considering that the World Health Organization (WHO) does not recommend second administration unless this is justified. Thus, for practical reasons, this action cannot be prolonged for more than approximately two days. Prolonged sheltering necessitates identification of those with specific support needs, such as the youngest, the elderly or ill and disabled persons, and may call for additional administration of stable iodine in case there is radioiodine in the release.

Sheltering in place might not be an option for groups that do not have access to adequate shelters (e.g. tourists in mobile homes, caravans or tents, dockworkers or sailors in harbours, scout camps), and they may need to be moved or evacuated whilst others in the same area are not.

Areas with housings (e.g. simple wooden construction) that provide poor shielding against radiation exposure might not be appropriate for considering sheltering for the population. Evacuation might be an option in this case if this action is justified.

III.2.4. Duration

Sheltering is a short term measure and can only be used for a short period (not more than 48 hours). In the case of a protracted release (expected to last for more than two days), evacuation of sheltered people between two releases, or during periods of reduced release, may need to be considered and carried out, if justified.

III.2.5. Timeframe for decision taking

The decision to shelter population needs to be taken before any significant release of radioactive materials occurs. It could be implemented as a precaution even when not much is known about the situation.

III.2.6. Decision making criteria

Generic criteria

Table II.2 (for effective dose and for equivalent dose in the fetus in the first seven days) in Appendix II to GSR Part 7 [2] provides the generic criteria for evacuation which may be used for sheltering as a temporary action until evacuation can be safely implemented. It may also be possible that the authorities ask the population to shelter at lower generic criteria, to facilitate the movement and activities of emergency workers and/or to be able to better prepare for evacuation.

Operational criteria

Decisions on sheltering as a precautionary action need to be taken on the basis of observable plant conditions (i.e. EALs). Using such operational criteria, sheltering can be automatically and precautionary taken within pre-set areas (e.g. UPZ) upon declaration of the emergency class (e.g. general emergency). Example EALs can be found in GSG-2 [9]. When evacuation is not safe, sheltering may also be implemented on the basis of OIL1 of GSG-2 [9] provided that the sheltering is done in large buildings that provide good shielding and away from walls and windows.

III.2.7. Considerations for implementation in response

To quickly implement sheltering, authorities need a functioning alarm system (e.g. sirens, public address systems, phone calls, SMS) to contact the populations concerned. It is necessary to pay particular attention to alerting hearing and/or visually impaired people. It is possible to use radio, television and other media to provide complementary, and regularly updated information and advice. Use of these channels allows limiting phone calls to urgent calls.

Decision needs to be made to leave children at school, kindergarten or nurseries, under the surveillance of their supervisors or to bring them to their families.

Those who do not have access to adequate shelters (e.g. tourists in mobile homes, caravans or tents, dockworkers or sailors in harbours, scout camps) may be invited to shelter in public buildings or, if not possible, evacuated instead. A system for the registration of individuals, information, medical and psychological support needs to be organized for those in public shelters.

If evacuation routes pass through areas subject to sheltering, clear explanations need to be provided to the sheltered population to avoid panic reactions and self-evacuation.

The access to the sheltered area needs to be controlled by the police to avoid the entry of people from outside the area (e.g. journalists), while authorizing people providing urgent medical and other interventions.

The authorities may need to activate contamination control and decontamination centres outside the sheltered area (e.g. in case of general emergency) to receive returning emergency

workers and possible self-evacuees and to be ready to provide information, contamination control and, if needed, decontamination.

While sheltering is ordered, some outside activities still have to be conducted (e.g. milking, safely stopping industrial processes) by workers who need to be duly informed of the risks and to be provided with adequate instruction how to best protect themselves. In some activity sectors, where shift work is the rule (e.g. hospitals, prisons), workers may be allowed to get to their workplace although sheltering is in place.

The population needs to be advised that good ventilation of the shelter is necessary to clear the inside air, which could be contaminated, and replace it by fresh air, once the plume has passed.

III.2.8. Considerations for preparedness

Planning for sheltering needs to consider:

- Identification of solidly constructed and reasonably airtight buildings that could serve as public shelters for those population groups that cannot shelter in place (e.g. tourists in mobile homes, caravans or tents, dockworkers or sailors in harbours, scout camps);
- Pre-information of these potentially affected population about what is expected and how to prepare for effective and efficient sheltering;
- A robust mechanism to alert and inform the population of the need for sheltering, including pre-signed conventions with telephone and broadcasting companies;
- Procedures and resources to maintain essential and urgent services (distribution of stable iodine in case ITB needs to be implemented, access to water, energy, urgent medical care, catering if needed) in the sheltered area; and
- A plan to control the access to the sheltered area.

Information leaflets need to be distributed to each family or household within the PAZ and UPZ to urge them to identify one or more rooms with, whenever possible, access sanitary equipment, water and communication means and to explain what to do and not to do, before starting and during sheltering. The following actions could be suggested:

- Gathering family members and bringing pets inside;
- Gathering employees and workers together;
- Checking the isolation of the building and rooms (close doors and windows, stop the ventilation systems, tight possible penetration such as broken windows);
- Making sure that stable iodine tablets, food, drinks, connection with the outside (phone, tablets, PCs, TV, radio, portable radios on battery), medicines, and games for children are available;
- Having a change of clothes prepared for those who are expected to arrive after the release has started; and
- Preparing for potential evacuation if this becomes necessary by collecting identity documents, documents of value, means of payment.

III.2.9. Considerations for adapting or lifting sheltering

Sheltering is not intended to be carried out for long periods (i.e. more than approximately two days). Before deciding to adapt or lift sheltering, the following aspects need to be considered:

- The evolution of the release;
- The level of contamination in the environment;

- The level of protection offered by the type of buildings used for sheltering (shielding factor and tightness against diffusion of outside atmosphere);
- The need for continued simultaneous administration of ITB, and the medical care and hygiene needs of those sheltered (availability of medicines, food supplies, etc.);
- Any necessity to gradually increase the time members of the public are allowed to spend outdoors, before sheltering is fully lifted; and
- The need for further protective actions based on generic criteria and OILs to replace sheltering (e.g. evacuation or relocation).

Depending on the evaluation, sheltering may be followed by the return to normal activities (lifting of sheltering), the limitation of the outside activities (partial sheltering), or evacuation or relocation of the inhabitants.

III.3. IODINE THYROID BLOCKING

III.3.1. Description and objectives

Iodine thyroid blocking (ITB) is the administration of a compound of stable iodine (usually potassium iodide) to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid in a nuclear or radiological emergency involving radioactive iodine [3]. Iodine thyroid blocking is an urgent protective action. The terms ‘stable iodine prophylaxis’, ‘thyroid blocking’ or ‘iodine blockade’ are sometimes used to describe the same action, but iodine thyroid blocking is preferred in IAEA publications.

III.3.2. Applicability domain and strengths

ITB is a protective action that is primarily considered and applicable during the urgent response phase. It is an urgent protective action to protect the population in areas threatened by a release of radioactive iodine. It is most effective if administered within a timeframe of six hours before up to a few hours after the beginning of exposure. However, a later administration after the beginning of exposure may still achieve a substantial dose saving in the case of prolonged or repeated releases (see Section III.3.5).

During early response phase, ITB may be implemented in cases in which the consumption of essential foods contaminated with radioiodine cannot be restricted, but only temporarily by the time essential food is substituted or relocation is prepared, as appropriate.

ITB is a protective action that is relatively low cost, prompt and straightforward to implement in large areas and for a large number of people, where stable iodine tablets have been pre-distributed and are available at home or in public shelters where people are located. Side effects are generally rare and benign. Pregnant and breast-feeding women, infants and children constitute the priority target group because of their sensitivity to developing thyroid cancers following internal exposure to radioiodine.

The WHO provides guidelines [44] for the implementation of ITB which can be considered when planning and responding to a nuclear or radiological emergency.

III.3.3. Weaknesses and limitations

ITB is only effective against intakes of radioiodine; it does not provide any protection against external exposure of any kind or the intake of other radionuclides.

Distribution of stable iodine and maintaining the stocks can be costly, depending on the areas to be covered and the population expected to be affected (e.g. within PAZ and UPZ). Where

tablets are pre-distributed to the population, the distribution might not have reached all families or households or tablets might have been lost or thrown away. There may therefore be some uncertainty about whether everyone has access to them in due time such that some form of distribution in the emergency is likely to be unavoidable.

Efficiency is reduced if stable iodine is taken too early, e.g. in anticipation of a release which then occurs later than expected. A reliable mechanism needs to be in place to deliver advice on ITB at the appropriate time to the population of concern.

Different formulations are used for iodine tablets in terms of quantities of active product (e.g. 100 or 50 mg of iodine per tablet), so that the adult dose is one or two tablets, respectively. If two different formulas are used in two neighbouring States, the recommendation to take one or two tablets needs to be clearly explained to citizens on both sides of the border.

ITB is a short term protective action that is not normally be repeated or prolonged for long periods; other protective actions (e.g. evacuation) need to be implemented instead.

Iodine is not considered to be an allergen. However, an acute administration of a large amount of stable iodine (about 700 times the daily requirement) can cause temporary symptoms such as minor skin rashes that disappear rapidly after the administration is ceased. It has only very rare medical contraindications that are generally known by those concerned, e.g. individuals with past or present thyroid disease (e.g. active hyperthyroidism), known iodine hypersensitivity or dermatitis herpetiformis. Individuals having side effects, although rare [44], after having taken ITB need to seek the attention of their doctor, but they are unlikely to require further specific medical follow-up.

III.3.4. Duration

Stable iodine is generally administered as a single dose that is judged be sufficient to give protection to the thyroid for 24 hours [44]. In the event of prolonged release, when evacuation is not possible or unsafe, repeated dosing might be judged appropriate to prolong thyroid protection provided second dose is available to do so. Repeated dosing is not advised for neonates, pregnant and breastfeeding women and older adults (over 60 years) [44].

III.3.5. Timeframe for decision taking

The optimal period of administration of stable iodine is less than 24 hours prior to, and up to two hours after, the expected onset of exposure. It is still reasonable to administer ITB up to eight hours after the estimated onset of exposure. Commencing ITB later than 24 hours following the exposure may do more harm than benefit (by prolonging the biological half-life of radioactive iodine that has already accumulated in the thyroid) [44].

These limitations dictate the time that is available for decision making to implement ITB effectively. Namely, the decision has to be taken before significant release of radioactive iodine takes place in order to be most effective. This means that it could be implemented as a precautionary protective action under certain circumstances depending on the hazard assessment.

III.3.6. Decision making criteria

Generic criteria

The generic criterion for taking ITB is 50 mSv equivalent dose to the thyroid ($H_{thyroid}$) due to exposure to radioiodine only in the first seven days (see Table II.2 in Appendix II to GSR Part 7 [2]).

Operational criteria

Decisions on ITB as a precautionary action need to be taken on the basis of observable plant conditions (i.e. EALs). Using such operational criteria, ITB can be automatically and precautionary taken within pre-set areas (e.g. UPZ) upon declaration of the emergency class (e.g. general emergency) along with either evacuation or sheltering. Example EALs can be found in GSG-2 [9].

ITB can also be taken in a nuclear emergency using radiation monitoring results, once available, using OIL3 values [9] in case essential foods contaminated with radionuclide cannot be restricted for whatever reason. In case of difficulties to provide substitutes to essential local produce or milk supplies, their consumption might be authorized in conjunction with the administration of ITB (and possibly together with other agents) to protect against intake of radioiodine from such foods when radiation monitoring results show OIL6 [9] values for radioiodine are exceeded. OIL3 for a radiological emergency is given in Ref. [38].

ITB might be taken also in a nuclear emergency when OIL4 values are exceeded [9, 17], depending on the timing the radiation monitoring of the skin is performed and in line with WHO recommendations for appropriate timing for stable iodine administration to ensure effective thyroid protection. OIL4 values for a radiological emergency are given in Ref. [38].

III.3.7. Considerations for implementation in response

ITB is effective against internal exposure from radioiodine only and generally needs to be implemented simultaneously with other protective actions (such as sheltering or evacuation and restriction of contaminated food consumption) to protect people from other exposure pathways and other radionuclides.

For timely administration of stable iodine, its pre-distribution is necessary particularly in those areas which are expected to be affected during a radioiodine release at levels warranting ITB to be taken (such as PAZ and UPZ). Depending on the characteristics of the areas, population distribution and other factors derived from the hazard assessment, 'pre-distribution' may be associated with stable iodine tablets being provided to each household (where efficient administration does not allow sufficient time for distribution in the course of the emergency, e.g. in PAZ and UPZ, for cases of general emergency), stockpiles of tablets being pre-distributed in different locations (e.g. pharmacies, city halls) within the country where individuals and communities can go and obtain the necessary number of tablets, or stockpiles of tablets are pre-positioned in different strategic locations from which rapid distribution to households and communities can be organized in an emergency (e.g. in potentially affected areas derived from the hazard assessment beyond the UPZ). A combination of these options in different areas, depending on the distance from a nuclear installation or applied in different phases, is also possible.

Each State needs to identify which of these options is the most appropriate for their situation and needs to verify their effectiveness in an exercise. Individuals tasked to distribute stable iodine tablets in the course of the emergency, if any, need to be considered as emergency workers and protected as such.

To quickly implement ITB, authorities also need a functioning alarm system (e.g. sirens, public address systems, phone calls, SMS) to contact the populations concerned. It is necessary to pay particular attention to reaching population groups which are particularly at risk, including infants and children at schools, in kindergartens or in nurseries, and those responsible for these groups (teachers, nursery nurses).

III.3.8. Considerations for preparedness

The authorities need to ensure that stable iodine tablets are pre-distributed within the PAZ and UPZ with instructions for use, so that it can be rapidly taken upon declaration of a general emergency, as soon as recommended by the authorities. Pre-distribution within these planning zones is essential because it might not be possible to distribute the stable iodine tablets during the emergency in the time required for them to be effective. The authorities need to develop a plan to extend the distribution of ITB agents to areas beyond the UPZ, if needed, unless stable iodine tablets are also pre-distributed in such areas at the preparedness stage.

To cope with the fact that pre-distribution may not be fully effective, and that the distributed tablets may have been lost, the authorities need to identify the best options for their rapid distribution to those in need during the emergency, taking into account the available means and time needed for distribution

Information and instructions on the use of ITB need to be prepared addressing following question:

- How do the iodine tablets work?
- Who benefits from taking iodine tablets?
- When and how should the iodine tablets be taken depending on your age? (e.g. crash the tablets between two spoons before mixing the obtained powder in drink water, milk or fruit juice)
- How much stable iodine should be administered depending on your age?
- How many iodine tablets should be taken?
- Are there special warnings and precautions for use? (e.g. taking iodine tablets during pregnancy or breastfeeding and undesirable side effects; warning of administration of stable iodine tablets without the instruction by the authority)
- Where or how to obtain iodine tablets for those who are not in possession?
- How should the tablets be stored?

Public health authorities also need to verify the iodine dietary status of the population and compensate with an adequate iodine prophylaxis if relevant.

To support effective implementation of ITB, various medical personnel, pharmacists etc. need to be trained on ITB and in providing support to the population.

III.3.9. Considerations for adapting or lifting iodine thyroid blocking

ITB is not a protective action to be implemented for prolonged periods, although under some circumstances repeated administration of stable iodine might be considered. Whenever there is a need to implement ITB for a longer duration (e.g. for several days), consideration has to be given to implementing evacuation or relocation [8].

III.4. RESTRICTIONS ON FOOD, MILK AND DRINKING WATER

III.6.1. Description and objectives

Restrictions on food, milk and drinking water relate to the actions taken to protect the food chain and water supply systems (e.g. milk from grazing animals or drinking water using open

sources (such as rain water)) from getting contaminated in a nuclear or radiological emergency as well as to the actions taken to protect individuals from ingestion of potentially or actually contaminated food, milk and drinking water (such as locally produced vegetables) in the emergency.

The end goal of taking this action is to prevent or reduce the internal exposure due to the consumption of potentially or actually contaminated food products, milk and drinking water. Actions on drinking water also avoid the contamination of food through the use of tap water during food preparation or for rinsing.

III.6.2. Applicability domain and strengths

Decisions on food, milk and drinking water restrictions might need to be made as early as in the urgent response phase as well as during the early response phase. The restrictions can be lifted during the early response phase (e.g. radiation monitoring may show that precautionary restrictions taken during the urgent response phase are not needed anymore) or during the transition phase but they may remain in place in the longer term within the existing exposure situation.

Restrictions on food, milk and drinking water always relate to non-essential foods. Restricting essential food, milk or drinking water could result in dehydration, severe malnutrition or other severe health impacts; therefore, essential food, milk and drinking water is to be restricted only if alternatives are available [2].

Restrictions on food, milk and drinking water are very effective in preventing internal exposures from ingestion of contaminated food, milk and drinking water and, once preparations are made, are relatively easy to impose.

III.6.3. Weaknesses and limitations

Restrictions on food, milk and drinking water, especially if applied on a large scale and for a long time, are a very disruptive protective action for the consumer, the producer and the food industry. Uncontaminated substitutes need to be found at reasonable price to replace the banned or restricted food products. If food is contaminated, it may remain so for a protracted time, leading to difficulties in lifting food measures and potentially prolonged economic impact.

Considerable volumes of contaminated waste can be generated through restrictions on the marketing of crops, milk and meat. In the absence of sufficiently diversified water sources (especially a mix of water sources between surface and ground water), and depending on the interconnectivity of the water supply network, provision of alternative supplies can take a long time before they are available and is expected to be rather costly. Individuals on private water supplies, especially those reliant on rainwater, are potentially more vulnerable to contamination and need specific considerations.

Some uses of mains water supplies for non-culinary uses, such as flushing toilets and floor cleaning, might be acceptable but this may be difficult to explain. Non-culinary uses such as watering garden or cattle need to be considered with regard to the potential radioactive contamination of vegetables, in particular leafy vegetables, and animal products.

Information and communication are essential to support effectiveness of imposed protective actions.

III.6.4. Duration

Restrictions on food, milk and drinking water have to be initiated as soon as possible in the urgent response phase. These restrictions could remain in place in longer term (even within the framework of an existing exposure situation).

III.6.5. Timeframe for decision taking

To be most effective, decisions to protect the food chain and the water supply systems from getting contaminated in a nuclear or radiological emergency need to be made before or shortly after the release. Such restrictions are precautionary. The restrictions could then be adjusted as radiation monitoring is deployed and results are obtained. Namely, once detailed characterization is performed (later in the emergency response), it is necessary to identify where and for what food restrictions are either justified in the longer term or can be lifted.

III.6.6. Decision making criteria

Generic criteria

The generic criteria for food, milk and drinking water restrictions are given in Tables II.2, II.3 and II.5 in Appendix II to GSR Part 7 [2] as follows:

- Effective dose/Equivalent dose to the fetus and embryo of 100 mSv in the first seven days and 100 mSv in the first year/during the full period of in-utero development, all exposure pathways considered, to be used for implementing restrictions on food, milk and drinking water as either urgent or early protective actions before sampling and analysis are performed and usually as a precaution due to limited information available at the time.
- Effective dose/Equivalent dose to the fetus and embryo of 10 mSv in the first year/during the full period of in-utero development, only ingestion pathway considered, to be used once sampling and analysis are performed to provide a basis for discontinuing restrictions imposed on food, milk and drinking water as a precaution earlier in the response.
- Effective dose/Equivalent dose to the fetus and embryo of 1 mSv in the first year/during the full period of in-utero development, only ingestion pathway considered, to be used once sampling and analysis are performed to provide a basis for imposing restrictions on the international trade[8] of food, milk and drinking water.

Operational criteria

To be most effective, decisions to protect the food chain and the water supply systems from getting contaminated in a nuclear or radiological emergency need to be made on the basis of the prevailing conditions at the facility (i.e. EALs or upon declaration of the appropriate emergency class). Additionally, precautionary restrictions on food, milk and drinking water (e.g. locally grown vegetables, milk from grazing animals, drinking water from open sources) may need to be considered in addition to those taken on the basis of EALs (before sampling and analysis can be performed) and on the basis of simple radiation monitoring results using OIL3 (see GSG-2 [9] for a nuclear emergency and Ref. [38] for a radiological emergency).

[8] Criteria for restricting the international trade of food, milk and drinking water are set in consideration of non-radiological impact (such as economic) the nuclear or radiological emergency may have. They are intended to provide a basis for resuming the international trade in the aftermath of the emergency and, thus, to minimize the economic losses.

Once sampling and analysis are performed, depending on the strategy (including factors such as areas impacted and resources available to allow for effective protection of the public against ingestion pathway), OILs need to be used to identify where and for what food restrictions are either justified to remain in place or can be lifted. In some cases (e.g. intentional dispersal of radioactive material causing food contamination or contamination of drinking water supply), OILs (including OIL3) need to be used to judge radiation safety of the food, milk and drinking water for consumption. In the case that limited resources are available, the following OILs can be used as screening criteria before a detailed analysis can be made:

- OIL5 of GSG-2 [9] for any nuclear or radiological emergency; and
- OIL7 of Ref. [17] for marker radioisotopes in a nuclear emergency at an LWR.

Results from detailed analysis need to be compared against OIL6 of GSG-2 [9], for any nuclear or radiological emergency, to judge the safety of food, milk and drinking water for consumption.

Guidance values given in the Codex General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995) [45] provide operational criteria in terms of activity concentrations to be used to appropriateness of the food intended for international trade.

III.6.7. Considerations for implementation in response

Early in the response, it is necessary to make every effort to prevent local produce, milk from grazing animals, etc. from getting contaminated. It may be challenging for decision makers to see the importance of such precautionary measures even before the release has started, patterns of deposition are known and/or radiation monitoring results are available, but failing to do so results in needs for managing contaminated foodstuff and biological radioactive waste later in the response.

The effectiveness of restrictions of consumption for the contaminated food, milk and drinking water very much depends on to what extent farmers, agriculturists and others conform with the recommendations and instructions provided to them. Extensive radiation monitoring may also need to be deployed in releasing the precautionary actions and deciding what foods are not safe for consumption. Further measures on how to deal with contaminated foods need to be considered. Certification may be needed as a measure to reassure the public in the safety of foods from affected areas. Further then the certification, considerations also need to be in place to address possible unwarranted actions, such as rejection of food products coming from the affected areas, so that the economic impact can be mitigated.

To avoid the production of foodstuffs contaminated above admissible concentration levels, agricultural remedial actions might be considered as early as during the transition phase, such as (deep) ploughing, top soil removal, increased application of fertilizers or amendments. If, despite of agricultural countermeasures, food restriction is expected to remain in place for a long time, an interdiction of production of food products could be decided upon, possibly involving a drastic conversion of the land use and agricultural production in the affected area.

Substitution of animals' diet with uncontaminated feed, adoption of a selective grazing regime or movement of animals to less contaminated pasture before slaughter is particularly effective at reducing radionuclide transfer to animal products. However, the supply of clean feed to animals has an economic impact. If an alternative supply of clean feed is not available, drying the dairy cows, moving the cattle to non-affected areas or even slaughtering are possible options.

Drinking water companies need to be ready to stop pumping water from affected reservoirs and to replace supplies by using alternative water sources. Authorities need to initiate the production and distribution of packaged water supplies to affected populations.

Interdiction or restrictions on collecting wild products (mushrooms and berries) may also need to be considered. Such restrictions need to be accompanied with clear instructions to the people that explain what wild products are not to be consumed and what wild products can be consumed under certain conditions (e.g. in terms of how they can be prepared to be safe for consumption).

In general, providing advice and information, as well as radiation monitoring for reassurance and support to the public for self-help actions, may be helpful and relatively inexpensive.

III.6.8. Considerations for preparedness

It is important that authorities, together with all concerned and interested parties (e.g. producers' unions, food industry) develop the approach for ensuring food safety as part of the protection strategy and to also consider the replacement of banned or restricted products, the compensation of producers and the management of banned products as conventional or radioactive waste, as appropriate. Options for the management and disposal of large volumes of biodegradable waste also need to be identified in planning.

Drinking water companies need to develop a plan for the replacement of banned water sources, the protection of water reservoirs and a possible modification of the water treatment processes, as response actions. Authorities have to prepare for distributing packaged water to the affected populations.

A good information and communication system for the public, the producers and the associated professional organizations, and an effective consultation mechanism with all the concerned parties are essential. Effective consultation during the development of the approach for ensuring food safety helps in ensuring feasibility of its implementation in an emergency. This is of particular importance not only in relation to efficient implementation of the agreed actions during the response, but also to adapting and lifting the restrictions imposed on food, milk and drinking water. Namely, any changes in the restrictions imposed earlier in the response would be very much impacted by the acceptance of the public, food industry and retailers or, as appropriate, other States.

III.6.9. Considerations for adapting or lifting restrictions on food, milk and drinking water

Restrictions on food, milk and drinking water that are imposed as a precaution in the emergency response phase on the basis of estimates (e.g. on the basis of EALs or OIL3 of GSG-2 [9] and thereafter adjusted on the basis of OIL5 and OIL6 of GSG-2 [9] or OIL7 of Ref. [17]) are characterized in detail in the transition phase. The purpose is to identify food production areas and foodstuffs that need to remain under restriction even in the longer term and to identify those restrictions that can be lifted. OILs for restrictions of food, milk and drinking water derived on the basis of sampling and analysis (i.e. OIL6 in GSG-2 [9]) need to be used when considering whether to adapt or lift this protective action.

The implementation, adaptation or lifting of restrictions on the international trade of food, milk and drinking water needs to take into account established national criteria (that, in turn, take account of the guideline levels contained in Ref. [45]), while ensuring consistency with GSR Part 7 [2] and GSR Part 3 [1].

Whenever consideration is given on adapting or lifting restrictions on food, milk and drinking water, the impact any decision may have on the residual dose has to be determined, and informed decisions have to be made in consideration of the reference level applicable to the situation.

III.5. RELOCATION

II.1.1. Description and objectives

Relocation is the non-urgent removal or extended exclusion of people from an area to avoid long term exposure from deposited radioactive material. Relocation is an early protective action. It may be a substitution for the evacuation. Relocation is considered to be permanent relocation if return is not foreseeable; otherwise it is temporary relocation [3].

Relocation is used to prevent or significantly reduce further exposures from all exposure pathways (notably external exposure, inhalation of resuspended material and inadvertent ingestion) from radioactive material deposited on the ground and other surfaces, including indoor contamination.

II.1.2. Applicability domain and strengths

Decisions on relocation are less urgent compared to evacuation. Relocation is considered once radioactive material is deposited on the ground and the release is over. It is taken based on results of the radiation monitoring, with account taken of what projected and residual doses might be in future.

As relocation is not an urgent action, more time is available (in comparison to evacuation) to prepare and implement this protective action, allowing households enough time to prepare and implement the action. The collateral risks associated with relocation are also relatively small compared with those for evacuation.

With relocation, better living conditions are provided to those leaving their homes. Namely, while during the rapid evacuation people may be evacuation to a stadium and other large areas, during relocation people are to be located in housing providing for normal living conditions and access to necessary services according to their needs. Relocation is often considered as a follow-on action after evacuation or sheltering. It may also be envisaged for populations in areas where no protective actions were early in the emergency response but where environmental radiation monitoring results show high depositions later on.

