ROPME SEA AREA
REGIONAL RADIOLOGICAL/NUCLEAR EMERGENCY RESPONSE PLAN

Volume 1

PLANNING BASIS

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Annual Review Certification

I hereby certify that I have reviewed the *ROPME Radiological/Nuclear Emergency Response Plan, Volume 1, Planning Basis*. This plan incorporates all necessary changes. I distributed changed pages to all recorded holders of the plan.

Date	Name/Signature

Record of Changes

Change Number	Date of Change	Date Entered	Change Made By (Signature)

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1. INTRODUCTION

1.1 Preamble

Radiation emergencies (radiological, nuclear and terrorism; hereinafter referred to as RN) represent one type of emergency that could significantly affect the Regional Organization for the Protection of the Marine Environment (ROPME) sea area (RSA) – see Figure 1. Planning for, and responding to a RN emergency requires a coordinated effort at all levels: local, regional, national and international. This coordination needs to be harmonized with other existing mechanisms and processes that have been developed to manage crises in general and to ensure a clear, coordinated and effective response.

1.2 Regional emergency response plan

The documents comprising the regional plan were developed to provide the required response structure and guidance to support a regional, coordinated response to an RN emergency in international waters within the RSA.

This regional plan, championed by the ROPME and the Marine Emergency Mutual Aid Center (MEMAC), is entitled the RSA (Regional) RN Emergency Response Plan (RNERP).

1.3 Participating Member States

The RSA RNERP includes the following participating Member States (MS):

- Kingdom of Bahrain;
- Islamic Republic of Iran;
- State of Kuwait;
- Sultanate of Oman;
- State of Qatar;
- Kingdom of Saudi Arabia; and
- United Arab Emirates.

All of these MS have a vested interest in the ongoing safety within the ROPME Sea Area, the safety and health of their population and the protection of the environment.

1.4 Structure

The RNERP is comprised of three volumes, as follows:

- Volume 1 – Planning Basis;
- Volume 2 – Regional Radiological/Nuclear Emergency Response Plan (RNERP); comprising
    - Volume 2a – Operational response plan; and
    - Volume 2b – Preparedness plan; and
- Volume 3 – RNERP Procedures.

This document is Volume 1 – Planning Basis.

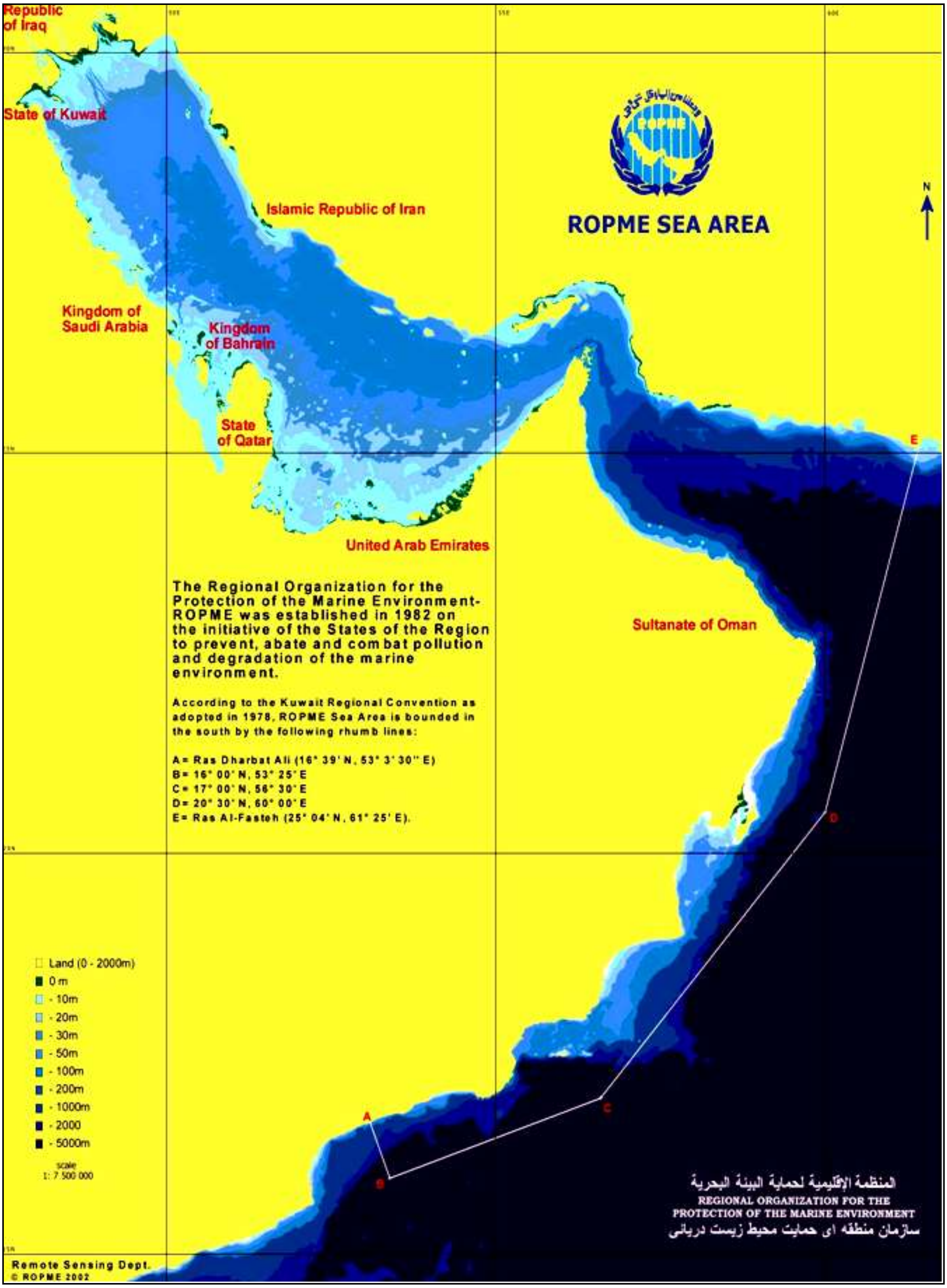

Figure 1: Regional area covered by the emergency plan

1.5 Relevant international, regional and bilateral agreements and conventions

The Regional RN emergency plan is intended to support and reinforce existing Agreements and Conventions. Table 1 summarizes the main relevant documents and how they are related to the RN emergency planning and response processes.

Table 1: Relevant Agreements and Conventions

Document	Relationship to this RN plan
The United Nations Convention of the Law of the Sea, 1982 (UNCLOS)	The principles of the nation's sovereignty over their respective territorial sea and the jurisdictions with regards to the protection and preservation of the marine environment are inalienable principles of the current plan.
International Convention for the Prevention of Pollution from Ships (MARPOL)	Contains requirements for the packaging of hazardous substances and a ship borne, marine emergency plan.
Convention on early notification of a nuclear accident	Commits signatory MS to the prompt notification of nuclear and radiation events having transboundary impacts. In this context, "impacts" is given the broadest meaning, and includes public interest and concern.
Convention on assistance in the case of nuclear or radiological emergency	Provides a mechanism for the International Atomic Energy Agency (IAEA) to coordinate assistance from signatory MS to requesting States. Assistance can also be provided to non-signatory States.
Bilateral agreements	TBD Regional MS are encouraged to establish bilateral agreements with other Regional MS.
Kuwait Convention	The governing agreement for the ROPME Sea Area is The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution 1978. This, together with its Protocol, provides the legal framework for actions concerning regional cooperation in combating accidental marine pollution. These legal instruments oblige the Contracting States to initiate, both individually and jointly, the actions required in order to effectively prepare for and respond to marine pollution incidents.
Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency	The Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency also established the Marine Emergency Mutual Aid Centre (MEMAC) to implement the requirements of the protocol and also to fulfill additional functions necessary for initiating operations to combat pollution by oil and other harmful substances on a regional level, when authorized by the Council.

1.6 Authority and responsibility for the planning basis processes

The MEMAC RN emergency Committee is responsible for the implementation and management of the RN emergency preparedness process (see Volume 3 – Preparedness Plan), including the Planning Basis. All ROPME MS are responsible for providing the required support and resources required to execute the processes contained in the preparedness plan.

1.7 Aim

The aim of this Planning Basis document is:

- To provide a general description of the emergency response, planning and preparedness concepts used as the basis for the RNERP;
- To provide the postulated emergency scenarios used as the planning basis for the RNERP; and
- To develop regional planning requirements and capabilities that forms the basis for the remainder of the RNERP.

1.8 Scope

This document provides a description of general IAEA emergency planning and preparedness concepts that are used in the development of the regional response requirements.

This document also describes the postulated emergency scenarios that are deemed credible and could affect the RSA. These scenarios constitute a justifiable and reasonable basis for the regional RN plan. The planning emergencies described herein are limited to those that could occur within the limits of RSA or that could have an impact on the RSA. Other emergency types (e.g. medical overexposure, loss of shielding, etc.) are deemed to be within the jurisdiction of the individual MS and are not specifically addressed in this planning.

This planning basis focuses on a broad scope of postulated RN emergency scenarios and their possible impacts. Though real emergencies often look very different from theoretical postulations, planning on the basis of the scenarios described in this document should provide a comprehensive and flexible response capability that can be easily adapted to different events, even those that are not specifically addressed in the present document.

1.9 Structure of this document

Section 2 of this document describes the general RN emergency response planning and preparedness concepts. Section 3 provides the planning basis, including a summary of each postulated scenario's regional response requirements. Sections 4 provides weather planning basis. Annex A contains a compilation of all regional response requirements derived from the planning basis scenarios.

1.10 Terminology

A glossary and list of abbreviations are provided at the end of this document in Annexes B and C, respectively.

2. EMERGENCY PLANNING AND PREPAREDNESS CONCEPTS

2.1 General

Emergency preparedness is one way to minimize risk. Emergency preparedness is defined as the measures that enable individuals and organizations to stage a rapid and effective emergency response, which includes the implementation of protective actions to limit the exposure of the public, environment and infrastructure to radioactive contamination.

Initial emergency planning requirements are based on a *Planning Basis*, which relates the analysis of hypothetical emergency scenarios to practical emergency preparedness considerations. The Planning Basis also describes the possible consequences of emergencies as well as their likelihood. In addition, the Planning Basis details the response requirements and inherent actions that can be taken to mitigate harmful effects on health, the environment, and infrastructure contamination leading to possible damage to the regional economy.

2.2 Goals of emergency planning and response

In the context of a radiation emergency, the practical goals of emergency response [1] are detailed in Table 2 with their associated response actions.

Table 2: Practical goals and response actions

Practical Goals	Response Actions
1. To regain control of the situation	Owner operator response and on-scene response
2. Prevent or mitigate consequences at the scene	Owner operator response and on-scene response
3. To prevent the occurrence of deterministic health effects in workers and the public	Urgent protective actions by MS Authorities
4. To render first aid and manage the treatment of radiation injuries	On-scene response and medical infrastructure response
5. To prevent, to the extent practicable, the occurrence of stochastic health effects in the population	Implementation of further protective actions based on intervention and action levels by MS Authorities
6. To prevent, to the extent practicable, the occurrence of adverse non-radiological effects on individuals and among the population	Medical infrastructure response; i.e., psychosocial support
7. To protect, to the extent practicable, the environment and property	Contamination control and decontamination by MS Authorities
8. To prepare, to the extent practicable, for the resumption of normal social and economic activity	Remediation and recovery by MS Authorities

The methodology for attaining these goals regionally for each scenario is detailed in the Operational and Preparedness Volumes (Volumes 2a and 2b) of the RNERP.

