International Peer Review of the Environmental Impact Assessment Performed for the Licence Application of the Baltic-1 Nuclear Power Plant, Kaliningrad, Russian Federation

Final Report of the IAEA International Review Team January 2015

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INTERNATIONAL PEER REVIEW OF THE ENVIRONMENTAL IMPACT ASSESSMENT PERFORMED FOR THE LICENCE APPLICATION OF THE BALTIC-1 NUCLEAR POWER PLANT, KALININGRAD, RUSSIAN FEDERATION

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FINAL REPORT OF THE
IAEA INTERNATIONAL REVIEW TEAM
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FOREWORD

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. The process of developing, reviewing and establishing the IAEA standards involves the IAEA, all Member States and also some international organizations. The IAEA standards are a key element of the global safety regime.

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

The Baltic-1 Nuclear Power Plant (NPP) is a two unit power plant that is under construction in the Neman District of Kaliningrad, Russian Federation. As part of the documentation that needs to be prepared by the operator of the Baltic-1 NPP for a licence application, an environmental impact assessment was prepared. Rosenergoatom Concern was assigned the responsibility for providing the materials for the Environmental Impact Assessment of the Baltic-1 NPP.

The State Atomic Energy Corporation "Rosatom" requested the services of the IAEA to conduct an international peer review of the Environmental Impact Assessment of the Baltic-1 NPP against IAEA safety standards. Noting that Kaliningrad borders Lithuania and Poland, Rosatom also requested that the environmental impact assessment materials be reviewed against the requirements of the Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context).

Peer reviews are increasingly being acknowledged as an important element in building broader stakeholder confidence in the safety and viability of related facilities. This publication presents the consensus view of the international group of experts convened by the IAEA to perform the review.

The IAEA responsible officer for this peer review was G. Proehl of the Division of Radiation, Transport and Waste Safety.

EDITORIAL NOTE

CONTENTS

This report includes four Annexes which are presented on an accompanying CD-ROM.

1. INTRODUCTION

1.1. BACKGROUND

The Baltic-1 Nuclear Power Plant (NPP) is a 2 unit power plant that is under construction in the Neman District of the Kaliningrad Oblast of the Russian Federation.

The Kaliningrad Oblast is a western exclave of the Russian Federation on the Baltic Sea, with an area of approximately 15 000 square kilometres. It borders Poland to the south and Lithuania to the east and north. According to estimates of future population growth, by 2020 the population of the Kaliningrad region will increase from 940 000 in 2006 to 1.6–2 million people. Economic development forecasts project that the demand for electrical power will have grown almost 1.9 times by 2020 and 2.6 times by 2030, as compared to the 2006 electrical demand.

The role of the Baltic-1 NPP is to provide for the increasing electricity demand in the Kaliningrad region, and to allow for the possibility of exports of electricity to neighbouring states.

As part of the documentation to be prepared by the operator of the Baltic-1 NPP for a licence application, an Environmental Impact Assessment (EIA) must be performed. Rosenergoatom Concern OJSC was assigned the responsibility for providing the materials for the Environmental Impact Assessment of the Baltic-1 NPP.

The State Atomic Energy Corporation of the Russian Federation (ROSATOM) requested the services of the International Atomic Energy Agency (IAEA) to conduct an international peer review of the Environmental Impact Assessment for the Baltic-1 NPP against the IAEA safety standards. The Terms of Reference for this peer review are provided in Annex I[1].

1.2. OBJECTIVE

To fulfil the request of the Russian Federation for a peer review of the Environmental Impact Assessment (EIA) of the Baltic-1 NPP, the IAEA established a team of international experts to conduct the peer review. Specifically, the International Peer Review Team reviewed the Materials of Environmental Impact Assessment for Baltic-1 NPP, dated 30 November 2012 [1–3], hereinafter referred to as the EIA Materials.

The objective of the international peer review was to provide Rosenergoatom with a report on the consistency of the EIA Materials with the IAEA safety standards in the field of radiation protection of the public and the environment. Noting that the Kaliningrad exclave borders Poland and Lithuania, ROSATOM also requested that the EIA Materials be reviewed against the requirements of the Espoo Convention, Environmental Impact Assessment in a Transboundary Context [4].

Further objectives of the review were to facilitate the sharing of good practices identified during the review, to provide feedback on the development of international standards, and to provide recommendations on the further development of the radiological parts of the environmental impact assessment.

[1] The report includes four Annexes which are presented on an accompanying CD-ROM.

1.3. SCOPE

The international peer review was conducted within the authority granted through the IAEA Statute. The review evaluated the scope and content of the EIA Materials for consistency with the requirements and guidance of the IAEA safety standards related to the radiation protection of the public and the environment. Additionally, as requested, the EIA Materials were reviewed against the requirements of the Espoo Convention.

The review deals only with aspects regarding radiological impacts to the public and the environment arising from discharges of radionuclides from the Baltic-1 NPP to the atmosphere and to the Neman River. This includes the assessment of exposures to the public during both normal operation and following accidental releases. Other topics were not included in the review. Specifically, the following topics are not part of this review:

- Nuclear safety and security of the installation;
- Justification of the practice;
- The derivation and evaluation of source term parameters for both releases during normal operation as well as during accidents;
- Occupational exposure of staff, when the Baltic-1 NPP is in operation.

1.4. STRUCTURE

This report has six main sections. Following the Introduction (Section 1), Section 2 describes the organization of the international peer review and the reference publications used in the review are described in Section 3. Section 4 provides details of the regulations and requirements of the Russian Federation, and provides an assessment of the consistency of the EIA Materials [1–3] with respect to the reference publications. Section 5 then presents a discussion of the radiological aspects of the EIA Materials, followed by Section 6 which provides a summary and the conclusions of the International Peer Review Team.

The report contains six Appendices. Firstly, Appendix I summarizes the content of the report for the Environmental Impact Assessment of the Baltic-1 NPP; Appendix II provides an overview on the reference publications that were used for the International Peer Review, Appendices III, IV, V and VI describe the radiological assessment models CONDOR, AIDA, PC CREAM 08, PC COSYMA and PACE (Probabilistic Accident Consequence Evaluation Software), respectively, which were used by the Review Team to assess radiological impacts to the public during normal operation and following accidental releases.

In addition, the report includes four Annexes which are presented on an accompanying CD-ROM. Annex I provides a copy of the Terms of Reference for the International Peer Review of EIA Materials for the Baltic-1 NPP, and Annexes II, III and IV provide compilations of questions to Rosenergoatom and the related responses in its original form as identified during the review meetings held in Kaliningrad (Russian Federation), Vienna (Austria) and in St. Petersburg (Russian Federation), respectively.

2. ORGANIZATION OF THE REVIEW

In February 2014, the Review Team met in Kaliningrad (Russian Federation). The visit included presentations by, and discussions with, Russian Federation experts and a visit to the site of the Baltic-1 NPP. In July 2014, the Review Team met at IAEA Headquarters in Vienna (Austria) to consider the outcomes from the review and to start the preparation of the interim report. The draft interim report was sent to Rosenergoatom in October 2014, as per the Terms of Reference (Annex I). In November 2014, a meeting was held in St. Petersburg (Russian Federation) to discuss the contents of the interim report.

A copy of the draft final report was provided to Rosenergoatom in December 2014 to enable the report to be checked for factual correctness. The final report was submitted to Rosenergoatom in January 2015.

The original of the EIA Materials were prepared in the Russian language. For the purposes of this international peer review, an unofficial English translation of the EIA Materials was supplied by Rosenergoatom Concern OJSC (Rosenergoatom) [1–3]. Instances of translation ambiguity were clarified through meetings with the counterparts, e.g. Refs. [5, 6], and through written responses to questions from the International Peer Review Team (see Annexes II–IV).

3. PUBLICATIONS USED IN THE INTERNATIONAL PEER REVIEW

3.1. PUBLICATIONS FROM THE COUNTERPARTS

The work of the International Peer Review Team is based upon a review of the EIA Materials [1–3]. The EIA Material is provided in 3 Books [1–3]; the aspects of the Environmental Impact are addressed in 16 sections and four appendices, the main topics are:

- Description of the site;
- Overview on the technical characteristics of the Baltic-1 NPP;
- Technical measure to reduce releases of radionuclides to the environment during normal operation and under accidental conditions;
- Discharges of radionuclides to the environment under normal operation and resulting radiation doses to people and to flora and fauna;
- Dispersion of radionuclides in the atmosphere and in freshwater bodies;
- Releases of radionuclides to the environment in during accidental conditions and resulting radiation doses to people;
- Impact of the Baltic-1 NPP on neighbouring states;
- Management of radioactive waste;
- Decommissioning of the Baltic-1 NPP;
- Involvement of the public.

A short description of each section of the EIA Materials is given in Appendix I. In addition to the EIA Materials [1–3], information was provided during a site visit in February 2014 [5], at a review meeting in St. Petersburg in November 2014 [6], and in response to questions from the International Peer Review Team (Annexes II–IV).

3.2. REFERENCE PUBLICATIONS

In accordance with the Terms of Reference for the review, the following IAEA publications were used as reference publications for the international peer review:

- IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [7];
- IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements [8];
- Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, GS-R-1[2];
- Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, Safety Reports Series No. 19 [10];
- Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3 [11];
- Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8 [12];
- Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2 [13]; and
- Site Evaluation for Nuclear Installations, NS-R-3[3].

In addition to the IAEA publications, the Espoo Convention [4] was included in the list of reference publications for the international peer review.

The objectives and the scope of each of these publications are summarized in Appendix II of this report.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, IAEA Safety Standards Series No. GS-R-1, IAEA, Vienna (2000). This has been superseded by IAEA Safety Standards Series No. GSR Part 1 (Rev. 1) [9].

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA Vienna (2003). This has been superseded by IAEA Safety Standards Series No. NS-R-3 (Rev. 1) [14].

4. REGULATIONS AND REQUIREMENTS

4.1. REGULATIONS OF THE RUSSIAN FEDERATION

The EIA Materials refer to Russian Federation Laws and other requirements, and in general terms about the NPP administration, and Rosenergoatom's Quality Assurance Programme. Information was also obtained from the 2009 IRRS Mission [15] and the 2013 Follow-up Mission [16], which found that the Federal Norms and Rules complied with the requirements of the IAEA safety standards. Additional information concerning the structure of the Regulation of Nuclear and Radiation Safety in the Russian Federation is provided in Ref. [17].

The following laws and regulatory documents regulate the radiological protection of NPP personnel, the public, and the environment in the Russian Federation:

- Federal Law No. 170-FZ of 21 November 1995 "On the Use of Atomic Energy" [18];
- Federal Law No. 3-FZ of 9 January 1996 "On the Radiological Safety of the Public" [19];
- Federal Law No. 7-FZ of 10 January 2002 "On the Environmental Protection" [20];
- "Radiation Safety Standards " (NRB-99/2009) No. 47 of 7 July 2009 [21];
- "Basic Health Rules for Radiological Safety Assurance" (OSPORB-99) No. 57 of 25 September 2000 [22];
- "Basic Safety Rules for Nuclear Power Plants" (OPB-88/97) No. 9 of 14 November 1997 [23];
- "Sanitary Rules for Design and Operation of Nuclear Plants" (SP AS-03) No. 69 of 28 February 2003 [24]; and
- "Radiation Safety Rules for NPP Operation" (PRB AS-99) No. 210 of 18 April 2001; and other rules and regulations in the field of nuclear energy, [25] as noted below.

The Federal Law No. 170-FZ [18] establishes a legal framework and regulation principles for the use of nuclear energy and is aimed at safeguarding the life and health of humans and protecting the environment. Federal Law No. 3-FZ, On the Radiological Safety of the Public, establishes a legal framework for the radiological protection of the public and personnel with the purpose of health protection. The law sets out the main concepts, standards, and regulatory principles in the area of radiological protection, identifies measures essential for the provision of radiological safety, and describes the responsibilities of the Russian Federation's authorities in the radiological protection area. This law, and NRB-99/2009, were developed taking into account the recommendations of the International Commission on Radiological Protection (ICRP) [26].

The main Russian regulatory documents that set the criteria for the radiological impact from nuclear installations are as follows:

- "Radiation Safety Standards" (NRB-99/2009) No. 47 of 7 July 2009 [21];
- "Sanitary Rules for Design and Operation of Nuclear Plants" (SP AS-03) No. 69 of 28 February 2003 [24];
- "Basic Safety Rules for Nuclear Power Plants" (OPB-88/97) No. 9 of 14 November 1997 [23];
- Siting of Nuclear Power Plants. Basic Criteria and Requirements for Safety Assurance. NP--032-01 [27].

4.1.1. Radiological criteria in the regulations of the Russian Federation for planned exposure situations and emergencies

4.1.1.1. Radiological criteria for normal operation

For the normal operation of Nuclear Power Plants, permissible releases of radioactive substances to the atmosphere (PR) and permissible discharges to the aquatic environment (PD) are set in accordance with Russian regulations (paras 5.11–5.19 of the SP AS-03) for a site as a whole (irrespective of the number of units at the site), based on a 10 µSv/a criterion for exposures to members of the public. This criterion is applied to gaseous and liquid effluents separately.

For radiologically significant nuclides or nuclide groups, the PR values are established by Russian regulations (SP AS-03), and these values are given in the Table 6.4.1.2.2 of the EIA Materials [2]. As per Russian regulations, final PR and PD values for a specific facility are derived taking into account the installed capacity, the reactor type, and the site characteristics (e.g. regional demography, living habits of the population).

These values for the permissible releases (PR) and the permissible discharges (PD) are subject to approval by the regulatory body before the operation of a facility.

As noted in the EIA Materials, and as confirmed during discussions at the review meeting in St. Petersburg, the final PR and PD values for the Baltic-1 NPP will be set immediately before the start of the commissioning phase.

For abnormal operation conditions (anticipated operational occurrences) there is a target dose limit established in the AES-2006 design. This defines that the dose for members of the public following abnormal operation conditions should not exceed 100 µSv/a per event.

4.1.1.2. Radiological criteria to be applied following accidental releases

Beyond the information given in the EIA Materials, at the review meeting in St. Petersburg (Ref. [6] and in Annex IV), Rosenergoatom provided additional information on the criteria and protective measures to be used in the early phase of a postulated accident. The EIA Materials could be further developed by the inclusion of this information.

The aim of the application of radiological criteria is to avoid deterministic effects and to minimize stochastic effects arising as a consequence of nuclear accidents. For this purpose, intervention levels are defined in NRB-99/2009 for protective actions. Following an accident, two emergency response zones will be established: the "mandatory population evacuation zone" and the "protective measure planning zone". The criteria for setting up these zones are summarized in Table 1.

According to NRB-99/2009, decisions on protective actions are based on the level of the dose that can be averted when implementing a specific protective action. For this purpose, NRB-99/2009 provides dose bands for various protective actions. The lower ends of these bands (Level A) provide values for the averted dose values, below which no actions need to be taken. The upper ends (Level B) represent levels for the averted dose that require actions in all circumstances. For dose levels within these ranges, the application of protective actions depends on the specific circumstances. The criteria applied are summarized in Tables 2–4. Decisions to be made on evacuation, sheltering, and iodine prophylaxis are made on the projected doses to be received during the first 10 days after the accident (Table 2), calculated using the exposure pathways specified in Table 5. Decisions related to food consumption and resettlement are based on dose assessments over the first year after the accident and on the doses to be received in subsequent years (Tables 3 and 4).

TABLE 1. CRITERIA FOR ESTABLISHING EMERGENCY RESPONSE ZONES (NRB-99/2009) [21]

Emergency response zones	**Target organ/ tissue**	**Absorbed dose received during a period of over 10 days after the accident (mGy)**
Mandatory population evacuation planning zone	Whole body	500
	Lung	5000
	Skin	5000
	Thyroid	5000
Protective measure planning zone	Whole body	5
	Lung	50
	Skin	50
	Thyroid	50

TABLE 2. RADIOLOGICAL CRITERIA FOR DECISIONS IN THE INITIAL PERIOD OF A RADIOLOGICAL ACCIDENT

Protective measures	**Averted dose during first 10 days (mGy)**			
	Whole body		**Thyroid, lungs, skin**	
	Level A	**Level B**	**Level A**	**Level B**
Sheltering	5	50	50	500
Iodine prophylaxis:				
Adults	–	–	250*	2500*
Infants	–	–	100*	1000*
Evacuation	50	500	500	5000

* For thyroid dose only.

TABLE 3. RADIOLOGICAL CRITERIA FOR DECISIONS ON RESETTLEMENT AND RESTRICTION OF CONSUMPTION OF CONTAMINATED FOODSTUFFS

Protective measures	**Averted effective dose**	
	Level A	**Level B**
Restriction of consumption of contaminated foodstuffs and drinking water	In the first year: 5 mSv In subsequent years: 1 mSv	In the first year: 50 mSv In subsequent years: 10 mSv
Resettlement	In the first year: 50 mSv	In the first year: 500 mSv
	During the whole resettlement period: 1000 mSv	

TABLE 4. CRITERIA FOR DECISIONS ON RESTRICTION OF CONSUMPTION OF CONTAMINATED FOODSTUFFS DURING THE FIRST YEAR AFTER AN ACCIDENT

Radionuclides	**Activity concentration in foodstuffs (Bq/kg)**	
	Level A	**Level B**
I-131, Cs-134, Cs-137	1000	10000
Sr-90	100	1000
Pu-238, Pu-239, Am-241	10	100

TABLE 5. EXPOSURE PATHWAYS TO BE CONSIDERED IN CALCULATIONS OF DOSIMETRIC VALUES (FOR THE INITIAL PERIOD OF A RADIOLOGICAL ACCIDENT AT A NUCLEAR PLANT)

Dosimetric values	Exposure pathways		
	External exposure from radionuclides in the plume	External exposure from radionuclides on the ground	Inhalation
Absorbed dose[a]	+	+	+
RBE[b] – weighted absorbed dose in red bone marrow	+	+	–
RBE – weighted absorbed dose in thyroid	–	–	+
Equivalent dose in thyroid	–	–	+
Effective dose	+	+	+

[a] Absorbed dose in whole body is calculated for plume and deposition exposure pathways.

[b] RBE: Relative biological efficiency.

The Review Team also noted that Section 6.4.4.2 of the EIA Materials [2], discusses plans for population protection in the late phase of an accident. These plans are to be based on environmental monitoring data and on an optimization process that takes into account a number of factors, e.g. social impacts arising from residual contamination after decontamination, natural decay, and weather conditions. The EIA Materials note that the late phase of recovery may last from several weeks up to several years after an accident. The EIA Materials could be further developed by providing more detail on how these plans would be developed, and the relationship of these plans to the requirements of the GSR Part 3 [8].

OBSERVATION

The EIA Materials could be further developed by including further details on: (i) the criteria and protective measures to be used in the early phase of a postulated accident; and (ii) the development of plans to address the recovery phase following an accident.

4.2. CONSISTENCY OF THE EIA MATERIALS WITH THE IAEA REFERENCE PUBLICATIONS

In this Section, the general consistency of the EIA Materials with the Reference publications used for this review is discussed.

4.2.1. IAEA Fundamental Safety Principles and IAEA Basic Safety Standards

The underlying reference publications are:

— IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [7];
— IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements [8].

The following paragraphs address aspects of the IAEA Fundamental Safety Principles and GSR Part 3, which refer to safety requirements to conduct an assessment of the protection of the public and the protection of the environment.

4.2.1.1. Limitation of doses and risk

The IAEA Fundamental Safety Principles [7] establish, among others, principles for ensuring the protection of the public and the environment, now and in the future, from harmful effects of ionizing radiation and the need for doses and radiation risks to be controlled within specified limits. These principles apply to all situations involving exposure to, or the potential for exposure to, ionizing radiation.

4.2.1.2. Assessment for protection of the public and protection of the environment

Principle 7 of the IAEA Fundamental Safety Principles [7] states that:

"People and the environment, present and future, must be protected against radiation risks".

The consideration of the protection of people and the environment is contemplated in the IAEA safety standards.
Requirement 31 of GSR Part 3 addresses radioactive waste and discharges[4].

"3.132. Registrants and licensees, in cooperation with suppliers, in applying for an authorization for discharges, as appropriate:

(a) Shall determine the characteristics and activity of the material to be discharged, and the possible points and methods of discharge;
(b) Shall determine by an appropriate pre-operational study all significant exposure pathways by which discharged radionuclides could give rise to exposure of members of the public;
(c) Shall assess the doses to the representative person due to the planned discharges;
(d) Shall consider the radiological environmental impacts in an integrated manner with features of the system of protection and safety, as required by the regulatory body".

These elements are addressed in Section 5 of the EIA Materials which deals with the methodologies for assessing doses to members of the public and to the environment.

4.2.1.3. Assessment and control of potential exposure

Paragraph 3.24 of GSR Part 3 states:

"3.24. For occupational and public exposure, registrants and licensees shall ensure that all relevant factors are taken into account in a coherent way in the optimization of protection and safety to contribute to achieving the following objectives:

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[4] Some aspects of assessment of radiological impact to public and the environment in general are included in Requirement 31 in GSR Part 3 [8]. However, the main objective of Requirement 31 is to establish authorized discharge limits. The procedure for establishing authorized discharge limits is not specifically addressed in this Safety Standard and it is discussed more fully in an IAEA Safety Guide on control of discharges [11].

(a) To determine measures for protection and safety that are optimized for the prevailing circumstances, with account taken of the available options for protection and safety as well as the nature, likelihood and magnitude of exposures;
(b) To establish criteria, on the basis of the results of the optimization, for the restriction of the likelihood and magnitudes of exposures by means of measures for preventing accidents and for mitigating the consequences of those that do occur".

Paragraph 3.15 of GSR Part 3 [8] establishes:

"3.15 Registrants and licensees:

(e) … shall assess the likelihood and magnitude of potential exposures, their likely consequences and the number of persons who may be affected by them".

It is stated in GSR Part 4[5], which is referenced through GSR Part 3 [8]:

"Requirement 6: The possible radiation risks associated with the facility or activity shall be identified and assessed.

4.19 The possible radiation risks associated with the facility or activity include the level and likelihood of radiation exposure of workers and the public, and of the possible release of radioactive material to the environment, that are associated with anticipated operational occurrences or with accidents that lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation".

Requirement 13 of GSR Part 3 states *inter alia:*

"3.31 Safety assessment shall be conducted at different stages, including the stages of siting, design, manufacture, construction, assembly, commissioning, operation, maintenance, and decommissioning (or closure) of facilities or parts of thereof, as appropriate, so as :

(a) To identify the ways in which exposures could be incurred, account being taken of effects of external events as well as of events directly involving the sources and associated equipment;
(b) To determine the expected likelihoods and magnitudes of exposures in normal operations and, to the extent reasonable and practicable, make an assessment of potential exposures".

GSR Part 3 provides the following dose limits for members of the public due to operation of facilities and activities:

— Effective dose: 1 mSv in a year;
  In special circumstances, a higher value of effective dose in a single year could apply, provided that the average effective dose over five consecutive years does not exceed 1 mSv per year;

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009). This has been superseded by IAEA Safety Standards Series No. GSR Part 4 (Rev. 1) (2016) [28].

— Equivalent dose to the lens of the eye: 15 mSv in a year;
— Equivalent dose to the skin: 50 mSv in a year.

For the management of nuclear or radiological emergencies, GSR Part 3 and IAEA Safety Guide GSG-2 [29] recommend the application of two dosimetric concepts: reference level and generic criteria. The proposed reference level for emergency exposure situation is in range of 20–100 mSv, either acute or annual, effective dose that includes dose contributions via all exposure pathways. The protection strategy should be optimized so that the residual doses[6] to be as low as reasonably achievable and below the reference level; as such the reference level is to serve as an optimization tool and for assessing the effectiveness of strategies implemented. The reference level to be applied in a specific situation has to be defined taking into account the particular circumstances. For the implementation of protective actions and other response actions, GSR Part 3 and GSG-2 provide a set of generic criteria for the projected dose or the dose that has been received at which protective actions and other response actions in an emergency need to be taken to avoid or minimize severe deterministic effects (Table 6) and to reduce the risk of stochastic effects (Table 7).