The period of relocation allows for the dose rate to fall either naturally due to weathering or physical decay or due to decontamination measures. Decontamination activities performed at the territories from which people were relocated, also could be used to allow quicker return of the relocated population.

II.1.3. Weaknesses and limitations

The cost of relocation can be particularly high, especially if it is implemented for a prolonged period (months or years). A precondition for relocation is the availability of accommodation, with normal living conditions, of various types including:

- Existing infrastructure (e.g. hostels/hotels, serviced apartments, short and long term lets, caravans and mobile homes); or
- New infrastructure such as prefabricated houses, portable cabins.

The choice between these options is likely to be primarily governed by many factors, including the number of people to be resettled and the expected duration of relocation.

Relocation is expected to have a significant impact on the local economy, on individuals as well as on whole communities, which may lead to mental health and psychological problems and social issues. Concerns are likely to include: (a) stigma towards resettled population and businesses; (b) loss of economic activity for businesses in the area; (c) loss of homes, properties and workplaces; (d) anxiety for the security of premises left unoccupied; (e) loss of self-esteem and depression; and (f) weakened resilience within community. Taking account of such issues needs careful planning and resourcing to provide for the wellbeing of those resettled.

Inhabitants in areas where people may be relocated can also find it difficult to accept large numbers of newcomers. This may cause social exclusion of and stigma towards the relocated population. Possible population conflicts in the relocated area between the local and displaced populations may necessitate investment in social support and security management.

Access to temporarily or permanently evacuated areas needs to be controlled to protect people and to avoid robbery. Measures may also need to be taken to prevent further degradation, for example to assure the upkeep of woodlands or the maintenance of firebreaks, especially in areas subject to frequent wildfires. Re-entry arrangements need to be planned and supervised. In order to facilitate return, decontamination work and environmental care need to be undertaken with various activities aimed at restoring social and economic activity in the area.

A distinction can be made between temporary relocation limited to short periods (up to few months), with the possibility of people being allowed to return to original housing, and permanent relocation, when return cannot be envisaged within one year after they have been relocated. Reactions to return are likely to differ in these two cases; during a prolonged absence, new social relationships are created, and they may replace ties to the area of origin and, thus, render the return being stressful again.

II.1.4. Duration

Relocation can last for weeks or months (temporary relocation) or indefinitely (permanent relocation).

II.1.5. Timeframe for decision taking

Decisions on temporary or permanent relocation generally take place during the early response phase, often following the lifting of sheltering or evacuation, based on the results of environmental radiation monitoring. Such decisions might also arise later, during the transition phase, following more comprehensive mapping of the deposited radioactivity and identification of areas of higher deposition (hotspots). To be effective, relocation as an early protective action is expected to be taken within days up to a few weeks after the emergency on-set. This allows for performing radiation monitoring of areas where higher deposition is expected (e.g. based on modeling data taking account of actual weather conditions) and decision to be made on the basis of the results obtained.

II.1.6. Decision making criteria

Generic criteria

Table II.2 (for effective dose in the first year and for equivalent dose to the fetus for the full period of in utero development) in Appendix II to GSR Part 7 [2] provides the generic criteria for relocation.

Operational criteria

Relocation is to be taken on the basis of OILs (using OIL2, see Table 8 of GSG-2 [9] for a nuclear emergency and Ref. [38] for a radiological emergency) once radiation monitoring results become available.

II.1.7. Considerations for implementation in response

Depending on the number of people to be relocated and the expected duration of relocation, a suitable range of accommodation is necessary to be available within a reasonable time period. The use of existing infrastructures (e.g. hostels, hotels, serviced apartments, short and long term lets, caravans and mobile homes) may provide a temporary solution. The army, Non-Governmental Organizations (e.g. Red Cross, Red Crescent) and citizens may need to be requested to provide equipment (tents, camping mattresses, blankets, kitchenware). In the longer term, the creation of new infrastructure (prefabricated houses, portable cabins) may be more appropriate.

Arrangements need to be made for relocated families to be registered, transported and offered financial, medical and psychological support. Special groups of population (e.g. patients, prisoners) also need specific considerations.

It is likely that populations that have not been sheltered, given ITB or evacuated during the urgent response phase find it difficult to understand the need for relocation. Authorities need to explain and justify such decisions, for example arising from unexpected deposition hotspots identified during deposition mapping process in the transition phase.

Relocation cannot be implemented without access control and surveillance of the areas from which people have been relocated. Entrance of restoration workers and duly authorized people need to be controlled, with measurement of contamination and decontamination, if needed. Maintenance and decontamination activities are necessary in the relocated areas in order to allow a future return. Even if a return is not possible, minimal maintenance could be necessary, for example to prevent shrub and forest fires.

The authorities need to establish plans to create, as soon as possible, the conditions for normal social and economic life in villages, towns or new settlements for both the population in place and the newcomers. Transparent and regularly updated information, as well as social and psychological support help to maintain the morale of the relocated population.

II.1.8. Considerations for preparedness

Considerations for preparedness are similar to those for evacuation. In addition, planning has to be made such that allows hotspots to be timely identified and located, so that relocation can be timely implemented. Locations or accommodation for temporary relocation need to be identified and the necessary agreements and conventions need to be established. This aims at their timely availability once needed. The availability of special needs for specific groups of population (e.g. patients, prisoners) also warrants considerations.

II.1.9. Considerations for adapting or lifting relocation

If people are allowed to return to an area, their well-being is not endangered and it is possible for them to carry out their routine social and economic activities in line with considerations for evacuation. However, limited restrictions on normal living habits may still need to be observed and might possibly extend into the longer term. The following considerations are necessary when deciding on lifting relocation (see GSG-11 [8]):

- In an area where the radiation monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [9]), relocation might be lifted if no or only limited restrictions (e.g. restrictions on locally produced food or limited access to certain recreational areas) continue to be necessary for those people living normally in the area. In addition, the following preconditions need to be also fulfilled:
    - Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies, telecommunication networks);
    - Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning;
    - Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning;
    - A strategy has been established for the restoration of workplaces and for the provision of social support; and
    - Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.
- In an area where the radiation monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [9]), but limited restrictions are not sufficient for the protection of the people returning to live normally in the area, or the abovementioned preconditions are not fulfilled, relocation need not to be lifted until this area can be managed as an existing exposure situation, after fulfilment of the prerequisites in Section 3 of GSG-11 [8] and of the abovementioned preconditions. OIL for enabling the transition from an emergency exposure situation to an existing exposure situation needs to be considered in this case as an operational criterion to trigger discussion on lifting the evacuation (see GSG-11 [8]). Example OIL_T for a nuclear emergency at an LWR is given in the Appendix to GSG-11 [8]. OIL_T for a radiological emergency is given in Ref. [38].

The impact the lifting of evacuation might have on the residual doses needs also to be assessed for informed decision making.

If return is not possible within a reasonable period (few months) for radiological or other reasons (social, economic, infrastructure), or if people are not willing to return, temporary relocation needs to be replaced by permanent relocation. This needs to be accompanied by transparent information on the rationale and the conditions and once consultation took place, allowing for the opinion of interested parties to be factored in in the decision making.

III.6. RESTRICTIONS ON NON-FOOD COMMODITIES

III.6.1. Description and objectives

Restrictions on non-food commodities relate to the actions taken to protect non-food commodities from getting contaminated in a nuclear or radiological emergency as well as to the actions taken to protect individuals from use of non-food commodities that are potentially or actually contaminated in the emergency.

The term ‘non-food commodities’ is broad and encompasses vehicles, cargoes, various items for use (such as plates, toys or cutleries) and any item intended for public use that is not a food but may get contaminated in an emergency.

The end goal of taking this action is to prevent or reduce both the external and internal exposure (through inadvertent ingestion primarily) caused by the use of potentially or actually contaminated non-food commodities.

III.6.2. Applicability domain and strengths

Decisions on non-food commodities’ restrictions might need to be made as early as in the urgent response phase as well as during the early response phase. These restrictions can be lifted during the early response phase (e.g. radiation monitoring may show that precautionary restrictions taken during the urgent response phase are not needed anymore) or during the transition phase.

Restrictions on non-food commodities relate to only non-essential use. Restricting essential commodities (e.g. emergency vehicle transporting a patient) could result in more harm than good; therefore, essential commodities are to be restricted only if alternatives are available.

Long term impact is not expected in this case in comparison to the restrictions on food, milk and drinking water.

Once preparations are made (which include identifying what commodities might be contaminated in an emergency and may require restriction on their use, sale and distribution), it is relatively easy to impose restrictions on non-food commodities. As the primary concern is surface contamination, decontamination can be used as a means to clean the commodities and put them in use again.

III.6.3. Weaknesses and limitations

If applied on a large scale and for a long time, this represents a disruptive protective action for the consumer, the producer and the industry/economy. However, based on past experience, it is not expected that a nuclear or radiological emergency would cause radioactive contamination of non-food commodities of that extent. Thus, major economic impact is not to be anticipated. Goods which may get contaminated can be decontaminated relatively easy and placed on market or put in use once radiation monitoring has confirmed their suitability to do so. Need for uncontaminated substitutes may be appropriate in some cases but this is expected to be only on an exceptional basis, taking account of the type of commodity and its use.

As surface contamination is of primary concern, radioactive waste can be expected to be produced as a result of the decontamination efforts. In some cases, fixed contamination may render a commodity as unsafe to use and it needs to be managed as a radioactive waste.

Information and communication are essential in identifying potentially or actually contaminated commodities and to support effectiveness of imposed restrictions.

III.6.4. Duration

Restrictions on non-food commodities need to be initiated as soon as in the urgent response phase as a precaution. These restrictions could then be adapted during the early and transition phase, once radiation monitoring results become available.

III.6.5. Timeframe for decision taking

To be most effective, decisions to protect relevant commodities from getting contaminated in a nuclear or radiological emergency need to be made before or shortly after the release. Such restrictions are precautionary. The restrictions could then be adjusted as radiation monitoring is deployed and results are obtained. Namely, once detailed characterization is performed (later in the emergency response), it is necessary to identify where and for what commodities' restrictions are either justified or they can be lifted.

III.6.6. Decision making criteria

Generic criteria

The generic criteria for restrictions on non-food commodities are given in Tables II.2, II.3, II.4 and II.5 of Appendix II to GSR Part 7 [2] as follows:

- Effective dose/Equivalent dose to the fetus and embryo of 100 mSv in the first seven days and 100 mSv in the first year/during the full period of in-utero development, all exposure pathways considered, to be used for implementing restrictions on non-food commodities as either urgent or early protective action before radiation monitoring can be performed and usually as a precaution due to limited information available at the time.
- Effective dose/Equivalent dose to the fetus and embryo of 10 mSv in the first year/during the full period of in-utero development, only relevant exposure pathways considered associated with the use of the commodity (external exposure and inadvertent ingestion, as discussed above), to be used once radiation monitoring is performed to provide a basis for discontinuing restrictions imposed as a precaution earlier in the response.
- Effective dose/Equivalent dose to the fetus and embryo of 1 mSv in the first year/during the full period of in-utero development, only relevant exposure pathways considered associated with the use of the commodity (external exposure and inadvertent ingestion, as discussed above), to be used once radiation monitoring is performed to provide a basis for imposing restrictions on the international trade of non-food commodities.

Operational criteria

To be most effective, decisions to protect relevant commodities from getting contaminated in a nuclear or radiological emergency need to be made on the basis of the prevailing conditions at the facility (i.e. EALs or upon declaration of the appropriate emergency class). Additionally, precautionary restrictions on non-food commodities may need to be done in

addition to those taken on the basis of EALs (before sampling and analysis can be performed) on the basis of simple radiation monitoring results using OIL3 [9].

Once sampling and analysis are performed, OIL_C (see GSG-11 [8]) needs to be used to identify where and for what commodities' restrictions are either justified to remain in place or can be lifted. The methodology for deriving such specific OILs for commodities is provided in GSG-11 [8]. OIL_C for a radiological emergency is given in Ref. [38].

III.6.7. Considerations for implementation in response

Early in the response, every effort has to be made to prevent relevant commodities from getting contaminated. It may be challenging for decision makers to see the importance of such precautionary measures before the release has started, patterns of deposition are known and/or radiation monitoring results are available, but failing to do so may result in needs for managing large amounts of potentially contaminated goods.

Extensive radiation monitoring may need to be deployed in releasing the precautionary actions and deciding what commodities are safe for use. Further measures on how to deal with contaminated commodities need to be considered, including prioritizing the decontamination of the contaminated items. Certification may be needed as a measure to reassure the public in the safety of commodities from affected areas. Further then the certification, considerations also need to be in place to address possible unwarranted actions, such as rejection of an item or commodity coming from the affected areas, so that the economic impact can be mitigated.

In general, providing advice and information, as well as radiation monitoring for reassurance and support to the public for self-help actions, may be helpful and relatively inexpensive.

III.6.8. Considerations for preparedness

It is important that authorities, together with all concerned and interested parties (e.g. producers' unions, food industry), develop the approach for ensuring safety of commodities as part of the protection strategy. As part of this work, authorities need to identify what commodities might get contaminated at levels requiring restrictions, what types of commodities need to be replaced while restrictions are in place, the compensation of producers and the decontamination means and responsibilities. Options for the management of any waste generated also need to be identified in planning.

A good information and communication system for the public, the producers and the associated professional organizations, and an effective consultation mechanism with all the concerned parties are essential. Effective consultation during the development of the approach for ensuring safety of commodities helps in ensuring feasibility of its implementation in an emergency. This is of particular importance not only in relation to efficient implementation of the agreed actions during the response, but also to adapting and lifting the restrictions on non-food commodities. Namely, any changes in the restrictions imposed earlier in the response would be impacted by the acceptance of the public, industry and retailers or, as appropriate, other States.

III.6.9. Considerations for adapting or lifting restrictions on non-food commodities

Decisions on the adaptation or lifting of restrictions on non-food commodities implemented during the emergency response phase as a precaution or based on estimates (e.g. on the basis of EALs or OIL3 of GSG-2 [9]) have to be based on comprehensive information and actual

radiation monitoring results. The purpose is to identify non-food commodities that are justified to remain under restriction and to identify those restrictions that can be lifted. Abovementioned OILs for non-food commodities to be used on the basis of results of sampling and analysis (using OIL_C as discussed in Section III.6.6) have to be used when considering whether to adapt or lift this protective action.

The implementation, adaptation or lifting of restrictions on the international trade of non-food commodities needs to be based on established OIL_C, taking into account the abovementioned criteria for international trade.

Whenever consideration is given on adapting or lifting restrictions on non-food commodities, the impact any decision may have on the residual dose needs to be determined and informed decisions need to be made in consideration of the reference level applicable to the situation.

III.7. CONTAMINATION CONTROL (PEOPLE, VEHICLES, EQUIPMENT AND OTHER ITEMS)

III.7.1. Description and objectives

Contamination control relates to various actions and measures taken to prevent spreading of contamination from an affected area in a nuclear or radiological emergency. These include measures taken to ensure control is in place on what enters in and exits from the affected area (access control), radiation monitoring of people, vehicles, equipment and other items leaving the affected area and their decontamination, when appropriate.

Access control involves setting up barriers to an affected area and maintaining them to ensure that people and vehicles including related items do not enter or exit the area unless authorized to do so, they are monitored and, where necessary, decontaminated. Such controls not only help preventing the contamination is spread outside the restricted areas, but help ensuring systematic control of exposures incurred by people (such as restoration workers, farmers caring for what was left behind) spending time in restricted area.

Decontamination is the complete or partial removal of contamination by a deliberate physical, chemical or biological process [3]. It includes a wide range of processes for removing contamination from people, equipment and buildings, but to exclude the removal of radionuclides from within the human body or the removal of radionuclides by natural weathering or migration processes, which are not considered to be decontamination. Personal decontamination processes may range from simply changing clothes, washing or showering to assisted decontamination, performed by trained personnel in special installations, possibly under medical supervision.

Access control, radiation monitoring and decontamination, where necessary, can also play a key role in public reassurance, especially to those resettled as well as for people who receive them.

III.7.2. Applicability domain and strengths

Actions and measures for contamination control are applicable to the emergency response phase as well as to the transition phase. Access control may still be warranted in the longer term for areas delineated as inappropriate to allow inhabitation and to resume social and economic activity. Actions and measures for contamination control needs to be implemented together with decisions on sheltering, evacuation or relocation and in the area where these actions are implemented.

Contamination control through radiation monitoring (including skin monitoring and thyroid monitoring, as appropriate) and personal decontamination are of particular importance for the emergency response phase, particularly for the population evacuated from the affected area after a radioactive release has started, undergoing relocation or persons who may have been in contact with an unsealed radioactive source. They may also be considered after sheltering during a release and for people entering or exiting the restricted areas. In principle, such actions are not necessary for people evacuated as a precaution, before any release occurs, unless there is a possibility that they were exposed to the radioactive plume during their travel.

Contamination control through radiation monitoring and decontamination applies to emergency workers and helpers who are working in restricted access areas as well as for any vehicles (e.g. ambulance, heavy machinery involved in restoration works, police patrol cars), equipment and other items leaving the restricted areas (such as evidence or personal belongings, valuables) and is applied as they leave the area through checkpoints. Any restrictions imposed on vehicles, equipment and other items need to consider whether they are essential or not, and decontamination might need to be considered at times.

These measures are effective in providing public reassurance which is important for public well-being. When limited to changing clothes and taking a domestic shower, personal decontamination is easy to implement and can be performed for large populations.

Restricting and controlling the access from outside to a sheltered zone prevent unnecessary exposure while contributing, in the emergency response phase, to freeing the roads of traffic and, hence, facilitating the movement and actions of emergency workers and helpers. Restricting and controlling the access from outside to an evacuated zone also prevent unnecessary exposure and secure the evacuated area against robbery and plundering.

III.7.3. Weaknesses and limitations

In case of a severe nuclear emergency, limitations on the radiation monitoring equipment, trained personnel and specific decontamination installations, place limitations on the number of people who can be checked and decontaminated, when needed, in due time. Triage criteria are of paramount importance to ensure that those who need decontamination are identified as a priority.

Decontamination of water, material and personal clothing and belongings might generate large amounts of radioactive waste. There may also be problems persuading people to dispose of personal belongings with high monetary or sentimental value and these may need to be decontaminated instead.

Access control may involve the mobilization of a significant number of police personnel, possibly with the support of army personnel. Depending on the area, controlling access may be difficult, therefore means of dealing with unauthorized access into the restricted areas need to be established. Some type of patrol within the restricted areas needs to be organized; however, implementation of this action is associated with radiation exposure to personnel who performs the patrol. Remote control systems and methods are preferable but may take some time to put in place.

Recording access times to restricted areas, radiation monitoring contamination levels at exit, carrying out decontamination, when appropriate, and recording exposure levels need significant resources, even if located at a limited number of checkpoints.

III.7.4. Duration

Contamination control needs to be put in place as early as in the urgent response phase and mostly maintained during the emergency response phase. Some aspects of contamination control need to be maintained for a longer period during the transition phase as well as after the emergency is terminated, for example for workers and helpers involved in restoration activities in restricted access areas and for (duly authorized) people re-entering restricted areas.

Access control needs to be put in place once areas have been evacuated and needs to be maintained until return or free access is authorized. Access control to highly contaminated areas are likely to be maintained in the existing exposure situation, e.g. for workers involved in the rehabilitation works.

III.7.5. Timeframe for decision taking

Decisions on performing radiation monitoring and, as appropriate, decontamination of populations need to be considered together with the decision on evacuation and later with the decision on relocation, in order to provide sufficient time to prepare the necessary infrastructure and to set up the necessary equipment. Radiation monitoring of the skin is only effective over the first few days. After a few days, most of the radioactive materials are removed from the skin by natural processes [17].

Decision on access control needs to be made in parallel with the decisions on evacuation, sheltering and relocation, so that adequate safety and security measures are in place for the areas where these protective actions are taken. The decisions can be directly associated with any decision for activating the protection strategy within the pre-planned zones or the inner cordoned off areas.

Thus, the timeframe for decision making on taking the measures and actions for contamination control corresponds to the timeframe for effective decision making on sheltering, evacuation and relocation.

III.7.6. Decision making criteria

Generic criteria

As the measures and actions for ensuring contamination control are associated with the decisions to implement sheltering, evacuation and relocation, the generic criteria for taking these actions for public protection, as discussed earlier in this Appendix, are the criteria to trigger contamination control as well.

Restrictions on the use of non-essential vehicles, equipment and other items leaving the affected area have to be considered on the basis of criteria contained in Table II.4 of Appendix II to GSR Part 7 [2], in order to reduce the risk of stochastic effects.

Operational criteria

As the measures and actions for ensuring contamination control are associated with the decisions to implement sheltering, evacuation and relocation, the operational criteria for taking these actions (i.e. EALs, OIL1, OIL2 given in GSG-2 [9]) have to be used as operational criteria to trigger the need for radiation monitoring and access control.

The decision to implement personal decontamination has to be based on OIL4 [9, 17]. When OIL4 is not exceeded, recommendation on changing clothes and showering at home is sufficient.

The decision to restrict the use of vehicles, equipment and other items and to perform their decontamination, if necessary, needs to be judged on the basis of OILs developed on the abovementioned generic criteria, applying a methodology similarly as the one elaborated for other OILs in Refs [17, 38].

III.7.7. Considerations for implementation in response

As soon as an emergency is declared and evacuation or relocation is ordered, the authorities need to activate the measure for contamination control and put in place the personal decontamination infrastructure. All necessary personnel (e.g. civil protection, fire brigades, police, medical and psychological support teams) needs to be mobilized in ensuring that control is in place. All necessary information and materials (e.g. information leaflets, registration forms, spare clothes), radiation monitoring equipment and decontamination material need to be conveyed to the respective centres and deployed. The personnel in charge needs to be considered as emergency workers and protected accordingly.

The risk to health from skin contamination is small and, therefore, radiation monitoring or decontamination of the skin does not warrant delaying or interfering with more important response actions (e.g. sheltering, evacuation, treatment of injured individuals or patients) [17].

The authorities need to differentiate priority groups, requiring assisted decontamination performed by trained personnel in special installations, from other groups for whom self-decontamination is sufficient. The detailed approach depends on the availability of specific detection devices, trained personnel, special decontamination installations, and on the number of people of concern and their ability to care for themselves. For those individuals for whom OIL4 is exceeded, dose from all exposure pathways needs to be assessed to identify whether there is a need for medical follow-up. However, as this could not be done early in the response due to lack of information and other priorities, such individuals and measurement data have to be registered and their records kept for retrieving later on.

The organization of the contamination control and decontamination has to consider specific needs of babies and children, disabled persons, prisoners, as well as for religious or cultural specifics. Radiation monitoring for internal contamination might be required to complement the external contamination control, especially for people still exhibiting high contamination levels after repeated external decontamination processes. For these people, internal exposure resulting from inhalation or ingestion may be more significant than external exposure.

The authorities need to ensure that transparent information, advice, medical and psychological support is provided and that the results of the contamination measurements, the decontamination process used, and its efficiency are registered for later follow-up, if necessary.

Plastic bags need to be provided for individual clothes and personal belongings together with adequate identification stickers. These bags might be measured at a later date, if necessary. Measurements of activity levels on the clothes might also be necessary for dose reconstruction, for individuals who have undergone self-decontamination (domestic shower), or to decide whether the clothing may be returned after washing or if it needs to be disposed of as radioactive waste.

Arrangements for waste management and treatment of decontamination water and contaminated clothes and belongings also need to be activated.

Authorities need to consider access restrictions where evacuation, relocation or sheltering are in force. If these protective actions are implemented, checkpoints need to be installed to monitor and control those authorized to access a restricted area. Lists stating who (e.g. emergency services, medical doctors, rehabilitation workers), when and for what purpose people may be allowed access (e.g. collect belongings, documents, medicine, to check on the security of property or to attend to the needs of pets and livestock) need to be defined at the preparedness stage. Duly authorized person needs to be registered at entry, informed about the conditions imposed by the authorities (personal protective equipment, dosimetry), monitored for contamination (and decontaminated if necessary) and registered (access times and exposure) on exit.

Checkpoints are able to provide for performing radiation monitoring and, if needed, decontamination of vehicles, equipment and other items leaving the restricted area. In case contamination is determined, decisions need to be made where and how to handle these items.

The controllers at checkpoints need to be informed about the risk, precautions and protective equipment necessary for their role.

In case of an emergency involving the release of radioiodine, personal radiation monitoring needs to consider thyroid monitoring. The monitoring aims at identifying individuals whose intake of radioiodine is such that OIL8 of Ref. [17] is exceeded. In such cases, individuals need to be registered and measuring results noted, so that dose can be estimated so as to identify need for subjecting the individual to further medical examination and medical follow-up.

III.7.8. Considerations for preparedness

The authorities need to identify suitable locations and infrastructure for contamination control and decontamination based on generic expectations; operational guidelines describing how to adapt the infrastructure for its purpose, when activated in an emergency, to cope with the different functions of such a centre (e.g. welcome, information, registration, medical and psychological support, re-orientation, control, decontamination, catering, temporary accommodation) also need to be provided.

The authorities need to establish a stock of clean clothes and plastic bags with identification codes for contaminated clothes. They also need to provide adequate information and training in preparedness to the pre-identified workers (army, civil protection, fire brigades) and, just in time, to helpers (e.g. Red Cross, Red Crescent, other non-governmental organizations) to welcome, inform, help those arriving at control and decontamination centres.

The authorities need to define a triage procedure to implement radiation monitoring and decontamination in case of an emergency potentially affecting many people. This procedure needs to differentiate between priority groups: those who will be directed towards a contamination control and assisted decontamination, and those who will take care for themselves, by changing clothes and having a domestic shower. Information leaflets explaining both options need to be prepared in advance.

A procedure to manage the storage, radiation monitoring, return or disposal of individual bags containing clothing and the necessary facilities for cleaning and waste management needs to be prepared.

The police need to develop a plan to rapidly cordon off the restricted access area and to be able to gather and deploy the necessary tools and means. Some of these tools (e.g. light panel, screens) can be installed at the most critical locations at the preparedness stage. The necessary equipment to cordoned restricted access areas needs to be prepared for rapid deployment.

Arrangements need to be made on how to monitor and decide on safety of various items that need to leave the restricted area, the procedures to follow when their further use warrant decontamination and means to do so.

Individual protective equipment and radiation monitoring instruments need to be available and periodically checked; the involved personnel need to be trained to use this equipment.

Leaflets explaining the rules and safety instructions need to be prepared for distribution to those entering the restricted access areas in advance.

III.7.9. Considerations for adapting or lifting contamination control

Access control is lifted in parallel with the decisions for reopening areas for inhabitation and for resuming normal social and economic activity, i.e. with the decisions to lift evacuation or relocation. Thus, any such decision needs to consider OIL_T [8, 38] and the impacts on the level of residual doses.