2.3 Level of planning and preparedness required

Achieving the right level of emergency preparedness is a challenge. In theory, the more resources that are invested in the planning process, the better prepared a response organization will be. In practice, resources are limited and the response organization must decide on an adequate level of effort to achieve an optimal degree of emergency preparedness. In general, this means investing more effort in planning for the more likely emergencies while making some provisions to deal with those that can be considered less likely. This concept is embodied in recommendations by the International Commission on Radiological Protection (ICRP) and in other international documents [2, 3]:

> *"The preparation of emergency plans should be based on considerations of a wide range of potential emergencies, including those having low probabilities of occurrence... [but] the degree of detail in plans should decrease as the probability of the accident decreases."*

However, postulated emergencies with very low probabilities are often the ones that have the largest consequences, the severity of which may be unacceptable (e.g., death). It is therefore important to recognize that there are two main emergency planning goals [2]:

1. The first is to ensure that appropriate measures are in place to prevent or significantly reduce the risk of severe health effects such as acute illness and death (morbidity and mortality), even for very low emergency probabilities; and
2. The second is to put in place arrangements that will minimize the less severe, longer-term health impacts of potential emergencies, focusing efforts on the more likely events.

The selection of credible postulated emergencies is a very important step. This planning basis is predicated on these concepts. This planning basis outlines these credible, postulated emergencies as well as their impacts and expected response requirements.

The Planning Basis must also describe the response priorities and capabilities for each scenario. The following sections describe some response concepts that are used in the determination of the response priorities and requirements.

2.4 Exposure pathways

In the case of a RN emergency, people may be exposed to radiation through several pathways. The first one is the exposure to gamma rays from an unshielded source or a contained reactor emergency. This pathway, normally called shine, would expose an individual in the vicinity to the source (i.e., the individual would not inhale nor ingest the radioactive material).

If the radioactive material were released to the atmosphere, an individual could be exposed to the radioactive cloud (also known as a plume), as illustrated in Figure 2. While in the plume, a person could be exposed to external radiation from the cloud, or cloud shine. The exposed person could also inhale radioactive contaminants, which would result in an internal exposure from direct inhalation of the cloud's contents, or from re-suspension of radioactive material after the cloud has passed. If the ground becomes contaminated from deposited radioactive material, the person would also be exposed externally from what is called ground shine. Finally, contaminated produce and milk, if ingested, would result in internal exposure. Therefore, the main exposure pathways are:

- external exposure from source shine;
- external exposure from cloud shine;
- external exposure from ground shine;
- internal exposure from the contaminated air (in the plume or contamination resulting from the resuspension of ground contamination); and
- internal exposure from contaminated food and water.

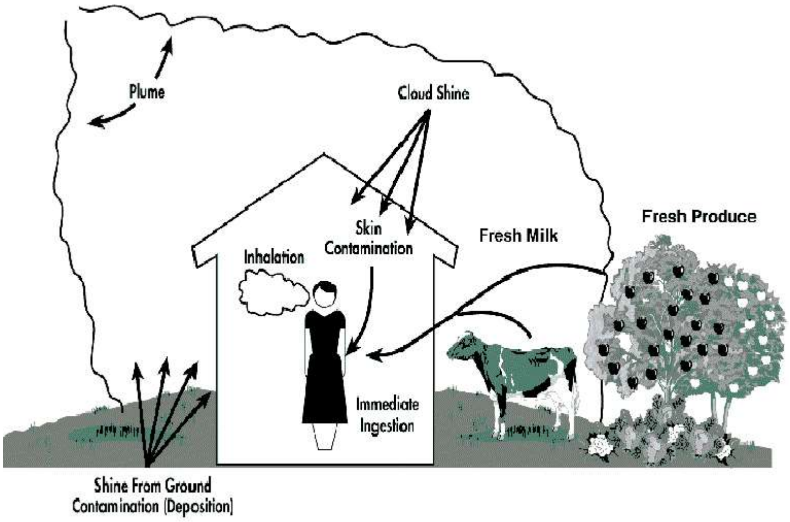

Figure 2: Main exposure pathways for a release to the atmosphere

2.5 Consequences of emergencies

A RN emergency leading to the release of radioactivity to the environment can have short and long-term health consequences, both of which are measured in terms of *dose*.

The most likely health consequences resulting from a nuclear emergency are small doses, which may lead to long-term (stochastic) health effects. Stochastic health effects are not directly observable in individuals and can only be detected statistically in a large population. They include cancer and generally involve a period of latency of several years. The measure of the risk of stochastic effects is called the *effective dose*, expressed in sieverts (Sv).

In some very unlikely postulated cases, a nuclear emergency can be so severe that a few individuals could hypothetically be exposed to very high dose rates, which could lead to some short-term (deterministic) health effects. Deterministic effects include early illness or death.

Even though deterministic health effects are extremely improbable, the planning basis looks at both stochastic and deterministic impacts for the postulated emergencies.

2.6 Protective actions

There are two broad categories of protective actions: urgent protective actions and longer-term protective actions. Urgent protective actions are implemented in the first few hours of an emergency and may last from one to seven days. Longer-term protective actions may need to be considered in the days, weeks or months following the emergency and may last up to several years.

Decisions on urgent protective actions must be made promptly to be effective. They are also often made when little outside expertise is available. Longer-term protective action decisions are not made under the same time constraints, and there are usually many more options to deal with when considering the longer-term impacts of a nuclear emergency. Hence, initially at least, longer-term protective action decisions are less critical. For this reason, this review focuses almost exclusively on the initial impacts of emergencies and on the need for urgent protective actions such as:

- Sheltering;
- Evacuation;
- Stable iodine administration;
- Food bans and controls; and
- Soft countermeasures.

2.6.1 Sheltering

Sheltering involves keeping members of the population indoors, closing all windows, sealing cracks, closing ventilation ducts and slits for window AC units and shutting down any ventilation in order to reduce ingress of external air into the structure and to partially protect against radiation exposure from cloud shine, ground shine, and inhalation. Some improvised means of protecting against inhalation, such as applying a wet towel over the nose and mouth, may also be effective for a short duration. In addition to protecting the population, sheltering allows better and more effective communication with the affected population (proximity to TV and radio, etc.). Sheltering is not recommended for a period exceeding 48 hours [2]; in practice, it is difficult to maintain for more than 24 hours. Beyond that period, evacuation or relocation needs to be considered.

2.6.2 Evacuation

Evacuation is the prompt removal of the population from the affected area. It is generally the most effective protective action against airborne releases of radioactivity, though less so if an evacuation were to take place in the plume during the release. Evacuation is not recommended for a duration exceeding 7 days [2]. Although evacuation has the most potential benefit in theory, it is difficult to implement in a timely and safe manner.

2.6.3 Stable iodine administration

Administration of stable iodine tablets is a measure that allows the saturation of the thyroid gland with non-radioactive iodine to prevent the absorption of radioactive iodine. If Potassium Iodide (KI) is administered within hours of a release, it is an effective protective action for nuclear reactor emergencies (i.e., a Nuclear Power Plant (NPP) or Nuclear Powered Vessels (NPV)), where radioiodine is a major hazard.

2.6.4 Food ban and food control

Urgent protective actions related to food involve an immediate ban on the consumption of locally grown food in the affected area. It also includes the protection of local food and water supplies by, for example, covering open wells and sheltering animals and animal feed.

2.6.5 Soft countermeasures

Soft countermeasures include actions that can be taken to reduce the effects of the contamination outside the 'affected zone.' They include:

- Tourism restrictions;
- Food export restrictions;
- Travel restrictions from affected areas; and
- Vehicle traffic restrictions, etc.

2.7 Intervention levels

Protective actions introduce a benefit, which is measured in terms of the reduction in the health impact. But protective actions also have an inherent detriment associated with them (e.g. economic loss, disturbance, public anxiety, etc.). Ideally, the benefit introduced by a protective action must outweigh its detriment.

The objectives of emergency response are to prevent acute health effects and to minimize long-term health impacts.

The first objective is achieved by avoiding the hazard, i.e., evacuating or substantially sheltering people from the immediate area, where radiological and conventional hazards may lead to acute health effects. In this case, the benefit (preventing acute health effects) almost always outweighs the detriment.

The second objective is also achieved by minimizing the dose received through the implementation of sheltering or evacuation. However, in this case, the health benefit is the statistical reduction of incremental long-term health effects in a large population. Unlike the reduction of acute health effects, it is not immediate and it is more difficult to measure. The benefit, which is the dose reduction achieved, does not always outweigh the detriment associated with the protective action unless the dose reduction is significant. The value of the dose reduction achieved at which the benefit becomes greater than the detriment can be calculated [2]. This value is called the intervention level for that particular protective action.

Table 3 lists the intervention levels for urgent protective actions for use in this document. These are based on IAEA guidance [2] and are consistent with other international guidance [3]. The value of the intervention level corresponds to the dose averted for the time during which the protective measure is in effect. For evacuation, this should not be greater than seven days. For sheltering, the IAEA [2] suggests two days as a maximum. However, in practice, this measure should not be in effect for more than one day, since many people would need to go out to get food and other essential supplies. It should also be noted that sheltering is less than 100% effective at reducing the dose and that an appropriate dose reduction factor must be applied to calculate the dose averted.

Table 3: Short term generic intervention levels [4]

Protective action	Generic intervention level
Sheltering up to two days	10 mSv
Evacuation up to seven days	50 mSv
Iodine prophylaxis[1]	100 mGy

Note 1 - Avertable committed absorbed dose to the thyroid due to radioiodine. For practical reasons, one intervention level is recommended for all age groups.

Long term intervention levels (Table 4) are planning values and are based on avertable dose. During an actual emergency, decisions must also take into consideration such practical factors as road conditions, weather, time of day, etc.

Table 4: Longer term generic intervention levels [4]

Protective action	Generic intervention level
Temporary relocation for 30 days	Initiate @ 30 mSv[1] Terminate @ 10 mSv[2]
Permanent resettlement	1 Sv in a lifetime

Note 1 - If the dose accumulated in a month is not expected to fall below this level in a year or two, permanent resettlement should be considered.
Note 2 - Provided the total life time dose to any member of the population will be less than 1 Sv.

In order to ensure that public safety is enhanced, emergency workers may have to receive a dose in order to perform their function more effectively. As their exposure is deliberate and purposeful, emergency workers follow different guidelines from the general public and there is a need to establish dose limits rather than avoidable dose. These levels are highlighted in Table 5.

Table 5: Emergency worker dose guidance levels [4]

Task	Level (mSv)
Life saving actions	>500
Potential life saving actions, or Actions to prevent the development of catastrophic conditions	500
Actions to prevent serious injury or Actions to avert a large collective dose	100
Other emergency phase intervention	50
Recovery operations	50 in a single year

2.8 Emergency planning areas and zones

Emergencies are categorized to occur in two distinct areas [4]:

- On site areas (referred to in the document as "site"); and
- Off site areas.