Operational criteria for implementing restrictions on food, milk and drinking water in order to reduce the risk of stochastic effects are given in table 9 and table 10 of IAEA GSG-2 [29].

4.2.1.4. Transboundary impacts

Requirement 29 of GSR Part 3 addresses the issue of exposure outside the territory under the jurisdiction or control of the State in which the source is located[7]:

"3.124. When a source within a practice could cause public exposure outside the territory or other area under the jurisdiction or control of the State in which the source is located, the government or the regulatory body:

(a) Shall ensure that the assessment of the radiological impacts includes those impacts outside the territory or other area under the jurisdiction or control of the State;
(b) Shall, to the extent possible, establish requirements for the control of discharges;
(c) Shall arrange with the affected State the means for exchange of information and consultations, as appropriate."

[6] Residual Dose: The dose expected to be incurred after protective actions have been terminated (or after a decision has been taken not to take protective actions).

[7] The consideration of the protection of the environment at the transboundary level and the obligations for assessing the impacts and sharing information between States should also be included within the broader context of relevant international agreements and conventions (e.g. Espoo 1991 [4] and Article 37 of the EURATOM Treaty [31].

TABLE 6. GENERIC CRITERIA FOR DOSES RECEIVED WITHIN A SHORT PERIOD OF TIME FOR WHICH PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS ARE EXPECTED TO BE UNDERTAKEN UNDER ANY CIRCUMSTANCES TO AVOID OR TO MINIMIZE SEVERE DETERMINISTIC EFFECTS

Generic criteria		**Examples of protective actions and other response actions**
External acute exposure (<10 hours)		If the dose is projected: — Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria — Provide public information and warnings — Carry out urgent decontamination
$AD_{\text{Red marrow}}$ [a]	1 Gy	
AD_{Fetus}	0.1 Gy	
AD_{Tissue} [b]	25 Gy at 0.5 cm	
AD_{Skin} [c]	10 Gy to 100 cm^2	
Internal exposure from acute intake (Δ = 30 days) [d]		If the dose has been received: — Perform immediate medical examination, consultation and indicated medical treatment — Carry out contamination control — Carry out immediate decorporation[f] (if applicable) — Carry out registration for long term health monitoring (medical follow-up) — Provide comprehensive psychological counselling
$AD(\Delta)_{\text{Red marrow}}$	0.2 Gy for radionuclides $Z \geq 90$[e] 2 Gy for radionuclides with $Z \leq 89$[e]	
$AD(\Delta)_{\text{Thyroid}}$	2 Gy	
$AD(\Delta)_{\text{Lung}}$ [g]	30 Gy	
$AD(\Delta)_{\text{Colon}}$	20 Gy	
$AD(\Delta')_{\text{Fetus}}$ [h]	0.1 Gy	

[a] $AD_{\text{Red marrow}}$ represents the average RBE weighted absorbed dose to internal tissues or organs (e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation.

[b] Dose delivered to 100 cm^2 at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source (e.g. source carried in the hand or pocket).

[c] The dose is to the 100 cm^2 dermis (skin structures at a depth of 40 mg/cm^2 (or 0.4 mm) below the body surface).

[d] $AD(\Delta)$ is the RBE weighted absorbed dose delivered over the period of time Δ by the intake (I_{05}) that will result in a severe deterministic effect in 5% of exposed individuals.

[e] Different criteria are used to take account of the significant difference in the radionuclide specific intake threshold values for the radionuclides in these groups [30].

f The generic criterion for decorporation is based on the projected dose without decorporation. Decorporation is the biological processes, facilitated by a chemical or biological agent, by which incorporated radionuclides are removed from the human body.

[g] For the purposes of these generic criteria, ‘lung’ means the alveolar-interstitial region of the respiratory tract.

[h] For this particular case, Δ' means the period of in utero development.

Source: Table 2 of GSG-2 [29].

TABLE 7. GENERIC CRITERIA FOR PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN EMERGENCY EXPOSURE SITUATIONS TO REDUCE THE RISK OF STOCHASTIC EFFECTS

Generic criteria		**Examples of protective actions and other response actions**
Projected dose that exceeds the following generic criteria: Take urgent protective actions and other response actions		
$H_{Thyroid}$	50 mSv in the first 7 days	Iodine thyroid blocking
E	100 mSv in the first 7 days	Sheltering; evacuation; decontamination; restriction of consumption of food, milk and water; contamination control; public reassurance
H_{Fetus}	100 mSv in the first 7 days	
Projected dose that exceeds the following generic criteria: Take protective actions and other response actions early in the response		
E	100 mSv per annum	Temporary relocation; decontamination; replacement of food, milk and water; public reassurance
H_{Fetus}	100 mSv for the full period of in utero development	
Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects		
E	100 mSv in a month	Screening based on equivalent doses to specific radiosensitive organs (as a basis for medical follow-up); counselling
H_{Fetus}	100 mSv for the full period of in utero development	Counselling to allow informed decisions to be made in individual circumstances

Note: H_T — equivalent dose in an organ or tissue T; E — effective dose.
Source: Table 3 of GSG-2 [29].

4.2.1.5. Monitoring

There is also a requirement on the regulatory body and relevant parties to ensure that programmes for source monitoring and environmental monitoring are in place (Requirement 32 of GSR Part 3 and para. 3.135). These requirements include the need to make ‘provision for maintaining records of discharges, results of monitoring programmes and results of assessments of public exposure’. Similar requirements are also placed on registrants and licensees (operators) including the need to: ’verify the adequacy of the assumptions made for the assessment of public exposure and radiological environmental impacts’.

According to the GSR Part 3 [8], registrants and licensees are required to establish and implement monitoring programmes to ensure that public exposure due to sources under their responsibility is adequately assessed and that the assessment is sufficient to verify and demonstrate compliance with the authorization.

OBSERVATION

The requirements of the IAEA Safety Fundamentals and GSR Part 3 with regard to radiation protection of the public during normal operation of nuclear facilities and in case of nuclear accidents are addressed in the EIA Materials.

The radiological criteria applied in the Russian Federation for exposures of the public during normal operation of nuclear power plants are well below the criteria in the IAEA safety standards. The radiological criteria to be applied for protection of the public after nuclear accidents are similar to those provided in the IAEA safety standards.

However, Rosenergoatom may wish to review the framework for defining potential protective actions based upon the concepts expressed in GSR Part 3 and GSG-2.

4.2.2. IAEA Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety

The underlying reference publication is:

— Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, GS-R-1[8].

This Safety Standard has been superseded by IAEA Safety Standards Series No. GSR Part 1 (Rev. 1) Governmental, Legal and Regulatory Framework for Safety [9]. The EIA Materials do not include a discussion of the legal and governmental infrastructure and responsibilities, since these topics are beyond the scope of an Environmental Impact Assessment.

4.2.3. Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment

The underlying reference publication is:

— Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, Safety Reports Series No. 19 [10].

The publications provide a set of generic models to assess annual effective dose to members of the public arising from routine discharges to the terrestrial and aquatic environment.

> OBSERVATION
>
> The models described in Safety Reports Series No. 19 have been applied by Rosenergoatom to assess radiological impacts to members of the public arising from routine discharges during normal operations.

4.2.4. Regulatory Control of Radioactive Discharges to the Environment

The underlying reference publication is:

— Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3 [11].

The publication provides guidance on the setting discharge limits in the framework of an authorization issued by the regulatory body which allows operation.

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[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, IAEA Safety Standards Series No. GS-R-1, IAEA, Vienna (2000). This has been superseded by IAEA Safety Standards Series No. GSR Part 1 (Rev. 1) [9].

4.2.4.1. Relevant content of the EIA Materials

The EIA Materials do not include permissible discharges for the Baltic-1 NPP. On request of the Review Team, Rosenergoatom provided a data set on the expected discharges during normal operation of the Baltic-1 NPP. Rosenergoatom indicates that the values of permissible discharges of the Baltic-1 NPP will be specified prior to operation and shall be approved by the Authorities (Rostechnadzor of Russian Federation).

OBSERVATION

The authorization of discharges of radionuclides to the environment is an important element of the control of anticipated impact of the NPP. Levels of authorized discharges are therefore an important component for the performance of the EIA to check compliance of resulting exposures to the public and the environment with radiological criteria.

The dose constraint for members of the public being exposed from discharges from the Baltic-1 NPP is 10 μSv/a. This dose constraint complies with the requirements of the IAEA Safety Standards GSR Part 3.

4.2.5. Environmental and Source Monitoring for Purposes of Radiation Protection

The underlying reference publication is:

— Environmental and Source Monitoring for Purposes of Radiation Protection, Safety Guide, Safety Standards Series No. RS-G-1.8, IAEA [12].

4.2.5.1. Requirements of the reference publication(s)

— One of the main goals of the monitoring programme is to check the assumptions and validate the results of the safety assessment. Thus, the monitoring programme should pay particular attention to the critical pathways and the critical radionuclides (Section 5.6).
— The design of an environmental monitoring programme should be consistent with the objectives of monitoring. The locations for measurements and sampling should be determined on a site specific basis with the aim of determining the highest radiation doses to the public and identifying the areas most contaminated with radionuclides (Section 5.25).
— The use of quality assurance is required by GSR Part 3 [8] and should be an integral part of programmes for source monitoring, environmental monitoring and individual monitoring. Quality assurance should be used to provide for a disciplined approach to all activities affecting quality, including, where appropriate, verification that each task has met its objectives and that any necessary corrective actions have been implemented (Section 9.1).

4.2.5.2. Relevant content of the EIA Materials

Section 11 describes the recommendations on the environmental monitoring programme arrangement.

OBSERVATION

The EIA Materials do not describe how the results from the monitoring programme will be used to check the assumptions and validate the results of the safety assessment.

Locations for automatic radiation system monitoring stations around the Baltic-1 NPP site cover directions towards the east and west. However, coverage towards the north (Lithuania) and south (Poland) is limited. Furthermore, selection of these locations seems not to take into account frequent wind directions towards north and north-east. The locations for measurements were not defined on a site specific basis to cover those areas with the expected highest radiation doses to the public and identifying the areas most contaminated with radionuclides. However, in this particular case, due to the low dose constraints set for the Baltic-1 NPP, this will not have a significant impact from the radiological point of view.

The EIA Materials do not provide information on quality assurance activities in the framework of the monitoring programmes.

4.2.6. Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants

The underlying reference publication is:

- Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, Safety Guide, Safety Standards Series No. NS-G-3.2 [13].

This Safety Guide provides details on the investigations on the uses of land and water that should be undertaken as part of an Environmental Impact Assessment for a site. The following land uses are listed for consideration:

- Land devoted to agricultural uses, its extent, and the main crops and their yields;
- Land devoted to dairy farming, its extent and yields;
- Land devoted to industrial, institutional and recreational purposes, its extent and the characteristics of its use;
- Bodies of water used for commercial, individual and recreational fishing, including details of the aquatic species fished, their abundance and yield;
- Bodies of water used for commercial purposes, including navigation, community water supply, irrigation, and recreational purposes such as bathing and sailing;
- Land and bodies of water supporting wildlife and livestock;
- Direct and indirect pathways for potential radioactive contamination of the food chain;
- Products imported to or exported from the region which may form part of the food chain;
- Free foods such as mushrooms, berries and seaweed.

4.2.6.1. Relevant content of the EIA Materials

The EIA Materials provide information on the general environmental conditions and socioeconomic aspects. Details of the habit data used for the radiological assessments are provided in Section 6 of the EIA Materials and in the responses to questions posed by the Review Team during this review.

The EIA Materials mention that the Neman River water can be used as drinking water and the Neman River sediment as fertilizer.

OBSERVATION

In terms of the topics related to the characterization of the land use, only some of these items are discussed in the EIA Materials provided for the Baltic-1 NPP. There is limited information provided on the land use characteristics of the surrounding area and, in particular, on the habits and behaviour of the population in the vicinity of the Baltic-1 NPP site. An example is the consumption rates of various foods that could be used to refine the definition of the critical group.

Currently, the assessment of exposures to the public from radionuclides discharged from the Baltic-1 NPP during normal operation in the EIA Materials is based on generic consumption rates from sources such as IAEA SRS 19 [10]. In this model, unusual pathways such as the consumption of wild foods (e.g. mushrooms or berries), are not considered. Local data that characterize habits in the vicinity of the Baltic-1 NPP is not included in the EIA Materials.

Other possible uses of the Neman River water such as irrigation, consumption of molluscs from the Neman River or feeding of cattle with Neman River water have not been investigated. The use of river sediments for fertilization purposes is also not included.

However, in view of the very low doses to the public predicted for normal operation of the Baltic-1 NPP, the consideration of more detailed habit data would have negligible impact on the results of the dose assessment.

4.2.7. Site Evaluation for Nuclear Installations

The underlying reference publication is:

— Site Evaluation for Nuclear Installations, NS-R-3[9].

The objective of NS-R-3 is to establish the requirements for the elements of a site evaluation for a nuclear installation so as to characterize fully the site specific conditions pertinent to the safety of a nuclear installation.

The purpose is to establish requirements for criteria, to be applied as appropriate to site and site–installation interaction in operational states and accident conditions, including those that could lead to emergency measures for:

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA Vienna (2003). This has been superseded by IAEA Safety Standards Series No. NS-R-3 (Rev. 1) [14].

(a) Defining the extent of information on a proposed site to be presented by the applicant;
(b) Evaluating a proposed site to ensure that the site related phenomena and characteristics are adequately taken into account;
(c) Analysing the characteristics of the population of the region and the capability of implementing emergency plans over the projected lifetime of the plant;
(d) Defining site related hazards.

4.2.7.1. Relevant content of the EIA Materials

The justification for the siting of the Baltic-1 NPP with respect to natural and environmental criteria is detailed in Section 5 of the EIA Materials. Other sections of the EIA Materials address other aspects of the topics covered by NS-R-3, e.g. radiological effects on humans as a result of normal operations and accident conditions.

OBSERVATION
The EIA Materials address the safety requirements for the site evaluation of nuclear installations.

4.2.8. Espoo Convention and Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material

The underlying reference publications are:

- Espoo Convention: The Convention on the Environmental Impact Assessment in a Transboundary Context, United Nations Economic Commission for Europe, Espoo, Finland, 1991 [4];
- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition), IAEA Safety Standards Series No. SSG-26 [32][10].

The Espoo Convention includes necessary legal, administrative or other measures to implement the provisions of the Convention, including, with respect to activities (e.g. operation of nuclear facilities, transportation of radioactive waste) that could cause significant adverse transboundary impacts. The Convention addresses the establishment of an environmental impact assessment procedure that permits public participation and preparation of the environmental impact assessment documentation. The IAEA publication specifies a number of requirements and controls for transport of radioactive materials.

4.2.8.1. Relevant content of the EIA Materials

Transportation of spent nuclear fuel and radioactive waste from the Baltic-1 NPP is described in general terms throughout the EIA Materials.

The requirements specified in Appendix II of the Espoo Convention (e.g. compliance with dose limits in normal operation, effect on neighbouring states in the case of accidents)

[10] Although this new IAEA document does not form part of the reference documents for this international peer review, Rosenergoatom may wish to have this aspect be included in the review.

are not completely fulfilled by the EIA Materials for the planned Baltic-1 NPP. For example, the routes and means of transportation by land of radioactive waste from Baltic-1 NPP to regional management facilities are not described in the EIA Materials.

At the review meeting in St. Petersburg (see Annex IV), Rosenergoatom noted that both spent nuclear fuel and radioactive waste would be shipped by rail to the Kaliningrad seaport, then by ship to the St. Petersburg seaport, and subsequently by rail to a nuclear fuel recycling plant and/or waste management facility.

Section 6.7 of the EIA Materials shows the transboundary impact of the planned Baltic-1 NPP under these aspects; however the section does not refer to the reference publication (Espoo Convention).

The EIA Materials describe transportation of radioactive material in general terms which agree with IAEA's requirements except for possible transboundary impacts in case of transportation of radioactive waste through neighbouring countries.

OBSERVATION
Transboundary aspects of the operation of the Baltic-1 NPP are described in the EIA Materials, but do not clearly make reference to the Espoo Convention. The EIA Materials could be further developed by including additional details of the communications with neighbouring states that have occurred, and that are planned. The EIA Materials describe transportation of radioactive material in general terms that agree with IAEA's requirements. The EIA Materials could be further developed by the inclusion of a more detailed description of the transportation of spent nuclear fuel and radioactive waste.

5. DISCUSSION OF THE RADIOLOGICAL ASPECTS OF THE EIA FOR THE BALTIC-1 NPP

5.1. GENERAL

The EIA Materials contain a summary of the results of the assessment of the radiological impacts of the proposed Baltic-1 NPP under normal operations and postulated accident conditions. The reader is referred to other documentation (in particular, the NPP Design and associated Preliminary Safety Assessment Report, PSAR) for further details of the calculation methods.

Since a detailed assessment of the radiation doses to people and the environment is not given in the EIA Materials, the Review Team decided to perform independent assessments of the exposures to the public for both normal operation and severe accidents. However, the data provided in the EIA Materials did not include all of the data sets that are necessary to appropriately consider the exposure conditions at the site of the Baltic-1 NPP. Therefore, during the review meetings being held in Kaliningrad (February 2014), Vienna (July 2014), and St. Petersburg (November 2014), the Review Team formulated three sets of questions that were provided to Rosenergoatom, who responded promptly. These questions and answers are provided in Annexes II–VI.

In addition, following the meeting in Vienna, Rosenergoatom provided — on request of the Review Team — an extended summary of the assessments of the doses to people due to releases to the Neman River under normal conditions. This summary is included in Annex III.

5.2. RADIOLOGICAL IMPACT DURING NORMAL OPERATIONS

5.2.1. Results from the Russian estimations of exposure to the public during normal operations

For the assessment of radiation doses to the public arising from discharges of radionuclides to the atmosphere and to the Neman River during normal operations, the models and parameters described in Ref. [10] are used.

The main purpose of Ref. [10] is to provide simple methods for calculating doses arising from radioactive discharges into the environment, for the purpose of evaluating suitable discharge limits and to allow comparison with the relevant dose limiting criteria specified by the relevant Regulatory Authority. The models described in [10] to assess doses from routine releases are designed as such that the results are very likely to overestimate the doses to members of the public. These models take into account all relevant exposure pathways following discharges to the atmosphere:

- Inhalation of radionuclides;
- Ingestion of radionuclides with food;
- External exposure from the passing plume;
- External exposure due to radionuclides deposited on the ground.

For discharges to rivers the following pathways are taken into account:

- Ingestion of fish and shellfish;
- External exposure during swimming;
- External exposure when using a boat on the river;
- External exposure when staying on contaminated river sediments.

This model includes all necessary components to estimate doses from routine discharges. It includes modules on:

- Dispersion in the atmosphere and in rivers;
- Transfer of radionuclides in the environment, including the transfer in terrestrial and aquatic food chains;
- Intake of radionuclides by humans through consumption of food and drinking water, as applicable;
- Coefficients for internal and external dosimetry for infants (1–2 years old) and adults (> 17 years old);
- Factors to estimate the exposure to infants and adults via internal exposure (inhalation and ingestion) as well as external exposure (from radionuclides in the plume and ground and from radionuclides deposited on the ground).

The dispersion of radionuclides in the atmosphere is calculated by applying a Gaussian plume model using weather statistics obtained from the meteorological station located in the town of Sovetsk, which is in a distance of about 10 km from the Baltic-1 NPP site. Due to the flat terrain in this region, it is thought that this weather data also appropriately represents the dispersion conditions at the site of the Baltic-1 NPP.

For the dose calculations, the annual discharges as summarized in Table 8 and Table 9 were applied for discharges to the atmosphere and to the Neman River, respectively.

Annual effective doses are calculated for infants (1–2 years old) and adults. It is assumed that the representative person consumes only food that is produced at a location that is very close to the plant. For external exposure, it is assumed that the representative person stays all the time at, or close to the location with the highest impacts. These assumptions are very conservative. Together with the conservative nature of the models and parameters as included in Ref. [10], the results obtained usually overestimate doses to real persons considerably.

The annual effective doses received by adults and children due to discharges to the atmosphere and to the Neman River are summarized in Table 10. The maximum exposure from atmospheric discharges occurs between 0.5 km and 1 km from the site and is 3 µSv/a.

The total exposure of the population due to liquid discharges from two power units of Baltic-1 NPP is 2.7 µSv/a for adults and 1.6 µSv/a for children; consumption of fish is the dominating pathway. Due to the fact that water from the Neman river is not actually used as drinking water, actual doses due to discharge of radionuclides to the Neman river would be considerably lower.

The total doses as reported in the EIA Materials are well below the dose limit of 10 µSv/a defined for normal operation of the Baltic-1 NPP in the regulations of the Russian Federation. According to the IAEA safety standards, the dose limit for an individual person is 1 mSv/a (1000 µSv/a) for exposures of individuals from all planned facilities and activities. The doses from the Baltic-1 NPP are well below this dose limit.

5.2.2. Independent assessment of the radiological impact to the public during normal operations

For calculating the doses in the EIA, the models described in the previous section were used. However, the description of the model in the EIA was not detailed enough to allow an in-depth evaluation of the method and — as a consequence — of the results obtained from the assessment of the dose performed by Rosenergoatom.

To verify the results provided in the EIA Materials for the radiation doses received by the public, during both normal operation of the Baltic-1 NPP and during severe accidents (see Section 5.3), the Review Team performed independent assessments of the radiological impact for those conditions.

It is important to note that for these calculations, the estimated discharges to both the atmosphere and to the Neman River (the source term) as provided by Rosenergoatom were used. The estimation of the source term is beyond the scope of this Review.

To enable these comparison calculations to proceed, the counterparts were requested to respond to various questions from the Review Team. These responses were provided promptly. These sets of questions were elaborated during the review meetings in Kaliningrad, held 24–28 February 2014 (Annex II), in Vienna, held 21–23 July 2014 (Annex III), and in St. Petersburg, held 5–7 November 2014 (Annex IV).

Two sets of independent assessments have been undertaken by the Review Team using the CONDOR (see Appendix III) software and PC CREAM 08 (see Appendix V).

The first independent assessment of the radiological consequences of the airborne routine discharges has been carried out using the CONDOR software, which is applied in France. This software has been developed by the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN) for the independent analysis of licensees' radiological impact assessment of routine discharges. The outline of the main features of the CONDOR software for dose assessment from routine airborne discharges is given in Appendix III.

TABLE 8. ANNUAL EXPECTED RELEASES OF RADIOACTIVE GASES AND AEROSOLS FROM THE PLANT DURING NORMAL OPERATION CONDITIONS OF THE BALTIC-1 NPP (PER UNIT)*

Radionuclide	Discharges during normal operation per NPP Unit (GBq/a)					
	Vent stack					Above the roof
	Reactor building ventilation systems	Special gas treatment systems KPL-2	Special gas treatment systems KPL-3	Ventilation system of the auxiliary building	Total release	Turbine building
H-3	3.9 E3	–	–	5.0 E1	3.9 E3	1.2 E0
C-14	–	–	–	–	3.0 E2	–
Kr-83m	5.6 E2	–	1.1 E2	2.9 E0	6.7 E2	2.7 E1
Kr-85m	2.0 E3	3.6 E-1	2.4 E2	8.4 E0	2.3 E3	6.1 E0
Kr-85	5.5 E0	3.5 E2	2.6 E-1	1.6 E-2	3.6 E2	6.6 E-2
Kr-87	1.1 E3	–	2.5 E2	6.6 E0	1.4 E3	6.4 E1
Kr-88	4.4 E3	–	5.8 E2	2.1 E1	5.0 E3	1.5 E2
Xe-131m	1.0 E2	1.4 E2	6.6 E0	3.1 E-1	2.5 E2	1.6 E0
Xe-133	2.6 E4	2.1 E2	1.8 E3	7.9 E1	2.8 E4	4.7 E2
Xe-135	6.2 E3	–	1.3 E3	2.2 E1	7.6 E3	3.3 E2
Xe-138	1.7 E2	–	1.2 E2	1.5 E0	2.9 E2	3.1 E1
I-131	1.6 E-2	–	2.0 E-2	3.6 E-2	7.3 E-2	3.1 E-3
I-132	3.3 E-2	–	–	6.4 E-2	9.7 E-2	1.0 E-2
I-133	4.3 E-2	–	–	9.4 E-2	1.4 E-1	9.3 E-3
I-134	2.4 E-2	–	–	4.2 E-2	6.6 E-2	2.8 E-3
I-135	3.6 E-2	–	–	7.7 E-2	1.1 E-1	7.1 E-3
Cr-51	3.4 E-6	–	–	7.5 E-5	7.9 E-5	1.5 E-7
Mn-54	2.1 E-7	–	–	4.6 E-6	4.8 E-6	2.1 E-7
Co-60	1.3 E-6	–	–	3.1 E-5	3.1 E-5	2.4 E-6
Sr-89	1.3 E-5	–	–	3.1 E-4	3.35 E-4	1.4 E-5
Sr-90	2.6 E-8	–	–	5.7 E-7	6.0 E-7	4.4 E-8
Cs-134	8.6 E-4	–	–	1.9 E-2	2.0 E-2	1.0 E-3
Cs-137	1.3 E-3	–	–	2.9 E-2	3.0 E-2	1.3 E-3
Noble gases	4.1 E4	7.0 E2	4.4 E3	1.4 E2	4.6 E4	1.1 E3
Iodines	1.5 E-1	–	2.0 E-2	3.1 E-1	4.9 E-1	3.2 E-2
Aerosols	2.2 E-3	–	–	4.9 E-2	5.1 E-2	2.3 E-3
Total	**4.1 E4**	**7.0 E2**	**4.4 E3**	**1.4 E2**	**4.6 E4**	**1.1 E3**

* From Annex II, Table AII.1 (presented on the accompanying CD-ROM).