However, it is to be expected that certain areas remain closed as inappropriate for inhabitation and resumption of normal social and economic activity in the longer term and, thus, they would be delineated. For such delineated areas, access control remains in place. This means that checkpoints for controlling the entrance and exit, as well as arrangements for radiation monitoring and registering people and items entering and exiting the delineated area, need to remain in place in the longer term, too. This covers the duly authorized persons, as well as workers and helpers engaged in restoration work in the restricted areas, and associated vehicles, equipment and other items.

Contamination control through radiation monitoring and decontamination of the population is maintained until the relevant population has been checked or evidence has been obtained that external contamination does not significantly contribute to the radiation exposure. For example, there are no continuing occurrence of individuals with levels of radioactive contamination of skin exceeding OIL4 [9, 17, 38].

III.8. PREVENTION OF INADVERTENT INGESTION

III.8.1. Description and objectives

Prevention of inadvertent ingestion relates to advice being given not to drink, eat or smoke and to keep hands away from the mouth until hands are washed and not to play on the ground or do other activities that could result in the creation of dust that could be ingested or inhaled.

Although simple action following general hygiene rules, the advice aims at reducing ingestion and inhalation of released or resuspended radioactive material.

III.8.2. Applicability domain and strengths

Actions to prevent inadvertent ingestion and inhalation (e.g. washing hands and limitations on playing on the ground or on working in gardens) have to be advised as early as during the urgent response phase. However, as a protective action, advice on preventing inadvertent ingestion and the inhalation of resuspended material also needs to be given in the transition

phase on the basis of actual conditions, to reduce the residual dose among those returning to live in an affected area once evacuation or relocation is lifted.

The prevention of inadvertent ingestion can be advised within predetermined areas (such as the EPD or the inner cordoned off areas). It is equally applicable to the actually or potentially affected population as well as to emergency workers and helpers in an emergency.

The advice is simple and follows mainly general hygiene rules, making it easy to implement and at no cost. In addition, it is very effective in reducing ingestion of released radioactive material or inhalation of resuspended radioactive material.

III.8.3. Weaknesses and limitations

Population may find it challenging and difficult to follow some of the advice for prevention of inadvertent ingestion (such as limitations on playing on the ground or on working in the gardens), despite evacuation or relocation has been lifted and the return to their homes advised.

III.8.4. Duration

Prevention of inadvertent ingestion could be advised during the emergency response phase (for people sheltered or undergoing evacuation or preparing for relocation or emergency workers in the affected areas) as well as during the transition phase (e.g. for people returning in an areas with limited restrictions still in place and emergency workers and helpers performing some tasks within the affected areas). The advice may extend even in longer term, e.g. in delineated areas to which access has been granted to duly authorized persons and to workers and helpers involved in restoration works.

III.8.5. Timeframe for decision taking

Prevention of inadvertent ingestion is not a standalone action. It needs to be advised as early as possible before or shortly after the release together with decisions made for sheltering or evacuation. It may also be advised within predetermined areas (such as EPD) during the urgent response phase or together with decisions to initiate relocation during the early response phase. Thus, the timeframe for decision on prevention of inadvertent ingestion, as an urgent protective action, is the same as the timeframe for decision on sheltering and evacuation.

III.8.6. Decision making criteria

Generic criteria

Prevention of inadvertent ingestion always needs to be advised when the generic criteria specified in Tables II.1 (for acute exposures) and II.2 (for exposures in the first seven days and the first year/or the full period of in-utero development) have been exceeded. These correspond to the criteria for taking evacuation, sheltering and relocation discussed earlier in this Appendix.

Operational criteria

To be most effective, advice to help reducing inadvertent ingestion of deposited radioactive material and inhalation of resuspended radioactive material need to be given before or shortly after the release. To do so, EALs or observables (see GSG-2 [9]) need to be used. Upon declaration of the emergency, advice to help reducing inadvertent ingestion of deposited radioactive material and inhalation of resuspended radioactive material may be automatically

advices within EPD or the inner cordoned off area. Advice to help reducing inadvertent ingestion of deposited radioactive material and inhalation of resuspended radioactive material need also to be given when evacuation or relocation are ordered on the basis of OILs discussed earlier in this Appendix.

III.8.7. Considerations for implementation in response

As easy to implement and cannot cause any harm but can provide for public reassurance, advice for following normal hygiene rules and those to prevent inadvertent ingestion and inhalation need to be given together with almost all public protective actions within the protection strategy. Combining such advice with other possible self-actions is useful.

Additional information and clarity needs to be provided to populations to explain the necessity to follow some of the advice for prevention of inadvertent ingestion (such as limitations on playing on the ground or on working in the gardens), despite evacuation or relocation has been lifted and the return to their homes advised.

III.8.8. Considerations for preparedness

The advice needs to be part of the protection strategy established at the preparedness stage and reflected in various operational arrangements (such as procedures for decision makers on public protective actions to recommend) including in leaflets and other information materials intended for populations living in emergency planning zones.

III.8.9. Considerations for adapting or lifting prevention of inadvertent ingestion and of inhalation

Actions to prevent inadvertent ingestion and inhalation (e.g. washing hands and limitations on playing on the ground or on working in gardens) could be advised during the urgent response phase. However, as a protective action, advice on preventing inadvertent ingestion and the inhalation of resuspended material also needs to be given in the transition phase on the basis of actual conditions, to reduce the residual dose among those returning to live in an affected area once evacuation or relocation is lifted (see GSG-11 [8]). Lifting any limitations on playing on the ground or on working in gardens can take place after their impact on the residual dose has been estimated, with account taken on the acceptable reference level to enable the transition to an existing exposure situation (based on GSG-11 [8], approaching residual effective dose of 20 mSv in the first year). Considerations to lift any such limitations can be initiated on the basis of OIL_T in line with GSG-11 [8] and Ref. [38].

REFERENCES

[1] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[2] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2018 Edition, IAEA, Vienna (2019).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (CD-ROM Edition, 2003), Safety Series No. 115/CD, IAEA, Vienna.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[6] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the ICRP, Publication 60, Pergamon Press, Oxford (1991).

[7] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the ICRP, Publication 63, Elsevier, Oxford (1993).

[8] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR OFFICE, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Arrangements for the Termination of a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-11, IAEA, Vienna (2018).

[9] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, Criteria for Use in Preparedness and Response for a Nuclear or

Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011).

[10] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the ICRP, Publication 103, Elsevier, Oxford (2008).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Legal Series No. 14, IAEA, Vienna (1987).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Nuclear Safety, Legal Series No. 16, IAEA, Vienna (1994).

[13] WORLD HEALTH ORGANIZATION, International health regulations (2005), Third edition, WHO, Geneva (2016).

[14] INTERNATIONAL LABOUR ORGANIZATION, ILO Radiation Protection Convention 1960 (No. 115) – C115, ILO, Geneva (1998).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), IAEA, Vienna (2016).

[16] 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).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Intervention Levels for Reactor Emergencies and Methodology for Their Derivation, EPR-NPP-OILs 2017, IAEA, Vienna (2017.

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Radioactive Material and Associated Facilities, IAEA Nuclear Security Series No. 14, IAEA, Vienna (2011).

[19] EUROPEAN POLICE OFFICE, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL CRIMINAL POLICE ORGANIZATION–INTERPOL, UNITED NATIONS INTERREGIONAL CRIME AND JUSTICE RESEARCH INSTITUTE, UNITED NATIONS OFFICE ON DRUGS AND CRIME, WORLD CUSTOMS ORGANIZATION, Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control, IAEA Nuclear Security Series No. 15, IAEA, Vienna (2011).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Dangerous Quantities of Radioactive Material (D-Values), EPR-D-Values 2006, IAEA, Vienna (2006).

[21] NUCLEAR REGULATORY COMMISSION, Accident Source Terms for Light-Water Nuclear Power Plants, Final Report, NUREG-1465, NRC, Washington, DC (1995).

[22] SANDIA NATIONAL LABORATORIES, Accident Source Terms for Light-Water Nuclear Power Plants Using High-Burnup or MOX Fuel, SAND2011-0128, Albuquerque, NM, and Livermore, CA (2011).

[23] NUCLEAR REGULATORY COMMISSION, State-of-the-Art Reactor Consequence Analyses (SOARCA), Vol. 1 (Rev. 1): Peach Bottom Integrated Analyses, and Vol. 2 (Rev. 1): Surry Integrated Analyses, NUREG/CR-7110, NRC, Washington, DC (2013).

[24] US ATOMIC ENERGY COMMISSION, Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants, U.S. Atomic Energy Commission Report WASH-740, Washington, DC (1957).

[25] US NUCLEAR REGULATORY COMMISSION, Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, WASH-1400 (NUREG-75/014), Washington, DC (1975).

[26] RITCHIE, L.T., et al., Calculations of Reactor Accident Consequences, Version 2, CRAC 2: Computer Code Users Guide, NRC Report NUREG/CR-2326, NTIS, Springfield, VA (1983).

[27] NUCLEAR REGULATORY COMMISSION, Severe Accident Risks: An Assessment for Five US Nuclear Power Plants, Final Summary Report, 3 vols, Rep. NUREG-1150, Washington, DC (1990).

[28] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Goiânia, IAEA, Vienna (1988).

[29] OECD NUCLEAR ENERGY AGENCY, The Chernobyl Reactor Accident Source Term, NEA/CSNI/R(95)24, OECD NEA, Paris (1995).

[30] INTERNATIONAL ATOMIC ENERGY AGENCY, The International Chernobyl Project, IAEA, Vienna (1991).

[31] INTERNATIONAL ATOMIC ENERGY AGENCY, Environmental Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience, IAEA, Vienna (2006).

[32] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Volumes 1-5, IAEA, Vienna (2015).

[33] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Cochabamba, IAEA, Vienna (2004).

[34] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Tammiku, IAEA, Vienna (1998).

[35] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Chilca, IAEA, Vienna (2018).

[36] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Samut Prakarn, IAEA, Vienna (2002).

[37] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public and the Optimisation of Radiological Protection: Broadening the Process, ICRP Publication 101, Elsevier, Oxford (2006).

[38]INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Intervention Levels for Radiological Emergencies, EPR-RAD-OILs, IAEA, Vienna (in preparation).

[39] INTERNATIONAL ATOMIC ENERGY AGENCY, Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor, EPR-NPP Public Protective Actions 2013, IAEA, Vienna (2013).

[40] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS

OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007).

[41] UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION, Sources, Effects and Risks of Ionizing Radiation: UNSCEAR 2012 Report to the General Assembly with Scientific Annexes, United Nations, New York (2015).

[42] INTERNATIONAL ATOMIC ENERGY AGENCY, Occupational Radiation Protection, IAEA Safety Standards Series No. GSG-7, IAEA, Vienna (2018).

[43] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations, ICRP Publication 109, Elsevier, Oxford (2008).

[44] WORLD HEALTH ORGANIZATION, Iodine thyroid blocking: Guidelines for use in planning and responding to radiological and nuclear emergencies, WHO, Geneva (2017).

[45] JOINT FAO/WHO FOOD STANDARDS PROGRAMME, CODEX ALIMENTARIUS COMMISSION, Codex General Standard for Contaminants and Toxins in Food and Feed, Schedule 1 — Radionuclides, CODEX STAN 193-1995, Codex Alimentarius Commission, Rome (2015).

ANNEX I
EXAMPLE PROTECTION STRATEGY FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

This annex provides an example of a protection strategy for a nuclear or radiological emergency. The example protection strategy has been developed using the outline given in Appendix II and is intended to help States identify the relevant information to be given in a strategy, as foreseen in this document, notwithstanding the fact that the level of information and details to be given in the national protection strategy will be driven by the national emergency preparedness and response framework.

The example protection strategy has been developed for a range of potential emergency scenarios associated with facilities, activities, sources, acts and areas in the five EPCs, as defined in [ ]. The potential emergency scenarios were grouped into the following three groups on the basis of the commonalities in various elements of the protection strategy for the emergency scenarios within a group and the differences among the different groups:

(1) Severe nuclear emergency (emergency class: General emergency) at facilities in EPCs I and II or at a facility located across the border (EPC V), that is characterized by extensive on-site and off-site consequences;

(2) Nuclear or radiological emergency (emergency class: Site area emergency or Facility emergency) associated with facilities in EPCs I, II and III, that is characterized by on-site consequences within the site area or specific location within the facility;

(3) Radiological emergency (emergency class: Other nuclear or radiological emergency) associated with activities and acts in EPC IV, that is characterized by on-site consequences occurring at any location within the State.

Despite the fact that the emergency scenarios within a group share a common protection strategy, the operational arrangements expected to be elaborated in various operational documents, such as emergency plans and procedures, are likely to differ between the different emergency scenarios within the same group.

The example protection strategy in this annex is based on IAEA Safety Standards Series publications and associated technical guidance in the area of emergency preparedness and response, and assumes that the hypothetical State has such facilities, activities and sources for which various recommendations and numerical values of the IAEA guidance apply. Relevant aspects of the example protection strategy that are expected to be given in the national context are left out and marked '[…]'.

The terminology used in the example protection strategy follows that used by the IAEA Safety Glossary [I–1]. However, it is expected that the national protection strategy will use terminology that is common for the State and does not necessarily follow that used in the IAEA Safety Standards Series.

Protection Strategy of Country A for a Nuclear or Radiological Emergency

Approved by:

Date of approval:

Version:

The protection strategy has been agreed by the authorities* listed below. These authorities are responsible for its proper implementation in their operational arrangements at the preparedness stage as well as during an emergency response. The protection strategy has also been distributed to these authorities who are responsible for its further dissemination among their staff.

Organization:	***Signature of responsible authority:***	***Date:***

* To be specified at the national level.

CONTENTS

1. INTRODUCTION

1.1 Background

Country A has been dedicated to a high level of emergency preparedness and response […]. In this context, it embarked on developing a protection strategy as required […] with the aim to put, at one place, all relevant information that enables timely and efficient decision making in an emergency response so that protective actions and other response actions can be taken effectively in a nuclear or radiological emergency.

This protection strategy outlines the national approach to protect individuals (i.e. the public, emergency workers and helpers in an emergency) in Country A in case of a nuclear and radiological emergency, should it happen despite efforts made to prevent it. The protection strategy has been developed with involvement of all concerned parties with role and responsibilities in emergency preparedness and response at national, regional or local level. The process of development was coordinated through […] and involved […].

Elements of this protection strategy have been initially developed during the [time period] with […] and have been further strengthened since then, taking account of national and international standards, guidance and good practices.

This protection strategy considers the feedback received through consultation with all relevant parties that include […].

1.2 Objective and scope

The protection strategy elaborated in this document aims to provide common understanding of how the public and other individuals are protected in a nuclear or radiological emergency, the principles of radiation protection it applies and the goals the emergency response it aims to achieve. It describes the common goals all concerned parties contribute to achieve when undertaking their response roles, including the basis for making decisions in an emergency response as well as the suite of protective actions and other response actions to be taken for an effective response.

The protection strategy takes into account the existing EPR framework comprising of […], lessons learned from past emergencies and exercises such as […] and international standards such as […]. It complements following existing arrangements and documents: […]

The protection strategy applies for any nuclear or radiological emergency, irrespective of the cause (i.e. safety and security related), associated with facilities, activities, areas and sources within Country A and beyond borders falling in the five emergency preparedness categories (EPCs) described in […] as following […].

Potential emergencies warranting emergency response actions for which the protection strategy is developed have been derived from the hazard assessment as required in […]. Various potential emergency scenarios have been studied to identify commonalities and differences in terms of the protection strategy applicable to them and then grouped into specific groups so that each scenario within a group share a common protection strategy. The three groups of potential emergency scenarios considered for the protection strategy are described in Section 3.2. Although the protection strategy is focused on these three groups of emergency scenarios, due to major commonalities in the strategy among the emergency scenarios within a group and the differences between the groups, the operational arrangements elaborated in various operational documents (such as plans and procedures)

may differ between the different emergency scenarios within the same group, despite the fact that they share a common protection strategy.

The protection strategy covers the entire period from the emergency onset by the time the emergency can be formally declared ended, i.e. it addresses the emergency response phase as well as the transition phase.

The protection strategy does not cover:

- Aspects related to operational arrangements that constitute part of the respective plans, procedures etc. such as emergency management system including the unified command and control system, operator's mitigatory actions, activation of emergency response, medical response, warning the public and provision of information to the public, requesting international assistance, analysis of the emergency and its response, staffing, training and exercises etc.;
- Long term recovery within the framework of existing exposure situation.

1.3 Target audience

The target audience for this document are decision makers (emergency managers), emergency planners (at the facility, local, regional and national level), emergency response coordinators, qualified experts/radiation protection officers (radiological assessors, technical advisers to decision makers) and relevant staff of different response organizations at all levels with roles and responsibilities in preparedness and response for a nuclear or radiological emergency.

In addition, the protection strategy is open to the public and other interested parties.

1.4 Terms used in the strategy

Terms are used in this document as defined in […].

2. UNDERLYING GOALS AND PRINCIPLES

2.1 Goals of emergency response

Nuclear or radiological emergency can have a wide range of consequences and an effective emergency response has to address them as a whole. Although the initial priority will be focused on those efforts that aim to protect the public against the harmful health effects due to radiation exposure, other consequences should also be timely addressed. Namely, nuclear or radiological emergency can have adverse non-radiological consequences (economic, social and psychological) that can overcome the radiological consequences and warrant adequate response to ensure that they are minimized. Thus, during a nuclear or radiological emergency, every effort will be made to achieve the following goals of emergency response, in accordance with para. 3.2 of GSR Part 7 [I–2]:

- To regain control of the situation and to mitigate consequences;
- To save lives;
- To avoid or to minimize severe deterministic effects;
- To render first aid, to provide critical medical treatment and to manage the treatment of radiation injuries;
- To reduce the risk of stochastic effects;
- To keep the public informed and to maintain public trust;
- To mitigate, to the extent practicable, non-radiological consequences;

- To protect, to the extent practicable, property and the environment;
- To prepare, to the extent practicable, for the resumption of normal social and economic activity.

Achieving these goals will help ensuring that no radiation induced health effects are to be observed, on an individual basis or collectively, among the affected population, that non-radiological consequences are mitigated to the extent practicable and that all needed is done to help resuming normal social and economic activity in the affected areas.

2.2 Radiation protection principles

The protection strategy was formulated with account taken of the main radiation protection principles of justification and optimization of protection and safety as stipulated in […]. Thus, the strategy ensures that actions taken in a nuclear or radiological emergency do more good than harm by outweighing the detriments associated with the actions being taken by the net benefit from taking the actions and that doses are kept as low as reasonable.

In justifying and optimizing the protection strategy, a range of factors were considered that go beyond the radiation protection considerations as following […]. The protection strategy was justified and optimized through a process that involved […] and comprised of […]. Notwithstanding this, it is expected that justification and optimization will also be carried out in the course of an emergency response, as information becomes available on the actual conditions and impacts, and as the time to do so allows without jeopardizing the effectiveness of the protection strategy.

2.3 Other guiding principles

The following principles guided the development of the protection strategy:

Resilience: The development of this strategy was driven by the need to help communities to strengthen their resilience so that they can recover easily from the consequences (both radiological and non-radiological) of a nuclear or radiological emergency should it happen within their jurisdiction. This protection strategy helps these communities to clearly identify protective actions and other response actions they need to take and how decisions are to be made […] Thus, the strategy assists these communities in identifying how they can prepare for an effective emergency response […]

Transparency: Transparency of the basis underpinning effective protection and safety in a nuclear or radiological emergency is essential for ensuring that actions are planned that are feasible to implement and that the planned actions are acceptable for all concerned parties. […]

3. PLANNING BASIS AND HAZARD ASSESSMENT

3.1 Planning basis

In order to develop the protection strategy, relevant information and data was collected and studied at national level so that informed decisions are made about the potential nuclear or radiological emergencies and their consequences warranting protective actions and other response actions to be taken in Country A. Such information and data relates to (1) the governmental, legal and regulatory framework currently in place, (2) the characteristics of the facilities, activities and sources in Country A and beyond borders that can give rise to an emergency, (3) the characteristics of the areas that can be potentially affected by the

consequences of an emergency and locations where emergency response actions might be warranted as well as of potentially affected populations, (4) resources and infrastructure available to support the implementation of the protection strategy, and (5) lessons learned from past emergencies, including […], exercises as well as operational experience in handling small scale events. It includes […]

The study of this information and data highlights the following: […]. These considerations had the following impact on the development of the protection strategy: […]

3.2 Hazard assessment

In order to develop a protection strategy that addresses effectively potential hazards and associated consequences of a nuclear or radiological emergency in the country, a hazard assessment was performed as required in […] using the information and data from the planning basis.

During this process, it was identified that Country A has facilities in the EPCs I, II and III as well as areas in EPC V. Country A has also activities involving mobile radioactive sources in EPC IV. Acts (criminal or intentionally unauthorized) within the same category were drawn that may result in an emergency at any location, taking account of the results of the threat assessment for nuclear security purposes. Emergency scenarios derived from the hazard assessment have been studied and they have been grouped into the following three groups on the basis for their familiarities and specifics for the applicable protection strategy:

(1) Severe nuclear emergency (emergency class: General Emergency) at facilities in EPCs I and II or at a facility located across the border (EPC V), that is characterized by extensive on-site and off-site consequences;
(2) Nuclear or radiological emergency (emergency class: Site area emergency or Facility emergency) associated with facilities in EPCs I, II and III, that is characterized by on-site consequences within the site area or specific location within the facility;
(3) Radiological emergency (emergency class: Other nuclear or radiological emergency) associated with activities and acts in EPC IV, that is characterized by on-site consequences occurring at any location within the State.

The assessment has shown the following: […]

For the first group of potential emergency scenarios, that is characterized by both on-site and off-site consequences, areas where protective actions and other response actions were identified on the basis of assessing the impact of the emergency as a function of the distance from the accident site, and taking into account national, regional and local circumstances. The results of the assessments showed that […]. Additionally, a full range of postulated emergency scenarios, as required in […], were considered in the process, such as […]. The aim was to ensure that precautionary, urgent and early protective actions and other response actions can be taken off-site effectively, regardless of the severity of the situation, the limitations in information available and the large uncertainties. These areas relate to the four emergency planning zones and distances required in […] as follows:

- A precautionary action zone (PAZ) for the area in which the focus is on taking precautionary protective actions to avoid or minimize severe deterministic effects;
- An urgent protective action planning zone (UPZ) for the area in which the focus is on taking urgent protective actions to reduce the risk of stochastic effects;
- An extended planning distance (EPD) for the area in which the focus is on taking early protective actions to reduce the risk of stochastic effects on the basis of monitoring and assessment;

− An ingestion and commodities planning distance (ICPD) for the area in which the focus is on taking actions for ensuring food and commodities safety so that the risk of stochastic effects is reduced.

The approximate radii that were justified and optimized to account for national, regional and local circumstances are presented in Table I-1. While the areas for EPD and ICPD are circular, the actual boundaries of the PAZ and UPZ consider the local circumstances and, thus, follow other physical and geographical boundaries. The locations of these facilities and the associated areas are shown in Appendix 1.

TABLE I-1. APPROXIMATE RADII OF EMERGENCY PLANNING ZONES AND DISTANCES AROUND THE REACTOR SITES

Emergency planning zones and distances	Approximate radii (km)	
	Nuclear Power Reactor (LWR, 2000 MW(th))	Research Reactor (100 MW(th))
PAZ	5	3
UPZ	30	15
EPD	100	50
ICPD	300	100

The second group of emergency scenarios may lead to the need for protective actions and other response actions that are confined to the sites at known locations and under the jurisdiction of the operating organization(s) with no radiological consequences expected off-site.

For the third group of emergency scenarios, that may happen at any location, protective actions and other response actions would be warranted primarily within the inner cordoned off area (or safety perimeter) established by the first responders or, when appropriate, the operator. Determining the initial size of the inner cordoned off area needs to consider observable conditions on the site (e.g. fire or explosion involving radioactive material or visible damage to the shielding of radioactive material) or results of the radiation monitoring, once available. The radii for the inner cordoned off area are given in Table I-2.

TABLE I-2. RADII FOR THE INNER CORDONED OFF AREA

Situation	Initial inner cordoned off area (safety perimeter)
Initial determination – Outside	
Unshielded od damaged potentially dangerous source	30 m radius around the source
Major spill from a potentially dangerous source	100 m radius around the source
Fire, explosion or fumes involving a dangerous source	300m radius
Suspected bomb (possible radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Conventional (non-nuclear) explosion or a fire involving a nuclear weapon (no nuclear yield)	1000 m radius

Situation	Initial inner cordoned off area (safety perimeter)
Initial determination – Inside	
Damage, loss of shielding or spill involving a potentially dangerous source	Affected and adjacent areas (including floors above and below)
Fire or other event involving a potentially dangerous source that can spread radioactive material throughout the building (e.g. through the ventilation system)	Entire building and appropriate outside distance as indicated above
Expansion based on radiation monitoring	
100 µSv/h at 1 m above ground level	Wherever these levels are measured

4. STRATEGY FOR REGAINING CONTROL AND MITIGATING CONSEQUENCES ON THE SITE

The first goal of emergency response stipulated in this strategy relates to efforts made on the source itself to mitigate the consequences. These efforts need to aim at preventing further escalation of the event or emergency or delaying it to allow for effective protection of the public. In case of a facility, activity or source under the responsibility of an operating organization, this organization is responsible to ensure the above goal is achieved through taking necessary actions to:

a) Return the facility and/or source to a controlled and stable state and prevent any release or exposures;
b) Delay and/or reduce, when and as appropriate, any release or exposures, if the situation escalated;
c) Take life-saving actions and protect individuals at the site (as either members of the public or emergency workers, as appropriate, in line with the strategy provided in Sections 5 and 6); and
d) Notify and keep informed the relevant off-site authority.

In the case of a dangerous source being involved in an emergency at any location (EPC IV) with no operating organization to be accounted responsible for, meeting the first emergency response goal remains under the responsibility of the first responders who need to take any action to secure the source and to prevent further exposures of individuals from being in contact or in proximity with the source. In this case, the strategy as elaborated in Sections 5 and 6 applies to ensure individuals (both members of the public and emergency workers) are protected adequately.