In the case of fixed facilities (e.g., NPP), these areas are pre-defined. However, in the case of mobile risk objects (e.g., ships), the zone cannot be pre-defined as the location of the source of risk changes constantly. In this case, safety distances, guidance on which is given in this Plan, are applied and define de facto a site area and an equivalent to the off-site area designated for fixed facilities. By definition, in this Regional Plan, the site is the scene of the accident that is controlled by the on-scene responders.

On-site area - This is the area surrounding the facility or emergency site within a predetermined or post emergency security perimeter, fence or other designated area demarcation. It can also be the controlled area around an emergency or contaminated area. It is the area under the immediate control of the facility, operator or on-scene controller. For transport emergencies or emergencies involving uncontrolled sources, malevolent act or localized contamination, there may not be an on-site area defined at the onset of the emergency. However, during the initial response to these emergencies, the first responders or operator establish a security perimeter containing the inner- and outer-cordoned areas as shown in Figure 3 [4], thereby defining the site area, which is under their control.

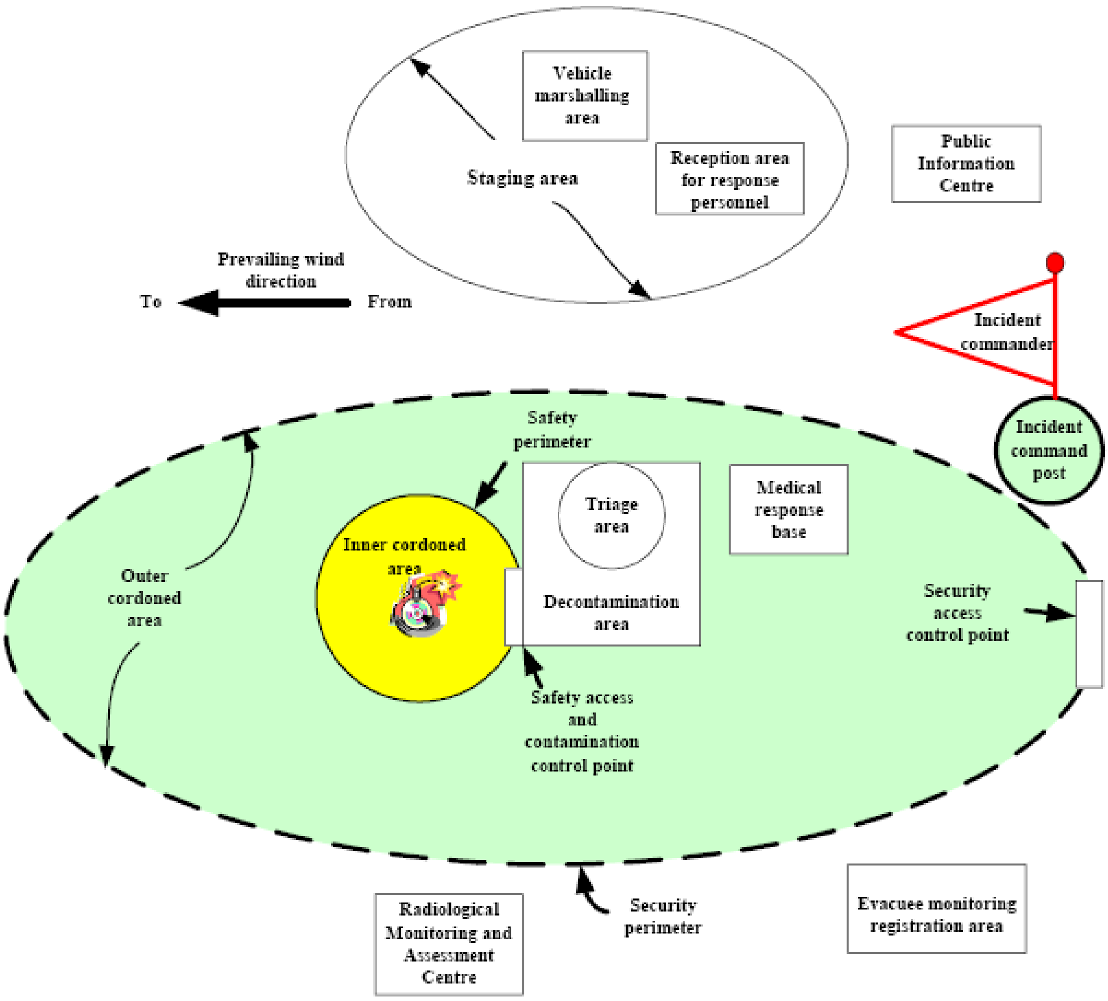

Figure 3: Areas established by responders

Off-site area - This is the area beyond that under the control of the facility operator or first responders. For facilities with the potential for emergencies resulting in major off-site releases or exposures, the level of planning will vary depending on the distance from the facility. For these facilities, planning can be discussed for two emergency planning zones (as illustrated in Figure 4):

- Precautionary Action Zone (PAZ); and
- Urgent Protection Action Zone (UPZ).

These emergency planning zones represent the areas within which planning for given protective actions should take place based on health risk. The zones are based on the assessment that the health risk in those areas justifies the investment of resources and efforts required for detailed planning. It *does not* mean that, when an emergency occurs, response will extend to the entire zone, or that it will be limited to these zones. Indeed, plans must have provisions to extend protective measures outside the planning zone.

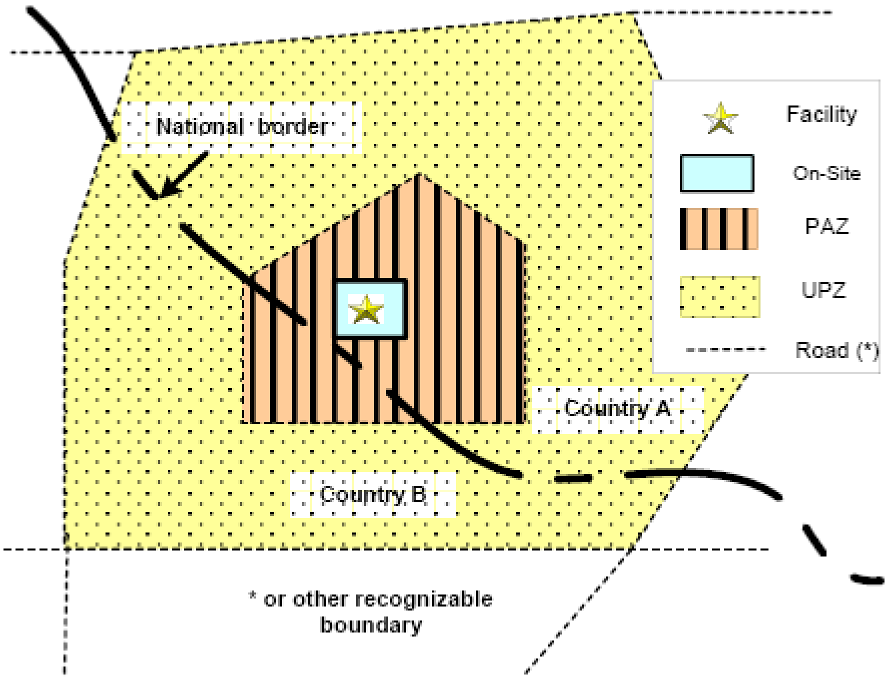

Figure 4: Concept of emergency zones

2.8.1.1 Precautionary Action Zone (PAZ)

The PAZ is the area where there is a risk of exceeding thresholds for acute health effects and where the risk of exceeding intervention levels for long-term health effects is the highest. The PAZ size is calculated as the distance up to which an accident, regardless of its probability, could lead to early health effects. Early health effects include both conventional impacts (explosion blast) and acute radiation illness.

In the PAZ, plans should be developed to automatically evacuate or shelter people from the potential hazard before it occurs. The goal is to substantially reduce the risk of severe deterministic health effects, by taking protective action within this zone before or shortly after a release.

2.8.1.2 Urgent Protective Action Zone (UPZ)

The UPZ is the area where the risk of exceeding intervention levels for long-term health effects is high but where the risk of acute health effects is negligible. The size of the UPZ is calculated as the distance up to which the *unlikely* events could lead to doses exceeding intervention levels for urgent protective actions.

In the UPZ, detailed plans should be developed to promptly perform airborne and ground monitoring and implement urgent protective actions based on the results and emergency conditions (i.e., the condition of the affected reactor). Plans should also ensure that emergency facilities, such as evacuee centres, are located outside the UPZ.

These zones should be roughly circular areas around the facility, with their boundaries defined by local landmarks (e.g., roads or rivers) to allow easy identification during a response (Figure 4). It is important to note that the zones do not stop at national borders. The size of the zones can be determined by an analysis of the potential consequences.

2.8.1.3 Food restriction planning radius

The IAEA presents a zone for off-site areas where contamination levels from various accidents and emergency types with a release could possibly lead to the requirement for food and agriculture restrictions. This zone is called the Food Restriction Planning Radius (FRPR). It should be noted that criteria is required for decisions pertaining to restrictions within this zone; i.e., restrictions must be based on validated measurements. This zone can extend past 300 km for severe NPP accidents.

IAEA recommended food restriction action levels are shown are shown in Table 6 and Table 7.

Table 6: Generic Action levels for food destined for general consumption

Radionuclides	kBq/kg
Cs-134, Cs-137, I-131, Ru-103, Ru-106, Sr-89	1
Sr-90	0.1
Am-241, Pu-238, Pu-239, Pu-240, Pu-242	0.01

Table 7: Generic Action levels for milk, infant foods and drinking water

Radionuclides	kBq/kg
Cs-134, Cs-137, Ru-103, Ru-106, Sr-89	1
I-131, Sr-90	0.1
Am-241, Pu-238, Pu-239, Pu-240, Pu-242	0.001

The levels shown in Table 6 and Table 7 apply to situations where alternative food supplies are readily available; higher levels can apply where food supplies are scarce. The levels are for food prepared for consumption, and would be unnecessarily restrictive if applied to dried or concentrated food prior to dilution or reconstitution. For practical reasons, the criteria for separate radionuclide groups should be applied independently to the sum of the activities of the radionuclide’s in each group.

Classes of food that are consumed in small quantities (e.g., less than 10 kg per person per year), such as spices, which represent a very small fraction of the total diet and would make very small additions to individual exposures, may have action levels ten times higher than those for major foodstuffs. The tables are based on, and consistent with, the Codex Alimentarius Commission's guideline levels for radionuclide’s in food moving in international trade following accidental contamination [5], but it is limited to the nuclides usually considered relevant to emergency exposure situations. The use of these levels is intended to be limited to the first year after a nuclear or radiological emergency.

2.9 Surveys and operational intervention levels

Outside of the area defined as the PAZ, the decision to implement protective actions should be based on measurements. Ideally, measurements try to estimate the dose that could be averted by implementing a given protective action. If that value is above a pre-established intervention level, then the protective action should be implemented, except if practical considerations suggest otherwise (e.g., road conditions preclude an effective evacuation).