TABLE 9. DISCHARGE OF RADIONUCLIDES FROM TWO UNITS OF THE BALTIC-1 NPP (Bq/a), PREDICTED RADIONUCLIDE CONCENTRATIONS IN WATER (Bq/l) AND SEDIMENTS (Bq/kg) AT A DISTANCE OF 500 M FROM THE DISCHARGE POINT (OUTLET OF THE DISCHARGE CULVERT)*

Radionuclide	Total discharge of radionuclides from two units, Bq/a	Concentration in water at a distance of 500 m of the discharge point, Bq/l	Concentration in sediments at a distance of 500 m of the discharge point, Bq/kg
H-3	1.8E+13	21.7	0
I-131	4.6E+07	5.5E-05	1.6E-02
I-132	8.6E+06	9.7E-06	2.9E-03
I-133	2.0E+05	2.4E-07	7.1E-05
Sr-89	2.0E+06	2.4E-06	4.8E-03
Sr-90	6.2E+03	7.4E-09	1.5E-05
Cs-134	2.2E+08	2.6E-04	3.6E+01
Cs-137	3.4E+08	4.1E-04	5.6E+01
Mn-54	1.2E+06	1.5E-06	1.3E-01
Co-58	1.4E+06	1.7E-06	1.8E-01
Co-60	5.0E+06	6.0E-06	6.3E-01

* From Annex III, Table AIII.1 (presented on the accompanying CD-ROM).

TABLE 10. ANNUAL EFFECTIVE DOSES TO CHILDREN AND ADULTS ARISING FROM DISCHARGES DURING NORMAL OPERATION OF THE BALTIC-1 NPP TO THE ATMOSPHERE AND TO THE NEMAN RIVER AS GIVEN IN THE EIA MATERIALS

Discharge Route	Annual effective dose (µSv/a)	
	Infants (1–2 years old)	Adults (> 17 years old)
Discharges to the atmosphere	not provided in the EIA Materials	3
Discharges to the Neman River	2.7	1.6

The second independent assessment has been carried out using the PC CREAM 08 code [33]. This software has been developed by Public Health England, UK and is made available on a commercial basis to customers worldwide. An outline of the main features of the PC CREAM 08 software for the assessment of doses due to routine releases is given in Appendix V.

5.2.2.1. Discharges to the atmosphere

Expected annual releases of nuclides have been provided by Rosenergoatom in its answer to questions from the Review Team (Annex II). The source term is given for one unit in Table 8. It should be noted that the analysis of the source term is out of the scope of this review.

For the independent assessments, the discharges through the vent stack have been added to the discharges from the turbine building and multiplied by a factor of two to take into account the proposed two units of the Baltic-1 NPP. All the nuclides specified in Table 8 have been taken into account. For radioactive iodine isotopes, it was assumed that iodine occurs in particulate form. In response to the questions of the Review Team (Annex III), Rosenergoatom indicates that the majority of the ^{14}C is discharged to the environment in the form of CO, CO_2 and compounds of C_nH_m type. In the independent assessments, it has been assumed that ^{14}C is discharged as CO_2. This leads to more conservative results, as in this form ^{14}C is most effectively incorporated into organic matter and consequently also into plant and animal food products. For tritium, it was assumed that it is discharged as tritiated water.

(a) Meteorological data

On request of the Review Team, Rosenergoatom provided after the first Review Meeting held in Kaliningrad, a data set on the meteorological data. This data was provided as a spreadsheet named “SOV00_07 (2014-04-01)”. Due to the size of this file, it is not attached to this report, but it is available at the IAEA. The data covers the period 2000–2007 and includes information on:

- The day of the observations;
- Observation period;
- During the observation period:
  - Wind direction (in degrees);
  - Average wind speed (in m/s) at a height of 10 m;
  - Wind maximum speed (in m/s);
  - Total precipitation.

This data has been used to produce meteorological parameters required by the CONDOR and PC CREAM 08 software packages.

(i) Application of the CONDOR model

The average precipitation is 750 mm/ a as given in the EIA Materials (Ref. [2], Section 3.1.4.2.4). The annual precipitation has been assumed uniformly distributed on the 18 sectors of 20°.

The CONDOR software is based on the Doury Gaussian dispersion model with two stability classes: unstable category and stable category. A stable category has been conservatively assumed 50% of the time. This is more cautious than the 32% fraction of the stable stratification assumed by Rosenergoatom (Ref. [2], Section 6.4.1.3.3.3). The stable conditions have been assumed to be uniformly distributed on the 18 sectors of 20°. For CONDOR, the annual average wind speed has been assessed in the 18 sectors of 20°. The time fraction of the year with precipitation has also been assessed from this data.

The discharges have been assumed at the height of the stack of 100 m. No depletion of the plume due to deposition of radionuclides during the atmospheric transport has been assumed, which is a conservative assumption. The degree of conservatism increases with increasing distance from the source.

(ii) Application of the PC CREAM 08 model

The PC CREAM 08 software is based on the Pasquill Gaussian dispersion model with six atmospheric stability classes. The frequency of stability classes has been derived from analysis of the data provided in “SOV00_07 (2014-04-01)”. Rainfall is only assumed to occur in Pasquill categories C and D.

For PC CREAM 08, the annual average wind speed has been assessed in 16 sectors of 22.5° starting at 348.75°–11.25°. The time fraction of the year with precipitation has also been assessed from this data. The annual precipitation has been assumed uniformly distributed on the 16 sectors of 22.5°.

The discharges have been assumed the height of the stack of 100 m. The depletion of radionuclides from the plume due to deposition during the atmospheric transport has been assumed in PC CREAM 08.

(b) Results of the dispersion assessment

The maximum atmospheric dispersion coefficient has been found in the 10°–30° direction, at 1 km with a value of 3.4×10^{-7} s/m^3; this value is consistent with the result given in the EIA Materials (Ref. [2], Section 6.4.1.3.3.3): 1.5×10^{-7} s/m^3 at a distance of about 0.5–1 km. The 10°–30° direction is consistent with the annual wind rose given in the EIA Materials (Ref. [1], Figure 3.1.4.1).

OBSERVATION

Independent assessments of the atmospheric dispersion in routine conditions with the CONDOR software confirm the results of the assessment of Rosenergoatom.

(c) Exposure pathways considered in CONDOR and PC CREAM 08

CONDOR was used to assess doses for both adults (> 17 years old) and infants (1-2 years old). The CONDOR software takes into account all exposure pathways:

- External exposure from the cloud (beta and gamma);
- External exposure from radionuclides deposited on the ground (gamma only);
- Inhalation;
- Ingestion of food.

The intake rates for terrestrial foods as provided by Rosenergoatom were used for the calculations. These values are given in Table 11 (from Annex II, Table AII.4)

OBSERVATION

The consumption rates for terrestrial food given in Table 11 seem simplified. More comprehensive and detailed data would allow for a more detailed assessment. However, this observation can be considered as second order as the order of magnitude of the dose would not be significantly modified with more comprehensive and detailed data.

Since the food items considered in CONDOR and in information provided by Rosenergoatom are similar, but not identical, for the dose assessment with the CONDOR software, the following assumptions have been made:

- Meat is beef meat;
- Wheat includes all cereals;
- Potato includes all root vegetables;
- Cabbage includes all leafy vegetables;
- Cucumber includes all fruit/vegetables.

In the assessment of the annual effective doses, it is assumed that all food consumed by the representative person is produced locally. This is a conservative assumption.

TABLE 11. MAIN FOODSTUFF CONSUMPTION BY VARIOUS AGE GROUPS OF THE POPULATION (IN kg/a OR l/a)

Foodstuff group	**Food consumption (kg/a, l/a)** **Age group** **Infants (1–2 years old)**	 **Adults (> 17 years old)**
Milk and dairy products	246	190
Meat	27	60
Wheat	54	112
Potato	84	110
Cabbage	10	21
Cucumber	5	6.8

For the assessment of external dose and internal dose from inhalation, no shielding by buildings has been assumed; moreover people have been assumed to spend 100% of the time at their home. All these assumptions are cautious.

The PC CREAM 08 model was used to assess doses for both adults (> 18 years old) and infants (1–2 years old). Also, the PC CREAM 08 software takes into account all principal exposure pathways:

- Inhalation of radioactive material in the plume;
- External gamma irradiation from the plume;
- External beta irradiation from the plume;
- External gamma irradiation from deposited materials;
- External beta irradiation from deposited materials;
- Inhalation of material resuspended from the ground;
- Ingestion of radionuclides within foods.

Since the food items considered in PC CREAM 08 and in the information provided by Rosenergoatom are similar, but not identical, for the dose assessment with the PC CREAM 08 software, the following assumption have been made:

- Meat is considered as cow meat;
- Wheat covers all cereals;
- Potato covers all root vegetables;
- Cabbage covers all green vegetables;
- Cucumber covers all fruit.

As for the calculations with the CONDOR model, it is assumed that all food consumed is from local origin. For the assessment of external dose, no shielding by buildings has been assumed and people have been assumed to spend 100% of the time at the assessed locations. For the assessment of the exposure due to inhalation, it is assumed that the radionuclide concentrations in air indoors and outdoors are the same. These assumptions are cautious.

TABLE 12. RESULTS FOR THE ASSESSMENT OF ANNUAL EFFECTIVE DOSES FOR INFANTS AND ADULTS USING THE CONDOR SOFTWARE

Pathway	**Annual effective dose (in µSv)**	
	Infants (1–2 years old)	**Adults (>17 years old)**
External exposure from the plume	0.52	0.52
Inhalation	0.01	0.01
External exposure from the ground	0.12	0.12
Ingestion	3.0	1.97
Total	**3.7**	**2.5**

(d) Results of the dose assessment

(i) Doses to members of the public assessed by use of the CONDOR model

For the expected discharges (Table 8) from the two units of the Baltic-1 NPP, the doses at a distance of 1 km from the stack, in the 10°–30° direction, are about 2.5 µSv/a for adults and 3.7 µSv/a for infants. These results are very similar to doses given in the EIA Materials (Ref. [2], Section 6.4.1.4.4): 3 µSv/a, at a distance of 0.5–1 km. In addition to the total doses, Table 12 shows the pathway breakdown of the dose for infants (1–2 years old) infants and adults, at 1 km from the stacks.

However, the independent dose assessment identifies the critical groups in the North-East Direction rather than the North-West Direction as reported in the EIA Materials (Ref. [3], Section 6.4.1.4.2). Rosenergoatom indicates in its responses to the questions of the Review Team (Annex 3) that this is an editorial error and that Section 6.4.1.4.2 of the EIA Materials [2] should read "North-Easterly direction" instead of "North-Westerly direction".

OBSERVATION

Independent assessment of radiation doses arising from the expected airborne routine discharges with the CONDOR software confirms the assessment of Rosenergoatom (both dose value and direction of the most exposed persons).

(ii) Doses to members of the public assessed by use of the PC CREAM 08 model

For expected discharges from the two units of the Baltic-1 NPP, the doses at 1 km from the stack, in the 11.25°–33.75° direction (NE), are about 2.8 µSv/a for adults and 5.5 µSv/a for infants. To account for accumulation processes in the environment, this dose has been assessed for the last year assuming a period of 50 years of continuous releases. These dose results are slightly higher but still consistent with the results given in the EIA Materials (Ref. [3], Section 6.4.1.4.4) of 3 µSv/a, at a distance of 0.5–1 km. However, as for CONDOR, the PC CREAM independent dose assessment finds the critical groups in the NE Direction rather than the NW Direction found reported in the EIA Materials (Ref. [2], Section 6.4.1.4.2). Rosenergoatom indicates in its responses to the questions of the Review Team (Annex III) that this is an editorial error and that Section 6.4.1.4.2 of the EIA Materials should read "North-Easterly direction" instead of "North-Westerly direction" [2]. The results of the dose assessment for the expected discharges are presented in Table 13.

TABLE 13. RESULTS FOR THE ASSESSMENT OF ANNUAL EFFECTIVE DOSES FOR INFANTS AND ADULTS USING THE PC CREAM 08 MODEL FOR EXPECTED DISCHARGES DURING NORMAL OPERATION

Exposure pathway	**Annual effective dose (µSv/a)**	
	Infant (1a)	**Adult**
Inhalation	0.10	0.13
External gamma from the plume	0.30	0.30
External beta from the plume	4.2E-03	4.2E-03
External gamma from the ground	6.1E-03	6.1E-03
External beta from the ground	1.6E-04	1.6E-04
Inhalation of resuspended particles	8.7E-07	4.7E-07
Ingestion	5.1	2.4
Total	**5.5**	**2.8**

OBSERVATION

Independent assessments of radiation doses arising from the expected airborne routine discharges with the PC CREAM 08 software confirm the results of the dose assessments performed by Rosenergoatom.

(iii) Model uncertainty

No comprehensive uncertainty analysis of the dose assessment has been performed. However, all the models used are designed and applied in a way to ensure conservative estimations of the doses that might be received by members of the public. The results of the three independent models (Rosenergoatom, CONDOR, PC CREAM 08) agree very well. The results of all three approaches indicate that the estimated radiation doses to members of the public arising from the expected discharges of the Baltic-1 NPP during normal operation are well below the radiological of criteria of 10 µSv/a, which is applied in the Russian Federation.

5.2.2.2. Liquid discharges

The description of the model and parameter used for the assessment of routine liquid discharges in the EIA Materials (Ref. [2], Section 6.4.1) is not given in detail. Rosenergoatom provided further details on request of the Review Team (Annexes II and III).

Irrigation is not taken into account as an exposure pathway to assess the dose from routine liquid discharges (Annex II). It is also suggested in the EIA Materials (Ref. [2], Section 6.4.1.4.6) that Neman River bottom sediment might be used as fertilizer, but this pathway is not taken into account as an exposure pathway to assess the dose from routine liquid discharges (Annex II). In their answer to the Review Team's questions (Annex III), Rosenergoatom indicates that no data is available on the use of water from Neman River for irrigation purposes and the use of bottom sediment as fertilizers.

Data on consumption of fish and molluscs are given in response to the questions of the Review Team (Annex II). It is to be noted that the consumption of mollusc from river water is unusual. In their answer to the Review Team's questions (Annex III), Rosenergoatom indicates that no data is available on the consumption of molluscs from the Neman River; therefore the inclusion of the consumption of molluscs can be considered conservative.

OBSERVATION

Rosenergoatom needs to explore the necessity of collecting data to ensure that the Neman river water is not used for irrigation and that the Neman River bottom sediment is not used as fertilizer. Alternatively, Rosenergoatom could take these pathways into account in their dose assessment of routine liquid discharges.

As for the discharges of radionuclides to the atmosphere, two independent assessments of the radiological consequences of the liquid routine discharges have been carried out using the CONDOR and PC CREAM 08 software packages. The outline of the main features of the CONDOR software for dose assessment from routine liquid discharges is given in Appendix III and for PC CREAM 08 in Appendix V.

(a) Expected annual liquid discharges

Expected annual discharges of nuclides for each unit have been provided in response to the request of the Review Team (Annex II). This source term is given in Table 14, below. It is to be noted that, contrary to the airborne discharges, no discharges of ^{14}C are mentioned. In their answer to the Review Team's questions (Annex III), Rosenergoatom indicates that it is expected that most part of ^{14}C is released to the atmosphere in the form of CO, CO_2 and compounds of C_nH_m type and that the level of liquid ^{14}C discharges is expected to be insignificant.

TABLE 14 ROUTINE LIQUID DISCHARGES OF RADIONUCLIDES TO THE NEMAN RIVER DURING NORMAL OPERATION (THE VALUES ARE GIVEN PER REACTOR UNIT)*

Radionuclide	**Annual radionuclide discharges to the Neman river per reactor unit (GBq/a)**			
	Drainage water from 'Controlled Access Area'		**Drainage water from 'Free Access Area'**	**Total discharge**
	Excessive water of KBF, KPF systems	**Filters (LCQ, KPF40) regeneration water**	**Filters (LD) regeneration water**	
H-3	9.1 E3	–	–	9.1 E3
I-131	1.8 E-3	1.7 E-5	2.1 E-2	2.3 E-2
I-132	3.9 E-3	2.3 E-9	4.5 E-4	4.3 E-3
I-133	4.6 E-3	1.7 E-7	5.8 E-3	1.0 E-4
I-134	3.5 E-3	–	9.6 E-5	3.6 E-3
I-135	4.0 E-3	–	1.5 E-3	5.5 E-3
Sr-89	1.4 E-5	2.0 E-4	8.0 E-4	1.0 E-3
Sr-90	1.1 E-7	8.1 E-7	2.2 E-6	3.1 E-6
Cs-134	2.6 E-2	1.8 E-2	6.6 E-2	1.1 E-1
Cs-137	4.0 E-2	2.8 E-2	1.0 E-1	1.7 E-1
Cr-51	6.4 E-4	3.0 E-5	1.5 E-4	8.2 E-4
Mn-54	6.0 E-4	1.0 E-5	1.4 E-5	6.2 E-4
Co-60	2.4 E-3	5.5 E-5	9.7 E-5	2.5 E-3
Co-58	4.2 E-4	5.9 E-5	2.3 E-4	7.1 E-4
Total activity (except tritium)	**8.8 E-2**	**4.6 E-2**	**2.0 E-1**	**3.3 E-1**

* From Annex II, Table AII.2 (presented on the accompanying CD-ROM).

OBSERVATION

When the Baltic-1 NPP is in operation, Rosenergoatom needs to ensure that the liquid discharges of ^{14}C are insignificant or should take this radionuclide into account in the dose assessment.

It is to be noted that for these calculations, the estimated discharges to the Neman River (the source term) as provided by Rosenergoatom were used. The estimation of the source term is beyond the scope of this Review.

The independent dose assessment has been carried out with the data of the column "total discharge" of the expected liquid discharges given in Table 14, multiplied by a factor of 2 to take into account the two units of the Baltic-1 NPP.

(b) Hydrological data

The hydrological data about the Neman River necessary for the dose assessment with the CONDOR and PC CREAM 08 software has been selected from the EIA Materials (Ref. [1] Section 3.1.3.4):

- Average annual flow rate: 571 m^3/s;
- Average monthly flow rate during the irrigation period (conservatively supposed to be during low flow rate): 180 m^3/s;
- Average suspended sediment load: 0.025 g/L.

(c) Exposure pathways

(i) The CONDOR model

Doses have been assessed for both infants (1–2 years old) and adults (> 17 years old). The CONDOR software takes into account all exposure pathways:

- External exposure (gamma) from recreational activities on the river and on the river banks (fishing, swimming);
- Ingestion of freshwater food (fish);
- Ingestion of terrestrial food (vegetables, milk, meat) from irrigated soils;
- Ingestion of drinking water from filtered river water;
- Inadvertent ingestion of river water when swimming and river bank sediment.

The consumption rates for terrestrial food — provided in response to the questions of the Review Team (Annex II, Table AII.4) — have been used as for the dose assessment of the airborne discharges (see Section 5.2.2.1 above). The consumption rates for drinking water and fish were provided in response to the questions of the Review Team (Annex II, Table AII.5). The values are given in Table 15; they follow IAEA recommendations for generic assessments [10].

TABLE 15. CONSUMPTION OF AQUATIC FOODSTUFFS FOR INFANTS AND ADULTS

Foodstuff group	**Annual intake of food (kg/a, l/a)**	
	Infants (1–2 years old)	**Adults (> 17 years old)**
Freshwater fish	15	30
Molluscs	0	15
Drinking water	260	600

TABLE 16. PARAMETERS FOR THE ASSESSMENT OF DOSES FROM RECREATIONAL ACTIVITIES

Activity	**Infants (1–2 years old)**	**Adults (> 17 years old)**
Inadvertent consumption of river water (kg/a)	0.05	1
Inadvertent consumption of river bank sediments (kg/a)	0.005	0.0005
Time spent for swimming in the river (h/a)	5	5
Time spent on the river bank (h/a)	100	100

It is to be noted that the CONDOR software only considered ingestion of freshwater fish, so the consumption of mollusc has not been taken into account in the independent assessment. For the pathways related to recreation, parameter values as used in assessments performed for French sites have been assumed (Table 16).

(ii) The PC CREAM 08 model

In addition to the CONDOR software, the PC CREAM 08 model has been applied to assess radiation doses to members of the public arising from the expected radionuclide discharges to the Neman River during normal operation of the Baltic-1 NPP. Annual effective doses have been assessed for both adults (> 18 years old) and infants (1 year old). The PC CREAM 08 software takes into account the principal exposure pathways:

- Ingestion of freshwater fish;
- Ingestion of drinking water from untreated river water;
- External irradiation from sediments (beta and gamma).

The fish consumption rates and drinking water consumption rates given in the responses to the questions of the Review Team (Annex II, Table AII.5) are used; they follow IAEA recommendations for generic assessment [10].

It is to be noted that the PC CREAM 08 software only considered ingestion of freshwater fish, so the consumption of mollusc has not been taken into account in this assessment.

(d) Results of the independent dose assessment

(i) Predicted doses to members of the public using the CONDOR model

For the expected discharges, the doses are extremely low, with values of 0.1 μSv/a for adults and 0.06 μSv/a for infants. Table 17 provides the results for the assessment of annual effective doses for infants and adults due to liquid discharges from the Baltic-1 NPP during normal operation using the CONDOR software.

TABLE 17. RESULTS FOR THE ASSESSMENT OF ANNUAL EFFECTIVE DOSES FOR INFANTS AND ADULTS DUE TO LIQUID DISCHARGES FROM THE BALTIC-1 NPP DURING NORMAL OPERATION USING THE CONDOR SOFTWARE

Effective dose (in µSv)	**Infants (1–2 years old)**	**Adults (> 18 years old)**
External exposure from recreational activities	6.5E-04	6.5E-04
Inadvertent ingestion (river water, sediment)	4.1E-06	1.5E-05
Drinking water ingestion	0.019	0.039
Aquatic food ingestion	0.013	0.029
Terrestrial food ingestion	0.026	0.029
Total	**0.059**	**0.097**

TABLE 18. RESULTS FOR THE ASSESSMENT OF ANNUAL EFFECTIVE DOSES FOR INFANTS AND ADULTS DUE TO LIQUID DISCHARGES FOR THE EXPECTED DISCHARGES FROM THE BALTIC-1 NPP DURING NORMAL OPERATION USING THE PC CREAM 08 MODEL

Exposure pathway	**Effective dose (µSv/a)**	
	Infant (1 year old)	**Adults (> 18 years old)**
External beta from sediment	4.4E-05	4.4E-05
External gamma from sediment	5.6E-03	5.6E-03
Ingestion of fish	0.010	0.024
Ingestion of drinking water	0.013	0.011
Total	**0.030**	**0.040**

These results are difficult to compare in detail with the results in the EIA Materials because the latter include only consumption of water (the EIA Materials mention doses of a few µSv/a for contamination of water by a few Becquerel's of tritium in the river water).