In any case, prompt identification of an emergency, its notification and activation of the emergency response is essential for implementing effectively the protection strategy both on-site and off-site so that all the goals of emergency response are achieved. To enable this, facility/plant conditions (i.e. emergency actions levels (EALs)) and observable conditions at a site indicating an emergency situation need to be identified by the operators and, when appropriate, first responders so that the emergency class could be declared and emergency

response activated that is proportionate to the hazard posed by the respective emergency class. The following emergency classification system (in terms of EPCs) needs to be used in this context at all levels, in accordance with para. 5.14 of GSR Part 7 [I–2]:

- *General emergency* at facilities in category I or II:
  - This emergency class is associated with the first group of emergency scenarios discussed in Section 3.2 and warrants taking (precautionary, urgent and early) protective actions and other response actions on the site and off the site, i.e. within the predetermined emergency planning zones and distances.
  - Upon declaration of this emergency class, the respective protection strategy associated with the first group of emergency scenarios discussed in Section 3.2 need to be implemented on-site and off-site in line with Sections 5 and 6.
- *Site area emergency* at facilities in category I or II:
  - This emergency class is associated with the second group of emergency scenarios discussed in Section 3.2 and warrants taking protective actions and other response actions on the site, increasing the readiness off-site should the situation escalates to General emergency and monitoring in the vicinity of the site.
  - Upon declaration of this emergency class, the respective protection strategy associated with the second group of emergency scenarios discussed in Section 3.2 need to be implemented on-site in line with Sections 5 and 6. Nevertheless, off-site response may still be warranted for this emergency class in relation to medical management of those individuals who are actually or potentially exposed during the emergency on-site or provision of public information.
- *Facility emergency* at facilities in category I, II or III:
  - This emergency class is associated with the second group of emergency scenarios discussed in Section 3.2 and warrants taking protective actions and other response actions at the facility and on the site but does not warrant taking protective actions off the site.
  - Upon declaration of this emergency class, the respective protection strategy associated with the second group of emergency scenarios discussed in Section 3.2 need to be implemented at the facility in line with Sections 5 and 6. Nevertheless, off-site response may still be warranted for this emergency class in relation to medical management of those individuals who are actually or potentially exposed during the emergency on-site.
- *Alert* at facilities in category I, II or III:
  - This emergency class is associated with events that warrant taking actions to assess and to mitigate the potential consequences at the facility but does not pose on-site or off-site hazard. Thus, no protection strategy is needed to be implemented for this class.
- *Other nuclear or radiological emergency* for an emergency in category IV:
  - This emergency class is associated with the third group of emergency scenarios discussed in Section 3.2 and warrants taking protective actions and other response actions at any location.
  - Upon declaration of this emergency class, the respective protection strategy associated with the third group of emergency scenarios discussed in Section 3.2 need to be implemented at the site in line with Sections 5 and 6.

5. PUBLIC PROTECTION STRATEGY

The public protection strategy has its specifics depending on the period of time after the emergency onset. While at the first hours to, as appropriate, days and weeks after the emergency onset the strategy focuses on public protection, afterwards the focus shifts to preparations for resuming normal living conditions within the affected area. Thus, where this is necessary, the public protection strategy addresses specifically the emergency response phase and the transition phase allowing for effective emergency response from the emergency onset by the time the emergency can be declared ended.

5.1 Description of the emergency phases

Emergency response phase is the period of time from the detection of conditions warranting an emergency response until the completion of all the actions taken in anticipation of or in response to the radiological conditions expected in the first days to the few months of the emergency. The emergency response phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify whether and where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been put into effect.

The emergency response phase comprises of the urgent response phase and the early response phase that have some specifics in relation to the development and implementation of the protection strategy:

- Urgent response phase is the period of time, within the emergency response phase, from the detection of conditions warranting emergency response actions that must be taken promptly in order to be effective until the completion of all such actions. Such emergency response actions include mitigatory actions by the operator and urgent protective actions on the site and off the site. The urgent response phase may last from hours to days depending on the nature and scale of the nuclear or radiological emergency.
- Early response phase is the period of time, within the emergency response phase, from which a radiological situation is already characterized sufficiently well that a need for taking early protective actions and other response actions can be identified, until the completion of all such actions. The early response phase may last from days to weeks depending on the nature and scale of the nuclear or radiological emergency.

Transition phase is the period of time after the emergency response phase when (a) the situation is under control, (b) detailed characterization of the radiological situation has been carried out, and (c) activities are planned and implemented to prepare for the resumption of normal social and economic activity. The transition phase ends with the emergency being declared ended, beyond which point the situation is managed as either a planned exposure situation or an existing exposure situation. The transition phase may last from days to months, notwithstanding that for a small scale emergency (e.g. a radiological emergency during transport or a radiological emergency involving a sealed dangerous source) the transition phase may last not more than a day.

The different emergency phases are presented in Fig. I-1.

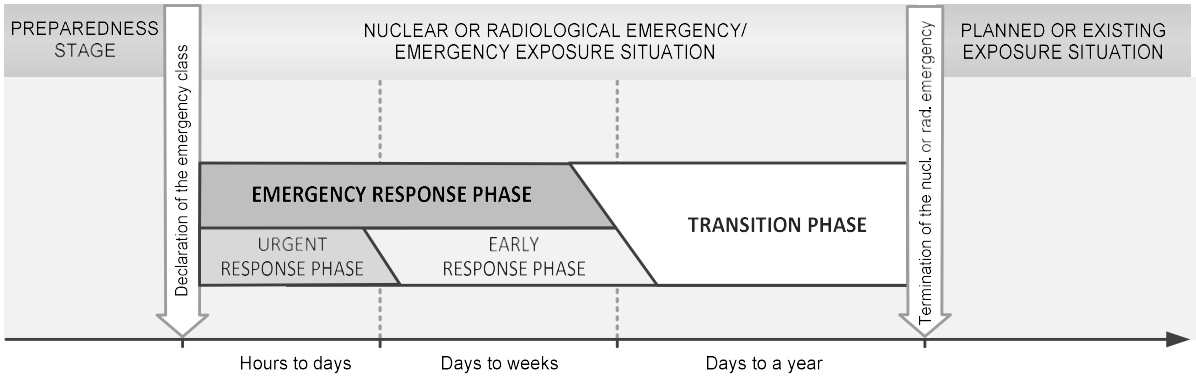


FIG. I-1. Temporal sequence of the various phases and exposure situations for a nuclear or radiological emergency within a single geographical area or a single site [I–3].

5.2 Decision making criteria

This section describes the dose criteria used in the protection strategy as either a decision-aiding tool for optimization of protection and safety or a trigger for the need to decide on specific protective actions and other response actions. It also elaborates the aspects to be considered when decisions need to be made to resume normal social and economic activity in the aftermath of the nuclear or radiological emergency.

5.2.1 Reference level

Reference level relates to the level of effective dose above which it is judged inappropriate to allow exposures to occur as a result of the exposure situation and below which optimization of protection and safety applies. Thus, the reference level is set up and used in this strategy not as a limit that may not be exceeded but as an upper constraint for optimization. Namely, the reference level is used as a tool for optimization so that any optimization of protection gives priority to exposures above the reference level with the possibility for the optimization of protection to continue to be implemented below the reference level as long as this is justified, i.e. does more good than harm.

A reference level of 100 mSv residual effective dose, acute or annual (given in Table I-3), has been used in the development and optimization of the protection strategy. This value has been chosen on the basis of […] as required in […]. The protection strategy was designed so that no exposures will occur above this level should an emergency occur, and the best is done under the prevailing circumstances so that doses are kept as low as reasonable below the reference level. With this approach, it is ensured that, if the protection strategy is applied effectively, no radiation induced health effects are to be observed among the affected population.

Moreover, the reference level, as selected, needs to be used for comparison with the residual doses assessed during an emergency response, so that a judgement is made on the effectiveness of the protection strategy as implemented. In the case that exposures are identified above the reference level, priority needs to be given to lowering these exposures below the reference level and the available resources need to be allocated to achieve this. Any action and the strategy to be applied at exposures below the reference level need to be proven to be justified, i.e. that they do more good than harm.

For an emergency response during the urgent phase, there is no time for an optimization due to the urgency associated with decision making and implementation of protective actions in

an effective manner. Therefore, a justified and optimized protection strategy for the urgent phase is hereby agreed to the extent practicable, so that doses are kept below the reference level. However, as the emergency evolves, particularly towards the transition phase, the time available for assessing the strategy in place, its adaptation, justification and optimization increases, and the abovementioned reference level needs to be used to assess the effectiveness of the strategy and, for the optimization, of its adaptation.

With a successful implementation of the protection strategy through such iterative processes for justification and optimization, it is expected that the residual doses will be increasingly reduced with time, allowing lower levels for the residual doses to be used in deciding the appropriateness for the situation to transit to an existing exposure situation and for the emergency to be terminated. In this context, a residual dose approaching the order of 20 mSv effective dose in a year (given in Table I-3) is considered as acceptable (as one of the conditions) for the termination of the emergency, notwithstanding the fact that continued efforts will likely be necessary to progressively reduce doses further in the longer term within the framework of an existing exposure situation.

TABLE I-3. REFERENCE LEVEL FOR EMERGENCY EXPOSURE SITUATIONS

	Emergency phase	**Residual effective dose**
	Emergency response phase	100 mSv, acute or annual
	Transition phase	20 mSv, annual

5.2.2 Generic criteria

Generic criteria present levels of projected doses or received doses at which protective actions and other response actions need to be taken. Protective actions and other response actions comprising the strategy are taken when projected doses (for protective actions) or received doses (for medical actions) are exceeding the generic criteria provided in Tables I-4 to I-6. These generic criteria are hereby grouped in three sets.

The first set of generic criteria given in Table I-3 relates to doses received within a short period of time (acute exposures) for which precautionary urgent protective actions and other response actions are expected to be undertaken under any circumstances to avoid or minimize severe deterministic effects. These criteria are associated with doses that, based on […], can result in deterministic health effects in an individual that could be unequivocally attributed to radiation exposure. Hence, these criteria, provided for RBE weighted absorbed dose to an organ or tissue, represent a basis for taking precautionary urgent protective actions and other response actions, before or shortly after the release or exposure occurs, primarily based on observables or plant conditions.

TABLE I-4. GENERIC CRITERIA TO AVOID OR TO MINIMIZE SEVERE DETERMINISTIC EFFECTS

Acute external exposure (<10 h)		**Acute internal exposure due to an acute intake (Δ = 30 d[e])**	
AD red marrow [a]	1 Gy	$AD(\Delta)_{\text{red marrow}}$	0.2 Gy for radionuclides with atomic number Z ≥ 90[f] 2 Gy for radionuclides with atomic number Z ≤ 89[f]
		$AD(\Delta)_{\text{thyroid}}$	2 Gy
AD fetus	0.1[b] Gy	$AD(\Delta)_{\text{lung}}$[h]	30 Gy
AD tissue [c]	25 Gy at 0.5 cm	$AD(\Delta)_{\text{colon}}$	20 Gy
AD skin[d]	10 Gy to 100 cm^2	$AD(\Delta')_{\text{fetus}}$[i]	0.1[b] Gy

[a] $AD_{\text{red marrow}}$ represents the average RBE weighted absorbed dose to internal tissues or organs (e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation.
[b] At 0.1 Gy there would be only a very small probability of severe deterministic effects to the fetus and only during certain periods post-conception (e.g. between 8 and 15 weeks of in utero development), and only if the dose is received at high dose rates. During other periods post-conception and for lower dose rates, the fetus is less sensitive. There is a high probability of severe deterministic effects at 1 Gy. Therefore, 1 Gy is to be used as the generic criterion for doses to the fetus received within a short period of time in relation to arrangements to avoid or to minimize the occurrence of severe deterministic effects (e.g. such as in establishing a precautionary action zone).
[c] Dose delivered to 100 cm at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source.
[d] The dose is to the 100 cm dermis (skin structures at a depth of 40 mg/cm (or 0.4 mm) below the surface).
[e] $AD(\Delta)$ is the RBE weighted absorbed dose delivered over a period of time Δ by the intake (I_{05}) that will result in a severe deterministic effect in 5% of exposed individuals.
[f] Different generic criteria are used to take account of the significant difference in RBE weighted absorbed dose from exposure at the intake threshold values specific for these two groups of radionuclides.
[g] Based on the projected dose without decorporation.
[h] For the purposes of these generic criteria, 'lung' means the alveolar–interstitial region of the respiratory tract.
[i] For this particular case, 'Δ' refers to the period of in utero development of the embryo and fetus.

An example of such actions is evacuation within PAZ taken upon declaration of General emergency. Taking effectively the precautionary urgent protective actions on the basis of these generic criteria will ensure that no deterministic effects that could be attributed to radiation exposure are to be observed in any individual. Should doses at this level be assessed to have been received, then they provide a basis for identifying the need for medical examination and screening followed, as required, by medical treatment.

The second set of generic criteria given in Table I-5 relates to doses at which protective actions and other response actions need to be taken to reduce the risk of stochastic effects. These criteria are associated with doses that, based on […], can result in an increased incidence of stochastic effects in a population (i.e. increase in the frequency of radiation induced cancers in a population) that could be attributed to radiation exposure through epidemiological analysis, although radiation induced cancers cannot be unequivocally attributed to radiation exposure on an individual basis. They are given for effective dose and for the equivalent dose to an organ or tissue and provide a basis for taking urgent and early protective actions and other response actions, as well as other activities aimed at enabling the transition to an existing exposure situation. Examples of urgent and early protective actions associated with these criteria are evacuation, sheltering, iodine thyroid blocking, relocation, food restrictions, and restrictions on non-food commodities. If doses at this level are assessed to have been received, then they provide a basis for identifying the need for longer term medical follow-up to identify radiation induced cancers within affected populations early and to treat them effectively.

Generic criteria to indicate the need to adapt or lift protective actions are associated with the generic criteria given in Tables I-5 and I-6 and are discussed in Section 5.4.

TABLE I-5. GENERIC CRITERIA TO REDUCE THE RISK OF STOCHASTIC EFFECTS

Basis for taking:	**Urgent protective actions and other response actions**	**Early protective actions and other response actions**		**Actions to enable transitioning to an existing exposure situation**	**Longer term medical actions**
Generic criteria	**Projected dose in the first 7 days**	**Projected dose considering all exposure pathways**	**Projected dose considering ingestion of food or use of non-food commodities, vehicles and other items**	**Projected dose considering all exposure pathways**	**Received dose considering all exposure pathways**
$H_{thyroid}$[a]	50 mSv[b]	-	-	-	-
E[c]	100 mSv	100 mSv in the first year	10 mSv in the first year	20 mSv in the first year	100 mSv in a month
H_{fetus}[d]	100 mSv	100 mSv for the full period of in-utero development	10 mSv for the full period of in-utero development	20 mSv for the full period of in-utero development	100 mSv for the full period of in-utero development

[a] The equivalent dose to the thyroid ($H_{thyroid}$) only due to exposure to radioiodine.

[b] This generic criterion applies only for administration of iodine thyroid blocking, if exposure due to radioactive iodine is involved.

[c] Effective dose.

[d] H_{fetus} is the equivalent dose to the fetus, derived as the sum of the dose from external exposure and the maximum committed equivalent dose to any organ of the embryo or fetus from intake to the embryo or fetus for different chemical compounds and different times relative to conception.

The third set of generic criteria given in Table I-6 relates to doses at which other response actions need to be taken to mitigate the non-radiological consequences, primarily the economic impact, by providing basis for resumption of international trade of food and non-food commodities.

TABLE I-6. GENERIC CRITERIA FOR TAKING RESTRICTIONS ON THE INTERNATIONAL TRADE OF FOODSTUFF AND NON-FOOD COMMODITIES

Basis for taking restrictions on the international trade of:	**Food, milk and drinking water**	**Non-food commodities**
Generic criteria for the projected dose		
E[a]	1 mSv in the first year	1 mSv in the first year
H_{fetus}[b]	1 mSv for the full period of in-utero development	1 mSv for the full period of in-utero development

[a] Effective dose.

[b] H_{fetus} is the equivalent dose to the fetus, derived as the sum of the dose from external exposure and the maximum committed equivalent dose to any organ of the embryo or fetus from intake to the embryo or fetus for different chemical compounds and different times relative to conception.

5.2.3 Operational criteria

As the generic criteria cannot be directly used in an emergency response, operational criteria that are associated with directly measurable quantities or observable conditions are developed on the basis of the generic criteria and elaborated in this section to provide for prompt implementation of protective actions and other response actions considered in the protection strategy without necessity for further assessments. The operational criteria used in the emergency response include observable conditions on the site (primarily associated with the third group of emergency scenarios; these are discussed in Section 4), emergency action levels (EALs, which are facility specific conditions used to declare an emergency class and activate the emergency response; these are discussed in Section 4) and operational intervention levels (OILs, associated with any group of the emergency scenarios, which are discussed in this section). OIL is a set level of a measurable quantity that corresponds to a generic criterion and in the context of this strategy, it is typically expressed in terms of dose rates, ground or surface activity concentrations, or activity concentrations of radionuclides in environmental, food or water samples.

OILs for the emergency response phase are used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of monitoring. In the transition phase, OILs serve as a screening tool to support decision making on adapting or lifting protective actions, including the determination of what protective actions may need to be lifted or adapted, when the protective actions may need to be lifted or adapted and to whom the decision may apply. In addition, they support implementation of activities to enable the transition from an emergency exposure situation to an existing exposure situation by providing a basis to guide simple activities aimed at reducing the residual doses. However, any decision to be made during the transition phase takes account of the impact on the residual doses against the reference level and any other relevant considerations.

OILs to be used to initiate protective actions and other response actions that are considered in this strategy and their applicability per group of emergency scenarios are given in Table I-7. OILs to be used to initiate discussions on adapting or lifting protective actions and other response actions are discussed in Section 5.5.

The values for OILs given in Table I-7 have been developed on the basis of conservative assumptions using the methodology provided in […] with account taken on the members of the public who are most vulnerable to radiation exposure (i.e. children and pregnant women). They can be revised in the course of emergency response only after convincing reasons requiring their revision have become evident, for example any evidence showing that certain parameters (e.g. consumption rates) are way too conservative for the actual situation affecting certain foodstuff or region. The revision in such cases needs to be carefully justified and implemented after the situation has been well understood, to follow the same methodology for deriving OILs given in […] and not be too frequent so as to weaken the public trust in authorities and in the response actions they have recommended.

TABLE I-7. OPERATIONAL INTERVENTION LEVELS TO INITIATE SPECIFIC PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN THE STRATEGY AND THEIR APPLICABILITY

OIL	Default OIL value	Monitoring type	Protective actions to be initiated	Applicability per group of emergency scenarios considered in the strategy		
				1st	2nd	3rd
OIL1	**1000 µSv/h**	GROUND MONITORING Ambient dose equivalent rate at 1 m above ground level	Evacuation and associated response actions	■	■	
	50 cps	Alpha count rate at 0.5 cm from the ground or surface				
	2000 cps	Beta count rate at 10 cm from the ground or surface				
OIL2	**100 µSv/h**	GROUND MONITORING Ambient dose equivalent rate at 1 m above ground level	Evacuation/Relocation and associated response actions	■	■	■
	10 cps	Alpha count rate at 0.5 cm from the ground or surface				
	200 cps	Beta count rate at 10 cm from the ground or surface				
OIL3	**1 µSv/h**	GROUND MONITORING Ambient dose equivalent rate at 1 m above ground level	Restrictions on food, milk and drinking water and associated response actions	■		■
	2 cps	Alpha count rate at 0.5 cm from the ground or surface				
	20 cps	Beta count rate at 10 cm from the ground or surface				
OIL4	**1 µSv/h**	SKIN MONITORING Ambient dose equivalent rate at 10 cm from the bare skin of the hand and face	Decontamination of individuals and associated response actions	■	■	■
	1000 cps	Beta count rate at 2 cm from the bare skin of the hand and face				
	50 cps	Alpha count rate at 0.5 cm from the bare skin of the hand and face				
OIL5	**5 Bq/kg**	MONITORING OF FOOD, MILK AND DRINKING WATER SAMPLES	Restrictions on food, milk and drinking water and associated response	■		■

OIL	Default OIL value	Monitoring type	Protective actions to be initiated	Applicability per group of emergency scenarios considered in the strategy		
				1st	2nd	3rd
		Gross activity of alpha (α) emitting radionuclides in food, milk and drinking water samples	actions			
	100 Bq/kg	Gross activity of beta (β) emitting radionuclides in food, milk and drinking water samples				
OIL6	**see Appendix 2**	MONITORING OF FOOD, MILK AND DRINKING WATER SAMPLES Radionuclide specific activity concentrations in food, milk and drinking water samples	Restrictions on food, milk and drinking water and associated response actions	■		■
OIL7	**1000 Bq/kg of I-131 and 200 Bq/kg of Cs-137**	MONITORING OF FOOD, MILK AND DRINKING WATER SAMPLES Activity concentration of I-131f and Cs-137f in food, milk and drinking water samples	Restrictions on food, milk and drinking water and associated response actions	■		
OIL8	**0.5 µSv/h**	THYROID MONITORING Ambient dose equivalent rate in front of the thyroid in contact with the skin	Registration and medical follow-up and associated response actions	■	■	■
OIL_T	**see Appendix 2**	GROUND MONITORING Ambient dose equivalent rate at 1 m above ground level […] Radionuclide specific surface activity concentrations	Consider adapting emergency response actions and taking activities to further reduce residual doses	■		■
OILc	**see Appendix 2**	MONITORING OF NON-FOOD COMMODITIES Ambient dose equivalent rate at 10 cm from the surface […] Radionuclide specific surface activity concentrations	Restrictions on non-food commodities and associated response actions	■		■

OIL	Default OIL value	Monitoring type	Protective actions to be initiated	Applicability per group of emergency scenarios considered in the strategy		
				1st	2nd	3rd
OIL_V	**see Appendix 2**	MONITORING OF VEHICLES, EQUIPMENT AND OTHER ITEMS Ambient dose equivalent rate at 10 cm from the surface […] Radionuclide specific surface activity concentrations	Restrictions on vehicles, equipment and other items leaving the affected area and associated response actions	■	■	■
$OIL_{IntTrade}$	**see Appendix 2**	MONITORING OF FOOD TRADED INTERNATIONALLY Radionuclide specific activity concentrations in food, milk and drinking water samples	Restrictions on foodstuff intended for international trade and associated response actions	■		■
	see Appendix 2	MONITORING OF NON-FOOD COMMODITIES TRADED INTERNATIONALLY Ambient dose equivalent rate at 10 cm from the surface […] Radionuclide specific surface activity concentrations	Restrictions on non-food commodities intended for international trade and associated response actions			

5.2.4 Prerequisites for terminating the nuclear or radiological emergency

The objective of terminating the nuclear or radiological emergency is to facilitate the timely resumption of normal social and economic activity. The termination marks the end of the emergency and the start of planned or existing exposure situation for which other requirements (i.e. applicable to either a planned exposure situation or an existing exposure situation) are applied than those applicable to a nuclear or radiological emergency. The activities aimed at enabling the termination and associated transition are undertaken primarily during the transition phase and provide not only for public protection but also for the well-being of affected populations. During this period it is ensured that the emergency response structure can be dismissed and all activities can be undertaken on a routine basis by relevant organizations, while the situation involving the facility, activity or source can be managed as a planned exposure situation irrespective whether it will be associated with decommissioning of the facility, ending the operational life of the source or continuing normal operation.

A number of considerations, hereby referred to as prerequisites, have been formulated to guide activities to be considered in the protection strategy during its adaptation based on actual conditions in the course of the emergency. They are intended to be applied during the transition phase to enable the termination of the nuclear or radiological emergency and associated transition. The prerequisites are given in Table I-8 as applicable to the three groups of emergency scenarios considered in the protection strategy.

The general prerequisites in Table I-8 are applicable, as appropriate, for any group of emergency scenarios considered in the protection strategy. Specific prerequisites for the transition to a planned exposure situation are applicable to the second group of emergency scenarios as well as to those emergency scenarios in the third group that do not involve release of radioactive material in the environment warranting decisions related to public protection. Specific prerequisites for the transition to an existing exposure situation are applicable to the first group of emergency scenarios considered in the strategy as well as to those emergency scenarios in the third group that involve release of radioactive material in the environment warranting protective actions and other response actions.

What prerequisites would be relevant for the actual conditions prevailing at the time of the emergency, and the extent of their fulfilment, needs to be judged during the actual emergency using Table I-8. Predicting accurately when, where and what the actual impact of the nuclear or radiological emergency might be, as well as what the potential impact of non-radiological factors, such as public concerns and the political situation, is not possible; consequently, the protection strategy for the transition phase of the emergency response is less detailed in terms of actual actions and activities to be carried out. However, once the situation is characterized sufficiently well (even during the early response phase), the relevant prerequisites can be selected and activities planned accordingly. Any decision to be made at this stage need to be based on the extent of fulfilment of these prerequisites.

5.3 Processes for assessing the situation against decision making criteria and for making the decisions

The priority of the protection strategy is to prevent people receiving high doses and being exposed to high dose rates and, thus, to avoid severe deterministic effects among affected populations or individuals. To achieve this goal, precautionary and urgent protective actions and other response actions need to be taken effectively either before the release or exposures occur, or shortly after the release or exposures occur. These emergency response actions are to be taken on the basis of observed conditions at the facility or at the site. Thus, EALs and other observables associated with the emergency classification system discussed in Section 4 are to be used in making decisions during the urgent response phase.

TABLE I-8. PREREQUISITES TO GUIDE ACTIVITIES TO BE TAKEN TO ENABLE TERMINATION OF THE NUCLEAR OR RADIOLOGICAL EMERGENCY AND ASSOCIATED TRANSITION

GENERAL PREREQUISITES

(applicable to any emergency scenario)

□ Necessary urgent and early protective actions implemented.

□ Exposure situation well understood and confirmed to be stable.

□ Radiological situation well characterized, exposure pathways identified and doses assessed for affected populations.

□ Radiological situation assessed, as appropriate, against the reference level and respective criteria.

□ Protection of all workers can be subjected to the requirements for occupational exposure in planned exposure situations.

□ Hazard assessment performed in respect of the situation and its future development and its impact on new EPR assessed.

□ The source secured in as required.

□ Revised or new EPR, if needed, formulated and coordinated or an interim response capability put in place.

□ Non-radiological consequences and other factors (e.g. technology, land use options, availability of resources and of social services) relevant to the termination of the emergency identified, and actions to address them considered.

□ A registry of those individuals who, by the time the emergency is to be terminated, have been identified as requiring longer term medical follow-up established.

□ Consideration given to the management of any radioactive waste arising from the emergency, as appropriate.

□ Interested parties consulted.

□ Relevant information communicated with the public.

SPECIFIC PREREQUISITES

(applicable in addition to General Prerequisites)

Transitioning to a planned exposure situation	Transitioning to an existing exposure situation
□ Circumstances that led to the emergency analysed, corrective actions identified and an action plan developed for the implementation of corrective actions in relation to the facility, activity or source involved in the emergency or administrative procedures established that limit or prevent the use or handling of the source until the circumstances that led to the emergency have been better understood. □ Conditions assessed to ensure compliance with the safe and secure handling of the source involved in the emergency. □ Compliance confirmed with the dose limits for public exposures in planned exposure situations and, as appropriate, with the requirements for medical exposure.	□ Justified and optimized actions taken to meet the generic criteria for enabling the transition and assessed residual doses approach 20 mSv annual effective dose. □ Areas delineated that are not permitted to be inhabited and where it is not feasible to carry out social and economic activity and administrative and other provisions established for them. □ A strategy developed for the restoration of infrastructure, workplaces and public services in the affected areas. □ A mechanism and the means for continued communication and consultation with all interested parties put in place. □ Change or transfer of authority and responsibilities from the emergency response organization to organizations responsible for the long term recovery operations completed. □ Sharing of any information and data completed among relevant organizations and authorities. □ Development of a long term monitoring strategy in relation to residual contamination initiated. □ Programme for longer term medical follow-up for the registered individuals developed. □ Strategy for mental health and psychosocial support for the affected population developed. □ Consideration given to the compensation of victims for damage due to the emergency. □ Administrative arrangements, legal provisions and regulatory provisions put in place or being put in place for the management of the existing exposure situation.