In practice, estimating a dose that could be averted is a complex process that takes considerable time and expertise. While in a plume, a person would be exposed to external radiation from the radioactivity in the air and on the ground, and to internal radiation from inhalation, unless effective respiratory protection is worn. External radiation can be monitored using hand-held gamma-beta dose rate instruments. Internal radiation measurements require more sophisticated diagnostic techniques. When the plume has passed, an individual would be exposed to ground shine (external) and to radioactivity in the air resulting from the re-suspension of ground contamination (internal). Since radioactive contamination decays with time, the total exposure is not directly proportional to the time spent on the contaminated ground. The total dose received is the sum of internal and external doses.

The IAEA recommends the use of operational intervention levels (OILs), which are instrument readings corresponding to intervention levels. OILs make assumptions regarding the duration of exposure and the isotopic composition of the contamination. Default OILs can be calculated based on the hypothetical emergency scenarios reviewed.

OILs are presented in the RNERP Volume 2a Operational Response Plan for each applicable scenario.

3. PLANNING BASIS

3.1 General

This Planning Basis provides the guidelines that form the basis of emergency response planning and preparedness, i.e., the remainder of the RNERP. This Planning Basis also provides the scenario based planning foundation for the determination of the requirements for the regional response plan. Detailed response requirements are included in Annex A.

The postulated scenarios considered in this planning basis include current and possible future threats; they take into account expected nuclear technology developments in the region.

The postulated emergency scenario categories are:

1) Nuclear Power Plant (NPP) reactor accidental release;
2) Nuclear Vessel emergency:
   a. Nuclear Powered Vessel (NPV); and
   b. Nuclear Capable Vessel (NCV);
3) Transportation emergency (marine or land-based, fire or spill);
4) Lost or stolen source;
5) Terrorist events:
   a. Radiological dispersal device (RDD) or "dirty bomb" that is (or can be) detonated in the RSA;
   b. Attack on a NPP; and
   c. Credible or confirmed terrorist threat affecting the RSA.

The technical planning basis includes a description of the postulated emergencies, including:

- Typical emergency descriptions and sequences;
- Impact of postulated releases of radioactive material to the environment;
- Postulated health effects; and
- Regional response requirements.

Planning distances, when mentioned in the planning basis, are based on a risk-based evaluation of all possible emergencies, and take into account the worst case scenarios. Unless otherwise noted, they are based on the International Atomic Energy Agency (IAEA) guidance provided in EPR2003 [6].

The quantitative probability of these emergencies is not considered in this Planning Basis; rather, a more qualitative assessment of the likelihood of the emergency is included. This is based on the following likelihood categories:

- Unlikely event – (estimated probability of occurrence 10^{-3} to 10^{-5} events per year);
- Very unlikely event – (estimated probability of occurrence 10^{-5} to 10^{-7} events per year); and
- Extremely unlikely event – (estimated probability of occurrence is less than 10^{-7} events per year).

The regional response requirements for each scenario are presented to highlight the requirements for effective regional response. These requirements, summarized in Annex A, are used to develop the remainder of the RNERP.

3.2 NPP reactor accidental release

3.2.1 Description

This planning basis emergency is a series of events, malfunctions, equipment and/or operator errors that, in combination, result in serious damage to the nuclear fuel (fuel overheating), with the subsequent release of the radioactive fission products from the fuel into the containment. Through additional errors and system failures, it is possible that a release from the containment into the environment can occur. The release can be waterborne or airborne.

It is important to consider that not all NPP emergencies lead to major releases to the environment. The response must be tailored to the magnitude of the release. Assuming that a release is always large could lead to detrimental and inappropriate response.

The power reactors under consideration are the Bushehr reactor in Iran and the planned NPPs in the region, notably those planned by the United Arab Emirates.

The likelihood of a severe NPP emergency that would affect the RSA is 'very unlikely.'

3.2.2 Possible impacts

In general, the impacts of such an emergency would likely be high within the MS where the NPP is located, and widespread (but lower) in the rest of the region. As a basic premise, it is therefore important to understand that this type of emergency has an immediate regional dimension, which calls for special priorities in the regional response, as discussed below.

3.2.2.1 Health effects

Severe, acute health effects are unlikely, except in the worst case scenarios. For Pressurized Water Reactors (PWR and VVER), severe health effects are only credible in the immediate vicinity of the NPP; i.e., within about 5 km.

Longer-term health impacts are likely, downwind, over considerable distances, although the risk of such impacts decreases significantly with distance from the plant. Indeed, it is not likely that the risk of health effects would be sufficiently high past 25 km to warrant the implementation of urgent protective actions.

Emergency workers within the facility have a higher risk of being severely overexposed or becoming contaminated. Therefore, as a basis, there could be a limited number of severely exposed or contaminated casualties from the facility.

Psychosocial impacts are not necessarily directly related to the presence of high levels of radiation. They could result over great distances from the NPP due to the ease of detecting even low levels of radiation.

3.2.2.2 Effects on the environment

Environmental effects would result from the deposition of the radioactive contaminants on the ground or in water. In the presence of rain, hot spots may form, resulting in high, localized concentrations of radioactive contaminants. Ground and water contamination can have a direct impact on the environmental components, such as animals, plants and fish, or an indirect impact on human health through contamination of the food chain such as:

- Contaminated water could enter water treatment or purification facilities and result in the contamination of the drinking water supply, unless appropriate filtration systems are in place; or
- Deposition on the ground would lead to the contamination of food products, including those consumed directly by the general public and those in the human and animal food chain.

The precise extent and nature of the impact is difficult to predict, but it is reasonable to expect that, in the case of severe emergencies, serious environmental impacts would be limited to a few kilometers from the NPP, but that lower level impacts could extend over great distances from the NPP. Based on an analysis of many possible accidental releases for PWR and VVER type reactors, it is reasonable to assume that in the worst cases, significant environmental impacts could result more than 300 km from the NPP.

3.2.2.3 Effects on critical infrastructure

Contamination of critical infrastructure components is possible over great distances. However, beyond approximately 25 km from the NPP, contamination levels are unlikely to be high enough to prevent the use of the critical component, at least from a scientific perspective. Yet the perception associated with radioactive contamination could result in reluctance on the part of the component operator or personnel to continue working, thereby resulting, effectively, in the impairment of the component. For planning purposes, it is assumed that wherever there is an environmental concern, there could also be concerns regarding the habitability of critical infrastructure components. Therefore, for planning purposes, such impacts could be felt over 300 km from the NPP.

3.2.3 Regional response requirements

The impacts of an NPP emergency would be mainly within the host MS, except for:

- The longer-range water/ ground contamination requiring food and agricultural countermeasures; and
- The low levels of radiation causing public concern and possibly affecting the critical infrastructure.

These impacts are likely to be on a regional scale, which means that several MS would be affected. Based on this possibility, the response priorities for the regional plan need to focus on the following:

- There must be a reliable notification system in place within the region to ensure that neighbouring MS and the regional organization are promptly notified of an emergency that could have an impact on the region;
- There should be a regional mechanism to ensure that MS have sufficient and correct information to determine the protective actions (urgent and longer term) they need to enact over their own territory. This suggests the need for a common or joint radiation monitoring arrangements, a regional plume tracking capability and a regional dose projection capability;
- As much of the region is covered by the RSA, the region must be able to complement the existing land-based radiation monitoring network with marine-based field surveys of ambient gamma, airborne concentration and water contamination, over a very large area. This will help determine the large-scale impacts (though expected to be low) on the region and will allow projections of the impact locations and levels; and
- Since such an emergency is likely to affect several MS, the region must have the ability to coordinate and harmonize individual MS responses, including ensuring that common intervention levels are used and they are consistently applied throughout the region. This will minimize or prevent discrepancies and inconsistencies in the regional response that could affect the effectiveness of the measures being implemented.

3.3 Nuclear Powered Vessel (NPV) emergency

3.3.1 Description

NPVs are routinely present within the RSA and also frequent ports within the RSA for repairs and periods of crew rest and relaxation. During operations in the RSA, the vessels are exposed to a collision hazard due to the high volume of vessel traffic.

Although emergencies that could lead to a significant radiological impact outside a NPV are very unlikely, emergency response plans to effectively deal with such situations are necessary.

Emergencies that are classified as extremely unlikely are those that involve melting of the reactor core inside the NPV with failed containment or containment bypass. The resulting release of radioactive material to the environment could be relatively large and could continue for hours, depending on the nature of the emergency. An emergency of this nature could result in the exposure of people onboard the NPV, exposure and/or contamination of the surrounding environment and possibly the public in the immediate area.

A more likely event is one that leads to nuclear fuel failure, but without containment failure or bypass. This may still result in a release of radioactive material, but it would be very small and would have little to no effect on the personnel on the vessel, the surrounding environment or the public. This emergency would be detected by the “shine” from the vessel itself.

Taking all things into consideration, the likelihood of a NPV emergency that would affect the RSA is ‘very unlikely.’

3.3.2 Possible impacts

In general, the potential impacts are similar to those of an NPP emergency, with two variations:

- The reactors on board NPVs have a maximum power of 200-800 MW_{th} (10-40% of some land based NPPs). Therefore, the release is expected to be comparatively small, though not proportionally so, due to the differences in fuel burn-up and containment design;
- The NPV is located in seawater, either at sea or in a port, in closer proximity to populated areas and drinking water supplies. This makes the sea environment particularly vulnerable to NPV emergencies; and
- The NPV is mobile, with a possibility of an emergency anywhere within the RSA.

These characteristics influence the regional response priorities. Of particular interest is the fact that the NPV is mobile and always in the sea environment, which calls for special measures. This fact is addressed in this section.

3.3.2.1 Health effects

Severe, acute health effects are unlikely, except is the worst case scenarios. For the most common type of nuclear powered vessel operating in the RSA, severe health effects are only credible in the immediate vicinity of the NPP, within approximately 1 km.

Longer-term health impacts are likely, downwind, over slightly larger distances, although the risk of such impacts decreases significantly with distance from the NPV. Indeed, it is not likely that the risk of health effects would be sufficiently high past 5 km to warrant the implementation of urgent protective actions.

3.3.2.2 Effects on the environment

As in the case of NPP emergencies, environmental effects would result from the deposition of the radioactive contaminants on the ground or water. The potential direct environmental impacts would primarily involve marine life, with indirect impacts on human health through the contamination of the food chain. If the vessel is at sea, the main impact will be on the marine environment. If the vessel is along side, the impact could be both on the land and on the marine environments.

The precise extent and nature of the impact is also difficult to predict. Based on previous studies, it is reasonable to assume that environmental impacts could be significant over 50 to 100 km, in the worst cases.

3.3.2.3 Effects on critical infrastructure

As discussed for the case of NPP emergencies, the real impact on infrastructure components is likely to be limited to about 5 km; however, the perceived impact could be much greater. For planning purposes, it is safe to assume that infrastructure components within 50 to 100 km could be affected.

3.3.3 Regional response requirements

The regional response priorities would vary depending on the location of the NPV when the emergency is postulated to occur.

If the vessel is in harbour, the responsibility for the response is the hosting MS, who would act as the lead MS for the regional response. The regional focus would then be on the provision of assistance to the affected MS.

