IAEA
International Atomic Energy Agency
Atoms for Peace and Development

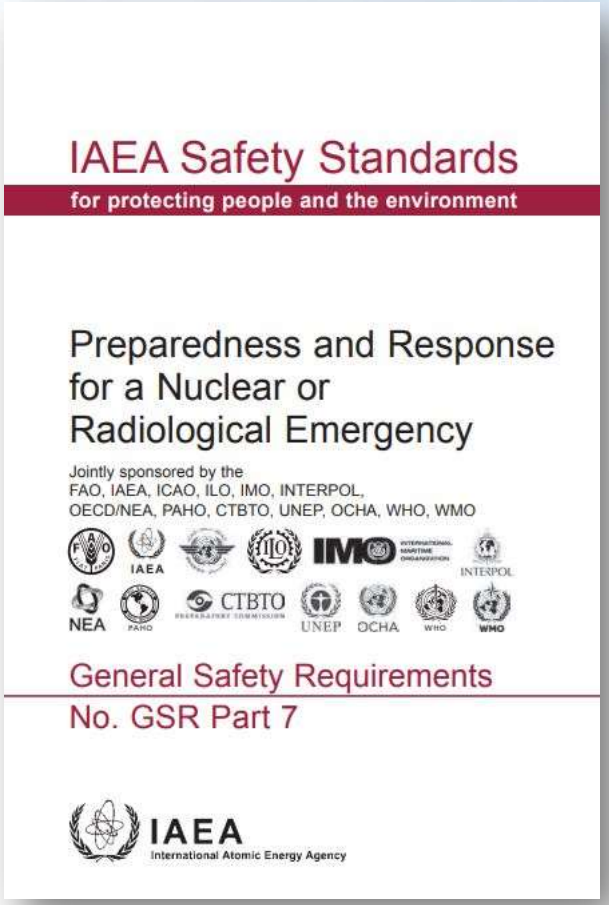
Arrangements for the Termination of a Nuclear or Radiological Emergency

Radioactive Waste Management Following a Nuclear or Radiological Emergency

Lecture 09

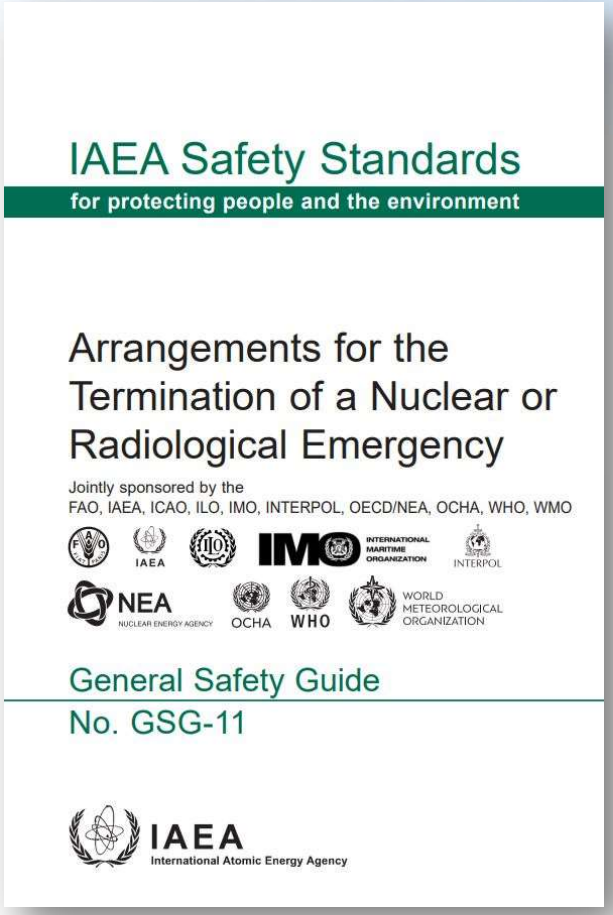
Introduction.
GSR Part 7, Requirement 15

"The government shall ensure that radioactive waste is managed safely and effectively in a nuclear or radiological emergency."



Introduction.
GSG-11, Section 3

"Consideration should be given to the management of any radioactive waste arising from the emergency, as appropriate, before the termination of the emergency."



Purpose

- Present and discuss arrangements for ensuring safe and effective management of waste during the transition phase.

Learning Objectives

- Recognize the challenges in managing radioactive waste generated during a nuclear or radiological emergency.
- Recognize relevant international requirements and guidance.
- Identify arrangements that need to be made at the preparedness stage to facilitate the safe and effective management of radioactive waste during the transition phase.

Contents

- Introduction to:
  - Origins of radioactive waste in an emergency
  - Issues and challenges in managing radioactive waste following an emergency
- Relevant international standards
- Planning basis
- Arrangements at the preparedness stage
- Some predisposal and disposal considerations
- Managing human remains and animal remains

Discussion

What are the sources of radioactive waste following a nuclear or radiological emergency?

Waste Origin

- Waste may originate from:
  - Decontamination activities;
  - Remediation and clean up activities;
  - Decommissioning;
  - Ending the operational life of a source.

Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Image reproduced from' The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Waste Origin Example. Goiânia, Brazil (1987)

- Goiânia, Brazil (1987): Radiological accident involving a radioactive source (Cs - 137, 50 TBq):
  - **3500 m^3** of radioactive waste;
  - A total of **3800 drums**, **1400 boxes**, **10 containers** and **6 concrete wells** used;
  - Cleanup cost of **$20 million.**

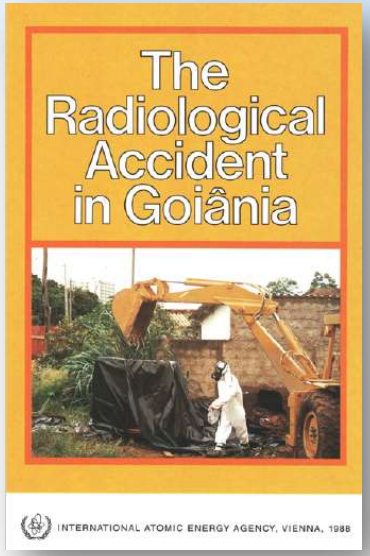


Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Waste Origin Example.
Goiânia, Brazil (1987) (cont'd)

Major challenges faced:

- **Delayed decontamination** due to temporary storage site (TSS) selection because of public opposition:
  - Selection and building of TSS completed in 1987.
- **Lack of proper packaging** for waste disposal.
- **Large amounts of waste and disposal costs** arising from the use of very low radiological criteria.

Waste Origin Example.
Fukushima Daiichi Accident (2011)

Fukushima Daiichi Accident, Japan (2011):

- **Off-site waste**: Remediation activities;
- **On-site waste**: Cooling of the reactors, dismantling, decontamination and demolition.

Images reproduced from The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Waste Origin Example.
Fukushima Daiichi Accident (2011) (cont'd)

Off-site waste:

- **2.3 Mt of contaminated debris** from the earthquake and tsunami collected during 2011;
- **16-22 million m^3 soil and waste were estimated (after volume reduction).**

Images reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Waste Origin Example.
Fukushima Daiichi Accident (2011) (cont'd)

On-site waste:

- **131 900 m^3** of debris and **79 700 m^3** of trees were collected (2014);
- Generation of contaminated water: **400 m^3/day;**
- Estimated contaminated material: **560 000 m^3 after fuel debris removal (2027).**

21 February 2012 *22 July 2013*

Images reproduced from' The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Discussion

What are the differences between radioactive waste generated routinely and as a result of an emergency?

Waste Origin Example.
Fukushima Daiichi Accident (2011) (cont'd)

Major challenges faced:

- Allocation of relevant **responsibilities** for waste management;
- Developing **legislative and regulatory framework** for dealing with on-site and off-site waste:
  - Development of detailed strategies, guidelines and instructions for radioactive waste management;
- **Management of large volumes of waste** (incl. liquids):
  - Developing waste conditioning techniques and procedures;
  - Construction and operation of waste treatment and storage facilities.
- **Transportation** of the waste;
- **Controlling the amount of contaminated material** generated during remediation activities.

Waste Management.
Issues and Challenges

For routine radioactive waste management expect to have:

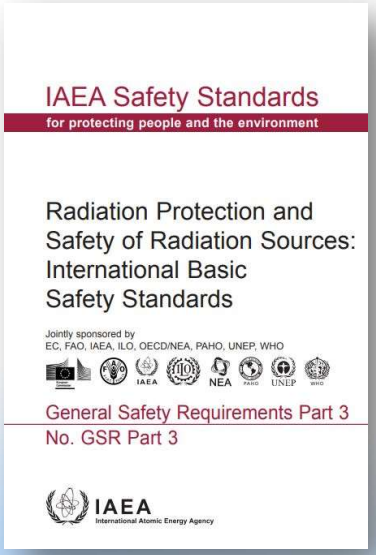
- A well defined and established governmental, legal and regulatory framework for waste management from normal operations, including:
  - National policies and strategies for radioactive waste management;
  - Criteria for classification of radioactive waste;
  - Storage and/or disposal options;
  - Well known waste streams.

Waste Management.
Issues and Challenges (cont'd)

- An emergency will introduce a new (high volume) waste stream:
  - Waste may have diverse characteristics:
    - Radiological, chemical, physical, mechanical, biological.
- Management may necessitate development of:
  - New techniques, equipment and methodologies for waste characterization;
  - Options for radioactive waste minimization;
  - Planning for appropriate predisposal management activities;
  - New storage and/or disposal facilities.