Although the EALs and other observables directly indicate the need to trigger specific protective actions and other response actions during the urgent response phase, with account taken of the generic criteria discussed in Section 5.2.1, they do not account for the prevailing circumstances (such as weather conditions or other events occurring at the same time rendering, for example, critical infrastructure unavailable) under which these emergency response actions might need to be undertaken, raising the need to reconsider the appropriateness of the pre-justified protective actions and the protection strategy before progressing in the course of the actual emergency.

Therefore, to ensure a safe and effective implementation of these emergency response actions during the urgent response phase, situation reports on the weather conditions, the status of the critical infrastructure and resources necessary for safe implementation of emergency response actions (and on any concurring events that may impact the emergency response) needs to be advised quickly so that decisions are made timely without jeopardizing the effectiveness of the planned protection strategy. Moreover, as the impact of the emergency might spread over wide areas and strain the resources available for a safe and effective implementation of the planned protection strategy, use of weather forecast, projections of how the released radioactive material may spread or readings of stationary monitoring systems might provide useful information to enable optimal use of the available resources, should this be necessary, for the sake of effectively implementing the strategy without endangering those in need.

Once the protection strategy for the urgent response phase is implemented, taking account of the specifics of the situation, it will be necessary to periodically reassess the situation to determine whether the protective actions and the protection strategy continue to be justified (by doing more good than harm) and to provide the best under the prevailing circumstances, considering any new information that becomes available. Such a reassessment starts in the early response phase and is primarily getting use of monitoring results upon which protective actions and the protection strategy are adapted on the basis of OILs through either expanding the protective actions in other areas and population groups, or their lifting as being not justified anymore. The focus of the protection strategy during the early response phase is to reduce the risk of stochastic effects among affected populations through identifying all those who might receive doses exceeding the generic criteria, taking early protective actions and other response actions for them and preventing the spread of contamination. In identifying all those for whom early protective actions and other response actions are needed, use of various tools and projections, as discussed for the urgent response phase, may be useful. However, decisions on taking emergency response actions, which include those for reducing the risk for stochastic effects and for preventing the spread of contamination, are made against OILs using the results from monitoring performed in predefined areas. During the early response phase, as the characterization of the radiological situation progresses, assessment of the effectiveness of the protection strategy in place against the selected reference level is expected to be done. Such exercise helps determining the result of implementation of the protection strategy under the prevailing circumstances as well as identifying for whom more needs to be done. Although for the early response phase the strategy is quite pre-planned in detail, to the extent possible, and there is limited time available to go through thorough justification and optimization of protection and safety, there may be circumstances warranting such an adaptation of the protection strategy to account for various non-radiological factors existing at the time, in order to ensure that a justified and optimized strategy is applied at all times and under all circumstances.

Once all public protective actions are implemented, the return to normality by resuming normal social and economic activity in the affected areas and providing for the well-being of affected individuals comes increasingly in the focus of the protection strategy. As the

emergency progresses, there is a progressively greater understanding of the precise nature of the emergency and the circumstances surrounding it. As a consequence, decision making is based on actual conditions rather than pre-planned response, to a progressively greater extent. Namely, during this phase of the emergency response, use of monitoring results against OILs is done only as a screening means to initiate discussion on the need to adapt or lift protective actions and associated arrangements in place or to take activities to further reduce exposures. Any decision during this phase is done after careful assessment of the radiological situation, which includes the assessment of residual doses and their comparison against the selected reference level, with account taken of various non-radiological conditions that need to be fulfilled against the prerequisites for the transitioning. Any adaptation of the protection strategy in place needs to be thoroughly justified and optimized, with account taken of various radiological and non-radiological factors. During the transition phase, as the emergency response efforts are increasingly focused on restoring the functionality of communities, the processes of justification and optimization are applied more rigorously, as the time allows, through an approach that is necessarily emergency- and site-specific and, thus, cannot be pre-planned in detail.

It is important to note that such delineation in time and space may not be possible in the course of the actual emergency, and that overlaps in implementing the different aspects of the strategy to certain extent are to be expected.

The process for assessing the situation in the course of an emergency response so that decisions are made on the protection strategy to be applied on the basis of the decision making criteria is shown in Fig. I-2. The process describing how decisions on protective actions and other response actions are made, and how this process changes with time (i.e. how the strategy is adapted with time) is shown in Fig. I-3 for the three groups of emergency scenarios considered in the protection strategy. The process for assessment of the effectiveness of the adapted protection strategy and its adaptation in the course of the emergency response is shown in Fig. I-4.

5.4 Process for adapting or lifting protective actions and other response actions

Once individual protective actions and other response actions are no longer justified, they need to be adapted or lifted. While judgement on the protective actions and other response actions to be taken in the course of the emergency response is a more straightforward process utilizing the OILs, adapting or lifting protective actions needs to consider also non-radiological factors. In addition, it needs to be clearly communicated to all concerned parties as to whom and where decision on adaptation or lifting applies and as of when it applies together with any information explaining the rationale for the decision.

Initiating considerations on adapting or lifting protective actions and other response actions can be taken once the following conditions have been considered:

- Any limitations associated with the protective actions itself (e.g. related to its duration or effectiveness);
- The radiological situation and its assessment against reference levels, generic and operational criteria, as appropriate, including assessment of the impact of adapting and/or lifting protective actions on the residual doses against the reference level;
- Other non-radiological factors relevant for the adaptation or lifting of protective actions that may be associated, e.g. with conditions that provide for the well-being of the affected population and with the conduct of normal social and economic activity;

- The need for the protective action to be adapted and/or lifted at different times in different areas or for different population groups;
- The need to consult concerned parties and to provide relevant information to them including on the rationale for the adaptation and/or lifting and on how this adaptation or lifting will affect them.

The generic criteria to indicate the need to adapt or lift protective actions are associated with those given in Tables I-4 to I-6 for initiating specific protective actions and other response actions and are presented in Table I-9 for individual protective actions.

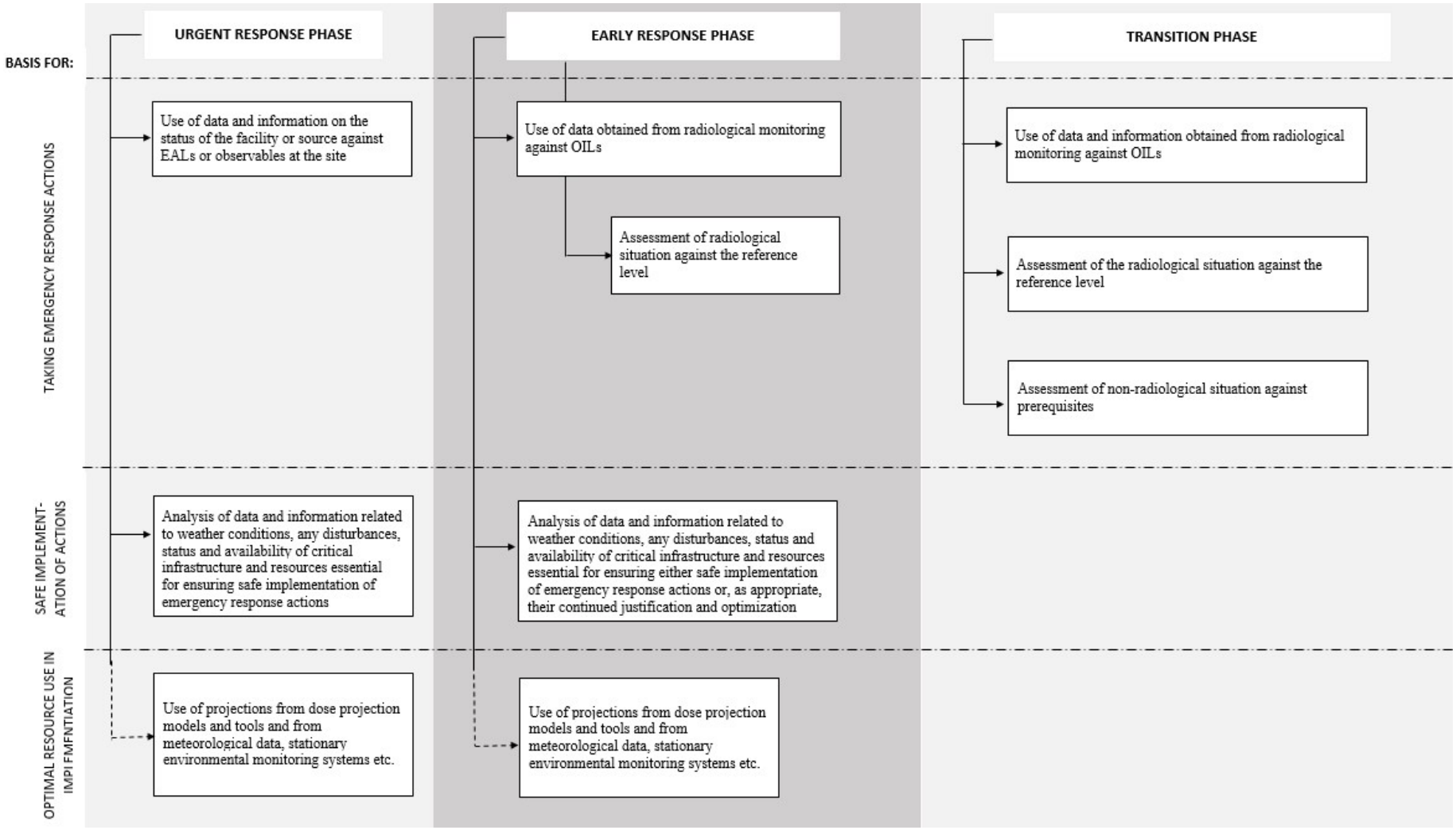
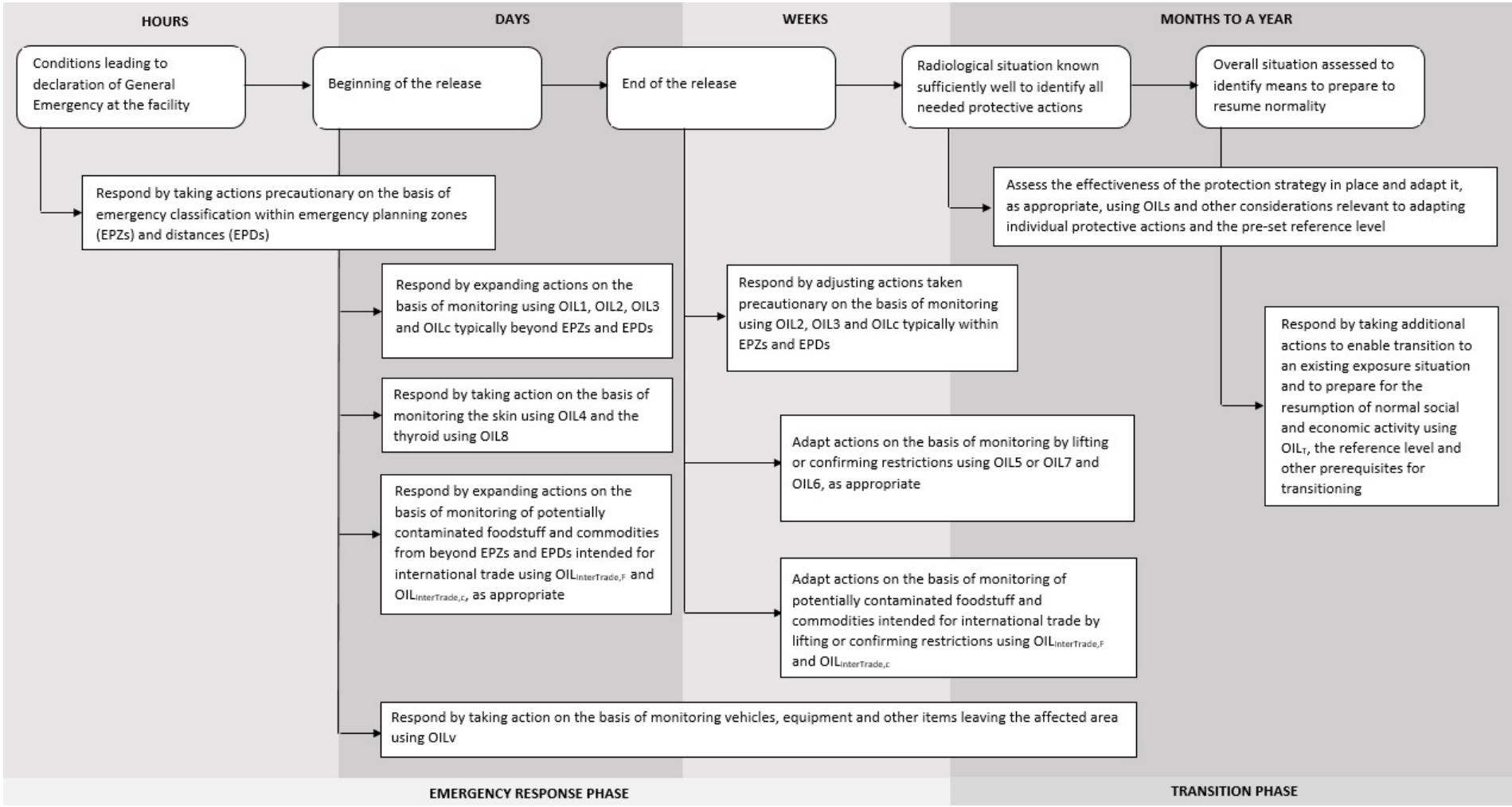
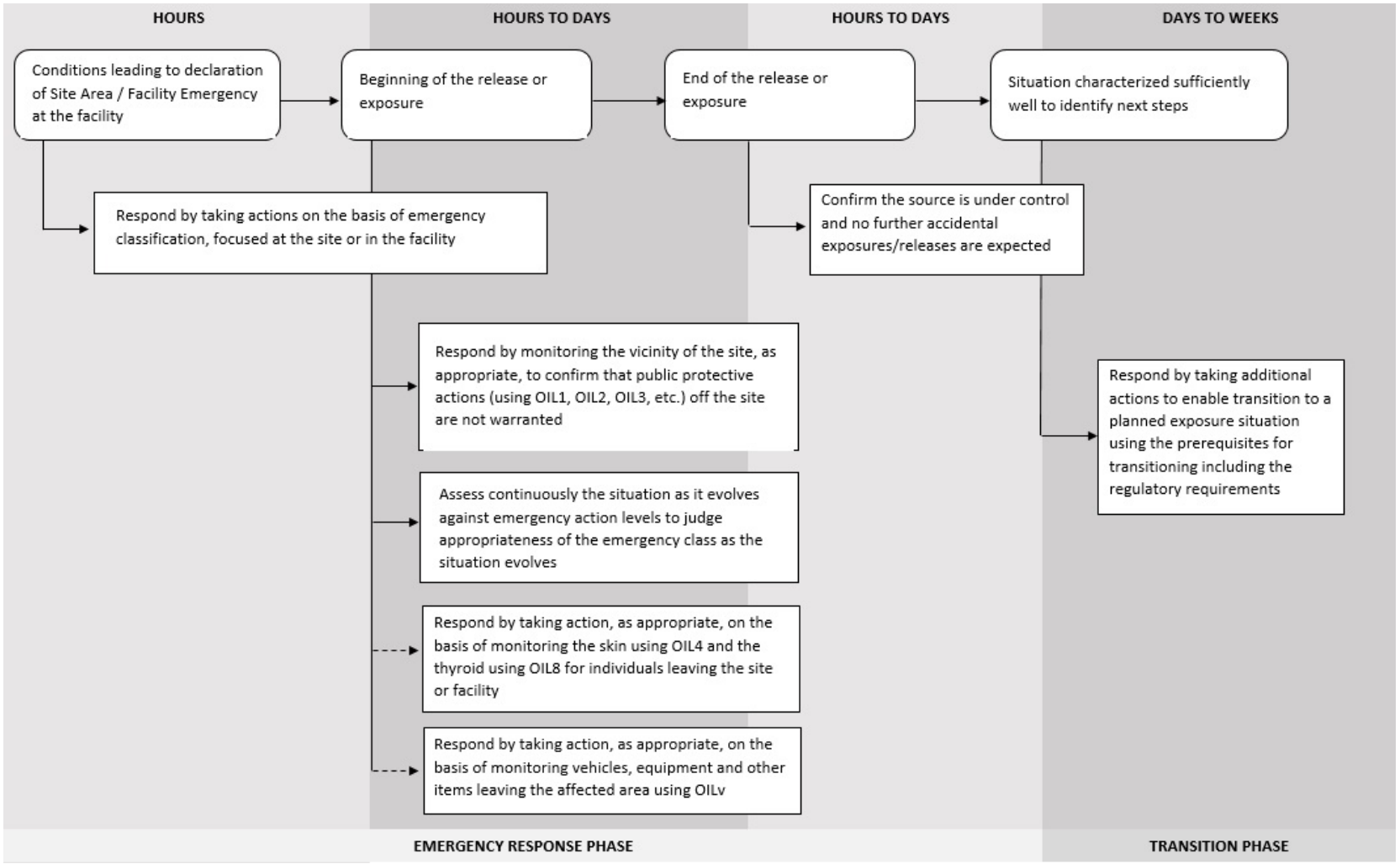


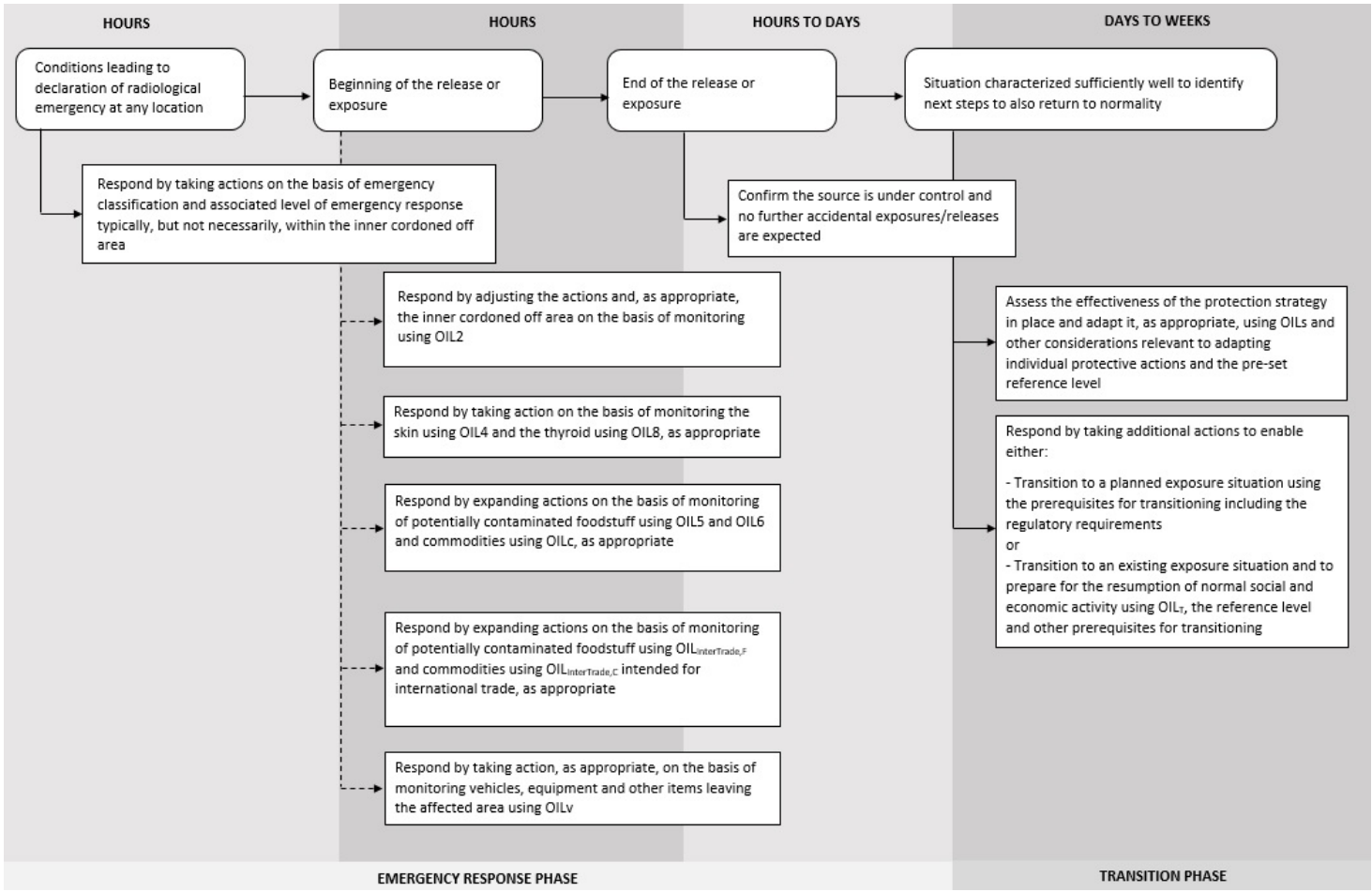
FIG. I-2. The process for assessing the situation in the course of an emergency response against decision making criteria.


HOURS
DAYS
WEEKS
MONTHS TO A YEAR
Conditions leading to declaration of General Emergency at the facility
Beginning of the release
End of the release
Radiological situation known sufficiently well to identify all needed protective actions
Overall situation assessed to identify means to prepare to resume normality
Respond by taking actions precautionary on the basis of emergency classification within emergency planning zones (EPZs) and distances (EPDs)
Assess the effectiveness of the protection strategy in place and adapt it, as appropriate, using OILs and other considerations relevant to adapting individual protective actions and the pre-set reference level
Respond by expanding actions on the basis of monitoring using OIL1, OIL2, OIL3 and OILc typically beyond EPZs and EPDs
Respond by adjusting actions taken precautionary on the basis of monitoring using OIL2, OIL3 and OILc typically within EPZs and EPDs
Respond by taking additional actions to enable transition to an existing exposure situation and to prepare for the resumption of normal social and economic activity using OILT, the reference level and other prerequisites for transitioning
Respond by taking action on the basis of monitoring the skin using OIL4 and the thyroid using OIL8
Adapt actions on the basis of monitoring by lifting or confirming restrictions using OIL5 or OIL7 and OIL6, as appropriate
Respond by expanding actions on the basis of monitoring of potentially contaminated foodstuff and commodities from beyond EPZs and EPDs intended for international trade using OILInterTrade,F and OILInterTrade,c, as appropriate
Adapt actions on the basis of monitoring of potentially contaminated foodstuff and commodities intended for international trade by lifting or confirming restrictions using OILInterTrade,F and OILInterTrade,c
Respond by taking action on the basis of monitoring vehicles, equipment and other items leaving the affected area using OILv
EMERGENCY RESPONSE PHASE
TRANSITION PHASE

(a)

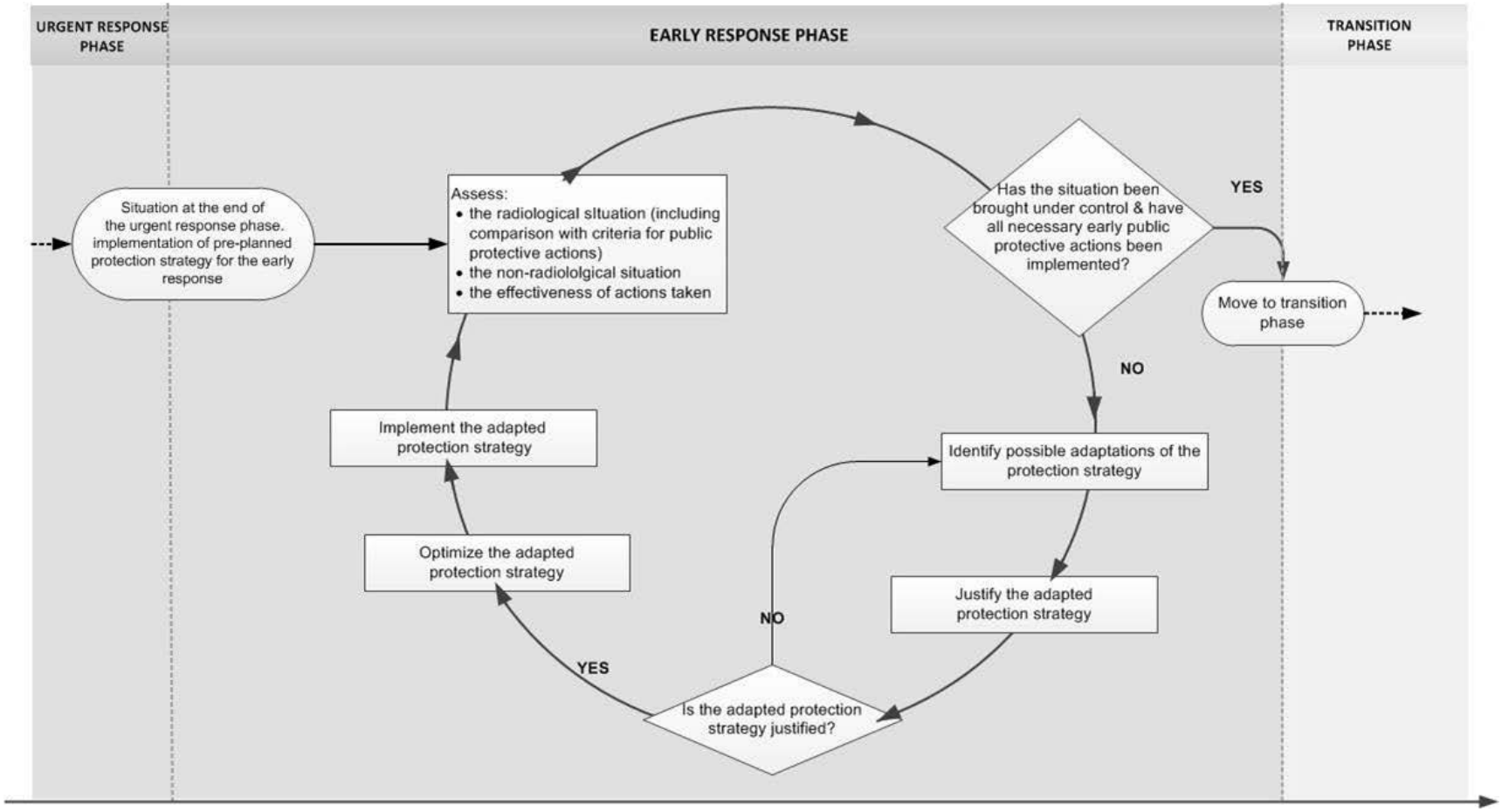

HOURS
HOURS TO DAYS
HOURS TO DAYS
DAYS TO WEEKS
Conditions leading to declaration of Site Area / Facility Emergency at the facility
Beginning of the release or exposure
End of the release or exposure
Situation characterized sufficiently well to identify next steps
Respond by taking actions on the basis of emergency classification, focused at the site or in the facility
Confirm the source is under control and no further accidental exposures/releases are expected
Respond by monitoring the vicinity of the site, as appropriate, to confirm that public protective actions (using OIL1, OIL2, OIL3, etc.) off the site are not warranted
Respond by taking additional actions to enable transition to a planned exposure situation using the prerequisites for transitioning including the regulatory requirements
Assess continuously the situation as it evolves against emergency action levels to judge appropriateness of the emergency class as the situation evolves
Respond by taking action, as appropriate, on the basis of monitoring the skin using OIL4 and the thyroid using OIL8 for individuals leaving the site or facility
Respond by taking action, as appropriate, on the basis of monitoring vehicles, equipment and other items leaving the affected area using OILv
EMERGENCY RESPONSE PHASE
TRANSITION PHASE