If the vessel is located in international water at the time of the postulated emergency, the regional priorities are far more complex. No significant health impacts would be expected in individual MS; only people in the immediate area of the NPV could be at risk. The main impacts on the MS would be environmental contamination. Therefore, regional response priorities would focus on the following:

- The region must be able to detect that an emergency has occurred. This calls for a reliable notification system between the NPV command and the regional organization, supported by an effective and rapid marine radiation monitoring network. Since an NPV emergency may occur anywhere in the RSA, the monitoring system must ensure a wide coverage, or be mobile;
- The region must also have the resources to conduct operations at sea, in a potentially contaminated or high radiation area, to carry out rescue and interdiction operations and to control the scene of the emergency;
- The region must be able to assess the potential impacts of the emergency. For this, the region must have teams capable of performing marine field survey, including the measurement of ambient gamma radiation, airborne contamination and water sampling;
- The region should be able to integrate these field surveys with readings from existing monitoring networks to determine the direction of the plume and long range impacts. This should be carried out in concert with qualified scientific resources capable of performing short and long-range impact projections and assessments; and
- The region must be capable of rendering assistance at sea in a potentially contaminated or high radiation area.

3.4 Nuclear Capable Vessel (NCV) emergency

3.4.1 Description

A NCV is a strategic nuclear submarine (also referred to as SSBN) that has the capability to carry nuclear weapons. Most of those vessels also have nuclear propulsion; therefore, an NCV is also an NPV. When referring to NCV emergency, though, we specifically mean emergencies involving the nuclear weapons.

The accidental detonation of a nuclear weapon onboard the most common type of NCV present in or near the RSA is practically impossible. Plans therefore focus on the accidental dispersion of the material contained in such weapons, primarily the plutonium.

An uncontrolled fire aboard the NCV is the most credible initiating event for the dispersal of plutonium. Exposure to high temperatures could lead to heat damage to the weapon's casing or to the explosion of the insensitive high explosive (IHE) contained in the weapon. There is a high degree of protection against such emergencies. However, should firefighting efforts fail, and should it not be possible to flood the compartment engulfed in flame, there is a possibility that the weapons may be subjected to very high temperatures. This scenario is very unlikely, but not impossible. Due to the silo construction, it is not likely that more than one missile at a time would be affected in an emergency. On the other hand, all warheads within a single missile could be destroyed.

There are two potential modes of destruction by fire for a plutonium core. The first is the pyrophoric combustion of the plutonium core (release by fire). In this case, a small fraction of the plutonium could be released as breathable aerosols. The second is the explosion of the high explosive charge surrounding the core. In that case, a more substantial fraction of the plutonium could be released as a fine aerosol (explosive dispersal).

This emergency scenario, a fire or explosion that causes the release of the nuclear material within a strategic nuclear weapon, involves a very quick release (i.e., less than 30 minutes) and leads to mainly a release of plutonium and daughter products.

The likelihood of a NCV emergency that would affect the RSA is 'very unlikely.'

3.4.2 Possible impacts

The most immediate and obvious consequence resulting from the conventional explosion of a nuclear weapon would be the conventional explosion itself. Blast safety distances are quoted from 200-800 m [7,8]. Nuclear weapons also contain chemically toxic material. These include, for example, beryllium, ammonium perchlorate, nitrocellulose, nitroglycerine and ester. Uranium and plutonium are heavy metals and are also chemically toxic, in addition to being radioactive.

The radioactive material that would be released from an affected missile includes plutonium, americium thorium and tritium. By far, the main contributor to dose would be plutonium, which is an alpha emitter. Alpha radiation may be difficult to detect since this type of radiation travels only a few cm in air. However, americium, which is a low energy gamma emitter that accompanies plutonium, can be more easily detected using special gamma instruments. Americium can be used to detect the presence of plutonium contamination.

The area affected depends on the size of the release and the weather conditions. For very dispersive weather conditions (e.g., Pasquill A), the area affected would be short but wide. For very stable weather conditions (e.g., Pasquill F), the cloud of plutonium dust would drift slowly over a large distance but the width of the contamination footprint would be very narrow. Although theoretical calculations are based on a straight-line plume, in reality the plume may meander, creating an irregular pattern of contamination.

3.4.2.1 Health effects

For an emergency involving the dispersion of the material contained in a nuclear weapon, the main hazard to people would come from the inhalation of plutonium. Exposure to other components such as tritium and americium represent a relatively minor risk. The greatest potential exposure would occur during the plume passage. Thereafter, deposition of plutonium on the ground may get re-suspended through natural disturbances or human activities, presenting a subsequent, though lower, risk of inhalation but a higher ingestion risk, unless a ban on locally grown food stuff is implemented. Indeed, analysis has shown that the dose from deposited material (from ground shine and re-suspension) represents less than 3% of the inhalation exposure, even for relatively high rates of deposition of the airborne contamination. While this is a minor concern compared to plume exposure, it remains a significant longer term concern after the plume has passed. In the longer term, ingestion of contaminated food would become the main exposure pathways.

Radiological health effects would be only stochastic in nature, and overall exposure levels would be low due to the relatively low levels of contamination expected downwind.

The distance at which potential health effects would be high enough to warrant an evacuation is about 2 km, and high enough to warrant sheltering, up to 10 km.

3.4.2.2 Effects on the environment

The area affected depends on the size of the release and the weather conditions. The presence of structures and high vegetation and the occurrence of local precipitations may create very local accumulations of contamination on the ground, or hot spots. These features will need to be recognized in the establishment of a survey strategy.

Should the wind blow towards the sea, there could be deposition and contamination of the seawater. Most of the released contaminants, including plutonium dioxide, are much less soluble in water than ordinary sand [9,10]. Aerosols would slowly sink to the bottom over hours and days. The contamination would disperse through diffusion, buoyancy and marine currents, including the tide movements. This impact would be much slower than the atmospheric dispersion. It could affect the environment and humans through consumption of contaminated seafood and the potential contamination of beaches and other recreational areas.

Experience with the accidental release to sea that occurred at the Sellafield nuclear reprocessing plant in the U.K. has shown that contamination of beaches is the most immediate consequence for this type of emergency, and that food chain concerns occur much later.

Environmental impacts on land could extend to a significant distance – several tens of km.

3.4.2.3 Effects on critical infrastructure

Contamination of critical infrastructure with plutonium and americium in the downwind area is possible. This would normally lead to denial of some infrastructure in the area due to possible hot spots. Remediation of this infrastructure could be weeks to months or even years. The distance up to which this could occur would be in the same range as the environmental impacts – several tens of km.

3.4.3 Regional response requirements

Due to the rapid nature of the release, the response to this emergency is based primarily on urgent protective actions triggered by the knowledge of an out of control fire, etc.

If the postulated emergency were to take place at sea, the main impact would be the environmental contamination of the water and possible subsequent contamination of the shore. Significant environmental contamination of individual MS is not very likely unless the vessel is within an approximate 10 to 20 km of the coast.

Therefore, for this type of emergency, the regional response priorities would be:

- To be notified promptly of an emergency that may threaten the integrity and safety of nuclear weapons, if they are indeed carried onboard military vessels within the RSA;
- To promptly notify the appropriate authorities so that prompt sheltering actions can be implemented within about 10 km from the vessel; there probably would not be time to take measurements to confirm the presence of plutonium in the air or the water;
- To promptly detect and quantify the contamination of plutonium in the water and on the ground; experience has shown that field measurements using alpha detection instruments is not practical, as the instruments are fragile and break often (the Mylar window). Therefore, special low energy gamma detectors (for americium) are required; and
- To quickly survey a wide area to determine the extent of contamination. This calls for coordinated survey teams or aerial surveys with appropriate instruments.

3.5 Transportation emergency

3.5.1 Description

Radioactive material is often transported by sea and land. Along the transport route, that material may be temporarily stored in containers or other special facilities, in or near maritime ports. A fire involving a transport ship, vehicle or storage facility could result in a release of radioactive material to the environment, air contamination and sea water contamination.

Similarly, a spill involving a transport vehicle or ship could result in the contamination of the land or the sea in the immediate vicinity.

This category of emergencies specifically addresses fires and spills in vehicles or ships operating within the RSA, or in the facilities that may be used to store the radioactive material.

The likelihood of a transport emergency that would affect the RSA is ‘unlikely.’

3.5.2 Possible impacts

A fire involving radioactive material could threaten the integrity of the containers and volatilize the material, resulting it its subsequent dispersion downwind. Typically, depending on the physicochemical form of the material, only a small fraction (0.001 to 10%) would be volatilized. Therefore, for a fire emergency, very large quantities of radioactive material would be required to cause any wide-spread impacts.

In the case of a spill, the quantity that would be released and dispersed in the environment would also depend on the physicochemical nature of the material, and on the nature of the leak.

In both cases, the impacts are expected to be mainly local. IAEA guidance on safe distances for such emergencies is up to 300 m.

3.5.2.1 Health effects

Given that the anticipated safe distance in the case of a spill or fire is within 300 m, no significant health impacts on the public should be expected provided that the scene is promptly isolated and evacuated. The only potentially significant health impact would be to the on-scene responders.

3.5.2.2 Effects on the environment

Effects on the environment could extend beyond the scene of the emergency, depending on marine currents and the wind. However, the impacts outside the scene would be expected to be low, though measurable from 1 to 5 km depending on the isotope and activity. Sampling and analysis would be required over this area to confirm this assumption.

3.5.2.3 Effects on critical infrastructure

There is no significant impact on critical infrastructure expected from this type of emergency, other than the facility itself and other components within the immediate vicinity of the emergency scene. Slight contamination due to dispersal may render infrastructure closed until remediation can be performed.

3.5.3 Regional response requirements

Given that the impacts are expected to be mainly local, if the emergency takes place in a port, the relevant MS would be responsible for the response and the regional plan would only focus on its generic role of providing assistance when requested.

If the emergency occurs at sea, the regional organization would be expected to play a significant role in the coordination of the intervention.

In all cases, this type of emergency presents special challenges to first responders, which the regional plan will need to take into account:

- Such events are not, a priori, RN emergencies. They tend to be initially treated as conventional emergencies, until the presence of radioactive material is discovered. Therefore, one of the regional response priorities should be to ensure that marine and port response teams and assistance teams provided by the regional organization to support the affected MS have sufficient alarming dosimeters or equivalent devices to warn them of the presence of radiation;
- Regional response teams must include medical first responders who are trained to work in potentially contaminated radioactive environment, and to conduct the medical evacuation and field treatment, as required, of potentially contaminated victims; and
- The regional organization may have to provide advice to the affected MS on how to deal with a fire or a spill involving radioactive material.

3.6 Lost or stolen source

3.6.1 Description

The critical hazard in this scenario does not come from the source itself being lost or stolen, but rather from the possible improper or inadvertent handling of the source by people (including those with malevolent intentions) who are not aware of the risks involved. In recent years, a number of incidents illustrating these points have occurred all over the world.

In Thailand in February 2000, a Cobalt-60 source was improperly discarded in a junk yard. It was found by junk hunters, who handled it for a few minutes before throwing it back in the junk pile. Three individuals died of infectious complications within two months of exposure, despite all efforts made by hospital staff that provided many treatment modalities. Other people suffered acute effects as a result of exposure to the radioactive source, however there was no contamination of the junk yard or any other sites [11].