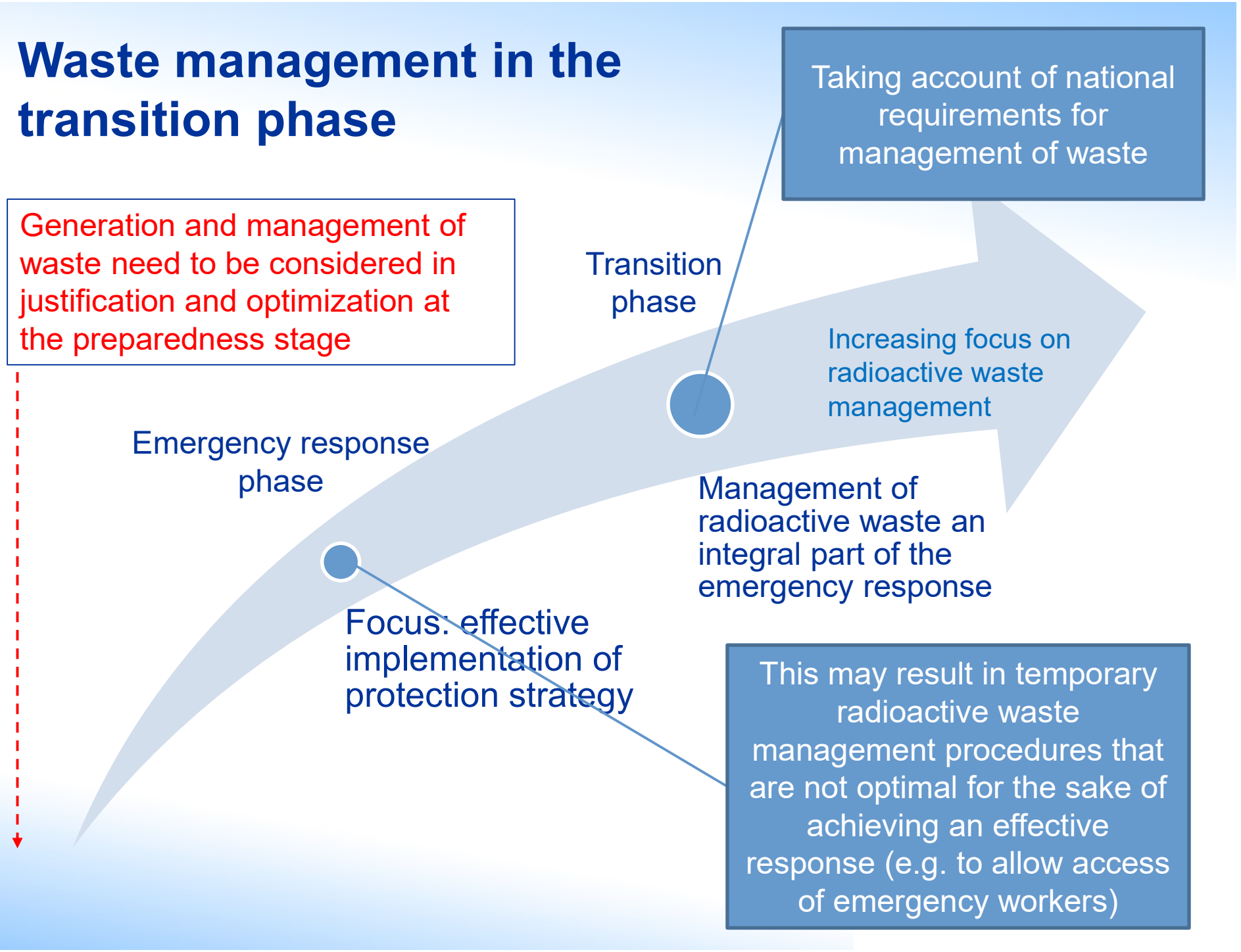
Waste Management.
Issues and Challenges (cont'd)

- Additional human resources (with necessary skills and training) and information management needs;
- Pressure to manage all waste as radioactive waste:
  - Usually due to public and political pressure;
  - May have significant impact on the economy and society.



Consider exemption and clearance levels in Schedule I of GSR Part 3

Waste management in the transition phase

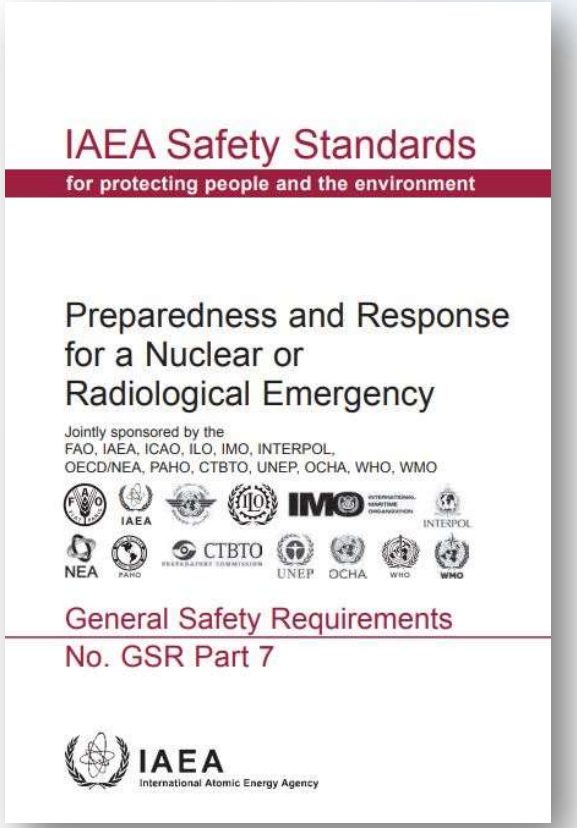


Discussion

How can we prepare to face these issues and challenges?