OBSERVATION

Independent dose assessment of the expected routine discharges to the Neman River confirms that expected doses are far below the regulatory limits.

(ii) Predicted dose to members of the public using the PC CREAM 08 model

For expected discharges, the assessed doses are below 0.1 µSv/a for adults and infants respectively. Table 18 shows the pathway breakdown of the annual effective dose for the expected discharges for infants and adults, at 500 m downstream from the river discharge point.

As for CONDOR, these results cannot be directly compared with the results in the EIA Materials because the latter includes only consumption of water, whereas the assessments of PC CREAM 08 also include the pathways "external exposures from contaminated sediments" and "ingestion of river fish". Nevertheless, it can be concluded that the exposures to members of the public arising from the expected radionuclides discharges to the Neman River are far below the values for the radiological criteria set by the Russian Federation and recommended in the IAEA safety standards.

OBSERVATION

Independent dose assessment of the expected liquid routine discharges using the PC CREAM 08 model confirms the exposures to members of the public arising from the expected radionuclides discharges to the Neman River are far below the values for the radiological criteria set by the Russian Federation and recommended in the IAEA safety standards.

5.2.3. Radiological impact to flora and fauna during normal operations

5.2.3.1. Radiological impact to flora and fauna as described in the EIA Materials

In the EIA Materials, the potential radiological impact to flora and fauna arising from discharges during normal operation of the Baltic-1 NPP to the atmosphere and to the Neman River is addressed, since it is a requirement of GSR Part 3 [8] to consider radiological impacts to the environment in the planning stage of nuclear facilities. It is concluded that the resulting dose rates to representatives of flora and fauna are orders of magnitudes below levels that could cause at least minor effects to population [34].

5.2.3.2. Independent assessment of the radiological impact to flora and fauna

In the EIA Material, doses to flora and fauna are assessed arising from the routine discharges to the atmosphere and into the Neman River. However, the assessment of the radiation doses to representatives of flora and fauna is not given in detail in the EIA Materials. Therefore, the Review Team decided to perform an independent assessment of the exposures to the representative flora and fauna during normal operation. The data summarized in Annexes II and Annex III was used as input data for the assessment of doses to flora and fauna.

For this assessment, the Review Team used the ERICA Assessment Tool [35], which is a computerized, flexible software system, which was developed in the framework of the a research project "Environmental Risk from Ionising Contaminants: Assessment and Management" (ERICA) [36]. The ERICA Assessment Tool is based upon the ERICA Integrated Approach for assessing the radiological risk to biota [36]. The ERICA approach is widely used in Europe to estimate radiological impacts to biota arising from radionuclides discharged to the terrestrial or aquatic environment. The ERICA Tool includes all sets of transfer and dosimetric parameters necessary to estimate dose rates to biota from those discharges.

The ERICA Tool also includes a module that estimates the dispersion of radionuclides in the atmosphere and in the aquatic environment; this module provides activity concentrations in air, soil, freshwater and sediments. These calculations are based upon the generic "transport" models described in Ref. [10]. The ERICA Tool assesses both internal and external exposure for estimating dose rates to biota.

The assessment of doses rates to representatives of flora and fauna considered reference animals and plants as recommended in [34]. The assessment was carried out using the expected discharges given in Annex II (Tables AII.1 and AII.2); this data was provided on request by Rosenergoatom following the February 2014 meeting in Kaliningrad.

For the discharges to the atmosphere, the organisms "big mammal", "small mammal", "grass and herbs", "soil invertebrates", "bird" and "tree" were considered as indicators for exposures to flora and fauna arising from the discharges. For all these organisms, the doses estimated for the point with the highest radionuclide impact in the vicinity of the Baltic-1 NPP. For all these organisms, the estimated additional dose rates are below 0.001 µGy/h.

For discharges to the Neman River, the organisms "benthic fish" (fish living on the sediments and being therefore exposed to radionuclides absorbed in the sediments), "pelagic fish" (fish living in the water column) and "phytoplankton" (small water plants), The resulting dose rates for aquatic organisms range from less than 0.1 µGy/h for benthic fish to less than 10^{-5} µGy/h for water plants.

For both terrestrial and aquatic organisms, the dose rates are far below natural background levels and orders of magnitudes below the Derived Consideration Reference Levels (DCRL) defined by the ICRP [37].

The DCRLs represent a set of dose rate bands within which there is some very low probability of deleterious effects of ionizing radiation to individuals of flora and fauna, which may have implications in the structures or populations. DCRLs have been defined on the basis of radiation effects observed for species corresponding to reference animals and plants. DCRLs bands span an order of magnitude; for dose rates below the lower level of the bands, no effects have been observed or no information reported [34, 37].

OBSERVATION

Radiological impacts to flora and fauna arising from discharges from the Baltic-1 NPP to the atmosphere and to the Neman River are well below natural backgrounds and orders of magnitude below dose levels that would cause at least minor effects. This observation is in agreement with the conclusions of the EIA Materials.

5.3. ESTIMATED RADIOLOGICAL IMPACT TO THE PUBLIC FOLLOWING ACCIDENTAL RELEASES

5.3.1. Results from the Russian estimations of exposures to the public following accidents

In addition to the radiological impacts to people during normal operation, the EIA Material includes the considerations of Anticipated Operational Occurrences, Design Based Accidents (DBA) and Beyond Design Based Accidents (BDBA); the latter are also called Severe Accidents.

The EIA Materials show the assessment of the radiological consequences of accidents at the Baltic-1 NPP reactor (Ref. [2], Section 6.4.2). The results of two assessments are given in the EIA Materials: a short term assessment (10 days) and a longer term assessment (1 year) (Ref. [2], Section 6.4.2.2). In the Russian regulations, these periods are considered for deciding on protective actions.

These events are classified according to their probabilities: anticipated operational occurrences occur with a probability which is larger than 10^{-2}/a. For DBAs, two categories with probabilities of occurrence above and below 10^{-4}/a are considered respectively. Special calculations are made for BDBA: in this category, events are included with a probability of less than 10^{-7}/a. (It should be noted that the consideration of probabilities for specific events and the associated source terms are beyond the terms of reference for this review).

In the EIA Materials, the estimation of exposures to the public subsequent to accidental releases is assessed for the following conditions:

- Exposures are calculated for infants (1–2 years old) and adults (>17 years old);
- Doses are calculated integrated over a period of 10 days and 1 year, respectively;
- The calculations include the exposure pathways “external exposure from the passing plume”, “external exposure from radionuclides deposited on the ground”, and inhalation. The ingestion of food is not considered in these calculations;
- Radionuclide releases from heights of 30 m and 100 m respectively are considered;
- The dispersion conditions are derived from long term weather statistics. For the calculations, atmospheric dispersion coefficients are used depending on the duration of the release;
- From the weather statistics, dispersion coefficients are derived in dependence of duration of the release, distance from the source and release height that cover 99.5% of the weather situations.

The doses given in the EIA Materials [1–3] for Anticipated Operational Occurrences, DBAs and BDBAs are given in Tables 19 and 20 (see below). These tables provide doses for infants (1–2 years old), since infants were identified as the critical group.

The EIA Materials conclude that, in the case of Design Basis Accidents, the predicted dose rate to the public in the first 10 days after the accident does not reach 1% of the dose level requiring immediate decisions on protective actions. The public dose in the first year following the accident does not exceed 5 mSv outside the plant site.

In the case of a severe accident, the EIA Materials conclude that protective measures are not required at a distance further than 7 km from the NPP, and protective measures in the 5-7 km zone are mainly limited to sheltering and/or iodine prophylaxis. According to NRB-99/2009, the mandatory emergency evacuation is not required at any off-site location.

TABLE 19. ESTIMATED EFFECTIVE DOSES OVER 1 YEAR FOLLOWING ANTICIPATED OPERATIONAL OCCURRENCES AND DESIGN BASED ACCIDENTS

Category	**Effective dose (mSv)**
Anticipated Operational Occurrences	<0.06
Design Based Accidents, probability higher than > 10^{-4} /a	< 1
Design Based Accidents, probability less than 10^{-4} /a	< 2.31

TABLE 20. ESTIMATED EXPOSURES TO INFANTS (1–2 YEARS OLD), AT A 95% CONFIDENCE LEVEL, FOLLOWING RELEASES AS A CONSEQUENCE OF BEYOND DESIGN BASIS ACCIDENTS INTEGRATED OVER A PERIOD OF 10 DAYS AND 1 YEAR RESPECTIVELY IN DEPENDENCE OF THE DISTANCE TO THE BALTIC-1 NPP

Distance to Baltic-1 NPP (km)	**Effective dose (mSv) Integration time**		**Thyroid dose (mSv) Integration time**
	10 days	**1 year**	**10 days**
0.8	9.5	110	280
1	6.9	76	205
5	0.7	8.5	22
10	0.2	2.5	6.4

5.3.2. Independent assessment of radiation doses to the public after severe accidents

The description of the model in the EIA is not detailed enough to allow an in-depth evaluation of the method and — as a consequence — did not allow the evaluation of the results obtained from the assessment of the dose performed by Rosenergoatom. In order to check the results given in the EIA, the Review Team decided to perform independent assessments. Three accident consequence codes being used in France and in the UK were applied by the review team.

It is important to note that, for these calculations, the estimated releases of radionuclides (the source term) to the atmosphere during “Beyond Design Based Accidents” as provided by Rosenergoatom were used. The analysis of the source term is beyond the scope of this Review.

(a) The French AIDA model

An independent assessment of the radiological consequences of a severe accident has been carried out using the French AIDA software based on the ACCI38 model. This software has been developed by the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN) for independent analysis of licensees’ assessment of nuclear accidents. The outline of the ACCI38 model is given in Appendix IV.

(b) The UK PACE model

An independent assessment of the radiological consequences of a severe accident has been carried out using the PACE software. This software has been developed by Public Health England, UK for internal and external use to probabilistically assess radiological consequences of nuclear accidents. The outline of the PACE model is given in Appendix VI.

(c) The UK PC COSYMA model

A further independent assessment of the radiological consequences of a severe accident has been carried out using the established PC COSYMA software. This software has been developed by NRPB (National Radiation Protection Board (UK) current name: Public Health England (PHE)) and FZK (Forschungszentrum Karlsruhe (Research Center Karlsruhe, Germany, current name: Karlsruhe Institute for Technology) and is an externally available software product used to probabilistically assess radiological consequences of nuclear accidents. The outline of the PC COSYMA model is given in Appendix VI.

5.3.2.1. Accidental release (source term)

Radionuclides released as a function of time (source term) have been provided in response to the questions of the Review Team (Annex II) for a severe accident. This source term is given in Table 21.

The analysis of the source term for accidental releases is out of the scope of this review. However, it is to be noted that this source term has been simplified compared to the full source term expected for a severe accident. In the response to the Review Team’s questions (Annex III), Rosenergoatom indicates that following simplifications have been made:

TABLE 21. EMERGENCY RELEASE TO THE ENVIRONMENT UNDER SEVERE ACCIDENT CONDITIONS AS A FUNCTION OF TIME (IN TBq)

Radio-nuclide	Nature of the release / time since the accident onset								
	Low altitude release							High altitude release	
	0–8 hours		8–24 hours		1–7 days		7–30 days	1–7 days	7–30 days
	Via containment leaks	Containment bypass	Via containment leaks	Containment bypass	Containment bypass	KLC* filters bypass	KLC filters bypass	Through KLC filters	
Gases									
Kr-85m	2.3E+01	2.2E+00	1.3E+01	8.3E-01	7.2E-02	3.6E-01	–	3.6E+01	–
Kr-87	8.8E+00	1.8E+00	2.6E-01	4.6E-02	–	–	–	–	–
Kr-88	4.6E+01	5.2E+00	1.1E+01	8.3E-01	1.9E-02	1.1E-01	–	1.1E+01	–
Xe-133	4.8E+02	3.4E+01	1.8E+03	7.9E+01	4.8E+02	5.7E+02	2.0E+02	5.7E+04	2.0E+04
Xe-135	1.1E+02	9.0E+00	4.7E+02	2.3E+01	1.8E+01	2.9E+01	–	2.9E+03	–
Xe-138	3.1E-01	4.7E-01	8.1E-03	3.2E-03	–	–	–	–	–
Ru-103	1.1E+00	6.2E-02	7.0E+00	2.9E-01	1.3E-01	3.1E-01	2.1E-01	3.1E+01	2.1E+01
Molecular iodine									
I-131	7.4E-01	4.8E-02	8.2E+00	4.0E-01	6.2E-02	3.5E-01	–	3.5E-01	–
I-132	4.9E-01	2.4E-02	2.6E-01	1.6E-02	2.4E-03	2.8E-03	–	2.8E-03	–
I-133	1.5E+00	8.9E-02	1.1E+01	5.3E-01	1.7E-02	2.9E-01	–	2.9E-01	–
I-134	2.4E-01	1.3E-02	1.1E-02	1.1E-04	–	–	–	–	–
I-135	1.1E+00	6.4E-02	3.7E+00	2.0E-01	9.4E-04	7.7E-02	–	7.7E-02	–
Organic iodine									
I-131	3.6E-01	2.5E-02	1.3E+00	5.7E-02	3.9E-01	4.5E-01	4.7E-01	4.5E+00	4.7E+00
I-132	1.3E-01	1.7E-02	2.1E-01	1.9E-02	1.5E-02	1.6E-02	–	1.6E-01	–
I-133	6.1E-01	4.6E-02	1.6E+00	7.3E-02	1.1E-01	1.8E-01	5.9E-04	1.8E+00	5.9E-03
I-134	2.2E-02	6.6E-03	4.8E-04	1.1E-03	–	–	–	–	–
I-135	3.9E-01	3.4E-02	4.4E-01	2.4E-02	5.9E-03	1.8E-02	–	1.8E-01	–
Aerosols									
I-131	2.3E+01	5.9E+00	1.3E+01	2.3E+00	6.3E-01	6.2E+00	–	6.2E-01	–
I-132	1.8E+01	7.9E+00	6.2E+00	2.1E+00	2.6E-02	5.3E-02	–	5.3E-03	–
I-133	4.2E+01	1.2E+01	1.8E+01	3.4E+00	1.7E-01	5.5E+00	–	5.5E-01	–
I-134	3.1E+00	2.6E+00	6.4E-02	4.0E-02	–	–	–	–	–
I-135	2.8E+01	8.7E+00	6.7E+00	1.5E+00	9.7E-03	9.1E-01	–	9.1E-02	–
Cs-134	5.7E+00	1.5E+00	3.3E+00	5.8E-01	1.2E-01	1.5E+00	2.5E-01	1.5E-01	2.5E-02
Cs-137	2.7E+00	6.9E-01	1.6E+00	2.7E-01	7.5E-02	7.3E-01	1.6E-01	7.3E-02	1.6E-02
Sr-90	6.4E-02	1.6E-02	2.6E-02	4.5E-03	6.0E-03	6.2E-03	1.3E-02	6.2E-04	1.3E-03
Te-131m	3.5E+00	9.3E-01	1.1E+00	2.0E-01	4.5E-03	5.4E-01	6.0E-05	5.4E-02	6.0E-06
Ba-140	1.5E+00	3.8E-01	5.8E-01	1.0E-01	1.3E-01	4.5E-01	1.3E-01	4.5E-02	1.3E-02
La-140	1.2E-01	2.9E-02	1.4E-01	2.5E-02	2.2E-02	1.6E-01	2.7E-02	1.6E-02	2.7E-03
Ce-141	3.5E-02	8.7E-03	1.4E-02	2.4E-03	4.5E-03	1.3E-02	7.1E-03	1.3E-03	7.1E-04
Total									
Gases	6.7E+02	5.3E+01	2.3E+03	1.0E+02	5.0E+02	6.0E+02	2.0E+02	6.0E+04	2.0E+04
Iodines	1.2E+02	3.7E+01	7.1E+01	1.1E+01	1.4E+00	1.4E+01	4.7E-01	8.6E+00	4.7E+00
Aerosols (except iodines)	1.4E+01	3.5E+00	6.8E+00	1.2E+00	3.7E-01	3.4E+00	5.9E-01	3.4E-01	5.9E-02

* KLC filters are a system to reduce the pressure in the reactor building, which is equipped with effective iodine and aerosol filters.

- It is assumed that no significant release occurs of heavy non-volatile compounds including alpha active aerosols. Therefore, no releases of such material are included in the source term;
- The various chemical elements were grouped into seven groups according to their physical-chemical properties. It was assumed that the physical-chemical properties of all nuclides are identical within any specific group. Differences between various nuclides of the same group are defined by their half-life;
- Both the nuclides with low release fractions from the corium and the radiation-insignificant nuclides with small contribution to gross activity accumulated in fuel were not taken into account.

The assessment of the consequences of the accident has been carried out with the source term provided by Rosenergoatom, which is the sum of all discharges during the first 7 days, including both low altitude and high altitude releases. It should be noted that the data provided by Rosenergoatom shows that a large fraction of the releases occurs during the first 24 hours after the accident.

For a conservative approach within AIDA, all the releases have been assumed to occur at the ground level, which leads to higher doses close to the facility. When applying PC COSYMA, the source term was separated into two phases: 1–8 hours and 8–24 hours, with all releases occurring at a height of 30 m. Within the PACE model, firstly the releases were spilt into 3 parts: low altitude 0–8 hours, low altitude 8–24 hours, and high altitude 1–7 days. The model was applied twice, once assuming low altitude releases occurred at a height of 0 m and high altitude at 100 m. The second run assumed a low altitude release of 30 m and high altitude of 100 m. The use of differing release heights also allows an additional potential source of uncertainty to be qualitatively considered.

5.3.2.2. Meteorological data

The software tools used for the independent assessment — AIDA, PACE and PC COSYMA — use different models for atmospheric dispersion. Therefore, the meteorological data needed for the models is different. The details below are separated by category.

(i) The AIDA model

The meteorological data provided by Rosenergoatom (in the spreadsheet SOV00_07) has been analysed to identify the local conservative weather conditions according to the Doury Gaussian model.

Two conservative weather conditions according to the Doury model, one for dry conditions and another for wet conditions, have been identified:

- Wind speed 5 m/s, stable conditions, dry weather;
- Wind speed 5 m/s, unstable conditions, 1.83 mm/h precipitation (this precipitation covers about 90% of the precipitation conditions).

It should be noted that stable conditions are always associated with dry conditions in the Doury Gaussian dispersion model. Meteorological data provided by Rosenergoatom shows that these two weather conditions cover about 99% of the weather conditions and, therefore, can be considered conservative.

This means that the doses assessed with these conditions would be an overestimation of the doses for more than 99% of the meteorological conditions according to the Doury Gaussian dispersion model. In particular, the stable conditions with 5 m/s wind speed can be considered very cautious for durations of more than a half day.

The wind direction has been considered stable during the release. This is very conservative. Therefore the atmospheric concentrations have been corrected in order to take into account the time dependence of releases after the accident which would allow higher dispersion and lower concentrations when the time dependence of releases is correlated with the time dependence of the wind direction. In order to provide for a more realistic assessment, the atmospheric concentrations have been divided by a factor of 5 to take into account the fluctuations of the wind direction during the release. This value of the factor is best fitted to a 24 hour release for the Doury model; this value has been assumed for the 7 day release because a large fraction of the source term is released during the first 24 hours.

(ii) The PACE model

PACE is a probabilistic accident consequence assessment tool. The tool performs assessments for individual weather conditions taken from a large meteorological data set to consider the consequences of accidents occurring in different meteorological sequences. As described in Appendix VI, the PACE software uses the NAME atmospheric dispersion model which is a Lagrangian particle model. The model requires 3 dimensional weather data, which is derived from Numerical Weather Prediction (NWP) datasets. To perform this assessment, a dataset for the European continent was used which covers the period 2003–2004. This clearly is an independent dataset from that provided for the Sovetsk site (Kaliningrad oblast, Russian Federation).

An analysis of the 2003–2004 NWP data for the Baltic-1 NPP site has been undertaken to compare with the Sovetsk data set which shows good consistency between the data. In terms of wind speed around 70% of the hourly data is between 3 and 6 m s^{-1}. The highest frequency wind directions are towards the NE direction. Finally, around 70% of the hourly data is described as Pasquill stability categories C and D.

(iii) The PC COSYMA model

PC COSYMA is also a probabilistic accident consequence assessment tool which samples from a meteorological data set to consider the consequences of accidents occurring in different meteorological sequences. As described in Appendix VI, the PC COSYMA software uses a Gaussian plume dispersion model. The model requires hourly weather data described in categories such as wind direction, speed, stability category and rainfall. This data has been derived from the provided Sovetsk dataset for use in PC COSYMA.

5.3.3. Results of the dispersion assessment

The maximum atmospheric dilution factor from AIDA is obtained for the stable conditions:

— 1 km: 3.6×10^{-5} s/m^3;
— 2 km: 1.1×10^{-5} s/m^3;
— 5 km: 2×10^{-6} s/m^3;
— 10 km: 5.2×10^{-7} s/m^3.

As mentioned above, these results have been obtained with the AIDA software for unfavourable conditions, i.e. for weather conditions which cover 99% of the weather conditions.

The EIA Materials (Ref. [2], Section 6.4.2.2.7) mention that a “maximum atmospheric dilution factor” has been used for the dose assessment of accidental releases. In their response to the Review Team’s questions (Annex III), Rosenergoatom gave the upper values of the 95% confidence interval of the dilution factors in the period 0–16 hours after the accident. For the ground level release, the maximum dilution factor has been found by Rosenergoatom:

— 1 km: 1.8×10^{-5} s/m^3;
— 2 km: 7.5×10^{-6} s/m^3;
— 5 km: 1.8×10^{-6} s/m^3;
— 10 km: 5.5×10^{-7} s/m^3.

OBSERVATION

Independent assessment of the atmospheric dispersion factors in accidental conditions applying the AIDA software provides similar results as the assessment of Rosenergoatom.

5.3.4. Exposure pathways

5.3.4.1. The AIDA model

Projected doses have been assessed for both adults (> 17 years old) and infants (1-2 years old). Two assessments have been carried out: a short term assessment (exposure in the first 7 days) and a longer term assessment (exposure in the first year following the accident). The 7 day period has been assumed for the short term assessment because releases have been provided for this period (see Table 21). This is a little less than the 10 day period assumed by Rosenergoatom but it is to be noted that the supplementary releases during days 8, 9 and 10 are much smaller than during the first 7 days after the accident and that the conclusion drawn from a 7 day assessment are likely to be similar to the conclusion drawn from a 10 day assessment. Therefore, the differences in dose results between the assessment over the 7 and 10 day periods are likely not to be significant for the conclusion of this review.

In the AIDA model, the following exposure pathways are taken into account:

- External exposure from the radionuclides in the passing plume;
- External exposure from the radionuclides deposited on the ground;
- Inhalation of radionuclides during the passage of the plume;
- Ingestion of food.

For assessment of the exposure during the first 7 days, food ingestion has not been taken into account. The stable conditions have been conservatively considered for this assessment.

For the assessment over a period of 1 year, all external and internal pathways have been taken into account. Food consumption rates provided by Rosenergoatom — as shown above for the dose assessment of routine discharges — have been used with the same assumptions as those described above in Section 5.2.2.1. Wet conditions (with unstable atmosphere) have been considered for this assessment.

For the assessment over a period of 7 days, both effective dose and equivalent dose to the thyroid have been assessed. For the assessment over a period of one year, only the effective dose has been assessed.

OBSERVATION

Table 6.4.2.2.1 of the EIA Materials [2] shows that according to regulations of the Russian Federation ingestion has not been taken into account by Rosenergoatom for the short term (10 days) assessment of the effective dose (compare with Table 5 above).

5.3.4.2. The PC COSYMA model

The PC COSYMA model has been used to assess doses for adults (> 18 years old) only. Two assessments have been carried out: a dose assessment for the first 10 days of exposure and an assessment for the first year following the accident.