Another scenario involving a lost radioactive source occurred in 1987, in Goiania, Brazil. A radiotherapy unit from an abandoned clinic was removed and dismantled. The extracted radiological source (1,375 curies of Cs-137) was dismantled, then spread and handled by many people. This emergency resulted in 5 fatalities and 20 injuries due to exposure to radiation, as well as many contaminated areas that required a substantial cleanup effort. A massive medical response had to be mounted including a survey of approximately 112,000 people in a soccer arena [12].

Dealing with a lost or stolen source, or the subsequent discovery of the source, is primarily a national issue, unless it is suspected that the source may have been taken outside the country; in which case, it becomes a regional issue.

The likelihood of a lost or stolen source emergency that would affect the RSA is ‘unlikely.’

3.6.2 Possible impacts

The consequences of lost or stolen sources can range from benign to very severe, depending on the source and on the management of the events that follow. In the worst cases, there will be dozens of exposed and/or contaminated people, many above the acute threshold, as well as contamination of the environment over a wide area (possibly up to several city blocks).

3.6.2.1 Health effects

Possible health effects to workers and the public from a lost or stolen radioactive source include:

1) Acute exposure of members of the public;
2) External contamination of the public;
3) Internal contamination of the public; and/or
4) Psychosocial effects.

In most cases, individuals directly involved with the lost or stolen source are unaware of the risks involved with the handling of radioactive material. As such, these incidents usually result in severe injuries to those persons, sometimes resulting in death due to extremely high levels of exposure and/or contamination. In Goiania, the two men who worked mainly on extracting the radioactive source from its casing received an estimated 4.5Gy and 5.3Gy. Both died shortly after the emergency [12].

If it is discovered that a radioactive source has been stolen or is missing, it will be necessary to notify the public. Depending on the nature and activity of the source, it may be required to warn the public about the possible symptoms of exposure to radiation. This can generate wide-spread concern, as some symptoms of overexposure resemble those of a common flu. In the worst case, this can cause a large number of people to report to medical institutions. It may be possible that some members of the public will be exposed and/or contaminated (externally or internally). While it is unlikely that any persons exposed will suffer severe acute effects from exposure, some may need to be decontaminated or treated for mild health effects from exposure.

The medical and public health system must be ready to deal with the impact on public perception of such an emergency. The number of people that may need to be screened for exposure and contamination may be very large. Even without evidence of contamination, people living and working in the affected area, as well as other concerned members of the public may feel that their health has been affected. These psychosocial impacts may prompt a large segment of the population to seek reassurance through the medical and public health institutions.

3.6.2.2 Effects on the environment

Depending on the nature of the lost or stolen source, the effects on the environment can range from minimal to quite severe. Should the source be sealed, as in the case of the Cobalt-60 source in Thailand, no contamination of the environment will occur and clean-up efforts will be minimal. However, should the source be unsealed, or broken, as in the case of the Cs-137 source in Goiania, the contamination could be very widespread and the cleanup efforts can take weeks to months. In many areas, topsoil had to be removed and stored in large disposal drums. Several houses were demolished and all the objects from within those houses were removed and examined. Objects that were found to be free of radioactivity were wrapped in plastic bags, while those that were contaminated were either decontaminated or disposed of as waste.

3.6.2.3 Effects on critical infrastructure

In the event of a large scale incident where a radioactive source is lost or stolen and is then dispersed throughout a city or town, the effects on infrastructure could be significant. Buildings may be condemned due to radioactive contamination and may need to be demolished. Large areas of land could be cordoned off to the public due to the high levels of radiation. Further, if large groups of people reside or work in these areas, the impacts to infrastructure could be devastating.

3.6.3 Regional response requirements

Considering that the management of a lost or discovered source is primarily a national concern unless the source is taken out of the country, the regional response priorities would be prevention:

- Ensure that detection systems are in place at choke border points;
- Establish a protocol to ensure that the regional organization is promptly notified of the loss or theft of dangerous sources (IAEA provides guidance on what activity should be considered “dangerous” depending on the isotope composition of the source);
- Coordinate with MS for investigation and search of missing sources;
- Coordinate with MS for the recovery of sources when they are discovered in international waters;
- Coordinate with MS for communication with the media and the public regarding missing dangerous sources to ensure that a consistent message is transmitted on a regional level, as required; and
- Provide support as applicable.

3.7 Radiological Dispersal Device (RDD) or “dirty bomb”

3.7.1 Description

Dispersion of radioactive material can take two forms:

- The non-explosive dispersion of contamination through, for example, the spread of powder or aerosol in buildings, cities or fields (conventional RDD); and
- The explosive dispersion RDD, using an explosive device, sometimes referred to as a dirty bomb.

A conventional dispersal device will produce the same type of contamination as a dirty bomb, based on isotope and activity. In cases where the event goes unnoticed, there is the possibility of a significant spread of contamination to areas well outside the originally contaminated area, making this a regional issue. Impacts and response would be similar to the fire involving transport of radioactive material scenario and the lost source (Goiania) scenario.

A dirty bomb involves combining radioactive materials with conventional explosives to spread contamination. In this scenario terrorists combine a traditional attack with the use of radioactive material to enhance the real impact, fear and the perception that authorities are not in control. The explosion can disperse radioactive contamination over a wide area (the blast radius) and downwind (contaminated plume). The main hazard, initially, is the probable damage and injuries/fatalities from the blast. Radiological health effects would be stochastic only. Impacts and response are the same as a conventional RDD, with the inclusion of blast injuries, fatalities and infrastructure damage.

The likelihood of a RDD emergency that would affect the RSA is ‘unlikely.’

3.7.2 Regional response requirements

Unless the event is perpetrated near a national border, or in a port, the impact is within the national jurisdiction and the regional plan would be limited to coordinating assistance to assist the target country. If the event takes place in the RSA, or in international waters, the regional plan would need to be invoked. In this case, the regional response needs would be similar to those described for fires involving transport of radioactive material, with the additional consideration of the need to coordinate intelligence and police efforts to investigate, perform forensics, and prepare for the possibility of a secondary attack.

3.8 Attack on an NPP

3.8.1 Description

This scenario could also be carried out by employees of an NPP with the knowledge and access to cause damage to primary transport and safety and control systems that could possibly lead to fuel failure and a release of radioactive material to the environment.

This scenario could also be carried out by employees of an NPP with the knowledge and access to cause damage to primary transport and safety and control systems; this could possibly lead to fuel failure and a release of radioactive material to the environment.

The likelihood of an attack on a NPP emergency that would affect the RSA is ‘unlikely.’

3.8.2 Possible impacts

The possible impacts are similar to those described above in the case of an NPP emergency.

3.8.3 Regional response requirements

The regional response priorities for consequence management would be the same as those associated with an NPP emergency.

3.9 Credible or confirmed terrorist threat

3.9.1 Description

This scenario is based on credible or confirmed intelligence or threat that a terrorist act is about to be carried out. This information could come from various sources, including intelligence agencies, from MS, from other countries, from IAEA, from INTERPOL, etc. This could also be detected by surveillance and detection networks. Normally, the threat will be managed by the targeted MS. However, the situation may be such that the specific target is unknown other than the fact that the region as a whole is a target. In either case, the regional response would need to focus on interdiction.

The likelihood of a credible or confirmed terrorist threat emergency that would affect the RSA is 'unlikely.'

3.9.2 Possible impacts

A threat in itself does not have any health or environmental impacts, unless the threat is realized. Therefore, as discussed below, the main regional response priorities will focus on interdiction rather than consequence management.

3.9.3 Regional response requirements

The response priorities would be to heighten detection and surveillance capabilities. Coordination of all MS capabilities should be implemented. Along with increased security presence at all potential targets, all detection systems should be monitored and mobile systems put into full operation. All hand held and personal alarming dosimeters (if applicable) worn and monitored. The use of random (mobile and patrol based) detectors and detection systems in this scenario are most effective. Coordinated communication of intelligence and data is also an important consideration.

4. WEATHER

The weather patterns within the RSA have been studied in detail due to the requirements for shipping within the Gulf area. Figures 5 to 8 show the multiple year average predominant weather in the Gulf for the four seasons [13]. This weather is a planning basis guide for operational planning.