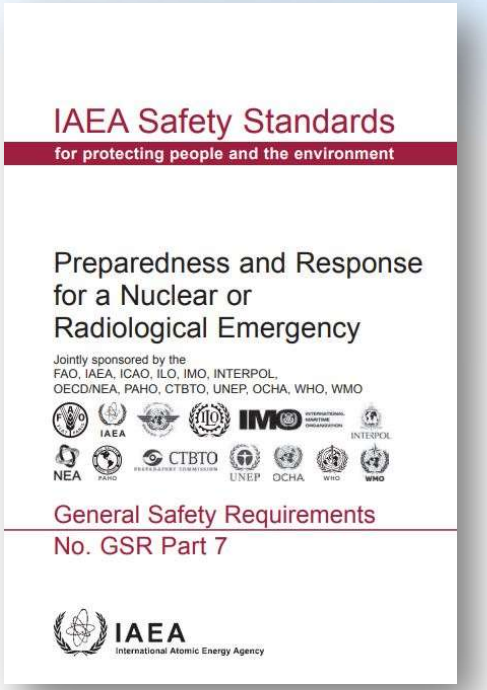
IAEA Safety Standards Series No. GSR Part 7 Requirement 15

- Account for the waste generation and management when justifying and optimizing the protection strategy.
- Prepare for:
  - Managing radioactive waste arising from a nuclear or radiological emergency without compromising the protection strategy;
  - Identifying, characterizing and categorizing radioactive waste in due time.



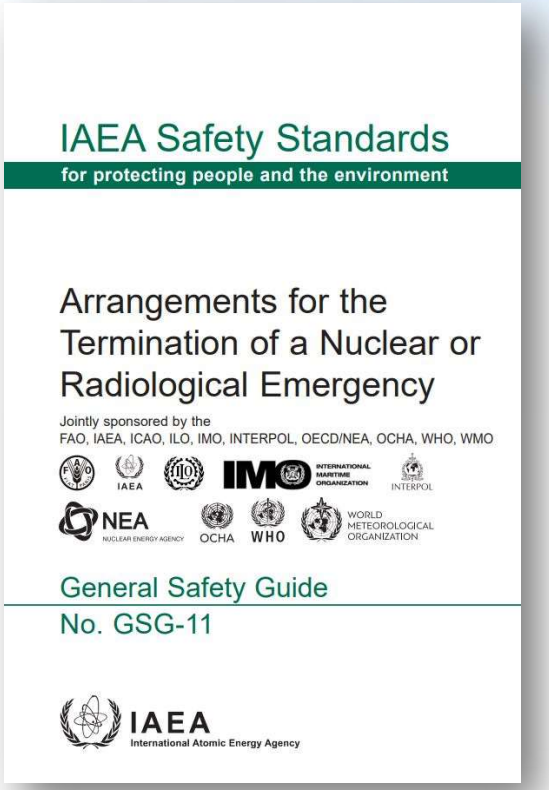
IAEA Safety Standards Series No. GSR Part 7 Requirement 15 (cont'd)

- Criteria for waste categorization;
- Avoiding the mixing of wastes;
- Waste minimization;
- Method for determining options for predisposal management;
- Method for identifying storage options and sites;
- Consideration of non-radiological aspects;
- Consideration of management of human remains and animal remains.



IAEA Safety Standards Series No. GSG-11

- Further guidance to support implementation of Req. 15 of GSR Part 7:
  - Basis for planning for radioactive waste management after an emergency as part of overall emergency response efforts.



Other relevant IAEA Safety Standards on radioactive waste management

- Further requirements and guidance on radioactive waste management are available:
  - Applicable to waste management in planned, emergency and existing exposure situations;
  - Areas beyond emergency preparedness and response.

Planning basis

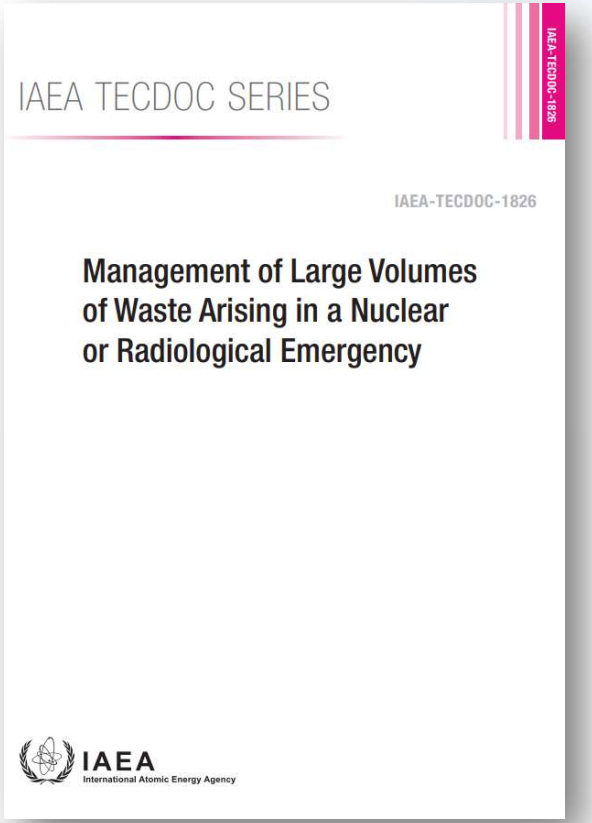
- Anticipate waste characteristics and volumes:
  - On the basis of hazard assessment;
  - Taking into account past experience.
- Review the legislative and regulatory framework for management of radioactive waste and conventional waste;
- Review existing practices and resources available.