(b)

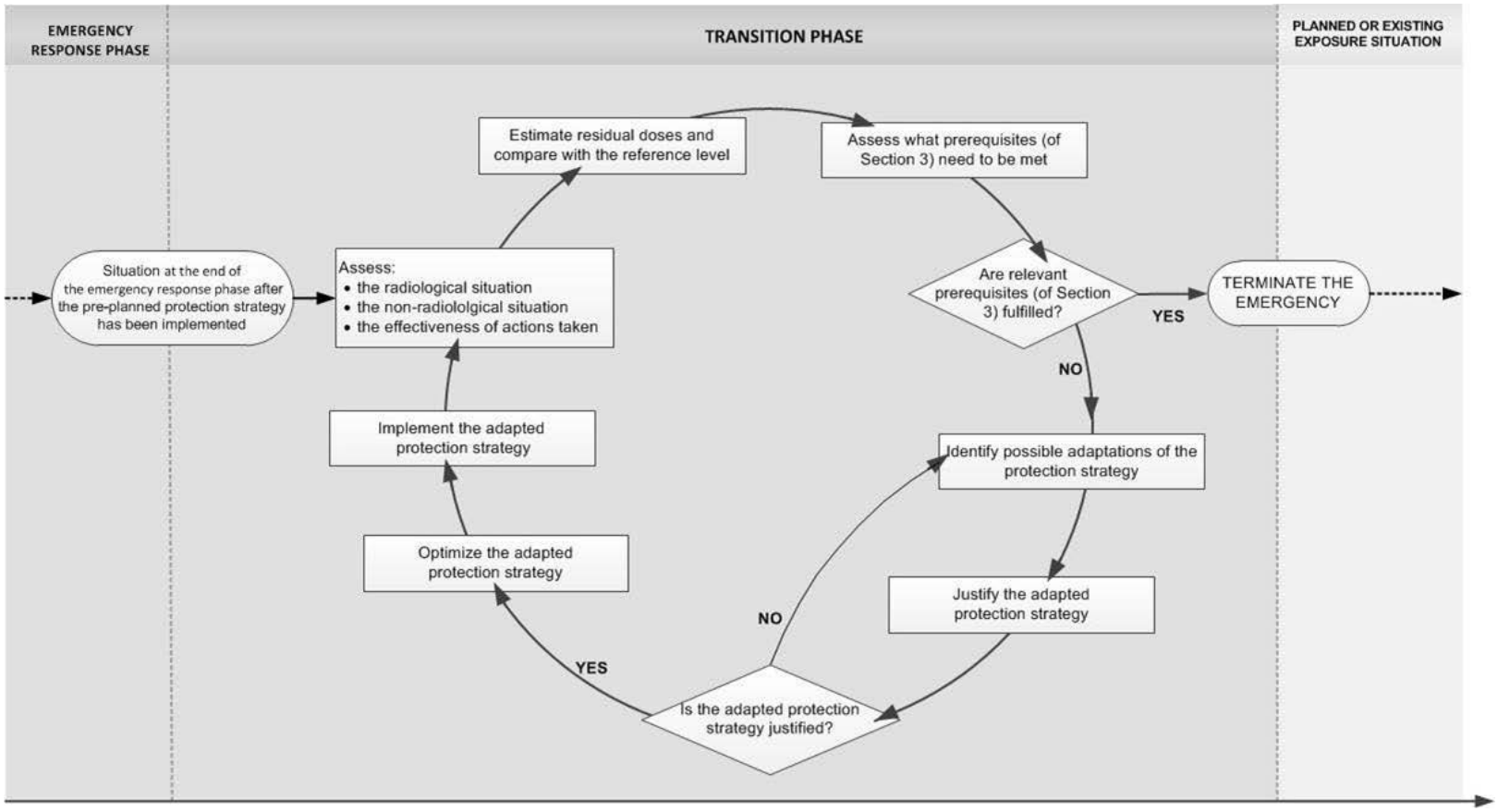


(c)

FIG. I-3. The process describing how decisions on protective actions and other response actions are made and how theses changes with time for (a) the first group, (b) the second group and (c) the third group of emergency scenarios considered in the protection strategy.


URGENT RESPONSE PHASE
EARLY RESPONSE PHASE
TRANSITION PHASE
Situation at the end of the urgent response phase. implementation of pre-planned protection strategy for the early response
Assess:
• the radiological sItuation (including comparison with criteria for public protective actions)
• the non-radiololgical situation
• the effectiveness of actions taken
Has the situation been brought under control & have all necessary early public protective actions been implemented?
YES
Move to transition phase
NO
Identify possible adaptations of the protection strategy
Justify the adapted protection strategy
Is the adapted protection strategy justified?
NO
YES
Optimize the adapted protection strategy
Implement the adapted protection strategy

(a)



(b)

FIG. I-4. The process for adaptation of the protection strategy in the course of the emergency response during the early response phase (a) and the transition phase (b) [I–3].

The OILs to be used to initiate discussions on adapting or lifting protective actions and other response actions and associated considerations are also given in Table I-9 together with different considerations to be taken into account before decision on adapting or lifting protective actions is made. The values for OILs given in Table I-9 have been developed on the basis of conservative assumptions using the methodology provided in […] with account taken on the members of the public who are most vulnerable to radiation exposure (i.e. children and pregnant women) and take account of the generic criteria and OILs given in Tables I-5 and I-6 for initiating protective actions and other response actions. They can be revised in the course of emergency response only after convincing reasons requiring their revision have become evident as for any other OILs.

TABLE I-9. CRITERIA FOR INITIATING CONSIDERATIONS TO ADAPT OR LIFT SPECIFIC PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS

Protective action	**Generic criteria for considering to adapt/lift the action**		**OILs for considering to adapt/lift the action**	**Additional considerations**
	E *	***H*$_{fetus}$** ** **for the full period of in utero development**		
Evacuation	≥100 mSv in the first year	≥100 mSv	≥OIL2	Not intended to be applied for long durations. Substitute evacuation with relocation after it has been confirmed that adequate living conditions for individuals are ensured, arrangements for granting short term access to evacuated areas is allowed in a controlled manner to evacuees to prepare for longer term relocation, impact the substitution may have on residual dose has been assessed and clear instructions are given to evacuees.
	<100 mSv in the first year	<100 mSv	<OIL2	Lift the evacuation after it has been confirmed that only limited restrictions are still necessary for people living normally in the area, with account taken of assessed residual doses against the pre-set reference level and the following conditions are met: - Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies, telecommunication networks). - Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and

Protective action	Generic criteria for considering to adapt/lift the action		OILs for considering to adapt/lift the action	Additional considerations
				habits, including land use, have been provided to those returning. - Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning. - A strategy has been established for the restoration of workplaces and for the provision of social support. - Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.
	≤20 mSv per year	≤20 mSv	<OIL_T	Lift the evacuation along with the decision to terminate the emergency within the affected area if the prerequisites to do so are met and the following is achieved: - Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies, telecommunication networks). - Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning. - Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning. - A strategy has been established for the restoration of workplaces and for the provision of social support. - Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.
Sheltering	N.A.	N.A.	N.A.	Not appropriate as longer term action, typically a few days. Lift sheltering if taken precautionary in case of positive evolution of the event fully or partially. Assess the impact the lifting may have on residual dose and make informed decision based on the following information: - The evolution of the release; - The level of contamination in the environment; - The level of protection offered by the type of buildings used for sheltering (shielding factor and tightness against diffusion of outside atmosphere);

Protective action	Generic criteria for considering to adapt/lift the action		OILs for considering to adapt/lift the action	Additional considerations
				- The need for continued simultaneous administration of ITB, and the medical care and hygiene needs of those sheltered (availability of medicines, food supplies, etc.); - Any necessity to gradually increase the time members of the public are allowed to spend outdoors, before sheltering is fully lifted; and - The need for further protective actions based on generic criteria and OILs to replace sheltering (e.g. evacuation or relocation). In all other cases, consider to substitute the sheltering with other protective actions (e.g. evacuation or relocation) depending on the criteria exceeded or once preparations to safely evacuate or relocate individuals are completed.
Iodine thyroid blocking	N.A.	N.A.	N.A.	Lift after the first administration unless second administration is indicated.
Relocation	<100 mSv in the first year	<100 mSv	<OIL2	Lift the evacuation after it has been confirmed that only limited restrictions are still necessary for people living normally in the area, with account taken of assessed residual doses against the pre-set reference level and the following conditions are met: - Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies, telecommunication networks). - Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning. - Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning. - A strategy has been established for the restoration of workplaces and for the provision of social support. - Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.
	≤20 mSv per year	≤20 mSv	$<OIL_T$	Lift the evacuation along with the decision to terminate the emergency within the affected area if the prerequisites to do so are met and the following is achieved: - Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services,

Protective action	Generic criteria for considering to adapt/lift the action		OILs for considering to adapt/lift the action	Additional considerations
				water services, sanitation, energy supplies, telecommunication networks). - Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning. - Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available to those returning. - A strategy has been established for the restoration of workplaces and for the provision of social support. - Information on the likely evolution of the exposure situation and the associated health hazards has been provided to those returning.
Food, milk and drinking water restrictions in affected areas	<10 mSv in the first year	<10 mSv	<OIL6	Lift the restriction only after estimation of the actual doses from the ingestion pathway and their contribution to the residual dose from all exposure pathways.
Food, milk and drinking water restrictions for international trade	<1 mSv per year	<1 mSv	< $OIL_{InterTrade,F}$	Lift restrictions on international trade for infant and non-infant food
Non-food commodity restrictions in affected areas	<10 mSv in the first year	<10 mSv	<OIL_C	Lift the restriction only after estimation of the actual doses from the use of non-food commodities and their contribution to the residual dose from all exposure pathways.
Non-food commodity restrictions in affected areas for international trade	<1 mSv per year	<1 mSv	< $OIL_{InterTrade,C}$	Lift restrictions on trading non-food commodities internationally.
Restriction of vehicles, equipment and other items leaving the affected area	<10 mSv in the first year	<10 mSv	<OIL_V	Lift the restriction only after estimation of the actual doses from the use of vehicles, equipment and other items and their contribution to the residual dose from all exposure pathways.

* Effective dose.
** Equivalent dose to the fetus.

The process for adapting and/or lifting protective actions is presented in Fig. I-5. Initial consideration whether a protective action is justified is made on the basis of the criteria established for their initiation (see Tables I-5 and I-6). However, there may be circumstances that, despite the criteria are still exceeded, other conditions render the protective action unjustified (e.g. significant decline in the reserves of essential foods in relation to food restrictions), warranting considerations be given for its adaptation. If this is the case or the criteria for taking that action are not exceeded anymore, then consideration is given, if relevant, on whether another criterion for taking other protective actions is exceeded. This

may be relevant, for example, in the case of sheltering or evacuation. In the case that criteria for another action are exceeded, then substituting the initial action with the other action is an option, after having considered any other conditions that may need to be fulfilled (e.g. if evacuation is substituted with relocation, other conditions relate to the considerations to substituting evacuation with relocation given in Table I-9). If such consideration is not relevant, then the protective action can be considered for lifting, provided that the impact the lifting has on the residual doses is assessed against the reference level and other relevant preconditions (given in Table I-9) are fulfilled. The process for adapting or lifting protective actions is presented in Fig. I-5. Applying this process is intended to ensure that protective actions or their adaptation or lifting are always justified and optimized, with account taken of radiological as well as non-radiological considerations.

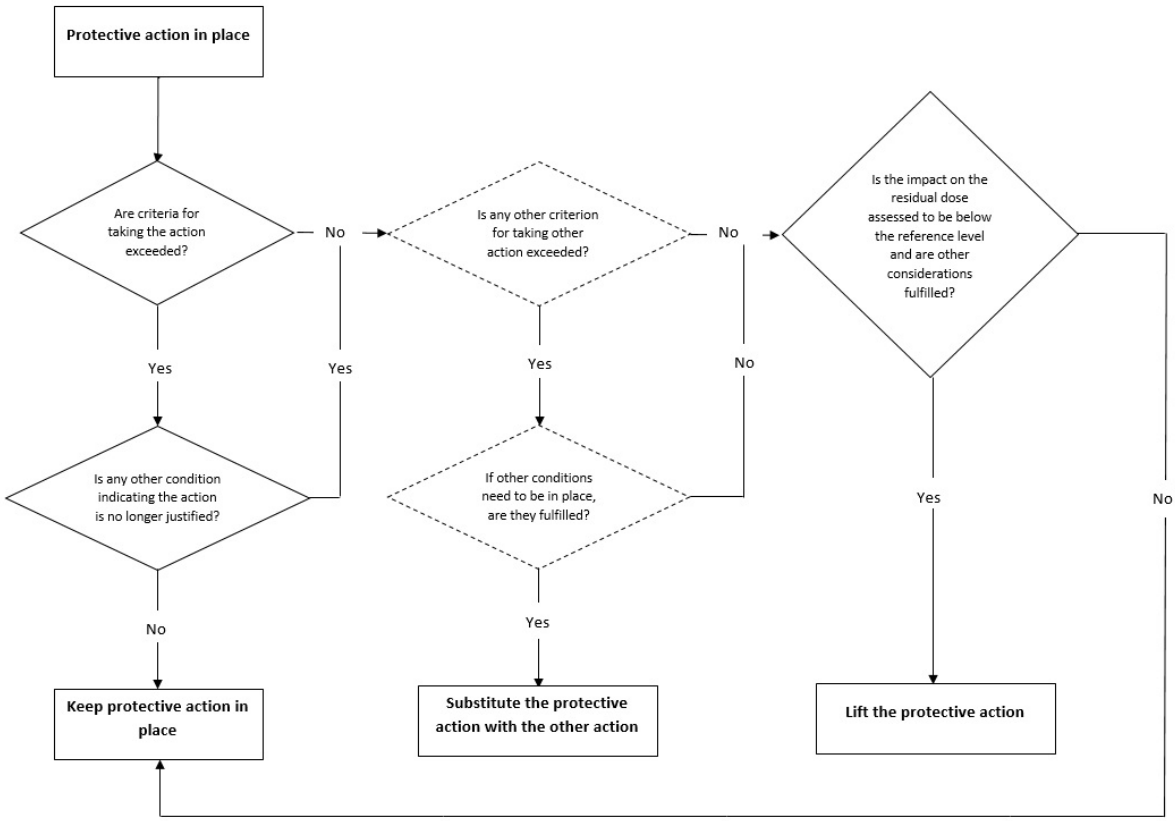


FIG. I-5. Process for adapting or lifting protective actions.

5.5 Protective actions and other response actions to be implemented

The key protective actions considered in this strategy are evacuation, sheltering, iodine thyroid blocking, relocation, restrictions on consumption of food, milk and drinking water, restrictions on use of non-food commodities, contamination control and decontamination, and prevention of inadvertent ingestion.

Evacuation is the rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure. By removing people from the location of the immediate hazard in a nuclear or radiological emergency, evacuation protects them from all the exposure pathways. However, it results in people being (compulsorily) moved to temporary accommodation, which is unlikely to be suitable for residence for more than a few days.

Sheltering is the short term use of a structure for protection from an airborne plume and/or deposited radioactive material. Sheltering is an urgent protective action, used to provide

shielding against external exposure and to reduce the intake of airborne radionuclides by inhalation. It consists of going inside a suitable building (a private house, a multi-storey building, a commercial mall, a private or public shelter), closing doors, windows and vents, shutting off all ventilation systems, listening to the information and further recommendations and advice provided by the authorities, through the media or other means of communication. Sheltering is a short term measure and can only be used for a short period (not more than 48 hours). In the case of a protracted release (expected to last for more than two days), evacuation of sheltered people between two releases, or during periods of reduced release, may need to be considered and carried out, if justified.

Iodine thyroid blocking (ITB) is the administration of a compound of stable iodine (usually potassium iodide) to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid in a nuclear or radiological emergency involving radioactive iodine. Iodine thyroid blocking is an urgent protective action. Stable iodine is generally administered as a single dose that is judged be sufficient to give protection to the thyroid for 24 hours. In the event of prolonged release, when evacuation is not possible or unsafe, repeated dosing might be judged appropriate to prolong thyroid protection provided second dose is available to do so. Repeated dosing is not advised for neonates, pregnant and breastfeeding women and older adults (over 60 years).

Food, milk and drinking water restrictions relate to the actions taken to protect the food chain and water supply systems (e.g. milk from grazing animals or drinking water using open sources (such as rain water)) from getting contaminated in a nuclear or radiological emergency as well as to the actions taken to protect individuals from ingestion of potentially or actually contaminated food, milk and drinking water (such as locally produced vegetables) in the emergency. The end goal of taking this action is to prevent or reduce the internal exposure due to the consumption of potentially or actually contaminated food products, milk and drinking water. Food, milk and drinking water restrictions have to be initiated as soon as possible in the urgent response phase. These restrictions could remain in place in longer term (even within the framework of an existing exposure situation).

Relocation is the non-urgent removal or extended exclusion of people from an area to avoid long term exposure from deposited radioactive material. Relocation is an early protective action. It may be a substitution for the evacuation. Relocation is considered to be permanent relocation if return is not foreseeable; otherwise it is temporary relocation. Relocation is used to prevent or significantly reduce further exposures from all exposure pathways (notably external exposure, inhalation of resuspended material and inadvertent ingestion) from radioactive material deposited on the ground and other surfaces, including indoor contamination. Relocation can last for weeks or months (temporary relocation) or indefinitely (permanent relocation).

Restrictions on non-food commodities relate to the actions taken to protect non-food commodities from getting contaminated in a nuclear or radiological emergency as well as to the actions taken to protect individuals from use of non-food commodities that are potentially or actually contaminated in the emergency. The term non-food commodities is broad and encompasses vehicles, cargoes, various items for use (such as plates, toys or cutleries) and any item intended for public use that is not a food but may get contaminated in an emergency. The end goal of taking this action is to prevent or reduce the external exposure and internal exposure (through inadvertent ingestion primarily) due to the use of potentially or actually contaminated non-food commodities. Non-food commodities' restrictions need to be initiated as soon as in the urgent response phase as a precaution. These restrictions could then be

adapted during the early response phase and the transition phase, once radiation monitoring results become available.

Contamination control relates to various actions and measures taken to prevent spreading of contamination from an affected area in a nuclear or radiological emergency. These include measures taken to ensure control is in place on what enters in and exits from the affected area (access control), radiation monitoring of people, vehicles, equipment and other items leaving the affected area and their decontamination, when appropriate. Access control involves setting up barriers to an affected area and maintaining them to ensure that people and vehicles including related items do not enter or exit the area unless authorized to do so, they are monitored and, where necessary, decontaminated. Such controls not only help preventing the contamination is spread outside the restricted areas, but help ensuring systematic control of exposures incurred by people (such as restoration workers, farmers caring for what was left behind) spending time in restricted area. Contamination control needs to be put in place as early as in the urgent response phase and mostly maintained during the emergency response phase. Some aspects of contamination control need to be maintained for a longer period during the transition phase as well as after the emergency is terminated, for example, for workers and helpers involved in restoration activities in restricted access areas and for (duly authorized) people re-entering restricted areas. Access control needs to be put in place once areas have been evacuated/relocated and maintained until return or free access is authorized. Access control to highly contaminated areas are likely to be maintained in the existing exposure situation, e.g. for workers involved in the rehabilitation works.

Decontamination is the complete or partial removal of contamination by a deliberate physical, chemical or biological process. It includes a wide range of processes for removing contamination from people, equipment and buildings, but to exclude the removal of radionuclides from within the human body or the removal of radionuclides by natural weathering or migration processes, which are not considered to be decontamination. Personal decontamination processes may range from simply changing clothes, washing or showering to assisted decontamination, performed by trained personnel in special installations, possibly under medical supervision.

Access control, radiation monitoring and decontamination, where necessary, can also play a key role in public reassurance, especially to those resettled as well as for people who receive them.

Prevention of inadvertent ingestion relates to advise being given not to drink, eat or smoke and to keep hands away from the mouth until hands are washed and not to play on the ground or do other activities that could result in the creation of dust that could be ingested or inhaled. Although simple action following general hygiene rules, the advice aims at reducing ingestion and inhalation of released or resuspended radioactive material. Prevention of inadvertent ingestion could be advised during the emergency response phase (for people sheltered or undergoing evacuation or preparing for relocation or emergency workers in the affected areas) as well as during the transition phase (e.g. for people returning in an areas with limited restrictions still in place and emergency workers and helpers performing some tasks within the affected areas). The advice may extend even in longer term, e.g. in delineated areas to which access has been granted to duly authorized persons and to workers and helpers involved in restoration works.

The suite of protective actions, other response actions and associated considerations of the strategy to protect the public for the three groups of emergency scenarios are given in Tables I-10 to I-12. These tables contain also information about the basis for taking the suite of

emergency response actions and the time allowing for their effective implementation per emergency phase.

5.6 Consultation with the public and other interested parties

Although the opinion of the public, the affected populations in particular, and other interested parties are useful input to adapting the protection strategy, during the response, the ultimate authority and final decisions remain with the decision making body. Thus, any consultation during the emergency response is to be organized in such a manner so as not to delay timely and efficient decision making.

During the urgent response phase, the effectiveness of protective actions and other response actions is critically dependent on their urgent implementation such that there is insufficient time to allow consultation to take place. Consultation is thus likely to be non-existent in the urgent response phase but would be expected to increase as the early response phase develops and during the transition phase, as the situation stabilizes (see Fig. I-6). It is anticipated that progressively more consultation occurs as time permits, and as more information becomes available. During the transition phase, it is possible to increase the involvement of interested parties in the adaptation of the protection strategy, while not delaying its optimal implementation.

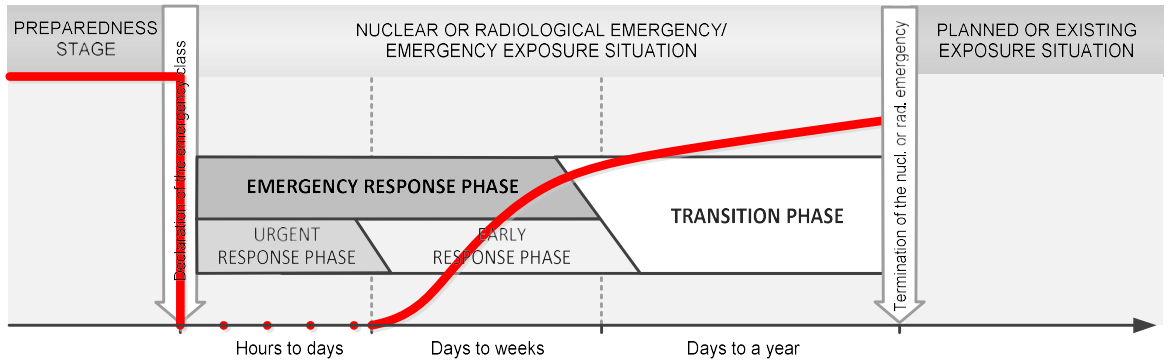


FIG. I-6. Involvement of, and consultation with, interested parties during different phases of a nuclear or radiological emergency [I–3].

The number of interested parties and the issues they are interested in are expected to vary as the emergency progresses and its impact is better known, with a tendency to increase with time and in comparison to the preparedness stage. Moreover, it is to be expected that, during the emergency response, the number of interested parties and their representatives may change from the ones who were engaged and consulted during the preparedness stage, raising the need for proper communication during the consultation process in the emergency response without assuming any previous knowledge on the topic of interest, so that it is ensured meaningful inputs are obtained.