The PC COSYMA software takes into account all principal exposure pathways:

- External exposure from the plume;
- External exposure from material deposited on the ground;
- External exposure from material deposited on skin and clothing;
- Inhalation of material in the plume;
- Inhalation of resuspended material;
- Ingestion of food.

For the assessment over a period of 10 days, food ingestion has not been taken into account. For the assessment over a period of 1 year, all external and internal pathways have been taken into account.

For the assessment over a period of 10 days, both effective dose and equivalent dose to the thyroid have been assessed. For the assessment of doses over a period of 1 year, all external and internal pathways have been taken into account.

5.3.5. Results of the independent dose assessment for severe accidents

5.3.5.1. Independent short term dose assessments

(i) Doses to members of the public using the AIDA model

As mentioned above, dilution factors and therefore doses are higher for the stable weather conditions. Table 22 shows the results of the short term assessment (in mSv) for stable conditions.

The equivalent dose to the thyroid for infants is similar in both the Rosenergoatom results and the present independent assessments. The equivalent dose to the body assessed by Rosenergoatom is about one third of the present independent assessment for the effective dose. This might be because inhalation is taken into account in the independent assessment, whereas it is not included in the Rosenergoatom assessment. Additionally, the difference in the confidence levels (95% for the Rosenergoatom assessment; 99% for the independent assessment) may contribute to the differences between the Rosenergoatom assessment and the independent assessment. Table 23 shows the pathway breakdown of the short term dose calculated by AIDA for distances of 1 and 10 km from the Baltic-1 NPP.

(ii) Doses to members of the public using the PC COSYMA model

Using PC COSYMA, a range of meteorological conditions have been assessed and the maximum doses are presented in Table 24 are the results of the short term assessment. The effective dose assessed by Rosenergoatom is similar to the presented independent assessment using PC COSYMA.

TABLE 22. SHORT TERM DOSES ESTIMATED FOR INFANTS AND ADULTS USING THE AIDA SOFTWARE

Age group	**Exposures in dependence of the distance to the Baltic-1 NPP (mSv)**									
Endpoint	**1 km**	**2 km**	**3 km**	**4 km**	**5 km**	**6 km**	**7 km**	**8 km**	**9 km**	**10 km**
Adults Effective dose	21	6.7	3.3	2.0	1.3	0.95	0.71	0.56	0.045	0.037
Infants Effective dose	30	9.3	4.5	2.7	1.8	1.3	0.95	0.74	0.59	0.48
Adults Thyroid dose	140	42	20	12	7.8	5.5	4.1	3.1	2.5	2.0
Infants Thyroid dose	310	95	45	27	17	12	9.0	6.9	5.5	4.4

TABLE 23. BREAKDOWN OF THE SHORT TERM DOSE FOR INFANTS (1–2 YEARS OLD) AND ADULTS FOR DISTANCES OF 1 KM AND 10 KM FROM THE BALTIC-1 NPP USING THE AIDA SOFTWARE

Age group/ exposure pathway	**Contribution of the pathways to total dose (%)**	
Adults	**1 km**	**10 km**
External exposure from cloud	35	47
External exposure from ground	26	21
Inhalation	39	32
Infants (1–2 years old)		
External exposure from cloud	25	36
External exposure from ground	19	16
Inhalation	56	48%

TABLE 24. MAXIMUM SHORT TERM DOSES ASSESSED WITH THE PC COSYMA SOFTWARE (IN mSv)

Age group	**Exposures in dependence of the distance to the Baltic-1 NPP (mSv)**									
Endpoint	**1 km**	**2 km**	**3 km**	**4 km**	**5 km**	**6 km**	**7 km**	**8 km**	**9 km**	**10 km**
Adults Effective dose	4.6	1.3	1.2	0.87	0.71	0.56	0.41	0.39	0.35	0.31
Adults Thyroid dose	61	17	17	14	12	7.4	6.9	6.2	5.7	4.4

(iii) Model uncertainty

No comprehensive uncertainty analyses of the dose assessments have been performed. However, the thyroid doses assessed with the three independent models (Rosenergoatom, AIDA, PC COSYMA) are of the same order. As the case for routine releases, it is considered that the greatest source of uncertainty relates to the source term used to represent the accident. For all three assessments, the same source term has been used. The review of the source term was outside the scope of this report.

OBSERVATION

Independent assessments of the equivalent doses to the thyroid following releases for severe accidents using the AIDA code confirm the order of magnitude of the Rosenergoatom assessment. The results obtained for the effective dose using AIDA are higher than the results from the Rosenergoatom assessment for the equivalent dose for the whole body, probably because Rosenergoatom did — according to NRB/99 — not take into account the inhalation pathway and because of differences in the confidence levels of the calculations. However, these differences have — in this particular case — no implications for the conclusion with regard to the implementation of protective measures.

The alternative assessment, using PC COSYMA calculated similar equivalent doses for the thyroid as those presented by Rosenergoatom.

For the accident of the type and magnitude considered in the EIA Materials [2], the independent short term assessment confirms that the urgent protective measures would be limited mainly to sheltering and iodine prophylaxis in a zone less than 10 km from the NPP, even in unfavourable meteorological conditions.

5.3.5.2. Independent dose assessment over a period of 1 year exposure

(a) Results from the AIDA model

Table 25 shows the results of the assessment of effective doses for infants and adults received during a period of 1 year. The ingestion pathway contributes up to 50% and 80% to the total dose for adults and infants respectively. The effective dose assessed over a period of 1 year by Rosenergoatom is about half that of the present independent assessment. This might be because ingestion is not taken into account in the Rosenergoatom assessment, and because of differences in the confidence levels of the calculations.

Table 26 shows the pathway breakdown of the longer term dose for adults and infants calculated using the AIDA software, at 1 km and 10 km from the stacks.

(i) Results from the PC COSYMA model

Table 27 shows the results of the PC COSYMA code for the assessment of the effective doses for adults received during a period of 1 year. The breakdown of exposure pathways to an adult comprises around 70% of the dose due to food ingestion, 20% due to external exposure, and around 10% of the dose is due to the initial inhalation of radioactive material whilst releases were occurring.

The effective dose assessed by Rosenergoatom is around one third lower than the PC COSYMA independent assessment. This may be because ingestion is not taken into account in the Rosenergoatom assessment, and because of differences in the confidence levels of the calculations.

TABLE 25. RESULTS OF THE ASSESSMENT OF DOSES (IN mSv) RECEIVED OVER A PERIOD OF 1 YEAR; THE DOSES ARE ASSESSED WITH THE AIDA SOFTWARE

Age group	**Exposures in dependence of the distance to the Baltic-1 NPP (mSv)**									
Endpoint	**1 km**	**2 km**	**3 km**	**4 km**	**5 km**	**6 km**	**7 km**	**8 km**	**9 km**	**10 km**
Adults Effective dose	93	27	13	7.4	4.9	3.5	2.6	2.1	1.6	1.4
Infants Effective dose	250	72	34	20	13	9.4	7.1	5.5	4.4	3.6

TABLE 26. BREAKDOWN OF THE LONG TERM DOSE FOR INFANTS (1–2 YEARS OLD) AND ADULTS FOR DISTANCES OF 1 KM AND 10 KM FROM THE BALTIC-1 NPP USING THE AIDA SOFTWARE (MAY NOT RESULT IN 100% DUE TO ROUNDING ERRORS)

Age group/ exposure pathway	**Contribution of the pathways to total dose**	
Adults	**1 km**	**10 km**
External exposure from cloud	1%	0.5%
External exposure from ground	47%	63%
Inhalation of the plume	1%	0.4%
Inhalation of resuspended particles	0%	0%
Ingestion	51%	36%
Infants (1–2 years old)		
External exposure from cloud	0.4%	0.2%
External exposure from ground	21%	34%
Inhalation of the plume	1%	0.4%
Inhalation of resuspended particles	0%	0%
Ingestion	78%	65%

TABLE 27. RESULTS OF THE ASSESSMENT OF DOSES (IN mSv) RECEIVED OVER A PERIOD OF 1 YEAR (PC COSYMA SOFTWARE)

Age group	**Exposures in dependence of the distance to the Baltic-1 NPP (mSv)**									
Endpoint	**1 km**	**2 km**	**3 km**	**4 km**	**5 km**	**6 km**	**7 km**	**8 km**	**9 km**	**10 km**
Adults Effective dose	150	52	27	21	15	12	10	8.1	6.5	6.1

OBSERVATION

Independent longer term assessments using AIDA and PC COSYMA of the consequences of accidental releases confirms the order of magnitude of the Rosenergoatom assessment. These results also confirm the conclusion of Rosenergoatom (Ref. [2], Section 6.4.2.2.7) that the contamination of local foodstuff may require restriction of their consumption.

5.4. TRANSBOUNDARY CONSIDERATIONS

5.4.1. Summary of text in EIA Materials on transboundary issues

The consideration of potential transboundary impacts is a requirement of the Espoo Convention. The distances of the Baltic-1 NPP to the borders to Lithuania and Poland are approximately 10 km and 65 km respectively, which requires the exploration of potential impacts to these countries for routine discharges and, in particular, for accidental scenarios.

In the EIA Materials, it is described that the calculations of doses to the public during both normal operation and accidental situations have included the considerations of impacts to Lithuania and Poland as well.

It is concluded in the EIA Materials that, during normal operation of the Baltic-1 NPP, radiological impacts to both Lithuania and Poland, are very low. For severe accidents, protective actions as evacuation, iodine prophylaxis, long term resettlement, and sheltering is limited to a zone of 5–7 km, when applying Russian regulations.

Furthermore, it is concluded that beyond a distance of 7 km to the Baltic-1 NPP, it may be necessary to restrict the consumption of certain agricultural products, which could potentially affect also Lithuania and Poland.

In the EIA Materials, not all details of the calculations necessary for the consequences of the radiological impacts arising from severe accidents are given. Therefore, the Review Team decided to perform independent assessments, for which the Review Team requested further information. This material was provided promptly, it can be found in Annexes II and III. The following results and conclusions are based on the independent assessments performed by the Review Team, which are presented above in Sections 5.2 (for normal operations) and 5.3 (for accidental releases).

5.4.2. Normal operations

5.4.2.1. Airborne routine discharges

(a) Results from the AIDA model

The independent dose assessment of the routine airborne discharges show that effective dose at 10 km in the 10°–30° direction (close to Lithuania) from expected discharges (Table 8) are very low, 0.12 µSv/a for infants and 0.09 µSv/a for adults. These doses are well below the dose limit of 1 mSv/a (equivalent to 1000 µSv/a) recommended in the IAEA safety standards.

(b) Results from the PC CREAM 08 model

The independent dose assessment of for the expected routine discharges to the atmosphere using the PC CREAM 08 code result in annual effective dose of 0.18 µSv/a for infants and 0.14 µSv/a for adults at 10 km in the NE direction (close to Lithuania). The doses are well below the dose limit of 1 mSv/a recommended in the IAEA safety standards.

> OBSERVATION
>
> The radiological consequences of routine airborne discharges in Lithuania would be less than 1 µSv/a. This is more than a factor of 1000 below the dose limits for members of the public as recommended in the IAEA safety standards.

5.4.2.2. Liquid routine discharges

During normal operation, radionuclides are discharged to the Neman River. Mixing is assumed to occur rapidly after the discharge into the river. The EIA Materials indicate that complete mixing is achieved within 50 m from the discharge point (Ref. [2], Section 6.4.1.4.6). This implies that the doses received by people in Lithuania would be the same as those received by people in the Kaliningrad region, i.e. for the AIDA software about 0.1 µSv/a (adults) and 0.06 µSv/a (infants) for the expected discharges. Using the PC CREAM 08 software, the estimated doses for expected discharges are 0.1 µSv/a (for adults and infants). These doses are very well below the dose limit of 1 mSv/a recommended in the IAEA safety standards.

OBSERVATION

The radiological consequences of routine liquid discharges in Lithuania would be less than 1 µSv/a. This is a about a factor of 1000 below the dose limits for members of the public as recommended in the IAEA safety standards.

5.4.3. Accidental releases

5.4.3.1. Assessment of short term doses

The results of two independent assessments using the AIDA and PC COSYMA software packages of the short term consequences of a severe accident and shown in Section 5.3.5.1 exhibit less than 1 mSv effective doses and less than 5 mSv equivalent doses to the thyroid for the 7/10 day assessment at a distance of 10 km (adults and infants).

OBSERVATION

In the event of accidental releases of radioactive effluents, which may follow an accident of the type and magnitude considered in the EIA Materials [1–3], the short term doses likely to be received by the populations in Lithuania and Poland would be below the values (Tables 6 and 7) that would require mandatory protective actions such as iodine thyroid blocking, sheltering, or evacuation.

5.4.3.2. Assessment of doses received during the first year after the accidents

The results of two independent assessments using the AIDA and PC COSYMA models of the consequences of a severe accident during the first year of exposure are shown in Section 5.3.5.2. The assessment using the AIDA code result in effective doses in the first year after the accident of 1 and 4 mSv for adults and infants respectively at a distance of 10 km. For the PC COSYMA assessment, the calculations provide maximum doses to adults at a distance of 10 km of about 6 mSv.

OBSERVATION

In the event of accidental releases of radioactive effluents, which may follow an accident of the type and magnitude considered in the EIA Materials, the long term doses likely to be received by the populations in Lithuania and Poland would be below the values that would require protective actions.

For completeness purposes, Rosenergoatom may wish to include the criteria that would be used to initiate protective actions in the event of accidental releases in the EIA Materials [1–3] (see also Ref. [8]).

5.4.3.3. Contamination of foodstuffs

Results of the independent assessment show that the contamination of some foodstuff may exceed the European maximum permissible levels [38] for a few days after the accident in the case of unfavourable meteorological conditions.

(a) Results from the AIDA model

With most unfavourable meteorological conditions, that is to say for less than 1% of the unfavourable weather conditions (in other words, 99% of the year, the weather conditions during the accidental releases would entail smaller distances), this could be the case to distances up to:

— About 50 km for iodine in cow milk;
— About 50 km for iodine in leafy vegetables;
— About 20 km for long lived nuclides in beef meat.

If the wind direction is toward the North Direction during the accidental releases, foodstuffs produced in Lithuania could therefore be more contaminated than European maximum permissible levels. Due the distance to the Poland boundary, it is unlikely that the contamination of foodstuffs in that country would exceed maximum permissible levels.

(b) Results from the PACE model

The PACE software was used to estimate the extent of food restrictions that may be required if such an accidental release occurred. The PACE software was used to sample 288 meteorological sequences from the 2 years of NWP meteorological data available. The results of the assessments were compared against both the EURATOM[11] maximum permissible levels (MPLs) in foods and the Codex Alimentarius [39] values for radionuclides in foods. The figures presented below (Figures 1–5) show the probability of food restrictions being required for the indicated criteria over all meteorological sequences sampled assuming a ground level (0 m) release height for low altitude releases. For the EURATOM MPLs, the restrictions for milk extend to a distance of around 40 km from the Baltic-1 NPP site for restrictions lasting for 7 days or longer. If the Codex Alimentarius values are applied, then the restrictions may be required over a larger area extending up to 120 km from the site.

The equivalent restrictions for green vegetables are more extensive than those for milk due to the potential direct deposition of released nuclides on vegetable surfaces. The

[11] European Commission's complementary research programme for nuclear research and training.

restrictions for green vegetables may be required at distances of up to 120 km from the Baltic-1 NPP site for a period of at least 7 days. Using the Codex Alimentarius values, the restrictions may be required to extend to distances of 300 km or more for a period of 7 days or more. An additional figure has been included for restrictions of 30 days or longer duration. This indicates that such restrictions may extend to distances of up to 200 km. For both green vegetables and milk, the restrictions are primarily due to the activity concentrations of iodine that are present in the food.

Additional calculations were undertaken using the PACE code to consider the effect of using a 30 m release height for the low altitude releases. Figures 6 and 7 show the 7 day EURATOM MPL restrictions for milk and green vegetables. These figures can be compared with Figures 1 and 3, which show that the change in release height only has a very minor effect on the extent of the presented probabilities.

OBSERVATION

The food production in Lithuania could be affected by a severe accident at the Baltic-1 NPP and restrictions may have to be implemented on a significant area.

This confirms the Rosenergoatom plan to restrict consumption of local foodstuffs within an up to 300 km radius area in case of an accident with significant release (Annex III) is to be taken into account in Lithuania.

However, the consequences for an accident of the type and magnitude considered in the EIA Materials would be limited in time as the contamination of vegetables, milk and meat would decrease significantly when the direct contamination of the plants (through leaves) becomes insignificant compared to indirect contamination (uptake from soil via the roots).

For the same type of accident, the food production in Poland would not be significantly affected and it is extremely unlikely that restriction would have to be implemented at significant time and space scales. As demonstrated in the presented results however, there is potential for food restrictions to be required in both neighbouring countries.

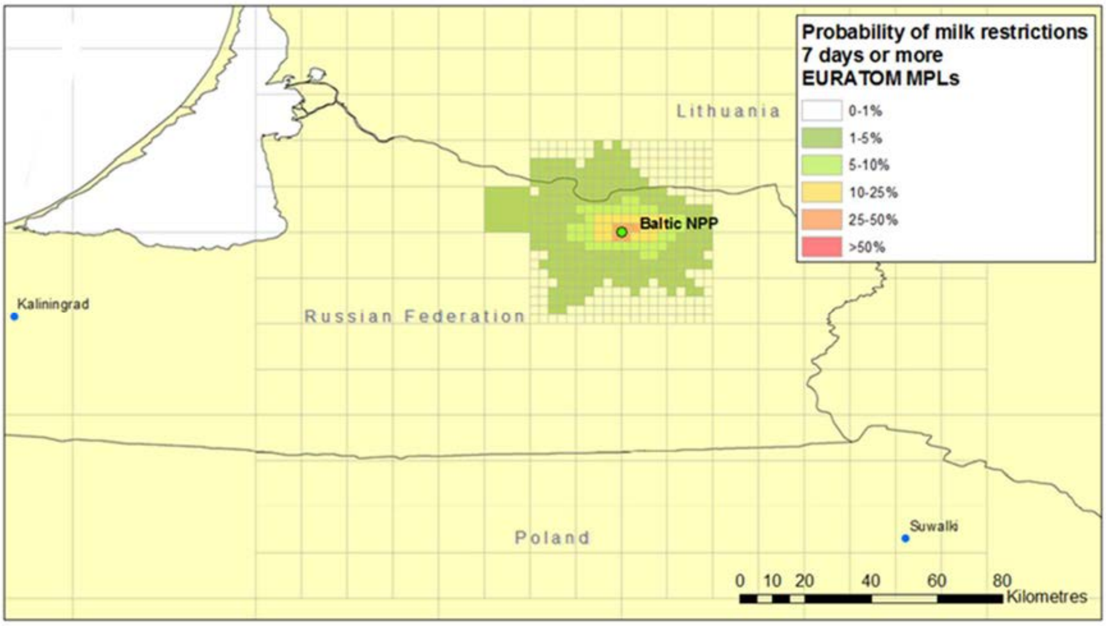

FIG. 1. Map showing the probability across sampled meteorological sequences of EURATOM maximum permissible levels in milk being exceeded for a period of greater than 7 days if a severe accident occurs (image courtesy of Public Health England).

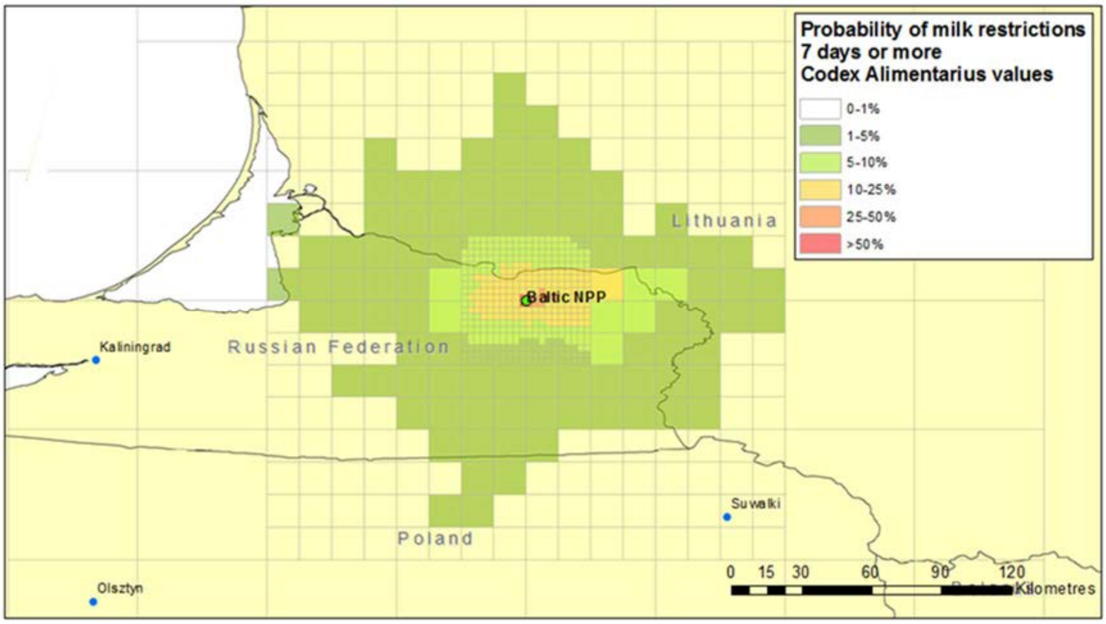

FIG. 2. Map showing the probability across sampled meteorological sequences of Codex Alimentarius values in milk being exceeded for a period of greater than 7 days if a severe accident occurs (image courtesy of Public Health England).

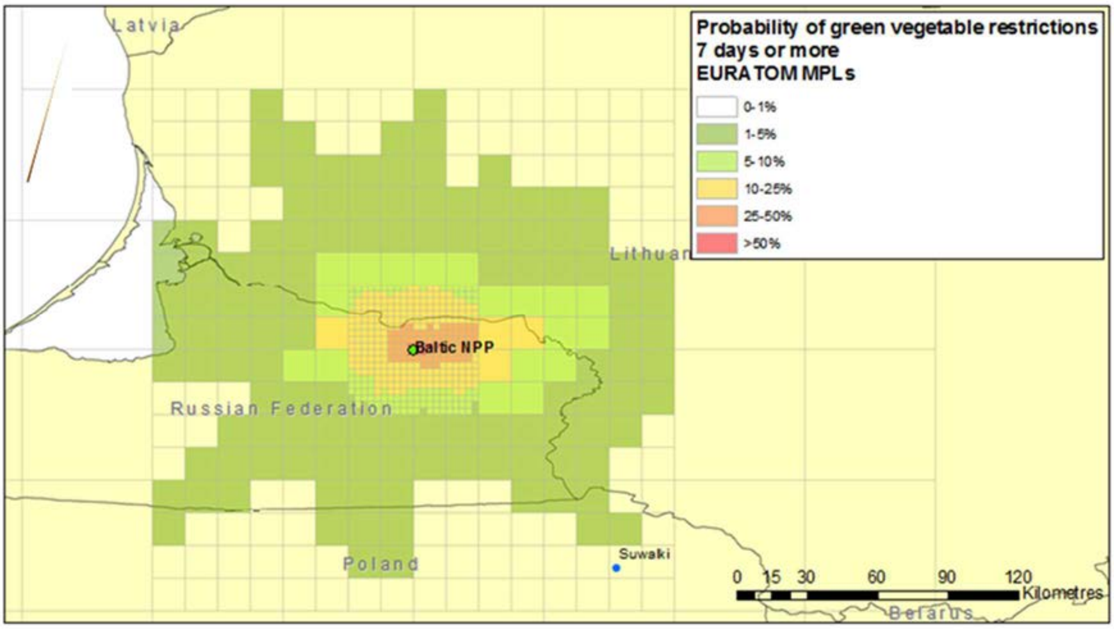

FIG. 3. Map showing the probability across sampled meteorological sequences of EURATOM maximum permissible levels in green vegetables being exceeded for a period of greater than 7 days if a severe accident occurs (image courtesy of Public Health England).