Planning basis (cont'd)

- The review of the legal and regulatory framework for radioactive waste management should include:
  - Provisions for exemption, clearance and classification;
  - Processes and options for predisposal waste management;
  - Robustness of safety demonstration and licensing process;
  - Licensing process for radioactive waste management following an emergency.

Past experience.
Chernobyl and Fukushima Daiichi accidents

"Both in Ukraine and Japan, major organizational changes and new roles related to remediation and associated waste management were required soon after the accidents …"



Allocate responsibilities

- Allocate responsibilities for radioactive waste management clearly and consistently:
  - Including responsibilities for management of conventional waste that may have some level of contamination as a result of the emergency.
- Determine the coordination mechanism for the development of arrangements by responsible organizations.

Prepare necessary guidance

- Guidance for:
  - Characterization and classification of radioactive waste:
    - Taking account of its diverse properties.
  - Handling **radioactive** waste and **conventional** waste.

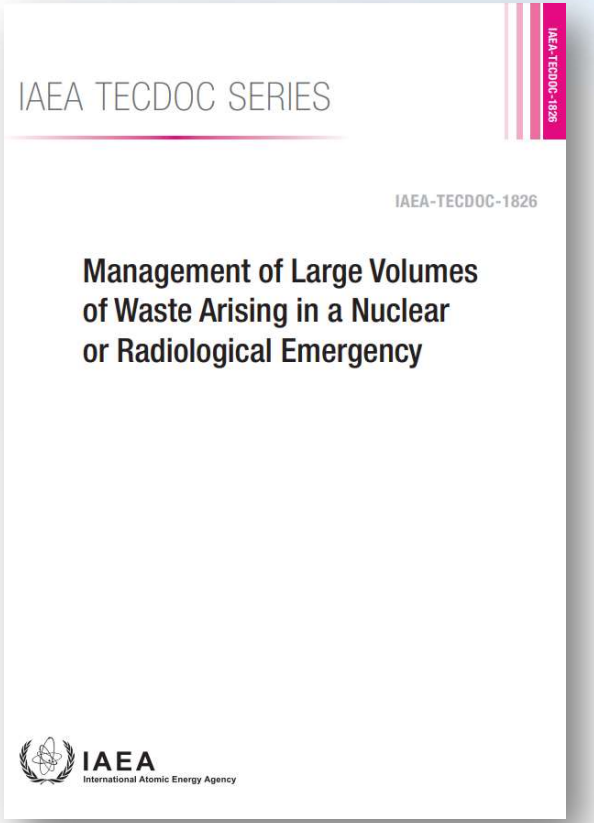
- In the guidance:
  - Consider the **acceptance criteria** of existing storage/disposal facilities;
  - Elaborate **measures to take in case of deviation** from these criteria.

Develop methodologies

- Develop methodologies for initiating predisposal management of radioactive waste:
  - Segregation, packaging, transport, storage;
  - Options for minimization.
- Identify needs for and ensure:
  - Tools, equipment, procedures, training and drills necessary for predisposal management.
- Consider interdependencies among steps in the predisposal management;
- Identify limitations of available options and resources.

Qualifications and training

- Identify relevant areas of technical expertise that may be needed;
- Develop and maintain a roster of technical experts and trained workforce;
- Consider the mobility of trained workforce;
- Establish systematic and effective training programmes:
  - Consider how additional staff can be recruited on a short-term basis, with just-in-time training and instructions to be given for their intended duties.