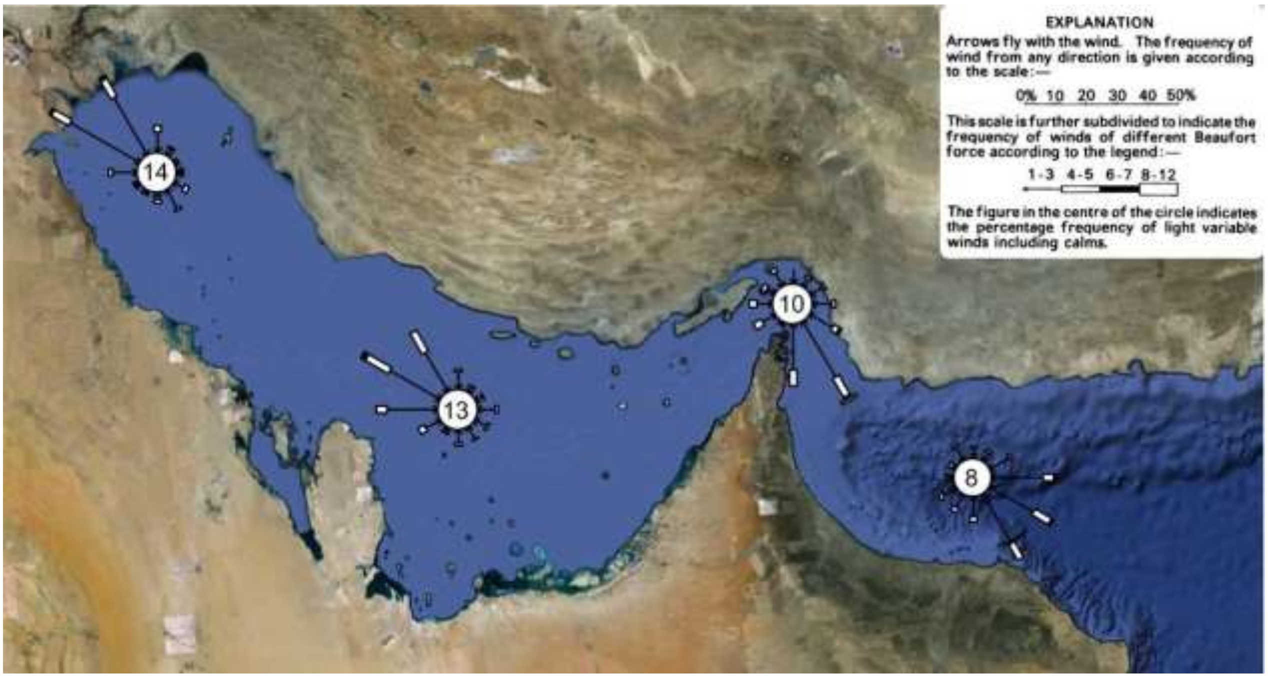

Figure 5: July RSA weather patterns

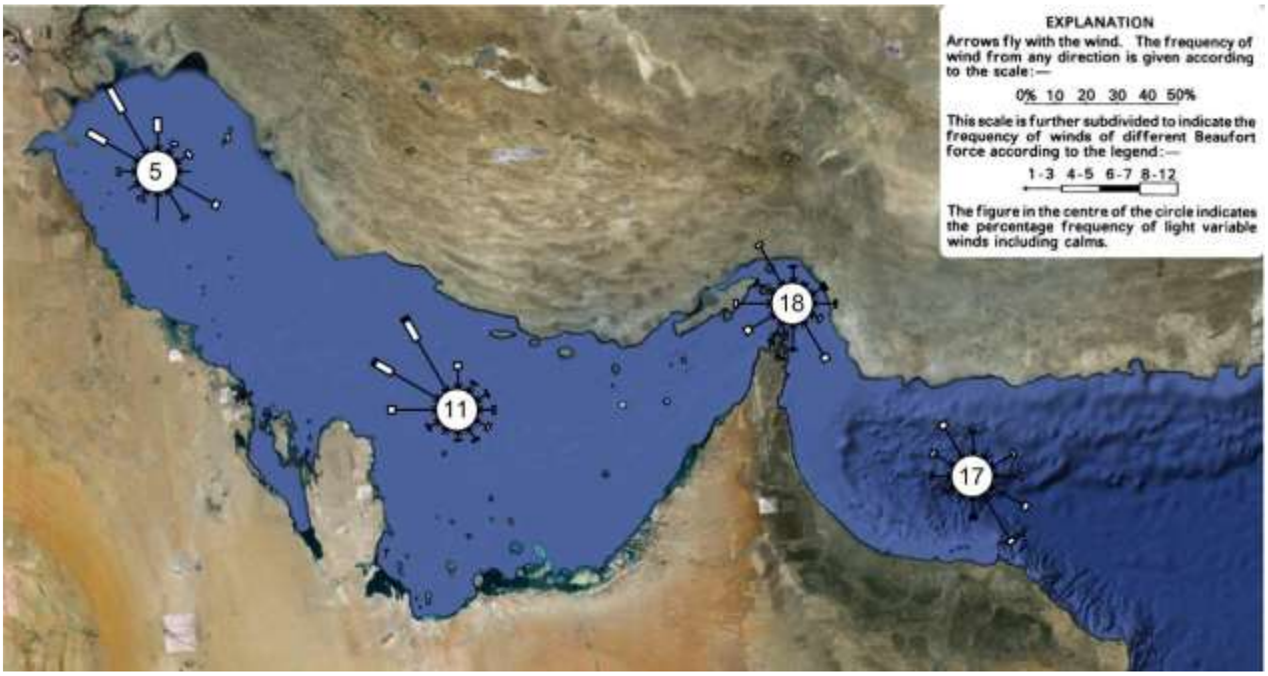

Figure 6: October RSA weather patterns

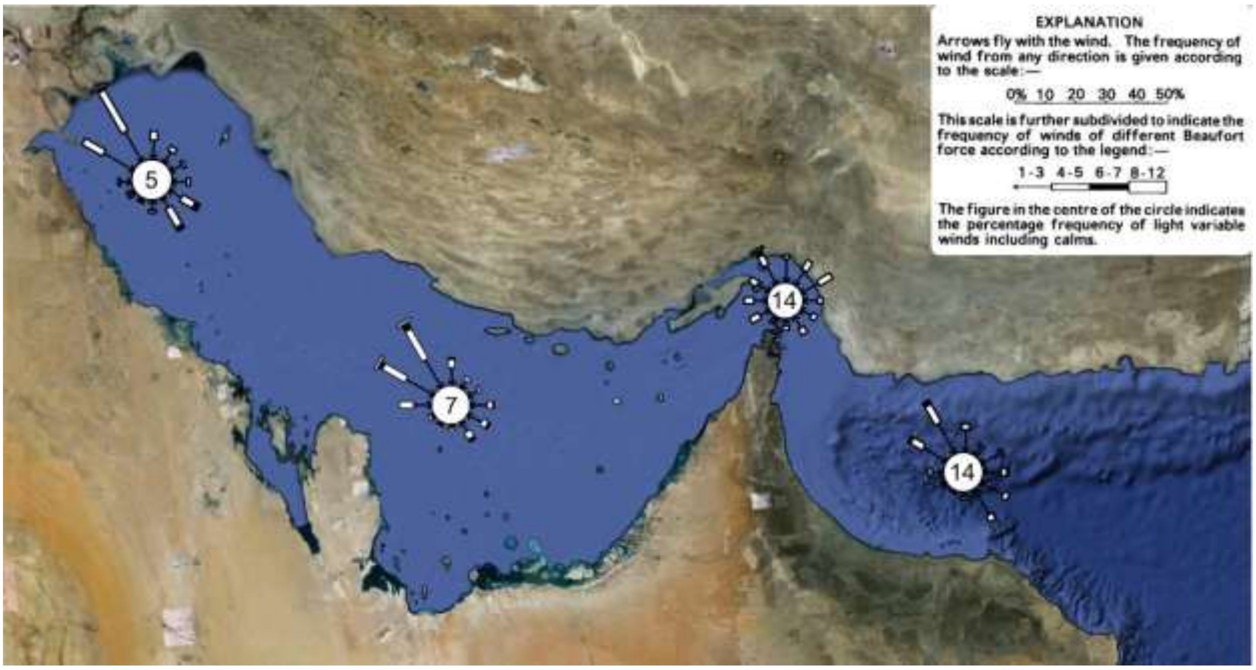

Figure 7: January RSA weather patterns

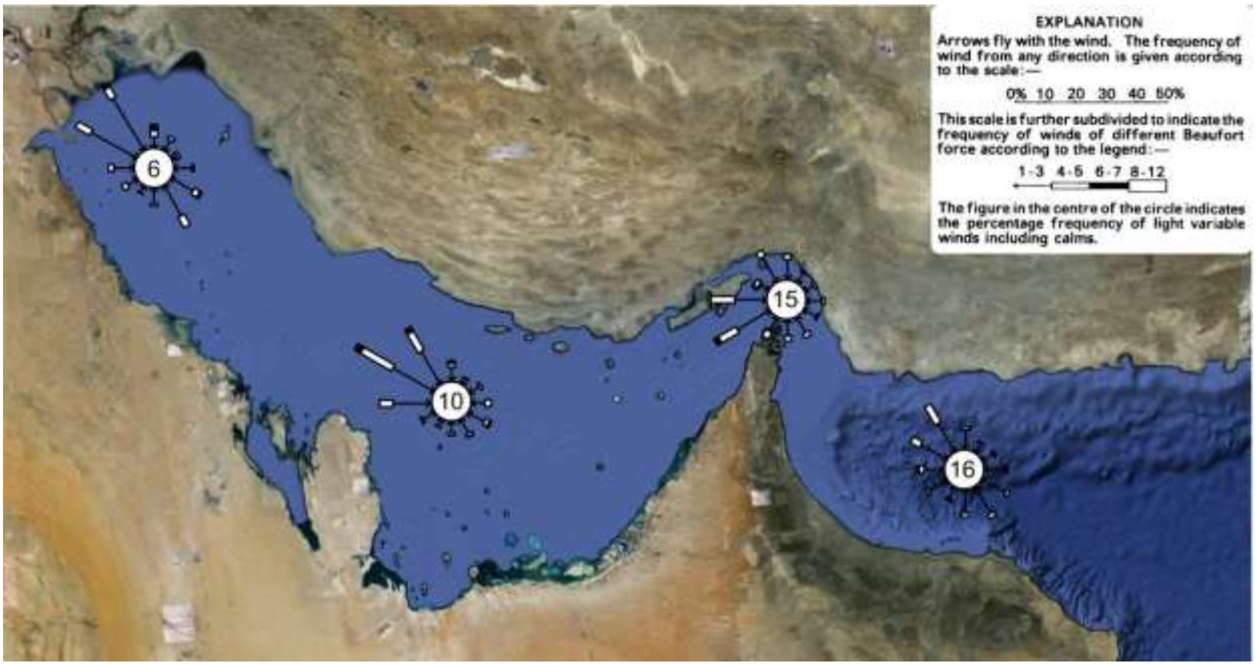

Figure 8: April RSA weather patterns

ANNEX A – RN EMERGENCY RESPONSE CAPABILITIES REQUIREMENTS

The capability requirements included in this Annex are based on IAEA GS-R-2, taking into consideration the types of emergencies and the scope for which the regional plan needs to be developed.

Table A-8 shows the capabilities required based on the functional requirements of GS-R-2 adapted for the needs of the regional plan.

Table A-8: Capabilities requirements

GS-R-2 functional area	Requirements for the regional plan
Manage and coordinate emergency operations	In general, MS are responsible for actions within their territory. The region must be able to coordinate assistance. In international waters, the region must be able to coordinate response at the scene through a designated on-scene controller (OSC).
Identify, notify and activate	The region must be able to detect events that take place in the RSA. The region must be able to classify these emergencies. Regional mechanisms must be in place to ensure notification of all affected MS and of the IAEA. This includes releases and the unauthorized presence of RN material. This also includes an effective regional RN early warning and detection system. See Appendix 1 to this Annex for more information on system requirements.
Mitigation	The region must be able to mobilize resources to render assistance in international waters. Individual MS are responsible for providing mitigation for emergencies within their own territory. The region must be able to coordinate assistance to those MS.
Urgent protective actions	Since MS are solely responsible for protective actions within their territory, the regional capability required is the coordination of protective actions on a regional scale to ensure consistency. For emergencies in international waters, the region must be able to evacuate affected areas, establish exclusion zones and conduct traffic control in the affected area.
Instructions to the public	Instructions to the public are the responsibility of the MS, except for international waters, where the region must be able to warn marine vessels and facilities in the affected area and provide basic instructions.
Protect emergency workers	Protecting emergency workers is the responsibility of the MS providing resources within the context of the regional plan. The region must be able to coordinate the level of protection required in cases involving more than one MS responding in a radiation area, and to provide advice in cases where a single MS is responding.
Assess and evaluate	The region must be able to coordinate the assessment of the real and potential impacts of an emergency and to provide a consolidated assessment and recommendations to all MS. This includes: ▪ The receipt and assessment of technical information from the affected facility; ▪ The coordination of survey teams and survey strategies; ▪ The consolidation of survey data from various monitoring networks, including the possible use of a regional network; ▪ The assessment of real-time survey data; ▪ Harmonized intervention levels and operational intervention levels; ▪ Plume tracking and projections; and ▪ Dose projections.

GS-R-2 functional area	Requirements for the regional plan
Manage the medical response	Dealing with medical casualties is primarily the responsibility of the MS or the facility. The region must be able to coordinate assistance to affected MS or facilities. In cases involving mass casualties with potential contamination, the region must be able to coordinate the dispatch of those casualties to appropriate medical facilities. In cases involving complications arising from radiation overexposure, requiring specialized assistance, the region must be able to coordinate the provision of such assistance from regional resources, out-of-region resources, or through the IAEA.
Keep the public informed	Keeping the public informed is the responsibility of the MS. The region must be able to provide information to people in international waters within the RSA (or those who are entering RSA), and to coordinate the provision of public information on a regional level to ensure consistency of messaging.
Longer-term protective actions and other measures	As for urgent protective actions.
Mitigate the non-radiological impacts	Dealing with the non-radiological impacts is a responsibility of the MS. The region must be able to coordinate such efforts to ensure consistency on a regional level.
Recovery	The region must be able to establish coordination mechanisms to ensure that recovery actions in the MS are consistent on a regional level and to carry out joint operations in the RSA aimed at determining the longer term impacts and remediating them.