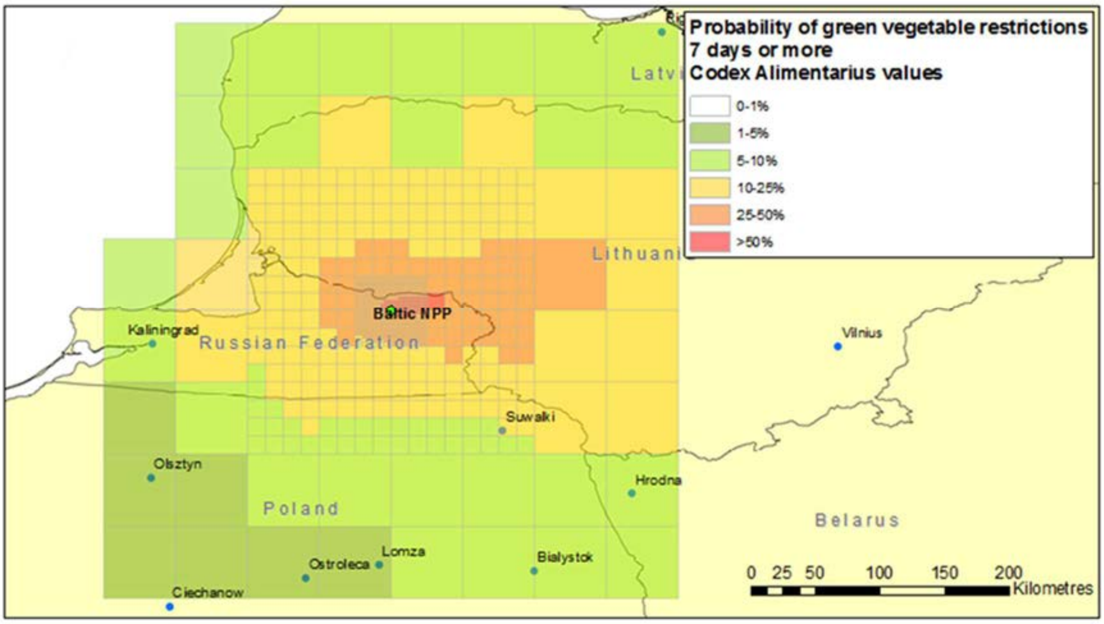

FIG. 4. Map showing the probability across sampled meteorological sequences of Codex Alimentarius values in green vegetables being exceeded for a period of greater than 7 days if a severe accident occurs (image courtesy of Public Health England).

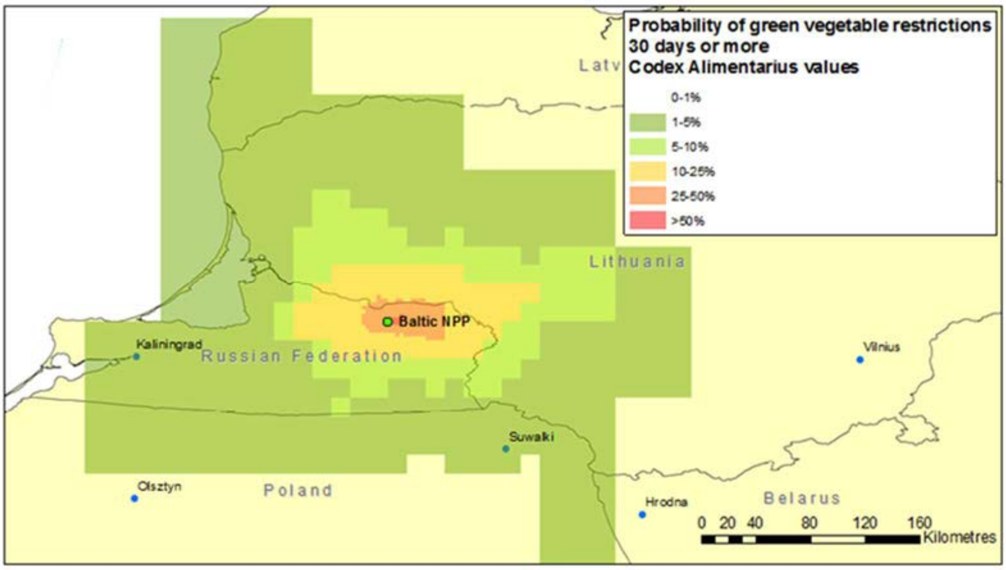

FIG. 5. *Map showing the probability across sampled meteorological sequences of Codex Alimentarius values in green vegetables being exceeded for a period of greater than 30 days if a severe accident occurs (image courtesy of Public Health England).*

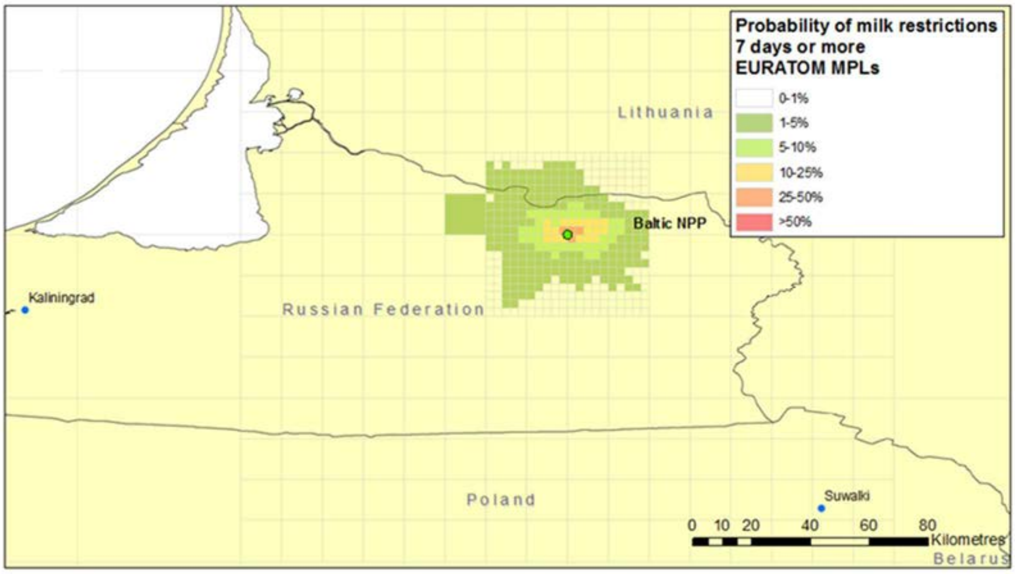

FIG. 6. *Map showing the probability across sampled meteorological sequences of EURATOM maximum permissible levels in milk being exceeded for a period of greater than 7 days if a severe accident occurs using a release height of 30 m for the low altitude part of the source term (image courtesy of Public Health England).*

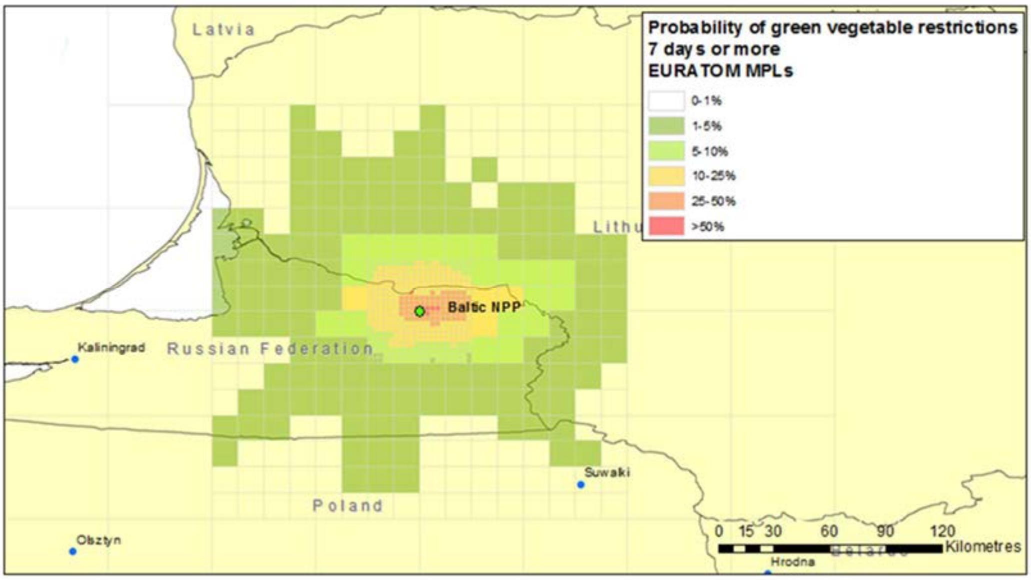

FIG. 7. Map showing the probability across sampled meteorological sequences of EURATOM maximum permissible levels in green vegetables being exceeded for a period of greater than 7 days if a severe accident occurs using a release height of 30 m for the low altitude part of the source term (image courtesy of Public Health England).

5.5. SOURCE AND ENVIRONMENTAL MONITORING

5.5.1. Source monitoring

Liquid discharges from the Baltic-1 NPP are transported via the 14 km cooling water pipeline to the Neman River. This is described in Section 9.1.2 of the EIA Materials. As the liquid effluents contain radionuclide, the effluents will be monitored prior to discharge ensuring that discharges are controlled and within authorized limits. Automated process radiation monitoring systems prevent unauthorized discharges of liquid effluents to the river.

Discharges from the Baltic-1 NPP to air through 100 m stacks are described in Section 9.2 of the EIA Materials [2]. Low levels of radionuclides comprising noble gases, radioiodine and aerosols will be released to air after filtration and automated process radiation monitoring systems will provide documentation that discharges are within authorized limits. These systems are planned to operate under all plant conditions, including accidents.

OBSERVATION

The Review Team notes that Baltic-1 NPP discharges to environment of liquid effluents and discharges to air are monitored and are in general agreement with IAEA recommendations and safety standards [12].

Information on particle size distribution of aerosols discharged to air can be helpful in order to evaluate the environmental impact. Rosenergoatom may wish to consider the inclusion of particle size distribution in the monitoring programme.

5.5.2. Environmental monitoring

A comprehensive programme is planned for monitoring of environmental radioactivity within the Baltic-1 NPP site limits and 20 km beyond as described in Section 11 of the EIA Materials [2]. The programme covers all environmental components of relevance to human exposure including air, water, soil, agricultural and forest products, freshwater systems and gamma dose rate. Monitoring of radioactivity includes relevant man-made radionuclides (^{3}H, ^{14}C, ^{54}Mn, ^{60}Co, ^{89,90}Sr, ^{131}I, ^{134,137}Cs, ^{239,240}Pu) as well as naturally occurring radionuclides.

A number of locations at and around the Baltic-1 NPP site will be equipped with automatic radiation monitoring stations, all of them record gamma dose rates and some of them samples will be collected for laboratory analyses of radionuclides in aerosols (filter ventilation units) and in precipitation (Table 28 and Figure 8). These automatic systems provide data under normal operating conditions as well as under accident conditions and therefore also cover needs for environmental monitoring in emergencies. At the same locations, samples will be collected intermittently including soil, vegetation, bed deposits, algae, fish, pine needles, milk, grain, vegetables, fruit and meat. The samples will be analysed in the laboratory for radionuclides.

Base line studies of environmental radioactivity in the area have been carried out (Section 3.9.5 of the EIA Materials [1]) describing pre-operational levels of man-made and naturally occurring radionuclides in the environment. The levels reported are low, in general, and in agreement with contamination of man-made radionuclides in Northern Europe from the Chernobyl accident in 1986.

Monitoring results of ^{3}H and ^{14}C will be compared with model calculations based on actual discharges enabling improvement of models using local data.

TABLE 28. LOCATIONS OF AUTOMATIC RADIATION SITUATION MONITORING STATIONS WITH AIR FILTER UNITS, DISTANCES AND DIRECTIONS FROM THE BALTIC-1 NPP TO THE LOCATIONS ARE LISTED

Location	Distance to Baltic-1 NPP (km)	Direction from Baltic-1 NPP	Gamma station	Air filter station
NPP site	0		4	
Meteorological station at Baltic-1 NPP	0		1	1
Neman river station	10	NNW	1	
Lagernoe (not on map)	10	NNE	1	
Malomozhayskoe	2	E	1	1
Uzlovoe	8	SE	1	
Gannovka	3	W	1	1
Yluanovo	12	SSW	1	
Lunino	6	W	1	1
Pokrovskoe	16	SW	1	
Zhilino	15	W	1	
Nemanskoe	17	NE	1	
Iskra	14	WSW	1	
Rakitino	14	NW	1	
Neman	14	NNW	1	1
Kalacheevo	6	NE	1	1
Krasnozhamensk	18	ENE	1	1

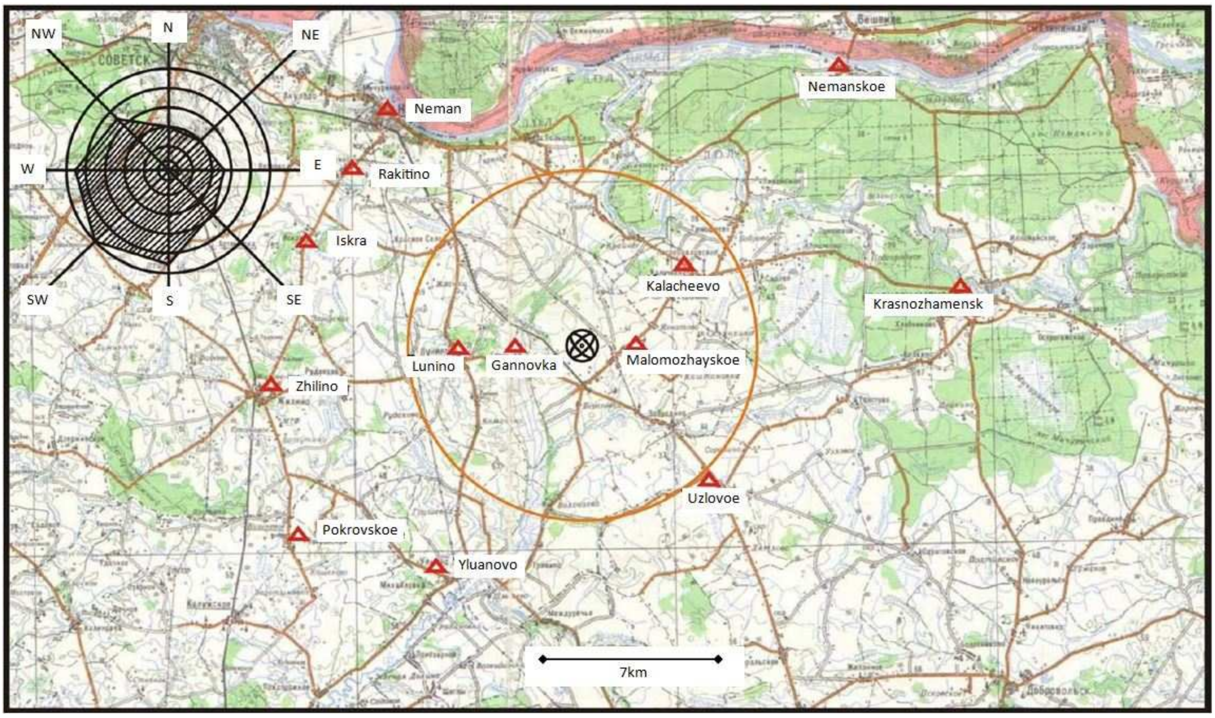

FIG. 8. Locations of monitoring stations and the wind rose at the site. The circle with a radius of 7 km indicates the protective measures planning zone (reproduced from Ref. [2] with permission).

OBSERVATION

The Review Team notes that the monitoring programme is very comprehensive and that the data collected will permit important documentation of the environmental impact from the Baltic-1 NPP in general agreement with IAEA recommendations and safety standards [12].

An important goal of the monitoring programme is to check the assumptions and validate the results of the safety assessment. Thus, the monitoring programme should pay particular attention to the critical pathways and the critical radionuclides. This is not clearly described in the EIA Materials.

The monitoring programme does not give detailed information on the frequencies of data collection. Automatic systems provide information continuously, but it would be useful to specify how frequent collection of environmental samples and analyses are made rather than stating that samples are collected and analysed intermittently (Table 11.9.2 of the EIA Materials [2]). The information in this table suffers from misprints (e.g. units of kg^3, range of measurement of ^3H of $1\text{-}10^3$ Bq/m^3, volumetric activities in units of Bq/kg).

The implications of the last statement in Section 11.2 of the EIA Materials [2] are not clear (“Information on land use and parameters of produced agricultural products in the eastern station location area requires solution”).

The filter ventilation devices collect aerosols, but it is not clear if they will also be equipped with charcoal cartridges for collection of gaseous iodine. Information on the latter is of importance in case of accidental releases.

The monitoring programme described in Section 11.6 of the EIA Materials [2] includes components from lake ecosystems, but such samples are not included in the recommended scope for the environmental monitoring programme listed in Table 11.8.1 of the EIA Materials [2].

OBSERVATION (continued)

Locations for automatic radiation system monitoring stations around the Baltic-1 NPP site cover directions towards East and West, but coverage towards North (Lithuania) and South (Poland) is limited. Furthermore, selection of these locations seems not to take into account frequent wind directions towards North to North-East. The locations for measurements and sampling should be determined on a site specific basis with the aim of determining the highest radiation doses to the public and identifying the areas most contaminated with radionuclides. The Review Team suggests that selection of locations for automatic monitoring stations should be reconsidered in view of these observations.

The use of quality assurance is a requirement in the IAEA safety standards [8, 12] and should be an integral part of programmes for monitoring. Quality assurance should be used to provide for a disciplined approach to all activities affecting quality, including, where appropriate, verification that each task has met its objectives and that any necessary corrective actions have been implemented. It is not clear from the EIA Materials to what extent quality assurance is taken into consideration in the monitoring programmes.

5.6. TRANSPORTATION

Spent nuclear fuel is planned to be stored on site for a minimum of 3 years to reduce radioactivity and heat release to levels that do not require forced cooling. Spent fuel is then loaded in special purpose containers and transported by sea to St. Petersburg from where the fuel is transported by train to a plant for nuclear fuel reprocessing.

Liquid radioactive waste is solidified on-site. Solidified liquid radioactive waste and solid radioactive waste is stored on site for up to 10 years and then transported to regional storage in St. Petersburg.

Design and operation of radioactive waste handling including spent nuclear fuel is based on normative documentation of the Russian Federation, IAEA standards and international practice.

OBSERVATION

Transportation of spent fuel is mentioned in Section 7.6 of the EIA Materials [2] to be carried out by land or by air. It is not clear if sea transport involves special vessels designed for the purpose and to what extent air transport of spent fuel may be used with specially designed aircraft and if that agrees with international regulations. The routes and means of transportation by land of radioactive waste from Baltic-1 NPP to the regional point (Sosnovy Bor, Leningrad region) are not described.

At the review meeting in St. Petersburg (see Annex IV), Rosenergoatom noted that both spent nuclear fuel and radioactive waste would be shipped by rail to the Kaliningrad seaport, then by ship to the St. Petersburg seaport, and subsequently by rail to a nuclear fuel recycling plant and/or waste management facility. The EIA Materials could be further developed by including more details on the transport of radioactive waste and spent fuel.

Section 6.1.1 of the EIA Materials [2] mentions the transportation of construction waste and rubbish to a burial site and gives reference to Section 7.3.5 of the EIA Materials [2], but such a section is not found in the publication.

5.7. DECOMMISSIONING

5.7.1. Plans for decommissioning as described in the EIA Materials

The EIA Materials do not clearly describe the arrangements for decommissioning of the Baltic-1 NPP after operation has ended. The expected lifetime of the main equipment of the Baltic-1 NPP is 60 years after which operation of the plant will end and decommissioning activities begin. Decommissioning constitutes the last major stage of the lifetime of the power plant and refers to the administrative and technical actions taken to allow the removal of regulatory controls of the plant.

The conceptual approach to decommissioning of the Baltic-1 NPP is described in Section 8 of the EIA Materials [2] and gives reference to a number of Russian normative standards that include basic safety rules for nuclear power plants as well as basic provisions and safety rules for decommissioning of nuclear power plants.

The design of decommissioning is developed 5 years before the expiration of the lifetime of the power unit. The design involves a large number of activities that include analysis of radioactivity and radiation in the plant, development of documentation regulating decommissioning work, development of methods for handling heavily contaminated equipment and areas. The design also involves a plan for protection of personnel and population in the event of an accident during decommissioning including emergency actions to be taken.

The decommissioning design will provide a number of technical solutions aimed at reducing radiation doses to personnel. These solutions include practical means of handling radioactive waste efficiently.

Decommissioning of a nuclear power unit is basically planned as either liquidation or burial. Liquidation means total dismantling, conditioning of radioactive waste and transport of the waste to a regional repository. Burial means removal or reuse of components and building structures while radioactive waste is conditioned and stored in the former controlled access area with reinforced radionuclide barriers. These two options have been analysed and burial was found to be preferable as compared to liquidation.

The environmental safety of the power unit under decommissioning will be ensured by removing spent nuclear fuel from the reactor after final shutdown followed by fuel transport to treatment facilities. Decommissioning of buildings and structures will follow in stages, and radiation monitoring in the environment of plant location area will provide information on the radiation situation during decommissioning.

Most parts of the power unit are not contaminated by radioactivity and will be dismantled by conventional means. According to Russian standards, materials and manufactured articles with low content of man-made radioactivity are allowed to be used if these articles do not have loose radioactive contamination on surfaces and the expected annual individual dose from the intended use is below 10 μSv/a. Decontamination techniques will be applied to reduce the amount of radioactive waste. The volume of low and intermediate level radioactive waste is estimated to 2050 m^3 and that of high level radioactive waste to 85 m^3.

5.7.2. Recommendations on decommissioning in the IAEA safety standards

According to the IAEA safety standards, considerations of decommissioning at the planning stage needs to address the principal feasibility with available technologies, mechanism to ensure the availability of financial resources in the decommissioning stage, a rough estimation of the waste streams and appropriate record keeping to during operation to facilitate decommissioning.

According to the recently published IAEA Safety Standards on decommissioning [40], the licensee shall select a decommissioning strategy that will form the basis for the planning for decommissioning. The strategy shall be consistent with the national policy on the management of radioactive waste (Requirement 8). The licensee shall prepare a decommissioning plan and shall maintain it throughout the lifetime of the facility, in accordance with the requirements of the regulatory body, in order to show that decommissioning can be accomplished safely to meet the defined end state (Requirement 10).

OBSERVATION

The Review Team notes that the description of decommissioning activities takes into account important features that promote safety, protection of workers and the public, and protection of the environment.

The Review Team notes that the IAEA has recently issued new requirements concerning decommissioning [40]. Although this new publication does not form part of the reference publications for this international peer review, Rosenergoatom may wish to incorporate some aspects into the EIA Materials, for example:

According to the new Safety Standards on decommissioning [40], it is required that a decommissioning strategy is selected and that a decommissioning plan is prepared at the early design stage of a new facility and shall continue through to termination of the authorization of decommissioning. Thus decommissioning should be taken into account in the siting, design, construction, commissioning and operation of the facility, by means which include features to facilitate decommissioning, the maintenance of records of the facility, and consideration of physical and procedural methods to limit contamination and/or activation. Decommissioning shall include aspects of safety, health, security, environmental, quality and economic elements.

Entombment, in which all part of the facility is encased in a structurally long lived material, is not considered as decommissioning strategy and is not an option in the case of planned permanent shutdown.

The description of decommissioning is not fully integrated in the EIA Materials, [2] therefore it cannot be evaluated whether the decommissioning plan developed is in agreement with IAEA's General Safety Requirements.

6. SUMMARY AND CONCLUSIONS

6.1. CONDUCT OF THE INTERNATIONAL PEER REVIEW

The Baltic-1 Nuclear Power Plant (NPP) is a 2 unit power plant that is under construction in the Neman District of the Kaliningrad Oblast of the Russian Federation. The State Atomic Energy Corporation of the Russian Federation (ROSATOM) requested the services of the International Atomic Energy Agency (IAEA) in conducting an international peer review of the Environmental Impact Assessment (EIA) for the Baltic-1 NPP.