Waste minimization options

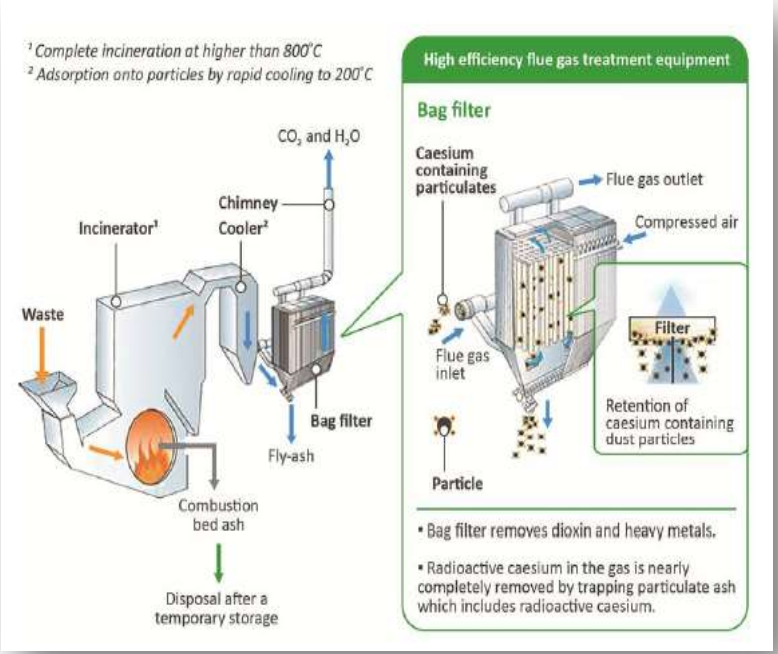


Image reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

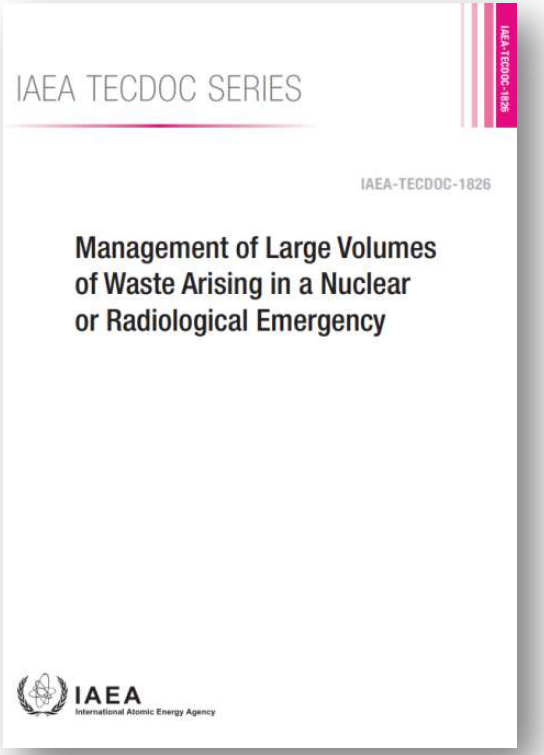
- A balanced selection of clean-up and remediation criteria;
- Selection of remediation techniques;
- Optimize possibilities for reuse, recycling, and/or disposal in non-radioactive waste management facilities:
  - Requires a clearance/exemption process.
- Use volume reduction technologies (incineration, compaction, evaporation, etc.).

Data and information management

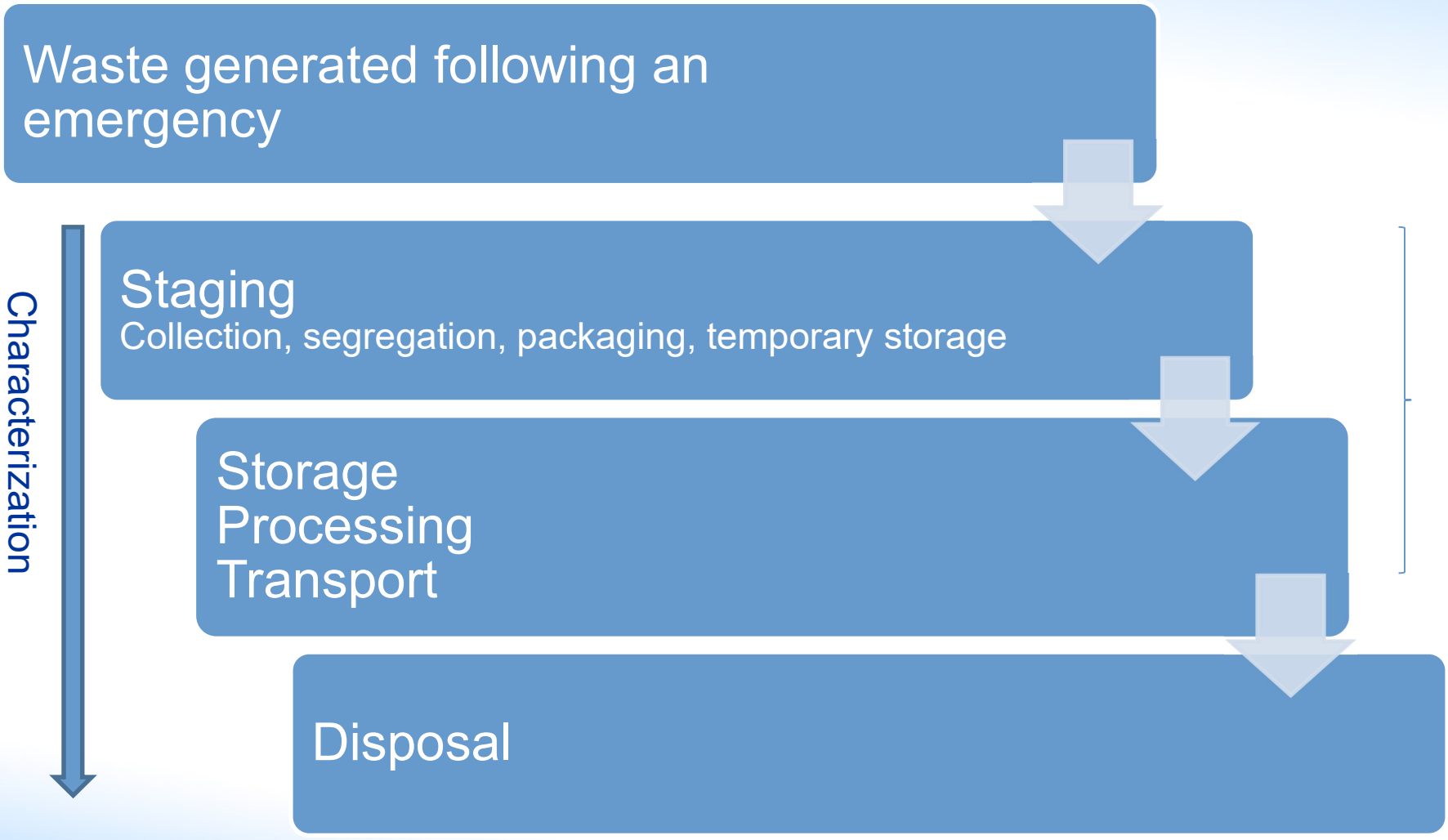
- Plan to expedite collection, retention and reporting of data and information critical to emergency response as well as waste management activities.