TABLE I-10. SUITE OF EMERGENCY RESPONSE ACTIONS AND ASSOCIATED CONSIDERATIONS FOR THE FIRST GROUP OF EMERGENCY SCENARIOS

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
Urgent response phase	- Take iodine thyroid blocking (if release of radioiodine is expected) by administering stable iodine agents within PAZ and UPZ - Evacuate the population within PAZ - Shelter the population within UPZ until evacuation, as appropriate - Reduce inadvertent ingestion within PAZ, UPZ and EPD - Protect the food chain and drinking water supplies from getting contaminated within ICPD (e.g. place grazing animals on protected feed, disconnect rainwater collection pipes and cover open sources of drinking water); - Stop the consumption and distribution of non-essential food and feed	- Place access control in the PAZ and UPZ - Instructs those responsible for transportation systems (air, land, sea) to avoid the UPZ - Register those who were in the PAZ and UPZ - Monitor those who were in the PAZ and UPZ to identify those for whom decontamination and/or medical action may be needed - Provide for medical care and mental health and psychosocial support to affected population - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as emergency workers including medical staff in hospitals carrying for	Notification on the declaration of General emergency	Hours to days	- Assess overall situation to ensure safe implementation of emergency response actions - Confirm arrangements in place for safe evacuation of special facilities or population groups - Give clear instructions regarding emergency response actions to concerned parties including on the treatment of pets - Do not delay provision of medical treatment to those in need irrespective of the presence of contamination (including those presenting symptoms of radiation overexposure) - Do not delay the evacuation of PAZ with actions taken in UPZ - Evacuate those in PAZ beyond EPD. Evacuate UPZ if potential for severe release persists - Issue instructions to those

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	(e.g. local produce, wild-grown products, milk from grazing animal, rainwater and animal feed) within ICPD - Protect relevant non-food commodities from getting contaminated within ICPD - Stop the use and distribution of non-essential non-food commodities within ICPD - Stop international trade of potentially contaminated foodstuff and non-food commodities	patients to be evacuated			refusing to evacuate - Give instructions for proper sheltering considering also those populations groups without proper shelter (e.g. tourists in mobile home or tents) - Provide support to those sheltered for access to essentials and medicines - Provide, where appropriate, supplies with clean food, milk, drinking water as well as animal feed - Lift sheltering after a day to two days by substituting with evacuation or allowing for partial/fully lifting - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Alert hospitals and medical staff to prepare to treat contaminated and exposed individuals

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Begin implementation of controls to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Increase readiness for timely deployment of monitoring teams following the release in areas beyond UPZ where deposition sufficient to warrant taking urgent protective actions is expected - Begin implementing controls on vehicles, items and other equipment exiting the affected areas using OIL_V to determine whether they are safe for use and any need for decontamination - Assess the results from skin and thyroid monitoring to decide on the course of medical action and need for individual decontamination using OIL4 and OIL8 - Instruct affected population to decontaminate, if appropriate, by removing outer clothing

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					and washing hands and face
Urgent response phase	- Take iodine thyroid blocking (if release of radioiodine is expected) by administering stable iodine agents in the areas beyond UPZ with early high deposition - Evacuate the population in areas beyond UPZ with early high deposition	- Place access control in these areas - Register those who were in these areas - Monitor those who were in these areas to identify those for whom decontamination and/or medical action may be needed - Provide for medical care and mental health and psychosocial support to affected population from these areas - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as emergency workers including medical staff in hospitals carrying for patients to be evacuated and members of monitoring teams	OIL1	A day	- Consider these actions after the beginning of the release - Assess overall situation to ensure safe implementation of emergency response actions - Remind those in these areas on instructions how to reduce inadvertent ingestion - Give clear instructions regarding emergency response actions to concerned parties including on the treatment of pets - Issue instructions to those refusing to evacuate - Assess the results from skin and thyroid monitoring to decide on the course of medical action and need for individual decontamination using OIL4 and OIL8 - Instruct affected population to decontaminate, if appropriate, by removing outer clothing

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					and washing hands and face - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Provide, where appropriate, supplies with clean food, milk, drinking water as well as animal feed - Ensure controls are in place for preventing the spread of contamination (using OIL_V, as appropriate)
Urgent response phase	- Stop the consumption and distribution of non-essential food and feed (e.g. local produce, wild-grown products, milk from grazing animal, rainwater and animal feed) in areas beyond ICPD with early high deposition - Stop the use and distribution of non-essential non-food commodities in areas	- Register those who may have consumed contaminated foodstuff - Provide for medical care and mental health and psychosocial support to affected population from these areas - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as	OIL3	Days	- Consider these actions after the beginning of release - Assess the situation to ensure safe implementation of emergency response actions - Provide, as appropriate, supplies with clean food, milk, drinking water as well as animal feed - In case of lack of essential foodstuff, consider other protective actions such as relocating people from these

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	beyond ICPD with early high deposition - Stop the international trade of foodstuff and other goods from areas beyond ICPD with early high deposition	emergency workers including the members of monitoring teams			areas - Implement controls to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place for preventing the spread of contamination (using OIL_V, as appropriate) - Give instructions for proper management of human and animal remains with actual or possible contamination
Early response phase	- Relocate population from areas within EPD with high ground deposition	- Register those individuals from these areas - Provide for medical care and mental health and psychosocial support to affected population from these areas - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as emergency workers	OIL2	A week to a month	- Consider these actions after the release seized - Assess overall situation to ensure safe implementation of emergency response actions - Issue instructions to those refusing to relocate - Assess the results from skin and thyroid monitoring to decide on the course of medical action and need for individual decontamination using OIL4 and OIL8

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Instruct affected population to decontaminate, if appropriate, by removing outer clothing and washing hands and face - Consider if evacuation in certain areas needs to be substituted with relocation - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Ensure controls are in place for preventing the spread of contamination (using OIL_V, as appropriate) - Give instructions for proper management of human and animal remains with actual or possible contamination
Early response phase	Adaptation of protective actions imposed during the urgent response phase: - Evacuation - Restrictions on the consumption and	- Ensure access control is in place - Delineate areas and implement administrative measures as appropriate - Provide medical care and mental health and	In line with Table I-9	Weeks to months	- Initiate activities to characterize the situation well - Use monitoring results against OILs and associated considerations to determine which protective actions taken precautionary during the

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	distribution of non-essential food and feed - Restrictions on the use and distribution of non-essential non-food commodities - Reducing inadvertent ingestion - Restrictions on international trade of contaminated foodstuff and non-food commodities	psychosocial support to affected population - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as emergency workers - Protect members from the public volunteering in the emergency response as helpers in an emergency			urgent response phase can be adapted or lifted - As the time allows, assess the radiological and non-radiological situation to ensure the strategy in place remains justified and optimized at all time. Use the reference level to assess residual doses when considering any adaptation - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Ensure control is in place to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place to prevent the spreading of contamination (using OIL_V, as appropriate) - Give instructions for proper management of human and animal remains with actual or

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					possible contamination - Assess received doses, when appropriate, to decide on the course of medical actions - Initiate establishment of a registry for all those who have been or are to be identified requiring longer term medical follow up - Initiate assessment of the disruption of normal living conditions and of the losses (i.e. economic impact) due to the emergency and the emergency response actions - Initiate activities for proper waste management - Initiate assessment of the needs of affected populations in terms of mental health and psychosocial support as well as medical follow-up in the longer term - Initiate assessment of the needs for longer term monitoring of residual contamination in the environment - Initiate analysis of the

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					emergency and emergency response
Transition phase	- Adaptation of protective actions imposed during the urgent and early response phases	– Take remedial actions to progressively reduce residual doses – Establish a registry for all those who have been identified requiring longer term medical follow up - Ensure access control is in place including delineation of areas and implementation of administrative measures, as appropriate – Provide medical care and mental health and psychosocial support to affected population – Keep the public and affected populations, in particular, informed – Protect all those engaged in the emergency response as emergency workers	In line with Tables I-8 and I-9	Weeks to months	- Characterize the overall situation to identify the course of actions to prepare for resuming normal social and economic activity and to provide for the well-being of affected populations - Use monitoring results against OILs such as OIL_T and associated considerations to determine which protective actions can be adapted or lifted - As the time allows, assess the radiological and non-radiological situation to ensure the strategy in place remains justified and optimized at all time. Assess effectiveness of the strategy using the reference level and prerequisites for the transition - Monitor the actions of the public, others and the media

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
		– Protect members from the public volunteering in the emergency response as helpers in an emergency – Take actions for restoration of infrastructure, workplaces and public services necessary to support normal living conditions in the affected areas – Take actions for proper waste management			(including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Provide advice on useful self-help actions - Ensure control is in place to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place to prevent the spreading of contamination (using OIL_V, as appropriate) – Assess received doses, as appropriate, to decide on the course of medical actions – Initiate the change or transfer of the authority and responsibilities from the emergency response organization to organizations responsible for the long term recovery operations – Initiate development of a long term monitoring strategy in

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					relation to residual contamination – Organize the sharing of any information and data that were gathered during the emergency and that are relevant for long term planning among the relevant organizations and authorities – Develop a programme for longer term medical follow-up for the individuals in the registry – Develop a strategy for mental health and psychosocial support for the affected population – Consider the needs for compensation of victims for damage due to the emergency and for any state support

TABLE I-11. SUITE OF EMERGENCY RESPONSE ACTIONS AND ASSOCIATED CONSIDERATIONS FOR THE SECOND GROUP OF EMERGENCY SCENARIOS

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
Urgent response phase	- Shelter the population within PAZ, if appropriate and give instructions for reducing inadvertent ingestion - Instruct preparations be made to protect the food chain and drinking water supplies from getting contaminated within ICPD (e.g. place grazing animals on protected feed, disconnect rainwater collection pipes and cover open sources of drinking water) should this become necessary; - Instruct preparations be made to protect relevant non-food commodities from getting contaminated within ICPD	- Provide emergency services and support on the site - Protect all those engaged in the emergency response as emergency workers - Keep the public and affected populations, in particular, informed	Notification on the declaration of Site area emergency	Hours to days	- Take sheltering precautionary to help taking effectively the protection strategy in case the situation escalates to General emergency - Give clear instructions for population to follow official information and any recommendations should it become necessary, particularly within PAZ and UPZ - Increase readiness off-site to take emergency response actions in line with those elaborated in Table I-10 should the situation escalates in General emergency - Do not delay provision of medical treatment to anyone in need irrespective of the presence of contamination (including those presenting symptoms of radiation overexposure) - Provide support to those sheltered for access to essentials and medicines, if

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					this becomes necessary - Lift sheltering after a day to two days by substituting with evacuation (should the situation escalates to General emergency) or allowing for partial/fully lifting - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Alert hospitals and medical staff to prepare to treat contaminated and exposed individuals - Deploy monitoring teams in the PAZ and UPZ to confirm that no off-site emergency response actions need to be taken - If appropriate, ensure controls are in place to prevent the spreading of contamination off-site

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
Urgent response phase	None	- Provide emergency services and support on the site, as needed - Protect all those engaged in the emergency response as emergency workers - Keep the public and affected populations, in particular, informed	Notification on the declaration of Facility emergency	Hours to days	- Give clear instructions for population to follow official information and any recommendations, as needed - Increase readiness off-site to take emergency response actions should the situation escalates in Site area or General emergency - Do not delay provision of medical treatment to anyone in need irrespective of the presence of contamination (including those presenting symptoms of radiation overexposure) - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Alert hospitals and medical staff to prepare to treat contaminated and exposed individuals - Deploy monitoring teams in the vicinity to the facility/site to confirm that no off-site

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					emergency response actions need to be taken - If appropriate, ensure controls are in place to prevent the spreading of contamination off-site (using OIL_V, as appropriate)
Early response phase	– Adapt any protective action imposed during the urgent response phase – Reconsider any instructions to prepare for taking protective actions that have been given	- Keep the public and affected populations, in particular, informed - Take medical actions for those exposed in the emergency, as appropriate	In line with Tables I-8 and I-9	Days	- Use monitoring results against OILs and associated considerations in Table I-9 to adapt protective actions and revoke instructions given - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Ensure controls are in place to prevent the spreading of contamination off-site (using OIL_V, as appropriate) - Take medical actions for those involved in the emergency or the response on-site/at the facility on the basis of OIL4/OIL8 and, when assessed, the received doses

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Initiate establishment of a registry for all those who have been or are to be identified requiring longer term medical follow up, if this is necessary - Initiate analysis of the emergency and emergency response
Transition phase	None	– Establish a registry for all those (if any) who have been identified requiring longer term medical follow up – Provide medical care and mental health and psychosocial support to overexposed individuals, if any – Keep the public and affected populations, in particular, informed	In line with Tables I-8 and I-9	Weeks to months	- Assess the situation for safe and secure conduct of the practice - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Ensure controls are in place to prevent the spreading of contamination (using OIL_V, as appropriate) – Assess received doses, as appropriate, to decide on the course of medical actions – Develop a programme for longer term medical follow-up for the individuals in the registry

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					– Develop a strategy for mental health and psychosocial support for the overexposed individuals, if any

TABLE I-12. SUITE OF EMERGENCY RESPONSE ACTIONS AND ASSOCIATED CONSIDERATIONS FOR THE THIRD GROUP OF EMERGENCY SCENARIOS

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
Urgent response phase	- Set up the inner cordoned off area and evacuate the area - Reduce inadvertent ingestion If appropriate: - Protect the food chain and drinking water supplies from getting contaminated - Stop the consumption and distribution of non-essential food and feed that is potentially or actually contaminated - Protect relevant non-food commodities from getting contaminated - Stop the use and distribution of non-essential non-food commodities that are potentially or actually contaminated	- Place access control for the inner cordoned off area - Record those who may have been contaminated or in close proximity to the source of exposure - If contamination is suspected or confirmed, monitor those who were in the close proximity to the source of exposure to identify those for whom decontamination and/or medical action may be needed - Provide for medical care and mental health and psychosocial support to affected individuals - Keep the public and those affected, in particular, informed - Protect all those engaged in the emergency response as emergency workers	Observable conditions given in Table I-2 or OIL2	Hours	- Assess overall situation (including the security) to ensure safe implementation of emergency response actions - Give priority to lifesaving actions and fighting any immediate non-radiation related danger/hazard (e.g. fire) - Provide emergency services as needed - If appropriate, consider sheltering those in the vicinity of the inner cordoned off area if needed to support emergency response efforts - Give clear instructions regarding emergency response actions to concerned parties - Do not delay provision of medical treatment to those in need irrespective of the presence of contamination (including those presenting symptoms of radiation overexposure)

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	- Stop international trade of potentially or actually contaminated foodstuff and non-food commodities				- Alert hospitals and medical staff to prepare to treat contaminated and/or exposed individuals - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - If appropriate: initiate search for the source, issue messages and instructions for public protection and notification in case the source is located - Give instructions for proper management of human and animal remains with actual or possible contamination, as appropriate If contamination is confirmed: - Begin implementing controls on vehicles, items and other equipment exiting the affected areas using OIL_V to determine whether they are safe for use and any need for decontamination

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Assess the results from skin and thyroid monitoring to decide on the course of medical action and need for individual decontamination using OIL4 and OIL8 - Instruct affected population to decontaminate, if appropriate, by removing outer clothing and washing hands and face - Reconsider the size of the inner cordoned off area based on monitoring results As appropriate: - Begin implementation of controls to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$
Early response phase	If contamination is confirmed: - Relocate population from the area - Reduce inadvertent ingestion As appropriate, also: - Stop the consumption and	- Place access control - Register those individuals from these areas - Provide for medical care and mental health and psychosocial support to affected individuals from	OIL2	Days to a week	- Initiate activities to characterize the situation well - Issue instructions to those refusing to relocate - Assess the results from skin and thyroid monitoring to decide on the course of medical action and need for

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	distribution of non-essential food and feed from the area - Stop the use and distribution of non-essential non-food commodities from the area - Stop international trade of potentially or actually contaminated foodstuff and non-food commodities from the areas	these areas - Keep the public and affected individuals, in particular, informed - Protect all those engaged in the emergency response as emergency workers			individual decontamination using OIL4 and OIL8 - Instruct affected population to decontaminate, if appropriate, by removing outer clothing and washing hands and face - Consider if evacuation applied earlier needs to be substituted with relocation or can be lifted - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Ensure controls are in place for preventing the spread of contamination (using OIL_V, as appropriate) - Implement controls to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$
Early response phase	If contamination is confirmed: - Stop the consumption and distribution of non-	- Register those who may have consumed contaminated foodstuff	In case of large areas:	Days	- Provide, as appropriate, supplies with clean food, milk, drinking water as well as

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
	essential food and feed (e.g. local produce, wild-grown products, milk from grazing animal, rainwater and animal feed) in areas with high deposition - Stop the use and distribution of non-essential non-food commodities in areas with high deposition - Stop the international trade of foodstuff and other goods from areas with high deposition	- Provide for medical care and mental health and psychosocial support to affected population from these areas - Keep the public and affected populations, in particular, informed - Protect all those engaged in the emergency response as emergency workers	OIL3 In case of moderate to small areas: OIL5 and OIL6	Days to weeks	animal feed - Consider providing iodine thyroid blocking in case of radioiodine contamination if replacement for essential food, milk and drinking water is not immediately available - In case of lack of essential foodstuff, consider other protective actions such as relocating people from the areas - Implement controls to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place for preventing the spread of contamination (using OIL_V, as appropriate)
Early response phase	Adaptation of protective actions imposed during the urgent response phase	- Ensure access control is in place - Provide medical care and mental health and psychosocial support to affected individuals - Keep the public and those	In line with Table I-9	Days to weeks	- Assess the radiological and non-radiological situation to ensure the strategy in place remains justified and optimized at all times - Use monitoring results against OILs and associated

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
		affected, in particular, informed - Protect all those engaged in the emergency response as emergency workers - Protect members from the public volunteering in the emergency response, if any, as helpers in an emergency			considerations to determine which protective actions can be adapted or lifted - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Assess received doses, when appropriate, to decide on the course of medical actions - Initiate establishment of a registry for all those who have been or are to be identified requiring longer term medical follow up - Initiate assessment of the needs of affected individuals in terms of mental health and psychosocial support as well as medical follow-up in the longer term - Initiate analysis of the emergency and emergency response If contamination has been confirmed, as appropriate:

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Ensure control is in place to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place to prevent the spreading of contamination (using OIL_V, as appropriate) - Initiate assessment of the needs for longer term monitoring of residual contamination in the environment - Initiate assessment of the disruption of normal living conditions and of the losses (i.e. economic impact) due to the emergency and the emergency response actions - Initiate activities for proper waste management If it has been confirmed that the integrity of the source has not been compromised: - Initiate planning for source recovery - Consider measures to be

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					fulfilled for safe and secure handling of the source
Transition phase	- Adaptation of protective actions imposed during the urgent and early response phases	– Establish a registry for all those who have been identified requiring longer term medical follow up – Provide medical care and mental health and psychosocial support to affected individuals – Keep the public and affected individuals, in particular, informed – Protect all those engaged in the emergency response as emergency workers – Protect members from the public volunteering in the emergency response, if any, as helpers in an emergency If contamination has been confirmed, as appropriate: – Ensure access control is in	In line with Tables I-8 and I-9	Days to weeks	- Assess the overall situation to identify to ensure the strategy is justified and optimized and to determine the course of actions to prepare for resuming normal social and economic activity - Use monitoring results against OILs such as OIL_T and associated considerations to determine which protective actions can be adapted or lifted - Monitor the actions of the public, others and the media (including web sites and social media) to identify and address inappropriate responses being taken and address new concerns that may arise - Provide advice on useful self-help actions - Assess received doses, as appropriate, to decide on the

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
		place, as appropriate – Take remedial actions to progressively reduce residual doses – Take actions for restoration of infrastructure, workplaces and public services necessary to support normal living conditions in the affected areas, as appropriate – Take actions for proper waste management If it has been confirmed that the integrity of the source has not been compromised: – Take actions to recover the source – Take actions to ensure safe and secure handling of the source within the framework of a planned exposure situation			course of medical actions - Initiate the change or transfer of the authority and responsibilities from the emergency response organization to organizations responsible for the recovery operations - Organize the sharing of any information and data that were gathered during the emergency and that are relevant for long term planning among the relevant organizations and authorities - Develop a programme for longer term medical follow-up for the individuals in the registry - Develop a strategy for mental health and psychosocial support for the affected individuals - Consider the needs for compensation of victims for damage due to the emergency and for any state support If contamination has been confirmed, as appropriate:

Phase	Protective actions	Other response actions	Basis	Time to implement	Other considerations
					- Ensure control is in place to ensure all trade meets international standards and to reassure interested parties (e.g. through certification) using $OIL_{IntTrade,F/C}$ - Ensure controls are in place to prevent the spreading of contamination (using OIL_V, as appropriate) - Initiate development of a long term monitoring strategy in relation to residual contamination

In order to enable effective consultation in the course of the emergency response, every effort has been made to identify the interested parties to be consulted and the areas of their interest, as well as to agree the means for their consultation. They are presented in Table I-13, notwithstanding the need to closely monitor news and media in an emergency response so that additional topics of interest be identified along with the associated interested parties to be engaged and consulted in the course of the actual emergency.

TABLE I-13. LIST OF INTERESTED PARTIES, PRIMARY AREAS OF INTEREST AND MEANS OF CONSULTATION DURING DIFFERENT EMERGENCY PHASES

WHEN	WHO	PRIMARY INTERESTS	HOW
Urgent response phase	Nobody	-	No interaction
Early response phase	Local authorities such as […]	Defining and implementing necessary protective actions for relevant populations and areas	Videoconferences Liaisons officers
	Selected representatives of critical sectors (education, agriculture, hospitals, prisons, […]) as following […]	Ensuring that the needs of special groups of the population are addressed in adapting the protection strategy to the specific conditions of the emergency	Through the national or regional authorities in charge of the sector (e.g. ministry of education, agriculture, public health, justice) as following […]
	[…]	[…]	[…]
Transition phase	Communities, associations, representatives of trade and industry as following […]	Identification of activities necessary for the recovery of economic activity	Individual or small groups hearings (only representatives) such as […]
	Authorities in neighbouring States as following […]	Continuing coordination regarding adaptation of protection strategy (e.g. return of evacuees)	Audio- and videoconferences, exchange of liaison officers as following […]
	Authorities in any State such as […]	Continuing coordination regarding criteria and means used to control the import and export of foods and commodities affected by the emergency	Audio- and videoconferences, response to enquiries organized on international web platforms, international working groups as following […]
	General public	Means of protection, including following termination of the emergency	Monitoring of the media, information requests to call centres, through local authorities as following […]
	[…]	[…]	[…]

Inputs obtained during the consultation process need to be carefully studied and considered, as appropriate, in the decisions made by the responsible decision making body. Various options need to be carefully analyzed so that concerns are adequately addressed, and selected options need to be justified. If some contributions to the process are not explicitly retained, for example because of a lack of justification, feasibility, resources or conflicting interests, the inputs and the rationale for not retaining them need to be documented. How the inputs have been reflected in the decisions made would need to be clearly explained to interested parties. Once the process has been concluded as such, the decisions would be put in practice and their impact assessed, so as to identify if anything else would need to be done and consultation arranged accordingly. A scheme of the consultation process during the emergency response is presented in Fig. I-7.

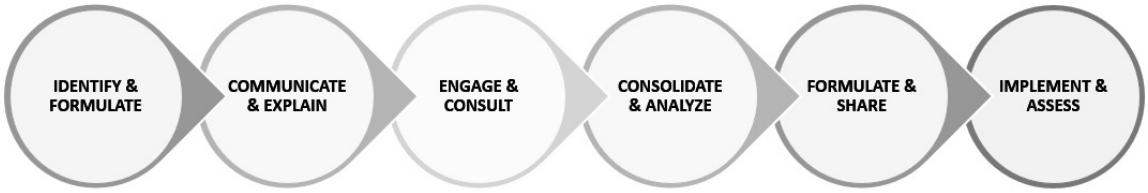


FIG. I-7. The consultation process during the emergency response.

6. PROTECTION STRATEGY FOR EMERGENCY WORKERS AND HELPERS

6.1 Emergency workers and helpers

Any person engaged as a worker in response to the nuclear or radiological emergency at any time between the onset of the emergency and its termination is to be considered as an emergency worker and to be protected accordingly. Emergency workers are relevant personnel from the response organizations and services, such as response managers, rescuers, firefighters, drivers and crews of evacuation vehicles, medical personnel, law enforcement personnel, members of monitoring teams, members of decontamination teams, workers engaged in activities such as restoration of essential infrastructure and the management of waste generated in the emergency as well as relevant personnel engaged in providing support and care to the affected population (e.g. in reception centres) and relevant personnel of operating organizations (those employed directly by the operating organization and those engaged indirectly through a contractor). Responsibility for their protection lies with the employers who need to ensure that the respective emergency workers are identified and designated as such at the preparedness stage. However, it is recognized that during the emergency response, emergency workers who have not be identified and designated as such might be needed to respond to the situation for whatever reason. Such undesignated emergency workers need to be protected as well and the responsibility to do so lies with a designated organization for this purpose at the preparedness stage.

Any member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency, despite the fact that (s)he could be exposed to radiation, is to be considered as a helper in the emergency and to be protected as such. Helpers are members of the public who are willingly and voluntarily helping in activities such as those aimed at restoring the essential infrastructure or management of conventional waste in order to support efforts for resuming normality in the affected areas. The responsibility for their protection lies with a designated organization for this purpose at the preparedness stage as for undesignated emergency workers.

6.2 Dose restrictions for emergency workers and helpers

National requirements for occupational exposure in planned exposure situations, including the occupational dose limits, established in […] need to be applied for emergency workers and helpers in an emergency, on the basis of a graded approach. Exception of this rule are emergency workers involved voluntarily (presented in a form of informed consent following information being given on associated risks) in taking the following actions as considered in this strategy:

- Actions to save human life or prevent serious injury;
- Actions to prevent severe deterministic effects or prevent the development of catastrophic conditions that could significantly affect people and the environment; or
- Actions to avert a large collective dose.

Namely, actions to save lives, prevent severe deterministic effects or avert the development of catastrophic conditions that could significantly affect people and the environment are typical during the urgent response phase of a nuclear or radiological emergency. These actions would likely be carried out while there is still a scarcity of information about the radiological situation where the action is to be performed and the uncertainties are large. Because of the urgency associated with implementing these actions and their importance for effective implementation of the protection strategy, detailed planning of the work of emergency workers might not be possible; thus, exposures exceeding the dose limits for occupational radiation protection in planned exposure situations are justified to ensure the net benefit of the overall response efforts.

Actions to avert a large collective dose, i.e. actions taken to reduce the risk of stochastic effects as foreseen in this strategy, may extend through the early response phase and into the transition phase of an emergency, depending on the range of activities needed to allow the timely resumption of social and economic activity. As the knowledge and understanding of the situation where the work needs to be done increases in the early response phase and, particularly, in the transition phase and there is no need to take urgent decisions on the deployment of workers, it is possible to implement more planning for efficient protection of emergency workers and helpers. Thus, any work would need to be done with account taken of information as it becomes available and planned accordingly, without jeopardizing the effectiveness of the protection strategy. This approach is expected to allow employers and the designated organization(s) to apply more stringently the requirements for occupational radiation protection for planned exposure situations, including the application of dose limits for occupational exposure, to emergency workers and helpers particularly during the transition phase.

For those tasks for which complying with occupational dose limits is not possible, the guidance values given in Table I-14 are to be applied for restricting the exposures of emergency workers. Dose restrictions to be applied for helpers are also given in Table I-14.

Female emergency workers, who are or might be pregnant, need to be excluded from taking actions, particularly during the urgent response phase, such as those to avert a large collective dose, if these actions could result in an equivalent dose to the embryo or fetus exceeding 50 mSv for the full period of in utero development. For those activities to be carried out in accordance with the requirements for occupational radiation protection during a planned exposure situation, the working conditions for female workers who are pregnant or suspect that they are pregnant or who are breast-feeding need to afford the same broad level of protection to the embryo or fetus or the breastfed infant as that required for members of the public in a planned exposure situation established in […].

TABLE I-14. DOSE RESTRICTIONS FOR EMERGENCY WORKERS AND HELPERS

Task	Guidance value *		
	$H_p(10)$ **	E ***	AD_T +
Emergency workers			
Lifesaving actions	<500 mSv	<500 mSv	$<AD_{T,\ Table\ I\text{-}4}$ ++
	This value may be exceeded — with due consideration of the generic criteria in Table I-4 — under circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts these health risks		
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	<500 mSv	<500 mSv	$<\frac{1}{2}AD_{T,\ Table\ I\text{-}4}$ ++
Actions to avert a large collective dose, such as: - Actions to keep the affected facility or source stable - Monitoring (environmental, source, individual)	<100 mSv	<100 mSv	$<\frac{1}{10}AD_{T,\ Table\ I\text{-}4}$ ++
Other activities, such as: - Remedial actions including decontamination on the site and off the site - Repair of the affected facility and restoration of the relevant essential infrastructure - Management of radioactive waste and conventional waste - Environmental, source and individual monitoring - Medical management of contaminated patients - Implementation of corrective actions	Dose limits for occupational exposure in planned exposure situations established in […]		
Helpers			
Specified activities in the national arrangements, such as: - Restoring essential infrastructure (e.g. roads, public transportation networks) - Management of conventional waste	E ***		
	≤50 mSv		

* These values apply to:
(a) The dose from external exposure to strongly penetrating radiation for $H_p(10)$. Doses from external exposure to weakly penetrating radiation and from intake or skin contamination need to be prevented by all possible means. If prevention is not feasible, the effective dose and the RBE (relative biological effectiveness) weighted absorbed dose to a tissue or organ have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.
(b) The total effective dose (E) and the RBE weighted absorbed dose to a tissue or organ (AD_T) via all exposure pathways (i.e. dose from external exposure and committed dose from intakes), which are to be estimated as early as possible to enable any further exposure to be restricted as appropriate.