The objective of the international peer review was to provide Rosenergoatom with a report which explores the consistency of the EIA Materials with the IAEA safety standards in the field of radiation protection of the public and the environment. Noting that the Kaliningrad exclave borders Poland and Lithuania, ROSATOM also requested that the EIA Materials be reviewed against the requirements of the Espoo Convention, Environmental Impact Assessment in a Transboundary Context.

Further objectives of the review were to facilitate the sharing of good practices, identified during the review, to provide feedback on the development of international standards, and to provide recommendations on the further development of the radiological parts of the environmental impact assessment.

For the purposes of this international peer review, an unofficial English translation of the EIA Materials was supplied by Rosenergoatom Concern OJSC (Rosenergoatom), and the IAEA established an international team of experts under the management of a staff member from the Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety (NSRW).

The work of the International Peer Review Team was conducted, primarily, through reviewing the materials at their base locations. The original EIA Materials provided for the review did not contain all information necessary for the performance of the peer review. Additional information was obtained through a visit to the Baltic-1 NPP site in February 2014, and through written responses to questions posed by the Review Team.

The International Peer Review Team held a meeting in July 2014 at IAEA Headquarters to consider the outcomes from the review and an interim report was submitted to Rosenergoatom in October 2014.

In November 2014, a meeting was held in St. Petersburg to discuss the contents of the interim report. A copy of the draft final report was provided to Rosenergoatom in December 2014 to enable the report to be checked for factual correctness. The final report was presented to Rosenergoatom in January 2015.

6.2. CONSISTENCY OF THE EIA MATERIALS WITH THE REFERENCE PUBLICATIONS

As a general observation, the content of the EIA Materials — complemented with responses to the Review Team's questions — meet the requirements of the reference publications.

The International Peer Review Team acknowledges that Rosenergoatom Concern OJSC has provided a comprehensive set of EIA Materials [1–3] for the proposed Baltic-1 NPP.

The International Peer Review Team has analysed the EIA Materials with respect to radiation protection of the public and the environment. The review emphasized whether the requirements in the IAEA Standards related to public exposure are appropriately addressed in the EIA Materials. Beyond the assessment of exposures during normal operation and following accidental releases, this includes the discussion of environmental monitoring, transboundary considerations, and — as far as aspects of radiation protection of the public is concerned — transport of radioactive material and decommissioning of the facility.

The Review Team concludes that the EIA Materials [1–3], complemented with the responses to the questions of the Review Team (Annexes II–IV), meet the requirements of the reference publications (IAEA Standards, Espoo Convention [1, 7–14]).

As requested, the International Peer Review Team has identified areas — for the consideration of Rosenergoatom, where the EIA Materials could be further developed. These areas are incorporated into the text of this report. In particular, the International Peer Review Team would like to highlight the following suggestions that Rosenergoatom may wish to consider:

— Some important information concerning the potential environmental impact of the Baltic-1 NPP has been provided by Rosenergoatom in response to the questions of the Review Team (Annexes II–IV). The EIA Materials could be further developed by the inclusion of this information.
— The transboundary aspects of the EIA Materials could be further developed by:
  - An explicit reference to the Espoo Convention;
  - The inclusion of additional details on the communications with neighbouring states that have occurred, and are planned;
  - By a more detailed discussion on the transport of radioactive waste (e.g. transportation modes and routes).
— The decommissioning aspects of the EIA Materials could be further developed by reference to the newly released IAEA safety requirements publication [40].

6.3. EXPOSURES TO THE PUBLIC DURING NORMAL OPERATION AND ACCIDENTAL RELEASES

In order to check the results of the estimation of radiation doses provided in the EIA Materials, the International Peer Review Team conducted independent prospective dose calculations for the Baltic-1 NPP, using source terms provided by Rosenergoatom, for both expected routine discharges and accidental releases to the environment. For the independent assessments performed by the Review Team, internationally recognized assessment models were used. The conclusions of the Review Team — achieved on the basis of the independent assessments — are in agreement with the statements in the EIA Materials. In particular:

- For the expected routine conditions, the doses received by the most exposed individuals from airborne and liquid discharges would be well below 10 μSv/a and at least two orders of magnitudes lower than the doses limit for the annual effective dose of 1 mSv/a recommended in the IAEA safety standard for planned exposure situations.
- For the accident of the type and magnitude considered in the EIA Materials [2], the independent short term assessment confirms that the urgent protective measures as required by the IAEA safety standards would be limited mainly to sheltering and iodine prophylaxis in a zone less than 10 km, even in unfavourable meteorological conditions.
- In the event of accidental releases of radioactive effluents, which may follow an accident of the type and magnitude considered in the EIA Materials, the short term and the long term doses likely to be received by the populations in Lithuania and Poland would be below the values given in the IAEA safety standards that would require protective actions.
- However, food production in Lithuania could be affected by such an accident at the Baltic-1 NPP and restriction may have to be implemented on a significant area, at least for a limited period of time.
- For the same type of accident, the food production in Poland would not be significantly affected and it is extremely unlikely that restriction would have to be implemented over significant areas or time periods.

The Review Team concludes that the results of the assessments of the exposures to the public arising from discharges of radionuclides during normal operation, and following accidental releases of radionuclides to the environment, confirm the conclusions in the EIA Materials that are related to the radiological impacts to people and the environment.

APPENDIX I.

CONTENT OF THE MATERIALS FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE BALTIC-1 NPP, SAINT PETERSBURG RESEARCH AND DESIGN INSTITUTE (JSC SPBAEP), 2012

1 General information

The section provides context and justification for the project.

2 Summary of the Baltic NPP

The section provides a brief description of the power plant, an overview of applicable nuclear and radiation safety criteria, and design basis principles.

3 Natural and environmental conditions

The section contains a detailed description of the environmental baseline characteristics for the area of the proposed NPP, and hazards to the NPP from the natural environment (e.g. seismic and tornadic loads, flooding hazards).

4 Social and economic characteristics

The section provides demographics of applicable Russian Federation and Lithuanian Republic territories.

5 Justification of compliance of the Baltic NPP site placement with natural and environmental criteria.

The section summarizes arguments presented in previous sections.

6 Environmental Impact Assessment

6.1 Environmental Impact in the Process of Construction

The section provides details of expected (non-radiological) atmospheric pollution and noise during construction.

6.2 Project Concept, Main Criteria

The section provides details of safety systems and NPP water supply, and discharge routes (to Neman River).

6.3 Physical and Chemical Impacts

The section provides details of the expected thermal, chemical, and electromagnetic impacts of the NPP.

6.4 Radiological Effects of the Baltic NPP on Environment Components and Population

The section is the key section of the EIA with respect to radiological aspects. The section discusses radiation safety criteria, expected radiological releases and doses to the public and critical ecosystem components, and comparison of doses with criteria for normal operations, AOOs, DBAs, and BDBAs. The section also describes the protective measures that correspond to the estimated radiological risk posed by the NPP.

6.5 Analysis and Forecast of Impact on Underground Water, Disturbance of Geological Environment

The section compares the non-radiological impact of the NPP to other, similar, construction projects.

6.6 Predictive Estimate of Expected Changes in Ecosystems

The section provides a summary of expected impacts to ecosystems.

6.7 Baltic NPP Transboundary Impact Assessment

The section discusses impacts on neighbouring states, primarily the Lithuanian republic (as per the requirements of the Espoo Convention). The section covers potential chemical, thermal, and radiological impacts.

6.8 Risk Analysis and Assessment

The section describes the risks associated with potential emergency situations, and details the associated protective measures.

7 Radioactive waste and spent fuel handling

The section describes the provisions for managing liquid, solid, and gaseous wastes.

8 Decommissioning

The section describes the conceptual approach to decommissioning, the wastes arising, and proposed measures to provide for environmental safety. Two concepts are mentioned: liquidation (dismantling and transportation of waste to a regional repository) and burial (dismantling and on-site management of the waste.

9 Environmental measures

9.1 Justification of Approaches to Waste Water Treatment and Decontaminated Element Utilization Aimed at Preventing Emergency Discharge of Waste Water

The section describes the waste water treatment measures.

9.2 Atmospheric Air Protection Measures

The section details the physical barriers in place to limit the airborne release of radionuclides.

9.3 Measures on Recycling Water Supply

The section provides a summary of the main cooling water system, service water supply, and drainage.

9.4 Measures for Protection and Efficient Usage of Land Resources and Soil Mantle, Measures for Reclamation of Fault Areas and Soil Mantle

The section provides a summary of land use measures and, in particular, the protection of agricultural land.

9.5 Measures for Collection, Utilization, Deactivation, Transportation and Disposal of Hazardous Waste.

The section describes the management of hazardous waste from the NPP.

9.6 Protection Measures for Objects of Cultural Heritage (Historical and Cultural Monuments)

The section describes a number of items of archeological heritage.

9.7 Protection Measures for Mineral Resources

The section notes that mineral resources are absent from the NPP Site.

9.8 Measures for the Protection of Flora and Fauna and their Habitats

The section notes that special measures are not required to protect flora and fauna and their habitats in the region of the NPP.

9.9 Measures, Technical Solutions and Structures Ensuring the Rational Use and Protection of Water Bodies, as well as the Preservation of Water Biological Resources

The section describes measures to conserve water (e.g. prevent leaks, reduce droplet entrainment from cooling towers, etc.).

10 General characteristic of the NPP impact on the environment

The section summarizes the conclusions from previous sections.

11 Recommendations on the environmental monitoring programme arrangement

The section provides details of risks to the population arising from environmental contamination in the vicinity of the NPP, and makes recommendations for radiological, chemical, biological, and industrial monitoring.

12 Uncertainties identified in the course of the EIA

The section notes areas where additional information may be required on an ongoing basis, e.g. information on burbot spawning grounds.

13 Social and economical consequences of the planned activity

The section notes the expected benefits of NPP construction and necessary compensation measures.

14 Ecological and economical assessment of design solutions

The section provides a summary assessment of the economics and ecological impacts of the NPP.

15 Preparation to public discussion of the EIA of the Baltic NPP

The section notes the measures to engage the public with respect to the NPP.

16 Summary of non-technical aspects

The section summarizes the conclusions from previous sections.

APPENDIX A: Technical Specification for assessment of environmental impact caused by the Baltic NPP Unit 2 construction.

APPENDIX B: Site selection resolution.

APPENDIX C: Parameters of pollutant releases for calculation of atmosphere pollution.

APPENDIX D Maps of pollutant dispersion during construction period.

APPENDIX II.

REFERENCE PUBLICATIONS FOR THE INTERNATIONAL PEER REVIEW

The objective of the international peer review was to provide Rosenergoatom with a report on the consistency of the EIA Materials with the IAEA safety standards in the field of radiation protection of the public and the environment and against the requirements of the Espoo Convention, Environmental Impact Assessment in a Transboundary Context.

The relevant reference publications for the review are defined in the Terms of References for this review (Annex I). This appendix provides details on the objectives and scope of these reference publications. The cited paragraphs are from the stated safety standards. They do not include references or footnotes which appear in the original. Where a safety standard has been superseded, this is indicated in a footnote.

II.1. IAEA SAFETY STANDARDS

II.1.1. IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles, IAEA, Vienna, 2006

OBJECTIVE OF THIS PUBLICATION

1.8 The objective of this publication is to establish the fundamental safety objective, safety principles and concepts that provide the bases for the IAEA's safety standards and its safety related programme. Related requirements are established in the Safety Requirements publications. Guidance on meeting these requirements is provided in the related Safety Guides.

SCOPE

1.9. This publication states the fundamental safety objective and ten associated safety principles, and briefly describes their intent and purpose. The fundamental safety objective applies to all circumstances that give rise to radiation risks. The safety principles are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes, and to protective actions to reduce existing radiation risks. They provide the basis for requirements and measures for the protection of people and the environment against radiation risks and for the safety of facilities and activities that give rise to radiation risks, including, in particular, nuclear installations and uses of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

1.10. Safety measures and security measures have in common the aim of protecting human life and health and the environment. The safety principles concern the security of facilities and activities to the extent that they apply to measures that contribute to both safety and security, such as:

- Appropriate provisions in the design and construction of nuclear installations and other facilities;
- Controls on access to nuclear installations and other facilities to prevent the loss of, and the unauthorized removal, possession, transfer and use of, radioactive material;

- Arrangements for mitigating the consequences of accidents and failures, which also facilitate measures for dealing with breaches in security that give rise to radiation risks;
- Measures for the security of the management of radioactive sources and radioactive material.

Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

In Chapter 3 of the IAEA Safety Fundamentals, ten safety principles are defined, which are the basis for the IAEA's safety standards:

Principle 1: Responsibility for safety

The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

Principle 2: Role of government

An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.

Principle 3: Leadership and management for safety

Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.

Principle 4: Justification of facilities and activities

Facilities and activities that give rise to radiation risks must yield an overall benefit.

Principle 5: Optimization of protection

Protection must be optimized to provide the highest level of safety that can reasonably be achieved.

Principle 6: Limitation of risks to individuals

Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.

Principle 7: Protection of present and future generations

People and the environment, present and future, must be protected against radiation risks.

Principle 8: Prevention of accidents

All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.

Principle 9: Emergency preparedness and response

Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

Principle 10: Protective actions to reduce existing or unregulated radiation risks

Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

II.1.2. IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements, Vienna, 2014

OBJECTIVE

1.38. These Standards establish requirements for the protection of people and the environment from harmful effects of ionizing radiation and for the safety of radiation sources.

SCOPE

1.39. These Standards apply for protection against ionizing radiation only, which includes gamma rays, X rays and particles such as beta particles, neutrons, protons, alpha particles and heavier ions. While these Standards do not specifically address the control of non-radiological aspects of health, safety and the environment, these aspects also need to be considered. Protection from harmful effects of non-ionizing radiation is outside the scope of these Standards.

1.40. These Standards are intended primarily for use by governments and regulatory bodies. Requirements also apply to principal parties and other parties as specified in Section 2, health authorities, professional bodies and service providers such as technical support organizations.

1.41. These Standards do not deal with security measures. The IAEA issues recommendations on nuclear security in the IAEA Nuclear Security Series.

1.42. These Standards apply to all situations involving radiation exposure that is amenable to control. Exposures deemed to be not amenable to control are excluded from the scope of these Standards.

1.43. These Standards establish requirements to be fulfilled in all facilities and activities giving rise to radiation risks. For certain facilities and activities, such as nuclear installations, radioactive waste management facilities and the transport of radioactive material, other safety requirements, complementary to these Standards, also apply. The IAEA issues Safety Guides to assist in the application of these Standards.

1.44. These Standards apply to three categories of exposure: occupational exposure, public exposure and medical exposure.

1.45. These Standards apply to human activities involving radiation exposure that are:

- Carried out in a State which decides to adopt these Standards or which requests any of the Sponsoring Organizations to provide for the application of these Standards;
- Undertaken by States with the assistance of the Food and Agriculture Organization of the United Nations, the IAEA, the International Labour Organization, the Pan American Health Organization, the United Nations Environment Programme or the World Health Organization, in the light of relevant national rules and regulations;
- Carried out by the IAEA or involving the use of materials, services, equipment, facilities and non-published information made available by the IAEA or at its request or under its control or supervision; or —
- Carried out under any bilateral or multilateral arrangement whereby the parties request the IAEA to provide for the application of these Standards.

1.46. Quantities and units used in these Standards are in accordance with the recommendations of the International Commission on Radiation Units and Measurements [7].

II.1.3. Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, GS-R-1[12], IAEA, Vienna, 2000

This safety standard has been superseded by the IAEA Safety Standards Series No. GSR Part 1 Governmental, Legal and Regulatory Framework for Safety. The EIA Materials do not include a discussion of the legal and governmental infrastructure and responsibilities, since these topics are beyond the scope of an Environmental Impact Assessment.

II.1.4. Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment, Safety Reports Series No. 19, IAEA, Vienna, 2001

OBJECTIVES OF THIS PUBLICATION

The main purpose of this Safety Report is to provide simple methods for calculating doses arising from radioactive discharges into the environment, for the purpose of evaluating suitable discharge limits and to allow comparison with the relevant dose limits or dose constraints specified by the relevant Regulatory Authority.

SCOPE

The models in this Safety Report have been developed as a screening tool for the purpose of estimating annual effective doses to the public in a conservative manner arising from discharges of radionuclides to the terrestrial and aquatic environment. This allows determining through a simplified but conservative assessment the order of magnitude of a radiological the impact, and whether it can be neglected from further consideration or whether it requires a more detailed analysis.

The use of simple screening models for dose assessment is one of the first steps in registering or licensing a practice. The function of the dose assessment within this process, and the value of an iterative procedure in which the complexity of the dose assessment method increases as the magnitude of the predicted doses increase, is discussed in SRS 19.

This Safety Report provides the information required to assess rapidly doses using a minimum of site specific information. Two alternative methods are presented — a ‘no dilution’ approach that assumes members of the public are exposed at the point of discharge, and a generic environmental screening methodology that takes account of dilution and dispersion of discharges into the environment.

The screening models contained in this report are expected to be particularly useful for assessing the radiological impact of discharges from small scale facilities, for example hospitals or research laboratories. In these situations the development of special local arrangements for dose assessment is likely to be unwarranted because the environmental discharges will usually be of a low level, and the methodology described in this report will usually be adequate. However, for many larger scale nuclear facilities the assessed doses from the screening models presented in SRS 19 are more likely to approach the dose limiting criteria set by the Regulatory Authority (e.g. dose constraint), and users are more likely to

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, IAEA Safety Standards Series No. GS-R-1, IAEA, Vienna (2000). This has been superseded by IAEA Safety Standards Series No. GSR Part 1 (Rev. 1) [9].

need to follow a screening calculation with a more realistic, site specific and detailed assessment. Such a re-evaluation may necessitate consultation with professionals in radiological assessment and the application of more advanced models.

Doses calculated using the screening models presented in SRS 19 do not represent actual doses received by particular individuals.

The modelling approaches described in SRS 19 are applicable to continuous or prolonged releases into the environment when it is reasonable to assume that an equilibrium or quasi-equilibrium has been established with respect to the released radionuclides and the relevant components of the environment. The approaches described in SRS 19 are not intended for application to instantaneous or short period releases such as might occur in uncontrolled or accident situations.

II.1.5. Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000

OBJECTIVE OF THIS PUBLICATION

1.4. The purpose of this Safety Guide is to describe how to apply IAEA safety requirements in the control of discharges of radionuclides to the environment from normal operation of practices and sources within practices. It provides a regulatory body with a structured approach to the limitation of doses and risks to members of the public and optimization of protection from such operations, which may be adapted to the specific legal and regulatory infrastructure within which such a body operates. It also gives guidance on the responsibilities of registrants and licensees in conducting radioactive discharge operations.

SCOPE

1.5. The scope of this Safety Guide is limited to discharges to the environment of radioactive substances in the form of airborne (gases, aerosols) or liquid effluents from the normal operation of practices and sources within practices. The sources considered range from radionuclides used for medical and research purposes to nuclear reactors and reprocessing facilities. The term 'discharge' is used in this Safety Guide to refer to the ongoing or anticipated releases of radionuclides arising from the normal operation of a practice or a source within a practice. Discharges to atmosphere and discharges directly to surface water bodies are considered, but discharges of liquid radioactive substances by injection deep underground and releases arising from accidents are beyond the scope of this Safety Guide. Discharges from uranium mining and milling facilities and from the disposal of solid radioactive waste are not considered.

1.6. Guidance is given for setting discharge limits for new sources as well as for existing sources in order to bring them within the requirements of the Fundamentals and GSR Part 3. Discharge limits would be included in, or would accompany, an authorization issued by the regulatory body which allows operation. The authorization can be in the form of a registration, a licence or similar documentation; guidance is given on which of these forms of authorization may be appropriate under different circumstances.

1.7 An additional principle of the IAEA Safety Fundamentals is that radioactive waste has to be managed in such a way as to provide an acceptable level of protection of the environment. This includes the protection of living organisms other than humans and also the protection of natural resources, including land, forests, water and raw materials, together with a consideration of non-radiological environmental impacts. This Safety Guide is concerned only with control measures to protect human health.

II.1.6. Environmental and Source Monitoring for Purposes of Radiation Protection, Safety Guide, Safety Standards Series No. RS-G-1.8, IAEA, Vienna, 2005

OBJECTIVE OF THIS PUBLICATION

1.7. The purpose of this Safety Guide is to provide international guidance, coherent with contemporary radiation protection principles and accounting for experience gained since the previous publication of guidance, on the strategy of monitoring in relation to: (a) the control of radionuclide discharges under the conditions of practices, and (b) situations requiring intervention, such as a nuclear or radiological emergency or the past contamination of areas with long lived radionuclides. Three categories of monitoring are discussed: monitoring at the source of the discharge (hereinafter called 'source monitoring'), monitoring in the environment ('environmental monitoring') and monitoring of individual exposure ('individual monitoring').

1.8. The Safety Guide also provides general guidance on the assessment of the doses to critical groups of the population due to the presence of radioactive material or due to radiation fields in the environment, which may arise both from the normal operation of nuclear and other related facilities (practices) or from a nuclear or radiological emergency or the past contamination of areas with long lived radionuclides (interventions). The dose assessment is based on the results of source monitoring, environmental monitoring or individual monitoring or on combinations of these.

1.9. This Safety Guide is primarily intended for use by national regulatory bodies that have responsibilities for regulating the introduction and conduct of any practice involving sources of radiation and for appropriate radiation monitoring procedures. It will also be valuable to other agencies involved in national systems for radiation monitoring as well as to operators of nuclear installations and other facilities in which natural or human made radionuclides are treated and monitored.

SCOPE

1.10. This Safety Guide is primarily concerned with source monitoring and environmental monitoring of discharges from authorized (registered or licensed) practices under normal operating conditions and during the decommissioning of facilities. The practices considered in this Safety Guide include the operation of nuclear power plants and research reactors, reprocessing plants and nuclear fuel production plants, uranium and thorium mining and milling facilities, near surface disposal facilities for radioactive waste, and facilities of other types where natural or human made radionuclides are used (medical, radiopharmaceutical, research, educational and others).

1.11. The guidance presented here applies for planning monitoring during waste emplacement in surface (uranium and thorium ore mining and milling sites) or near surface (for low and intermediate level waste) disposal facilities and for borehole and deep underground (geological) waste disposal facilities, and specifically for post-closure monitoring — although radionuclide releases would not be expected from such facilities under normal circumstances.

1.12. General issues of emergency monitoring in the aftermath of a radiation accident are also considered in this publication.

1.13. This Safety Guide also addresses general aspects of monitoring for long lived radionuclides widely dispersed in the environment following a radiation accident, or as residual waste from past practices. This includes monitoring of the content of natural and human made radionuclides in commodities, especially in foodstuffs and drinking water.

1.14. This Safety Guide does not address the monitoring of workers and the workplace, although its recommendations and guidance may be useful for the occupational protection of emergency workers in the event of an accident accompanied by the release of radionuclides to the environment. Neither does the Safety Guide address monitoring for research purposes, which is not for the purposes of radiation protection, or monitoring of the global fallout of radionuclides released during past nuclear weapon tests, which are unamenable to control.

1.15. A general surveillance and monitoring programme for the release to, or the presence of toxic chemicals in, the environment is not addressed in this Safety Guide, which is devoted to the monitoring of radionuclides only. However, operators and other responsible organizations may find it convenient to combine chemical and radiological monitoring programmes.

II.1.7. Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, Safety Guide, Safety Standards Series No. NS-G-3.2, IAEA, Vienna, 2002

OBJECTIVE OF THIS PUBLICATION

1.5. Radioactive materials discharged from a nuclear power plant might reach the public and might contaminate the environment in the region by way of both direct and indirect pathways. The objective of this Safety Guide is to provide guidance on the studies and investigations necessary for assessing the impact of a nuclear power plant on humans and the environment. It also provides guidance on the feasibility of an effective emergency response plan, in consideration of all the relevant site features.

1.6. This Safety Guide provides guidance on investigations relating to population distribution, and on the dispersion of effluents in air, surface water and groundwater. The guidance is intended to help determine whether the site selected for a nuclear power plant satisfies national requirements and whether possible radiological exposure and hazards to the population and to the environment are controlled within the limits set by the regulatory body, with account taken of international recommendations.