Chernobyl accident:

"The exact location of temporary storage sites quickly built during the emergency, as well as the characteristics of waste disposed during the emergency response, was neither collected nor retained (e.g. the characteristics of waste disposed in the first ten disposal cells at Buryakivka are largely unknown …"



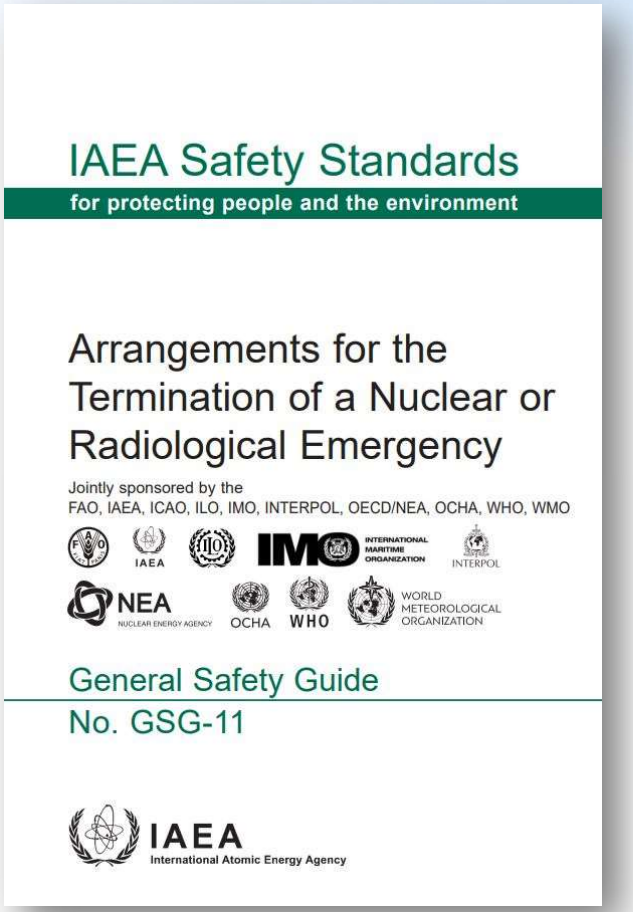
Steps for management of waste from a nuclear or radiological emergency



Adapted from
IAEA-TECDOC-1826

Predisposal management

- National experience in radioactive waste management;
- Acceptable waste collection points and characteristics;
- Characteristics of acceptable storage sites:
  - Geographical, physical, demographic, proximity and infrastructure.
- Transportation, transport regulations and deviations necessary.

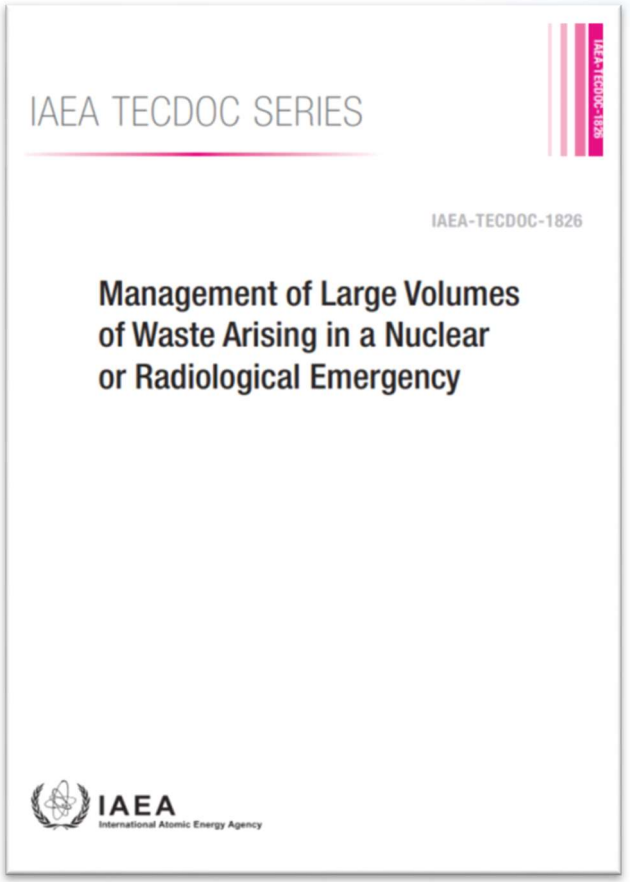


Discussion

How can we prepare for identifying acceptable waste collection points and storage sites after an emergency?

Predisposal management (cont'd)

- An advance planning can include:
  - A methodology for site selection or developing site selection/exclusion criteria;
  - A range of conceptual designs for potential waste management facilities;
  - Regulatory framework as necessary to support expedited licensing of waste management facilities following an emergency;
  - Plans to upgrade or utilize existing infrastructure to support waste management.



Disposal management

- Disposal of radioactive waste is a long term issue:
  - Beyond emergency preparedness and response consideration;
  - Dependent on national policy and strategy for radioactive waste management.
- Identification of disposal options need not delay decision to terminate the emergency.

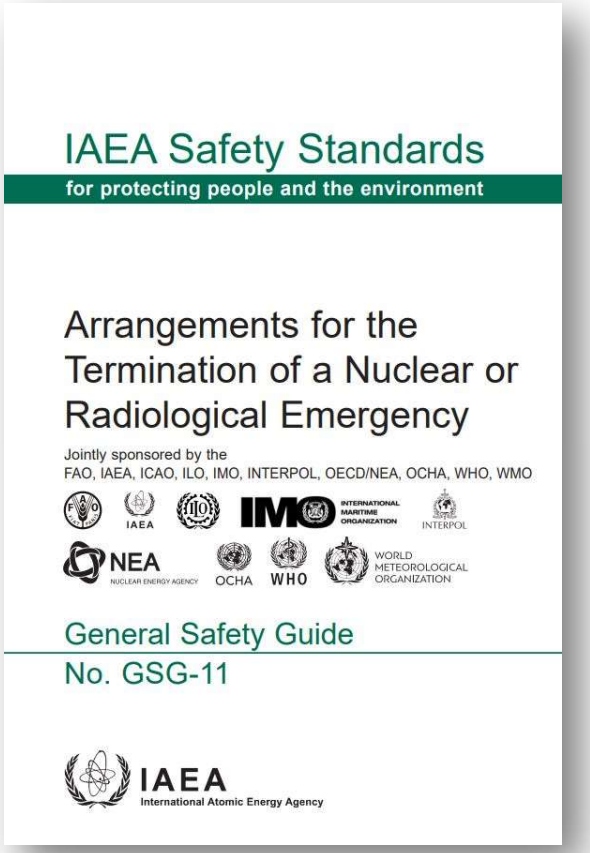
Disposal management (cont'd)

Goiânia accident (1987):

- Temporary storage site (1987)
- Final disposal facility (1997)

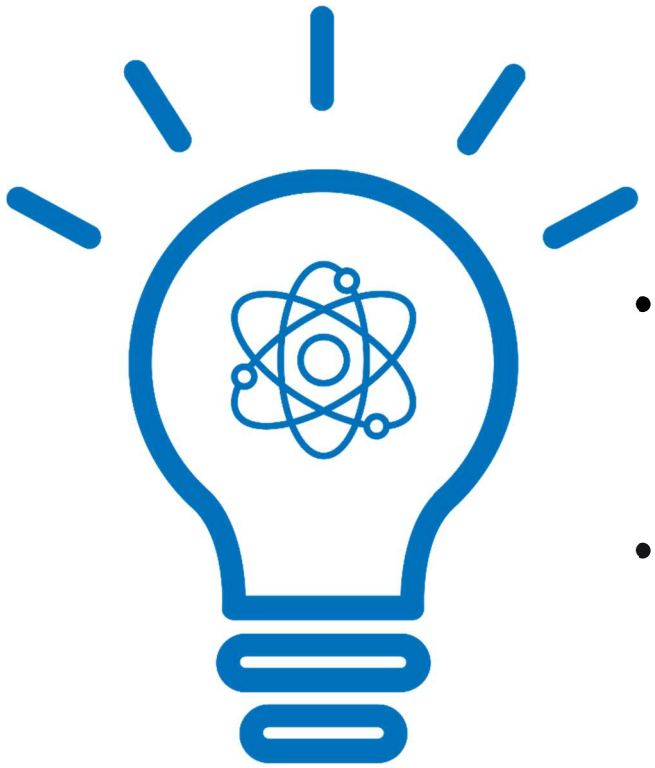
Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Managing human and animal remains



- Religious practices and cultural practices;
- Possible options applicable to practices and type of contamination;
- Consultation with relevant interested parties on what options may be acceptable;
- Training of workers on the basic radiation protection principles.

Summary



- Management of waste (radioactive and conventional) will be an important aspect of the emergency response during the transition phase.
- Management of radioactive waste should be planned as part of overall emergency preparedness effort .
- Specific challenges to be considered include:
  - Diverse characteristics of waste;
  - The amount/volume of waste;
  - Acceptability of storage sites and waste collection sites;
  - Available resources.

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Thank you!