Appendix 1 to Annex A – RSA Fixed Detection Network

The placement of fixed detection equipment should be determined in close consultation with the MS, MEMAC and Regional RN committee on emergency response. In combination with other MS detection networks in the region, the number of detectors comprising the RSA network should be determined to provide sufficient coverage to detect, as a minimum, the following types of emergencies:

- Severe nuclear power plant emergency far outside of the member states;
- Nuclear power plant emergency inside one of the member states; and
- Nuclear power plant emergency near a member state border.

Table A-9 shows the density of detector networks internationally.

Table A-9: National detector network densities

Country	Metric					
	Ambient Gamma Detectors	Population (millions)	Land Area (km^2)	Stations per 1000 km^2	Stations per million inhabitants	Theoretical Nearest Neighbour Distance (NND)
Netherlands	153	16.7	33,873	4.52	9.15	14.88
Germany	2,150	82.3	357,020	6.02	26.10	12.89
Belgium	212	10.4	30,510	6.95	20.40	12.00
France	156	64.1	543,964	0.29	2.44	59.05
Canada	70	33.5	9,093,507	0.01	2.09	360.43
USA	124	307	9,161,966	0.01	0.40	271.82

Notes: The "stations per million inhabitants" metric is shown for comparison purposes only. It is not an indication of the effectiveness of the network to perform its function.

The RSA shoreline is over 4,500 km in length (shoreline coverage from Ras Dharbat, Oman to Konarak, Iran). Nominal detector spacing on the shoreline should be approximately an average of 30 km or less, based on the estimated plume spread over the width of the Gulf. This would require approximately 130 fixed detectors along the coastline. These detectors for this Early Warning and Assessment Network (EWAN) should be positioned at:

- Points closest to hazard and furthest from populated areas to provide maximum warning;
- At a spacing no greater than 50 km apart on the shoreline;
- At the extremity of territorial waters (buoys);
- At closer spacing near high hazard areas (if present); and
- Marine choke points (e.g., Strait of Hormuz).

The system should have a common data transfer capability and a protocol for data sharing between MS during an emergency. The system should allow for both detection and identification.

ANNEX B – GLOSSARY

Action Level	The level of dose rate or activity concentration above which remedial actions or protective actions should be carried out in chronic exposure or emergency exposure situations. An action level can also be expressed in terms of any other measurable quantity as a level above which intervention should be undertaken.
Acute Exposure	An exposure to radiation received in a short period of time, i.e., seconds, minutes, or hours.
Acute Radiation Syndrome	A collection of symptoms caused by receiving a relatively high dose of radiation to the body in a short time (usually minutes). The earliest symptoms are blood cell changes, nausea, fatigue, vomiting and diarrhea. Hair loss, bleeding, swelling of the mouth and throat and general loss of energy may follow. Deterministic effects may be detectable above 0.5 Sv and severe deterministic health effects are possible above 1 to 5 Sv.
ALARA	All reasonable measures are taken to minimize radiation exposure to levels As Low As Reasonably Achievable (ALARA), social and economic factors taken into consideration. For military operations, operational considerations are also taken into consideration.
Background Radiation	Radiation associated with natural sources or any other sources in the environment that are not amenable to control.
Bioassay	Any procedure used to determine the nature, activity, location or retention of radionuclides in the body by direct (in vivo) measurement or by in vitro analysis of material excreted or otherwise removed from the body.
Chronic Exposure	Exposure persisting in time. Normally refers to exposures persisting for many years as a result of long-loved radionuclides in the environment.
Cloud Shine	External exposure from airborne radionuclides.
Controlled Access Area	An area where the dose rate may exceed the level permitted in public access areas and to which access by any person other than a worker is controlled.
Decontamination	The complete or partial removal of contamination by a deliberate physical, chemical or biological process.
Deterministic Effects	A radiation effect for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. Such an effect is described as a 'severe deterministic effect' if it is fatal or life-threatening or results in a permanent injury that decreases the quality of life.

Dirty Bomb A device designed to spread radioactive material by conventional explosives when the bomb explodes. A dirty bomb kills or injures people through the initial blast of the conventional explosive and spreads radioactive contamination over possibly a large area—hence the term “dirty.” Such bombs could be miniature devices or large truck bombs. See also Radiological Dispersal Device (RDD).

Dose Averted The dose prevented by the application of a countermeasure or set of countermeasures, i.e. the difference between the projected dose if the countermeasure(s) had not been applied and the actual projected dose.

Dosimetry Assessment (by measurement or calculation) of radiation dose.

Downwind Sector The sector 30° on either side of the prevailing wind direction, downwind of the emergency site.

Emergency Classification Level A simple system that describes the severity scale of an emergency. The emergency class is directly related to risk for the workers and the public. It is used for communicating to the response organizations and the public the level of response needed.

Emergency Worker A worker who may be exposed in excess of occupational dose limits while performing actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

Fission Products The radioactive elements created by the fission process.

Hull Shine The external gamma radiation hazard on the exterior of a nuclear powered vessel due to fission products released to and dispersed within the reactor compartment of the vessel.

Noble Gases A group of gaseous elements (e.g., xenon, krypton, etc.) that do not interact with other elements (i.e., NER team). Radioactive noble gases dissipate quickly and are not retained inside the body even when inhaled, thus pose little threat to an individual (except in a closed-in area).

Nuclear Capable Vessel (NCV) A ship or submarine that is designed for the transport, storage or deployment of nuclear weapons.

Nuclear Powered Vessel (NPV) A ship or submarine that is powered wholly or partly by nuclear energy.

Nuclear Weapon Emergency An unexpected event involving a fire or explosion involving a nuclear weapon.

Off-Site Emergency A nuclear emergency involving a reactor or nuclear weapon, which has led, or may lead, to a significant release of radioactive material from the facility.

On-Scene Response	This is the portion of the response that takes place within the immediate area of the emergency. There is no fixed or firm definition of what is meant by "immediate". In general, this includes the area that is controlled by the emergency first responders and from which non-essential personnel and persons are evacuated.
On-Scene Controller (OSC)	An Officer who, through their training and experience, is capable of overseeing the on-scene non-radiological response to a nuclear emergency.
On-Scene Authority	In general, this is the Lead MS. The direct on-scene authority is the senior designated officer at or near the emergency site. A designated component of the on-scene authority is responsible for liaison with the off-site authority.
Operational Intervention Levels (OIL)	A calculated level measured by instruments or determined by laboratory analysis that corresponds to an intervention level or action level.
Recovery	This involves two concepts. The first one is "back to business", and the second is return to normal. In the first case, measures are taken to render the affected areas safe enough for business activities to resume, though special precautions may need to be taken to reduce the potential exposure of the public or workers. In the second case, longer term measures are taken to return the affected area to its pre-emergency state.
Regional Nuclear/Radiological Coordination Center (RNCC)	This is the centre from which the regional response is coordinated. Normally, this is the CRISIS CENTER operations centre, unless otherwise agreed to by the lead MS and CRISIS CENTER. In this concept of operations, within the context of an RN event, the CRISIS CENTER operations centre is referred to as the RNCC.
Senior Technical Advisor	A person who, through their training and experience, is qualified to advise on all radiological and technical aspects of a RN emergency. This person is normally a post-graduate qualified nuclear engineer or physicist.
Site	Area immediately surrounding the location where an emergency has taken place or can take place. For a fixed facility, this is a geographical area that contains the authorized facility, activity or source, and within which the management of the authorized facility or activity may directly initiate emergency actions. For an event that takes place in the RSA, the site refers to the area controlled by the on-scene emergency response services.
Site Emergency	Events resulting in a major decrease in the level of protection for those on or near the site. Emergency response level adopted when there is a confined nuclear emergency with no radiological threat to the public.
Surveillance	This is part of the prevention phase preceding the discovery of a RN emergency. It involves active and passive measures to detect the present of illicit RN material, or the unexpected presence of radiation in the environment.

Survey Specialist	A person who through their training and practical experience is qualified to conduct surveys of radioactive contamination.
Threat	An act of coercion wherein a negative consequence is proposed to elicit response.

ANNEX C – LIST OF ABBREVIATIONS

ACMZ .... Automatic Countermeasure Zone

ACP .... Access Control Point

AEZ .... Automatic Evacuation Zone

ALARA .... As Low As Reasonably Achievable

Bq .... Becquerel

CAZ .... Controlled Access Zone

CC .... Crisis Center

CCP .... Contamination Control Point

Ci .... Curie

cpm .... Counts Per Minute

cps .... Counts Per Second

CPZ .... Contingency Planning Zone

CVN .... Nuclear Powered Aircraft Carrier

DCP .... Decontamination Control Point

DM .... Deputy Minister

dps .... Disintegrations per Second

DPZ .... Detailed Planning Zone

DRD .... Direct Reading Dosimeter

ED .... Electronic Dosimeter (see DRD)

EOC .... Emergency Operations Center

EPZ .... Emergency Planning Zone

ERBS .... Environmental Radionuclide Baseline Study

ERL .... Emergency Response Level

ERMP .... Environmental Radiological Monitoring Program

Gy .... Gray

HE .... High Explosives

HF .... High Frequency

IAEA .... International Atomic Energy Agency

ICRP .... International Commission on Radiation Protection

IEC .... Incident and Emergency Center of the IAEA

IHE .... Insensitive High Explosive

KI .... Potassium Iodide

LPZ....................Longer Term Protective Action Zone

MARPOL....................International Convention for the Prevention of Pollution from Ships

MEMAC....................Marine Emergency Mutual Aid Center

MS....................Member State

mSv....................milliSievert

MS EOC....................Member State Emergency Operations Center

NCV....................Nuclear Capable Vessel

NER....................Nuclear Emergency Response

NPP....................Nuclear Power Plant

NPV....................Nuclear Powered Vessel

OIL....................Operational Intervention Level

OSC....................On-Scene Controller

PA....................Public Affairs

PAZ....................Precautionary Action Zone

PB....................Planning Basis

PIT....................Potassium Iodide Tablet

PPE....................Personal Protective Equipment

PWR....................Pressurized Water Reactor

RAM....................Radioactive Material

RCC....................Regional Coordination Center

RN....................Radiological/Nuclear

RNCC....................Regional RN Coordination Center

RNEPC....................Regional RN Emergency Preparedness Committee

RNCT....................Regional RN Coordination Team

RNERP....................RN Emergency Response Plan

RO....................Regional Organization

ROPME....................Regional Organization for the Protection of the Marine Environment

RSA....................ROPME Sea Area

SCBA....................Self Contained Breathing Apparatus

SOP....................Standard Operating Procedure

SSBN....................Nuclear Powered Ballistic Missile Submarine

SSGN....................Nuclear Powered Guided Missile Submarine

SSN....................Nuclear Powered Attack Submarine

STA....................Senior Technical Advisor

Sv..Sievert

TBD...To Be Developed

TBP .... To Be Promulgated

TLD ....Thermoluminescent Dosimeter

TTX ....Table Top Exercise

UNCLOS...United Nations Convention of the Law of the Sea

UPZ...Urgent Protective Action Zone

WMO ....World Meteorological Organization

WSC ....Working Sub Committee

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