SCOPE

1.7. This Safety Guide provides guidance for the site evaluation stage of a facility, specifically on:

- The development of meteorological, hydrological and hydrogeological descriptions of a plant site;
- Programme to collect meteorological and hydrological data (for surface water and groundwater);
- Programme to collect data on the distribution of the surrounding population in order to demonstrate the feasibility of an effective emergency plan.

1.8. The effects of the proposed plant on the uses of land and water in the region of the site are covered by this Safety Guide. This Safety Guide does not give guidance on dose assessment in relation to the siting of a nuclear power plant nor does it give detailed information on specific methods or mathematical models.

1.9. This Safety Guide does not give guidance on dose assessment in relation to the siting of a nuclear power plant. Specific guidance on the calculation of doses and for the identification of characteristics of the site that are relevant to the local and regional radiological impact of a nuclear power plant is given in Refs [4, 5].

1.10. This Safety Guide does not give detailed information on specific methods or mathematical models. Methods for calculating the concentrations and rates of deposition of radioactive material due to the dispersion of effluents in air or water are presented in Ref. [4]. Attention should be paid to the use of environmental data in conjunction with calculational models to ensure that the type of data is appropriate for the regulatory objective.

II.1.8. Site Evaluation for Nuclear Installations, NS-R-3[13], IAEA, Vienna, 2003

OBJECTIVE OF THIS PUBLICATION

1.3. The objective of this publication is to establish the requirements for the elements of a site evaluation for a nuclear installation so as to characterize fully the site specific conditions pertinent to the safety of a nuclear installation.

1.4. The purpose is to establish requirements for criteria, to be applied as appropriate to site and site installation interaction in operational states and accident conditions, including those that could lead to emergency measures for:

(a) Defining the extent of information on a proposed site to be presented by the applicant;
(b) Evaluating a proposed site to ensure that the site related phenomena and characteristics are adequately taken into account;
(c) Analysing the characteristics of the population of the region and the capability of implementing emergency plans over the projected lifetime of the plant;
(d) Defining site related hazards.

1.5. This publication does not specifically address underground or offshore installations.

SCOPE

1.6. The scope of this publication encompasses site related factors and site–installation interaction factors relating to plant operational states and accident conditions, including those that could lead to emergency measures, and natural and human induced events external to the installation that are important to safety. The external human induced events considered in this Safety Requirements publication are all of accidental origin. Considerations relating to the physical protection of the installation against willful actions by third parties are outside its scope.

1.7. The phrase ‘external to the installation’ is intended to include more than the external zone [41]. In addition to the area immediately surrounding the site, the site area itself may contain

[13] INTERNATIONAL ATOMIC ENERGY AGENCY Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA Vienna (2003). This has been superseded by IAEA Safety Standards Series No. NS-R-3 (Rev. 1) [14].

objects that pose a hazard to the installation, such as an oil storage tank for diesel generators or another reactor on a multiunit site.

1.8. The siting process for a nuclear installation generally consists of an investigation of a large region to select one or more candidate sites (site survey), followed by a detailed evaluation of those candidate sites. This publication is primarily concerned with the latter stage.

1.9. Previous safety standards on this subject related to land based, stationary thermal neutron power plants. This Safety Requirements publication has been extended to cover a more comprehensive range of nuclear installations: land based, stationary nuclear power plants and research reactors, as well as nuclear fuel cycle facilities, including but not limited to enrichment plants, processing plants, independent spent fuel storage facilities and reprocessing plants. In some instances in this publication a requirement is stated to apply to nuclear power plants. In these cases, the requirements are most appropriate for nuclear power plants, but they may also apply to other nuclear installations.

1.10. The level of detail needed in an evaluation to meet the requirements established in this publication will vary according to the type of installation being sited. Nuclear power plants will generally require the highest level of detail. Depending on the level of risk posed by the installation, less detail and smaller areas of coverage may be necessary to comply with the requirements established in this publication.

1.11. This publication is concerned with the evaluation of those site related factors that have to be taken into account to ensure that the site–installation combination does not constitute an unacceptable risk to individuals, the population or the environment over the lifetime of the installation. The evaluation of the non-radiological impacts of a nuclear installation is not considered.

1.12. As used in this publication, the term ‘risk’ refers to the product derived from the multiplication of the probability of a particular event that results in the release of radioactive material by a parameter corresponding to the radiological consequences of this event. In concept, a comprehensive risk analysis includes all the sequential steps of analysing all the initiating events, following for each initiating event all the possible sequences of subsequent events, associating a probability value with each of these sequences and ending with the consequences for individuals, the population and the environment. In some States, it is an established practice to utilize parts of such a risk analysis and to define probabilistic requirements to supplement traditional deterministic analysis and engineering judgement.

1.13. This publication is concerned mainly with severe events of low probability that relate to the siting of nuclear installations and that have to be considered in designing a particular nuclear installation. If events of lesser severity but higher probability make a significant contribution to the overall risk, they should also be considered in the design of the nuclear installation.

1.14. The scope of the investigation for the site of a nuclear installation covers the entire process of the site evaluation — the selection, assessment, pre-operational and operational stages. The requirements established in this publication do not apply to the site selection stage, for which a different series of criteria may be used. These may include criteria that have little direct relevance to safety, such as the distance to the planned consumers of the power to be generated.

II.2. ESPOO CONVENTION (THE CONVENTION ON THE ENVIRONMENTAL IMPACT ASSESSMENT IN A TRANSBOUNDARY CONTEXT, ESPOO, FINLAND, 1991)

In addition to the IAEA guidance, noted above, the text of the Espoo Convention was also used as a reference publication for the international peer review.

The ESPOO Convention entered into force in 1997. It sets out the obligations to assess the environmental impact of certain activities at an early stage of planning. The Espoo Convention defines the general obligation of States for mutual notification and consultation on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

Article 4 of the Espoo convention requires the preparation of an EIA documentation. The details of Article 4 "Preparation of the Environmental Impact Assessment Documentation" are as follows:

(1) The environmental impact assessment documentation to be submitted to the competent authority of the Party of origin shall contain, as a minimum, the information described in Appendix II.
(2) The Party of origin shall furnish the affected Party, as appropriate through a joint body where one exists, with the environmental impact assessment documentation. The concerned Parties shall arrange for distribution of the documentation to the authorities and the public of the affected Party in the areas likely to be affected and for the submission of comments to the competent authority of the Party of origin, either directly to this authority or, where appropriate, through the Party of origin within a reasonable time before the final decision is taken on the proposed activity" .

Appendix 2 of the ESPOO Convention lists, in accordance with Article 4, the minimum information to be included in the environmental impact assessment documentation:

(a) A description of the proposed activity and its purpose;
(b) A description, where appropriate, of reasonable alternatives (for example, locational or technological) to the proposed activity and also the no action alternative;
(c) A description of the environment likely to be significantly affected by the proposed activity and its alternatives;
(d) A description of the potential environmental impact of the proposed activity and its alternatives and an estimation of its significance;
(e) A description of mitigation measures to keep adverse environmental impact to a minimum;
(f) An explicit indication of predictive methods and underlying assumptions as well as the relevant environmental data used;
(g) An identification of gaps in knowledge and uncertainties encountered in compiling the required information;
(h) Where appropriate, an outline for monitoring and management programs and any plans for post-project analysis; and
(i) A non-technical summary including a visual presentation as appropriate (maps, graphs, etc.).

APPENDIX III.

THE CONDOR MODEL TO ASSESS RADIOLOGICAL IMPACTS TO THE PUBLIC DURING NORMAL OPERATION

III.1. INTRODUCTION

IRSN has developed software to assess the radiological impact on critical groups of the liquid and airborne discharges, i.e. the CONDOR software (CONséquences DOsimétriques des Rejets) [42].The software is based on the FOCON96 model for airborne discharges, on the AQUAREJ model for liquid discharges into rivers and on the CREMER model for liquid discharges in the marine environment. This later model is not described here.

III.2. GENERAL DESCRIPTION

The assessments include three main steps:

(1) Assessment of the dispersion of the radionuclides in the atmosphere and in aquatic media;
(2) Assessment of the transfers of the radionuclide in the environmental compartments and in the food chain;
(3) Assessment of the radiological impact (the annual effective dose) received by the critical groups.

III.3. DESCRIPTION OF THE CONDOR MODEL FOR RIVER WATER

For liquid discharges to rivers, the model assesses:

(1) The concentration of nuclides in unfiltered and filtered river water;
(2) The concentration of nuclides in the following environmental compartments:
    (a) Sediments of river banks;
    (b) Soils that are irrigated with contaminated river water;
    (c) Aquatic food;
    (d) Terrestrial vegetable food from irrigated fields and gardens;
    (e) Terrestrial animal food from irrigated pasture and from feeding with river water.
(3) Annual effective doses from the following pathways:
    (a) External exposure from recreational activities on the river and on the river banks (fishing, swimming);
    (b) Ingestion of freshwater food (fish);
    (c) Ingestion of terrestrial food (vegetables, milk, meat) from soils irrigated with contaminated river water;
    (d) Ingestion of drinking water prepared from filtered river water;
    (e) Inadvertent ingestion of river water when swimming and river bank sediment.

III.4. DESCRIPTION OF THE CONDOR MODEL FOR AIRBORNE DISCHARGES

For airborne discharges in the atmosphere, the model assesses:
(1) Dilution factors with the Doury model and concentrations of nuclides in the atmosphere;
(2) Concentrations of nuclides in the following environmental compartments:
    (a) ground surface;

(b) soils;
(c) leafy-, fruit-, root-vegetables and cereals through leafy and root uptake;
(d) cow, goat and sheep meat and milk from animals contaminated by pasture ingestion and inadvertent ingestion of soil, poultry meat and eggs.

(3) Effective dose from the following pathways:
(a) Inhalation;
(b) External exposure from radionuclides in the plume;
(c) External exposure from radionuclides deposited on the ground;
(d) Inadvertent ingestion of soil;
(e) Ingestion of plant food products (leafy-, fruit- root vegetable and cereals);
(f) Ingestion of meat, milk and eggs.

APPENDIX IV.

THE AIDA MODEL TO ASSESS RADIOLOGICAL IMPACTS TO THE PUBLIC FOLLOWING ACCIDENTAL RELEASES OF RADIONUCLIDE TO THE ATMOSPHERE

IV.1. INTRODUCTION

Beginning in the 1980s IRSN has developed software to assess the radiological impact of accidental airborne discharges in the framework of safety studies. This software is called AIDA and is based on the ACCI38 model which has been updated periodically until now [43–46].

The model takes into account the four main pathways, or some of them for specific assessments, i.e. inhalation, external exposure from the plume, external exposure from the ground deposition and ingestion. The software can therefore be used for short term as well as longer term assessments.

IV.2. GENERAL DESCRIPTION

The model considers a punctual release of a number of nuclides at a height specified as an input. The weather conditions are considered stationary during the release. The dispersion model is the Gaussian Doury model, which considers two stability classes (stable or low diffusion, unstable or normal diffusion).

The model calculates the contamination of the environmental compartments (air, ground surface, pasture, food chain).

The model assesses the dose received by individuals (infants, children and adults) during the dispersion of the plume (inhalation and external exposure from the plume) and after deposition of radionuclides to the ground (ingestion, inhalation of resuspended aerosols and external exposure from the ground deposition).

The model calculates:

- The atmospheric dispersion factor with the Doury Gaussian model;
- Plume depletion by dry deposition and precipitation;
- The time integrated concentration of the nuclides in the plume and the atmospheric concentration of resuspended nuclides after the dispersion of the plume;
- The ground surface deposition;
- The contamination of pasture, vegetables, fruits and cereals by direct contamination of the plant surface by the plume and indirect contamination by root uptake;
- The contamination of milk, meat and egg;
- The effective dose from the various pathways;
- The distance where the contamination of the food equal the European permissible levels.

IV.3. MAIN ASSUMPTIONS

The weather conditions are assumed stationary in time and uniform in space. The release height is specified as input. The topography is assumed flat and no disturbance of the air flow is considered (no buildings, no cooling towers…).

Constant dry and wet deposition velocities are considered for aerosols.

Resuspension is assessed with a time dependent resuspension coefficient (in m^{-1}) which relates the concentration in the atmosphere (in Bq/m^3) to the ground deposition (in Bq/m^3).

The contamination of the following meat and milk products is calculated: beef meat, cow milk, sheep meat, sheep milk, pork meat, poultry meat.

IV.4. PARAMETERS USED IN AIDA SOFTWARE FOR THE BALTIC-1 NPP EIA REVIEW

The following parameters values have been used in the AIDA software:

- Height of the release: 0 m (ground level);
- Resuspension factor: short term 1×10^{-5} m^{-1}, long term 1×10^{-9} m^{-1};
- Decay period of the resuspension factor: short term 63.3 d, long term 34700 d;
- Dry deposition velocity of aerosols: 5 mm/s;
- Aerosol wash out constant for wet deposition: 1×10^{-4} s^{-1};
- Breathing rate: adults 0.92 m^3/h, 1–2year old infants 0.22 m^3/h.

TABLE 29. FOOD CONSUMPTION RATES FOR 1–2 YEAR OLD INFANTS AND ADULTS (IN kg/a OR L/a)

Foodstuff group	**Food consumption (in kg/a or L/a)**	
	Infants (1–2 years old)	**Adults (> 17 years old)**
Cow milk	246	190
Beef meat	27	60
Cereals	54	112
Root vegetables	84	110
Leafy vegetables	10	21
Fruit vegetables	5	6.8

APPENDIX V.

THE PC CREAM 08 MODEL TO ASSESS RADIOLOGICAL IMPACTS TO THE PUBLIC DURING NORMAL OPERATION

To provide a comparative set of results for review of the EIA data, the PC CREAM 08 software tool was used to assess the radiological impact for both atmospheric and river discharges proposed to occur from the Baltic-1 NPP. In order to carry out this assessment the software tool PC-CREAM 08 was used [33]. PC-CREAM 08 was developed by the Centre for Radiation, Chemicals and Environment Hazards within Public Health England (formerly Health Protection Agency) with endorsement from the European Commission (EC), and is an implementation of the methodology described in Ref. [47].

PC CREAM 08 was run using data provided within the Baltic-1 NPP EIA materials or subsequent responses to questions directly posed by the peer review team.

V.1. ATMOSPHERIC RELEASES

V.1.1. Input data

Two assessments were performed for atmospheric releases which relate to the proposed discharges and the permissible limits as described in Table 30.

TABLE 30. PROPOSED DISCHARGES AND PERMISSIBLE LIMITS FOR ATMOSPHERIC RELEASES FROM BALTIC-1 NPP

Radionuclide	Proposed discharges (in GBq/year×Unit) Vent stack Total release	Permissible limits (GBq for the whole site)
H-3	3.9 E3	
C-14	3.0 E2	
Kr-83m	6.7 E2	
^{m}Kr-85m	2.3 E3	
Kr-85	3.6 E2	
Kr-87	1.4 E3	
Kr-88	5.0 E3	
Xe-131m	2.5 E2	
Xe-133	2.8 E4	
Xe-135	7.6 E3	
Xe-138	2.9 E2	
I-131	7.3 E-2	1.8 E1
I-132	9.7 E-2	
I-133	1.4 E-1	
I-134	6.6 E-2	
I-135	1.1 E-1	
Cr-51	7.9 E-5	
Mn-54	4.8 E-6	
Co-60	3.1 E-5	7.4 E0
Sr-89	3.35 E-4	
Sr-90	6.0 E-7	
Cs-134	2.0 E-2	9.0 E-1
Cs-137	3.0 E-2	2.0 E0
Noble gases	4.6 E4	6.9 E5 *
Iodines	4.9 E-1	
Aerosols	5.1 E-2	
Total	**4.6 E4**	

* The category of inert gases has been assumed to comprise the same proportions of specific radionuclides as described by the proposed discharges.

The exposure pathways considered in the assessment were:

- Inhalation of the plume;
- External gamma irradiation from the plume;
- External beta irradiation from the plume;
- External gamma irradiation from deposited materials;
- External beta irradiation from deposited materials;
- Inhalation of material resuspended from the ground;
- Ingestion of radionuclides within foods.

Meteorological data was provided to the peer review team for the Sovetsk meteorological station covering the period from 2000 to 2007. This data was analysed and used as input to the PC CREAM software. Further supporting data required in the assessment are summarized in Table 31. The consumption rates used for assessing doses due to consumption of food are provided in Table 32. Equivalent food categories have been selected within PC CREAM to represent the categories supplied to the peer review team.

TABLE 31. ASSESSMENT DATA FOR ATMOSPHERIC DISCHARGES

Parameter	Value applied
Stack height	30 m
Receptor distances	0.1, 0.5, 1, 2, 3, 4, 5, 10 km
Outdoor occupancy	100%
Inhalation rates	Adult – 8100 m^3/a, Infant – 1900 m^3/a

TABLE 32. CONSUMPTION RATES (kg/a) ASSUMED FOR THE ASSESSMENT OF ANNUAL EFFECTIVE DOSES FROM ATMOSPHERIC DISCHARGES

EIA foodstuff group	Equivalent categories used in PC CREAM	Consumption rates (kg/a)	
		Infant	Adult
Milk and dairy products	Cow milk (50%) Cow milk products (50%)	246	190
Meat	Cow meat	27	60
Wheat	Grain	54	112
Potato	Root vegetables	84	110
Cabbage	Green vegetables	10	21
Cucumber	Fruit	5	6.8

V.1.2. Assessment results

As noted above, assessments were undertaken for the proposed discharges and the permissible limits. Using the proposed discharges, the effective doses were estimated accounting for continuous releases over a 50 year period (to allow for buildup of long-lived radionuclides in the environment). The doses to adults at a distance of 1 km are around 2.8 µSv for 2 units at the Baltic-1 NPP site. The dose is primarily due to ^{14}C. For 1 year old infants, the corresponding dose for 2 units is estimated to be 5.5 µSv.

For the permissible limits, the estimated effective dose in the last year of a 50 year period of continuous releases to an adult was 2.3 µSv. The corresponding dose to a 1 year old infant was also 2.5 μSv. It should be noted that the doses calculated for the permissible limits are lower than those for proposed discharges. This is due to the discharge limits being for 4 radionuclides only and inert gases. Carbon-14 which dominates the dose from the proposed discharges is not included in the radionuclides given for the permissible limits.

V.2. RIVER DISCHARGES

V.2.1. Input data

The data provided in the Baltic-1 NPP EIA Materials was used to model the discharges to the Neman River using the screening and dynamic models available within the PC CREAM 08 software. Parameters for the river characteristics are given in Table 33. A compilation of habit data is given in Table 34.

TABLE 33. ASSESSMENT DATA FOR RIVER DISCHARGES

Type of model	**Extended screening model with complete mixing**				
River characteristics	Mean flow rate over a year (m^3/s)	Suspended sediment load (kg/m^3)	Mean depth of water (m)	Mean width of river (m)	Downstream distance of interest (m)
Value used	571	0.025	530	225	500

TABLE 34. HABIT DATA FOR RIVER DISCHARGES

Age group	**Pathways and habit information**					
	External beta	**External gamma**	**Occupancy (h/a)**	**Ingestion rate of fish (kg/a)**	**Water treatment**	**Ingestion rate of water (l/a)**
Infant	Yes	Yes	100	15	No	260
Adult	Yes	Yes	100	30	No	600

V.2.2. Assessment results

As noted above, assessments were undertaken for the proposed discharges and the permissible limits. Using the proposed discharges, the effective doses for a 50 year integration period to adults and infants at a distance of 500 m downstream are around 0.1 μSv for 2 units at the Baltic-1 NPP site. The dose to an adult is primarily due to ^{134}Cs (36%) and ^{137}Cs (35%).

For the discharge limits, the estimated effective dose was assessed using a continuous discharge over a period of 50 years (to allow for buildup of long lived radionuclides in the environment) to both adults and infants is estimated to be 2 μSv. The dose to an adult is primarily (~75%) due to ^{54}Mn.

APPENDIX VI.

THE PC COSYMA AND PACE MODELS TO ASSESS POTENTIAL RADIOLOGICAL IMPACTS TO THE PUBLIC FOLLOWING ACCIDENTAL RELEASES

To provide a comparative set of results for review of the EIA data, two level 3 probabilistic safety analysis (PSA) tools were used. PACE (Probabilistic Accident Consequence Evaluation Software) is a Geographic Information System (GIS)-based offsite accident consequence tool that has been developed by Public Health England [48, 49] that uses a Lagrangian atmospheric dispersion model (NAME III developed by the UK Met Office [50]). PC COSYMA is a PC version of the COSYMA PSA software that was jointly developed by Public Health England (as a predecessor organization — NRPB [51]. The use of the two tools allows a comparison to be made between a Gaussian, Lagrangian dispersion models). The PACE and PC COSYMA software tools were used to assess the radiological impacts due to the accidental releases to atmosphere from the Baltic-1 NPP.

VI.1. PACE

PACE is a recently developed GIS-based probabilistic assessment tool which uses the UK Met Office NAME III atmospheric dispersion model to sample over different meteorological sequences (Figure 9). The outline process for a PACE calculation is shown in Figure 9. For each site, the endpoints will have different values for each of the sample meteorological sequences. This range of values can be presented statistically for example using minimum, mean, maximum or percentile values.

All endpoints are initially calculated as a function of location e.g. deposition level, dose received, health effects and the implementation of countermeasures. Presenting location dependent results for each of the meteorological sequences is not straight forward given the number of meteorological sequences sampled. To represent the range of results in one figure, for this study results from PACE have been analysed to present probability maps which show the likelihood of endpoints such as food restrictions being required given a defined input criteria.

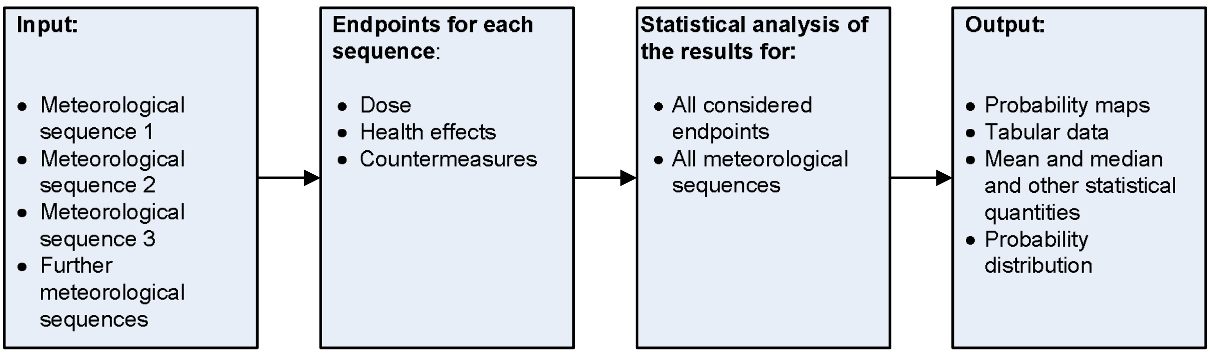

FIG. 9. Outline schematic of the calculation process undertaken in PACE.

VI.2. PC COSYMA

PC COSYMA is a package of programs and databases to undertake off-site probabilistic accident consequence assessments rather than a single programme. It contains an accident consequence assessment programme together with a number of preprocessing and evaluation programmes. Some models are included directly within the various modules or subsidiary programmes but in other cases results of models are taken from data libraries. Thus the atmospheric dispersion models are used directly. PC COSYMA does not, however, include models for the contamination of food or dosimetric calculations, using instead data libraries giving the results of other models.

The main endpoints which PC COSYMA can calculate are the numbers of health effects, the impact of countermeasures and the economic costs resulting from an accidental release. A large number of intermediate results are obtained in the process of calculating the major endpoints; these results include activity concentrations, individual and collective doses and the countermeasures assumed at different locations.

PC COSYMA can be used for deterministic or probabilistic assessments. Deterministic assessments give detailed results for a release in a single set of atmospheric conditions. Probabilistic assessments give results taking account of the full range of atmospheric conditions that may be experienced and their respective frequencies of occurrence.

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