** Personal dose equivalent $H_p(d)$, where d = 10 mm.

*** Effective dose.

\+ RBE weighted absorbed dose to a tissue or organ.

++ Value of RBE weighted absorbed dose to a tissue or organ given in Table I-4.

6.3 Processes for assessing the situation, decision making and adaptation

Emergency tasks are carried out during the urgent response phase under circumstances that are characterized by large uncertainties and by a lack of information concerning the actual

conditions. Despite this fact, provision of measures and taking actions to protect emergency workers is of outmost importance as it is the timely implementation of planned precautionary and urgent protective actions and other response actions considered in the protection strategy. To allow for effective protection under these circumstances, hazardous conditions that emergency workers may face when taking necessary emergency tasks need to be assessed as part of the hazard assessment and addressed in operational arrangements, taking account of the planned protection strategy. The hazardous conditions need to include radiological as well as other hazardous conditions (such as fires and chemical hazards) that may be present in areas where emergency tasks are carried out. Depending on the assessed conditions, measures and actions to be taken to protect emergency workers during the urgent response phase need to be planned, even as a precaution, at the preparedness stage. Because of the urgency associated with implementing the strategy during the urgent response phase, detailed planning of the work of emergency workers might not be possible in the course of the emergency response. Therefore, exposures exceeding occupational dose limits are to be expected and would need to be controlled so that any decision on further involvement of emergency workers in undertaking emergency tasks involving radiation exposure be restricted, taking account of the guidance values in Table I-14.

As the situation evolves, the understanding of the conditions in areas where emergency tasks need to be carried out increases. Moreover, there is no need to take urgent decisions on the deployment of emergency workers and, as appropriate, helpers in the emergency. Thus, for the work to be done in the early response phase, planning of the emergency work to a certain degree becomes feasible without jeopardizing the effectiveness of the protection strategy. Such situation allows for better protection of emergency workers and, as appropriate, helpers in the emergency through selection of the measures and actions for their protection according to the actual conditions to be faced while performing the assigned tasks. Assessment of the hazardous conditions done at the preparedness stage may still provide useful information in this process. However, situations can be expected during this phase for which occupational dose limits can be exceeded and, thus, guidance values in Table I-14 would have to be used instead.

As the situation is characterized well and the focus of emergency response shifts from public protection to preparations for resumption of normal social and economic activity, detailed planning of the emergency work according to actual conditions is feasible. Therefore, emergency tasks during the transition phase need to be taken only after detailed planning that takes account of the actual conditions. As a result, the protection of emergency workers and helpers in the emergency in the transition phase needs to be applied stringently, in accordance with the requirements for occupational radiation protection for planned exposure situations, including the application of dose limits for occupational exposure as given in Table I-14.

The process for assessing the situation and making decision on protecting emergency workers and helpers in a nuclear or radiological emergency as discussed in this section is presented in Fig. I-8.

The effectiveness of measures and actions taken to protect emergency workers and helpers is continually assessed against dose restrictions given in Table I-14. In judging the effectiveness and the need for any adaptation of the measures and actions taken, the actual circumstances need to be known under which the emergency tasks have been performed in comparison to what has been expected. To enable this, meticulous and up-to-date records need to be established and maintained on the assigned tasks, expected conditions, actual conditions faced which include readings from monitoring instruments, time spent for completion of assigned tasks and measures and actions taken to protect emergency workers and helpers and, as early as possible, doses received need to be assessed. Assessment of the need for medical actions,

including medical treatment and long term medical follow up for emergency workers and helpers, is made based on the doses that have been received, taking into account the criteria given in Section 5 as for any individual.

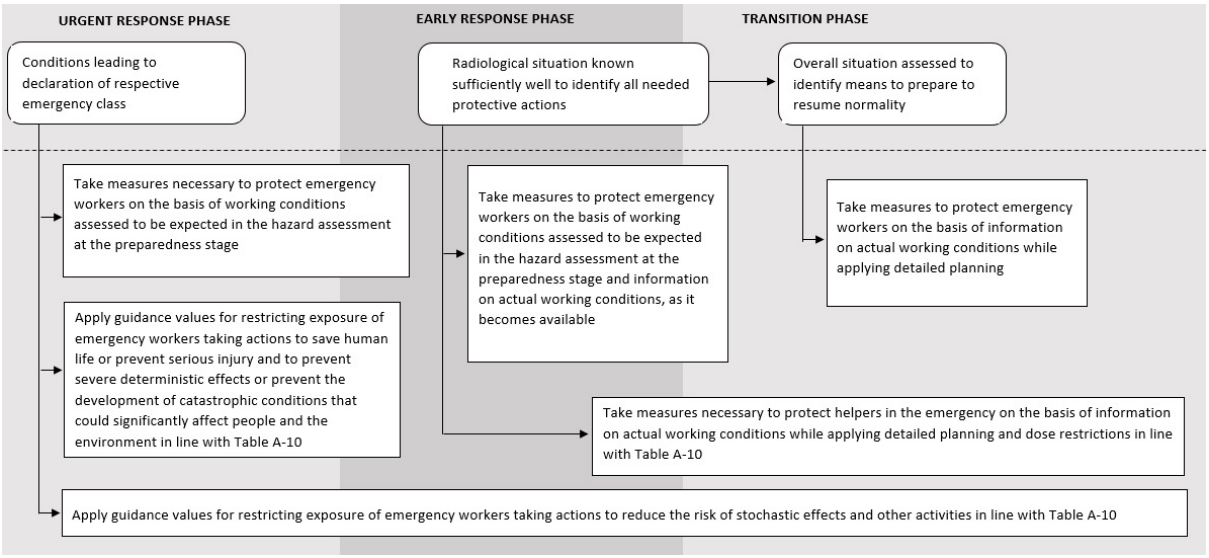


FIG. I-8. Process for assessing the situation and making decision on protecting emergency workers and helpers in a nuclear or radiological emergency.

Finally, the doses (to be) received by emergency workers and helpers and associated risks need to be factored into the justification and optimization of the protection strategy both at the preparedness stage and during the response. They need also to be considered when assessing the effectiveness of the strategy and any adaptation of the protection strategy to meet the prevailing conditions as the emergency evolves.

6.4 Protective actions and measures to be implemented

All emergency work needs to be planned such that the protection and safety of emergency workers and helpers is optimized, with account taken of the characteristics and necessity of the emergency work to be done to effectively implement the required protection strategy. In doing so, every effort needs to be made to prevent as far as possible doses from external exposure to weakly penetrating radiation and from intake or skin contamination.

The following actions and measures have to be implemented to protect emergency workers and helpers, as appropriate:

- At the preparedness stage:
  - Assessing hazardous conditions in which emergency work need to be done;
  - On the basis of assessed hazardous conditions:
    - Identifying measures and actions to effectively protect against the assessed hazardous conditions while performing emergency tasks;
    - Designing emergency response facilities so that they provide adequate protection against assessed hazardous conditions in which emergency work needs to be done;
  - Provision of training to designated emergency workers on how to perform emergency tasks under the expected working conditions and to safely and effectively implement planned measures and actions for their protection.

- During the emergency response, with account taken of assessed hazardous conditions and any information, as it becomes available:
  - Providing adequate personal protective equipment including respiratory protection when performing emergency work in contaminated areas;
  - Iodine thyroid blocking through administering stable iodine agents, if radioiodine is present;
  - Provision of instructions for reducing inadvertent ingestion;
  - Registering emergency workers and helpers engaged in the emergency response;
  - Recording information necessary for dose assessment and assessment of effectiveness of measures and actions taken to protect emergency workers and helpers;
  - Providing 'just-in-time' training on taking assigned tasks under the actual conditions;
  - Providing psychological counselling and continuous medical care during the emergency response;
  - Providing health screening, longer term medical follow-up and counselling aimed at detecting radiation induced health effects early and treating them effectively;
  - Providing of information (e.g. on their families, in case they are affected by the consequences of the emergency) on regular intervals to help reduce stress among emergency workers during the emergency response;
  - Controlling doses by means of:
    - Comprehensively planning the expected work while accounting for the hazardous conditions to be faced and the time needed to complete the work;
    - Continuously monitoring hazardous conditions in which emergency workers and helpers are to perform their tasks;
    - Providing adequate monitoring equipment, which includes personal dosimeters or use of a team/group dosimeter;
    - Assessment of doses (total effective dose and RBE weighted absorbed dose) via all exposure pathways as early as possible and their recording;
    - Restricting further exposures in cases of exceeding the guidance values in Table I-10;
  - Providing, when appropriate, qualified medical advice to those exposed in the emergency response regarding incurring further occupational exposure;
  - Using equipment for carrying out certain tasks remotely, when and where this is possible.

In implementing these measures and actions, consideration need to be given to protecting female workers who are pregnant or suspect that they are pregnant or who are breast-feeding so that the same broad level of protection to the embryo or fetus or the breastfed infant is afforded as that required for members of the public in a planned exposure situation.

6.5 Communicating risks and doses to emergency workers and helpers

Risks associated with the exposure of emergency workers and helpers in a nuclear or radiological emergency, particularly when undertaking actions for which occupational dose limits can be exceeded, need to be communicated to emergency workers and helpers in a plain and understandable language with associated health hazards placed in perspective. This will

help emergency workers to make informed decision in cases in which their informed consent is warranted. It will also help to alleviate their concerns and to improve their understanding on the course of actions being taken for their protection and well-being. Once known, doses that have been received need likewise to be communicated in a manner that places radiological health hazards in perspective and associates them with the needed medical actions and their purpose. When doing so, the system and plain language explanations presented in Table I-14 needs to be used.

TABLE I-15. EXPLANATION OF RADIOLOGICAL HEALTH HAZARDS ASSOCIATED WITH RADIATION EXPOSURES OF EMERGENCY WORKERS AND HELPERS

Type of exposure	Radiological health hazards	Plain language explanation of the health hazards	Associated medical actions	Communicating associated risks
High doses and high dose rates that could result in criteria in Table I-4 to be exceeded	Dangerous to health	If emergency worker has been exposed at these levels, developing a serious injury or physical harm due to radiation exposure that is life threatening or that could reduce the quality of life is possible	Emergency workers exposed at these levels are provided with medical examination and screening that is followed by medical treatment, as necessary, including longer term medical follow up. Psychological support needs also be provided	Any explanation made on the projected health effects among emergency workers need to be clearly explained and related to the course of medical actions being taken
Moderate doses and dose rates that could result in criteria for received doses in Table I-5 be exceeded	Possible health effects resulting from radiation exposure	Observing an increase in the frequency of radiation induced cancers among emergency workers is possible but attributing any individual case of cancer as being due to radiation exposure is not possible	Emergency workers exposed at these levels are provided with longer term medical follow-up with the aim of ensuring that radiation induced cancers in an individual are detected early and that they are treated effectively	When projections are made of numbers of health effects among emergency workers, the meaning of the numbers should be clearly explained and related to the objective of the longer term medical follow- up
Low dose and dose rates below the criteria in Tables I-4 and I-5	No observable health effects resulting from radiation exposure	No increase in the frequency of radiation induced cancers in a large population is observed, and no individual case of cancer can be attributed as being due to radiation exposure	No medical attention in relation to radiation induced health effects is warranted in such cases	Projections of hypothetical numbers of health effects among emergency workers and helpers in such cases, made for whatever reason, should not be used in public communication on radiological health hazards

7. SPECIFIC CONSIDERATIONS

Effective implementation of the protection strategy depends on how the information and data necessary for prompt decision making, as foreseen in this document, can be obtained in the course of an emergency response and how priorities for other activities to be carried out in the emergency response are formulated in support of the strategy's goals. Therefore, priorities in carrying out various activities in an emergency response such as in managing and directing the emergency response, monitoring and assessment, public communications, waste management […] would need to be set in such a manner that they support an effective implementation of the protection strategy.

7.1 Management

The protection strategy serves as the main policy document on which basis the emergency management system is designed pertaining the objectives in emergency preparedness and response it aims to achieve in an efficient and effective manner. Organizational structure and processes of the system need to be formulated so as to allow inclusion of all relevant participants with any responsibility of implementing or supporting the implementation of the protection strategy as well as to enable developing, at the preparedness stage, consistent, transparent and effective operational arrangements across various participants in the emergency management system. This includes processes for sharing on information on […], coordinating actions on […], communicating on aspects such as […], cross-border coordination in relation to […], […]. In addition, processes for regular review and for initiating revision to existing operational arrangements, consultation and coordination in doing so as well as for supervising the implementation of the protection strategy in the operational arrangements and associated verification and enforcement measures need to be part of the system.

Exercises and training programmes involving all the participants is essential in ensuring the readiness of the system to be activated promptly in a nuclear and radiological emergency and to fulfil effectively its functions. Technical, human and other necessary resources need to be allocated accordingly with account taken of the level of response needed to effectively implement the protection strategy if an emergency happens.

Moreover, the unified command and control system to be used to manage and direct the emergency response efforts should comprise of processes that follow the various processes for decision making and assessment as elaborated in the protection strategy and, thus, should be fed with the necessary information in support of its functions. The following specific considerations for the emergency management system at the national level are implicated by this strategy: […]

Finally, the emergency management system needs to be structured in a manner to allow for information essential for the emergency, the emergency response and their analysis as well as for the long term management of the situation, when this is appropriate, to be recorded and shared among relevant participants in the emergency management system.

7.2 Radiation monitoring and assessment

Monitoring activities to be conducted in an emergency response need to support effective implementation of the protection strategy as planned in this document. However, the monitoring itself may not be sufficient in providing such support, and further assessments need to be utilized. The aim is to help authorities and decision making body:

- To better understand the situation as it evolves;

- To identify promptly any need for taking public protective actions and other response actions;
- To identify necessary measures and actions to protect emergency workers and helpers;
- To determine the course of medical actions required for exposed individuals;
- To effectively adapt the protection strategy as the emergency evolves;
- To plan for recovery and prepare for resumption of social and economic activity;
- To identify when would be appropriate for the emergency to be declared ended.

In the context of this protection strategy, assessment relates to processes and tools applied to:

- Assess the conditions at the facility or plant against EALs or the conditions at a site against observables and the emergency classification system;
- Assess radiological consequences and needs for protective actions and medical actions which includes:
  - Modelling the dispersion of radioactive releases in the environment;
  - Ensuring availability of high quality meteorological data;
  - Estimating […]
- Assess non-radiological consequences and need for other response actions which includes:
  - […]
- […]

These processes and tools along with the monitoring play important role in supporting the decision making at different stages of the emergency response. To enable effective implementation of the protection strategy they need to be integrated in the overall emergency arrangements and their use considered in the context of enabling timely and effective decision making without impairing the emergency response.

The type of measurements, the quantities to be measured, areas and frequency of measurements in the monitoring strategy including the monitoring instruments are to be selected in a manner so that the comparison with the OILs given in this document is done directly and decisions are made accordingly following the established processes. In designing the monitoring strategy, account need to be taken of the time available for effective decision making. Considering that the exact areas that may need to be monitored can be wide, such that the monitoring of the whole area would take significant time for completion with limited resources available, setting the priorities in the monitoring strategy on areas that should be monitored first may be supported by decision aiding tools and models, in order to allow for the effective and efficient use of available (but usually limited) resources and capabilities. For example, meteorological analyses and forecasts, especially of rainfall, wind and atmospheric stability data, as well as atmospheric transport modelling, may help to identify areas of potentially higher deposition. However, the use of such tools and models need to be planned in the monitoring strategy so that it does not jeopardize the effectiveness of the protection strategy with monitoring being ultimately conducted in all geographical areas and not just in those areas indicated by modelling tools.

In addition, assigning priorities for monitoring needs to consider the following aspects:

- The type of the areas themselves (e.g. residential, agricultural or rural), so that priority for monitoring is assigned focusing on public protection and effective implementation of the protection strategy rather than characterizing the radiological situation in any affected area;
- Local food production patterns, local diets and food preferences;
- […].

Taking into account these aspects and the suite of emergency response actions given in Section 5, the following implications for the monitoring strategy have been derived from the planned protection strategy:

- For the first group of emergency scenarios:
  - Urgent response phase, following identification of plant conditions indicative of an emergency:
    - Rapidly assess the observed conditions and plant parameters comprising of […] against EALs given in […] to determine if EALs indicating General emergency are met so that the required level of emergency response is activated following declaration;
    - […]
  - Urgent response phase, following release:
    - Rapidly measure external gamma dose rates due to ground deposition in areas beyond UPZ where OIL1 is expected to be exceeded so that urgent decisions are made on evacuation of affected population within hours. Such areas relate to […] and are shown on Figure […] in Appendix 1. In order to ensure that reliable measurements are available timely, the order of coverage with monitoring of different sectors in these areas is done on the basis of […] as following […]. In deciding this approach, the following is considered: […]
    - […]
- For the second group of emergency scenarios:
  - […]
- For the third group of emergency scenarios:
  - […]

The interpretation of monitoring data, products of assessment and their consideration in the decision making need to account for the uncertainties associated with e.g. measurement results as they might affect the quality of the decision making process. Depending on the origin of the uncertainties, efforts need to be made to reduce them to the extent practicable by: […]. The uncertainties are considered in the decision making process through […].

Members of the monitoring teams are to be designated as emergency workers and protected as such in line with Section 6. In justifying the emergency tasks to be carried out by the monitoring teams at a given time, the doses to be received by its members and associated risks need to be considered against the benefits of the monitoring.

7.3 Public communication

Keeping the public informed is one of the emergency response actions that is applied as part of this strategy at any stage and for any type of emergency scenario. Effective public communication is important aspect of the emergency response that supports, to a great extent, efficient implementation of the protection strategy, alleviating public concerns and reducing actions being taken that are not warranted. To enable this, the communication strategy need to be designed in a manner that helps authorities and decision making body deliver clear and understandable messages to the general public and, in particular, affected populations on the emergency itself as well as on the recommended emergency response actions (particularly in terms of what is to be applied, where and for whom the decisions apply) and associated considerations.

In the communication strategy, the objectives, target audience, the most effective communication activities, information products and tools as well as the channels through which messages will be communicated need to be determined and selected in a manner so that they support effective implementation of the protection strategy, with due consideration being given on the time allowing to do so.

The following implications for the public communication strategy have been derived from the planned protection strategy:

- For the first group of emergency scenarios:
  - Urgent response phase, upon declaration of General emergency:
    - Alert the public from the emergency planning zones and distances and warn them on the on-going situation while providing clear instructions on the emergency response actions being recommended for them through […]
    - […]
- For the second group of emergency scenarios:
  - […]
- For the third group of emergency scenarios:
  - […]

Effective communication during the response largely depends on the communication exercised at the preparedness stage and the trust built with the targeted audience. To enable effective communication during the response, the following information needs to be communicated at the preparedness stage: […]

8. IMPLEMENTING THE PROTECTION STRATEGY IN OPERATIONAL ARRANGEMENTS

The protection strategy elaborated in this document is implemented, should a nuclear or radiological emergency happen, through execution of operational arrangements such as plans and procedures of responsible response organizations. Therefore, all relevant organizations (listed at the beginning of this strategy) with roles and responsibilities in emergency preparedness and response need to ensure that all operational arrangements under their responsibility are developed or updated in a manner and are tested to ensure the effective implementation of the protection strategy in an emergency response concerning not only the protection of the public but also the protection of relevant emergency workers and helpers in the emergency.

The process of putting in place consistent and complementary operational arrangements in line with the protection strategy elaborated in this document is to be coordinated by […] through the dedicated processes of the emergency management system comprising of […]. This process is to be completed by […] and the appropriateness of the operational arrangements is to be tested in exercises on a regular basis. Any revision of the operational arrangements following this period would need to be transparent in terms of the revisions needed and the rationale for the revisions and their implications for the arrangements of other organizations and the implementation of the planned protection strategy to be assessed and made know to all participants of the emergency management system. Ensuring the effectiveness of revised arrangements in implementing the planned protection strategy and coordinating any associated revisions needs to be done through […].

Taking into account the fact that the protection strategy elaborated in this document does not cover in details the strategy for on-site response as the latter is facility- and site-specific, the operating organizations are responsible in ensuring that the strategy for on-site response is consistent with this protection strategy. This is verified and enforced through the regulatory processes of […].

APPENDIX I: Maps with location of facilities in EPCs I and II and associated areas of emergency planning zones and distances

[…]

APPENDIX II: Operational Intervention Levels

[…]

APPENDICES (AS NEEDED)

[…]

REFERENCES

[…]

ANNEXES (AS NEEDED)

[…]

REFERENCES TO ANNEX I

[I–1] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2018 Edition, IAEA, Vienna (2019).

[I–2] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).

[I–3] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR OFFICE, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Arrangements for the Termination of a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-11, IAEA, Vienna (2018).

ANNEX II
FACTORS FOR JUSTIFCATION AND OPTIMIZATION

Many factors, listed in Table II-1 of the basis of GSG-11 [II–1], influence the choice of protective actions and other response actions within a protection strategy for a nuclear or radiological emergency. For each of these factors, different organizations and bodies may contribute to the decision making processes. The table below lists a number of these factors to help emergency planners and decision makers in identifying the organizations and relevant interested parties that need to be prepared to contribute to, and need to be involved in, the development and implementation of justified and optimized protection strategies.

TABLE II-1: COMPILATION OF FACTORS FOR CONSIDERATION IN THE JUSTIFICATION AND OPTIMIZATION OF THE PROTECTION STRATEGY

Factors	
General goals	• Goals of emergency response • Primary objective for the termination of an emergency • Primary prerequisites for the termination of the emergency • Specific prerequisites for the termination of the emergency
Legislation and regulations	• Criteria for implementing protective actions and other response actions • Reference level for emergency exposure situation • Generic criteria • Operational criteria (OILs, EALs, observables) • Measures for protecting emergency workers, including guideline values for restricting their exposures in emergency response • Other respective requirements and guidance for: o Planned, emergency and existing exposure situations o Commitments under relevant international instruments, bi-lateral and multilateral agreements in relation to transnational and/or transboundary emergencies
Nature of the emergency exposure situation	• Radionuclides involved, activities and associated hazards • Expected evolution of the situation • Location and size of the affected area • Number of exposed people • Emergency response actions implemented during the urgent and early phases
Radiation protection	• Radiological situation • Exposure scenario and dominant exposure pathways • Contamination of living environment (dose rates, surface activity concentrations, activity concentrations in samples) • Contamination of food, milk and drinking water • Contamination of non-food commodities

	• Dose to the public (projected dose, received dose, residual dose) • Dose to the emergency workers and helpers • Radiation induced health effects • Need for medical follow-up
Timing	• Urgency associated with implementation of effective protective actions • Time needed for the implementation of protective actions • Duration of protective actions • Timescale over which doses will be and/or are received
Efficiency	• Feasibility of actions (season of the year, weather conditions, etc.) • Reducing exposure and contamination in consideration of pre-set reference level • Limitations (technical, social, environmental, economic) • Acceptability of protective actions • Interaction between different actions
Resources	• Availability of human resources • Knowledge, skill and training needs • Availability of material (trucks, busses, machinery etc.) • Availability of financial resources • Availability of stable iodine tablets • Availability of chemicals and other means/resources for decontamination and decorporation • Availability of infrastructures (e.g. for the relocation of people, for waste treatment, storage and disposal, for land use reconversion and change in industrial processes) • Availability of logistical support
Environmental aspects	• Type of affected area: urban, recreational, industrial, agricultural, forest, etc. • Type of surfaces: buildings, roads, agricultural or forest soil • Geographical location of area (e.g. coast, mountain) and geology • Indirect effects (e.g. use of land for other purposes)
Economic aspects	• Direct costs associated with the implementation of emergency response actions • Indirect costs associated with impacts from consequences of the emergency • Compensation issues • Interruptions in international trade • Expected market response and evolution in the future
Social and ethical aspects	• Disrupted living conditions • Reduction in life expectancy due to stress associated with

	resettlement • Psycho-social effects • Possibility of public self-help • Feedback from interested parties on their concerns • Socioeconomic aspects, including issues associated with public trust and credibility of authorities • Need for routine public services (e.g. transport, shops, medical care, education)
Waste management	• Production of radioactive waste and its relation to emergency response actions • Type of waste and options for its characterization • Options for pre-disposal management and for minimizing amount of waste • Available waste management facilities and practices

REFERENCES TO ANNEX II

[II–1] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR OFFICE, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Arrangements for the Termination of a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-11, IAEA, Vienna (2018).

ABBREVIATIONS

ALARA	as low as reasonably achievable
EAL	emergency action level
EPC	emergency preparedness category
EPD	extended planning distance
EPR	emergency preparedness and response
ICPD	ingestion and commodities planning distance
ICRP	International Commission on Radiation Protection
ITB	iodine thyroid blocking
LWR	light water reactor
NPP	nuclear power plant
OIL	operational intervention level
PAZ	precautionary action zone
RBE	relative biological effectiveness
UPZ	urgent protective action planning zone
WHO	World Health Organization

CONTRIBUTORS TO DRAFTING AND REVIEW

Bergman, L.	Radiation Protection Bureau, Health Canada, Canada
Buglova, E.	International Atomic Energy Agency
Close, L.	Radiation Protection Bureau, Health Canada, Canada
Gering, F.	Federal Office for Radiation Protection, Germany
Grzechnik, M.	Australian Radiation Protection and Nuclear Safety Authority, Australia
Haywood, S.	Department Public Health England, UK
Martincic, R.	International Atomic Energy Agency
Martins, J.O.	Portuguese Environment Agency, Portugal
Motomitsu, K.	Nuclear Regulation Authority, Japan
Nestoroska Madjunarova, S.	International Atomic Energy Agency
Owen, D.	Office for Nuclear Regulation, UK
Rauber, D.	National Emergency Operations Centre, Switzerland
Robinson, C.	International Atomic Energy Agency
Vandecasteele, C.	Federal Agency for Nuclear Control, Belgium
Vilar Welter, P.V.	International Atomic Energy Agency

IAEA
International Atomic Energy Agency

No. 26

ORDERING LOCALLY

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.

NORTH AMERICA

Bernan / Rowman & Littlefield

15250 NBN Way, Blue Ridge Summit, PA 17214, USA
Telephone: +1 800 462 6420 • Fax: +1 800 338 4550

Email: orders@rowman.com • Web site: www.rowman.com/bernan

REST OF WORLD

Please contact your preferred local supplier, or our lead distributor:

Eurospan Group

Gray's Inn House
127 Clerkenwell Road
London EC1R 5DB
United Kingdom

Trade orders and enquiries:

Telephone: +44 (0)176 760 4972 • Fax: +44 (0)176 760 1640
Email: eurospan@turpin-distribution.com

Individual orders:

www.eurospanbookstore.com/iaea

For further information:

Telephone: +44 (0)207 240 0856 • Fax: +44 (0)207 379 0609
Email: info@eurospangroup.com • Web site: www.eurospangroup.com

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

Marketing and Sales Unit
International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 or 22530 • Fax: +43 1 26007 22529
Email: sales.publications@iaea.org • Web site: www.iaea.org/publications

EPR-PROTECTION STRATEGY

2020

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA