Strategic Environmental Assessment of the National Programme for the safe management of spent fuel and radioactive waste

Environmental Report
for Public Participation

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In the event of discrepancies between this translation and the original German version, the latter shall prevail

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Contents

Summary

The National Programme

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) published a draft of its Programme for Responsible and Safe Management of Spent Fuel and Radioactive Waste – National Programme - on 6 January 2015. The fundamental elements of the national programme are characterised by the following key points:

- The management of radioactive waste shall as a rule be carried out within German national responsibility. Disposal is to be on German national territory. Spent fuel from research, development and demonstration reactors may be shipped to a country where research reactor fuels are supplied or manufactured.
- Disposal facilities are to be established at two sites: the Konrad disposal facility for radioactive waste with negligible heat generation and a disposal facility according to the Site Selection Act especially for heat-generating radioactive waste.
  - The radioactive waste in the Asse II mine is to be retrieved and as a precaution considered in the planning of the disposal facility according to the Site Selection Act; an extension the Konrad disposal facility for suitable waste is not precluded and is to be examined following its commissioning, if necessary.
  - Providing for the case that it will not be reutilised, the depleted uranium that has been generated and will be generated in Germany as a result of uranium enrichment, as a precaution, is to be considered in the planning of the disposal facility according to the Site Selection Act; an extension of the Konrad disposal facility to include this radioactive material is not precluded and is to be examined following its commissioning, if necessary.
- The dismantling of all power plants as well as other nuclear facilities and installations taken out of operation during the period under consideration is to be executed, subject to an available disposal facility,– in due time so that the negligible heat-generating radioactive waste generated during this process can be emplaced in the Konrad disposal facility.
- The Konrad disposal facility is expected to become operational in the year 2022. The emplacement operation for the licensed waste volume of 303,000 m³ should not exceed 40 years.
- The site for the disposal facility especially for heat-generating waste is to be determined by the year 2031according to the Site Selection Act. The disposal facility is to be commissioned around the year 2050.
- With the first partial license for the disposal facility for especially heat-generating waste, a receiving storage facility is also to be approved at the site for all spent fuel and waste from reprocessing, and therewith provide the precondition needed for the start of clearing the existing storage facilities.
- Until then, the spent fuel and waste from reprocessing is to be kept at the existing storage facilities.

- Emplacement of low-level and medium-level radioactive waste in the Morsleben disposal facility for radioactive waste has been concluded. The disposal facility is to be closed and safely sealed for the long term.

With regard to the management of radioactive waste, up to the delivery to a disposal facility or Land collecting facility, the polluter-pays principle applies in terms of the obligation to act - in the sense of a duty to act. So those handling radioactive material shall make provisions to ensure that residual radioactive material as well as disassembled or dismantled radioactive components are utilised without detrimental effects or are disposed of as radioactive waste in controlled manner (direct disposal).

Radioactive waste from industrial, medical and research applications has to be delivered to a Land collecting facility and has to be stored there. The Land collecting facilities will deliver the radioactive waste stored within their responsibility to a disposal facility.

Strategic Environmental Assessment of the National Programme

A Strategic Environmental Assessment (SEA) will be carried out for the National Programme. The SEA will examine the environmental impacts of the following proposed measures related to the management of spent fuel and radioactive waste:

- Site selection process and disposal, especially of heat-generating waste, including fuel from research, development and demonstration reactors;
- alternatively – to the extent that it can be assessed within this SEA - shipment of fuel from research, development and demonstration reactors to a country where fuel for research reactors is supplied or manufactured;
- storage of spent fuel and waste from reprocessing ;
- management of the radioactive waste retrieved from the Asse II mine and decommissioning of the Asse II mine;
- management of depleted uranium from enrichment operations.

Each of these measures is subdivided into individual projects, for which the environmental impacts are determined.

The above-mentioned measures, which are planned to be carried out under the National Programme, will be conducted in facilities or installations for which the site and design have not yet been determined. For that reason, it is not possible for the SEA of the National Programme to describe actual facilities or environmental components of areas under exploration. Instead, the impact factors associated with facilities or installations are estimated and described in qualitative terms or as a quantitative spectrum. A prediction is made about the environmental impacts of the impact factors described in this way based on assumptions about the impact on protected environmental assets and other objects to be protected and assessed with regard to compliance with general environmental objectives. The assessment is carried out with a view to taking effective precautions to protect the environment. Impact factors that exceed the precautionary levels are identified as potentially relevant environmental impacts: potentially significant environmental impacts arise when the nature of the impact factors leads to situations where it is not possible to comply with environmental objectives.

The SEA of the National Programme takes the following impact factors into account:

- land consumption and spatial impact;
- air pollutants, noise and vibrations (quantitative consideration only when protecting human wellbeing is the main concern);
- lowering of the groundwater level;
- conventional wastewater generated by building projects (lowering of the groundwater level), mining (lowering of groundwater level, drainage, mining heap drainage) and operation of facilities;
- substances hazardous to water, rainwater on circulation areas and roofs, sanitary wastewater;
- conventional waste, heat input, light emissions;
- release into environmental media, blow-out, hydraulic shortcut, surface subsidence and radon emissions;
- direct radiation and radioactive operational waste;
- emissions of radioactive substances via air and water pathways (discharges);
- emissions of radioactive substances or other pollutants from disposal facilities in the post-closure phase;
- incidents

Substances hazardous to water, rainwater on circulation areas and roofs, sanitary wastewater, conventional waste, light emissions and radon emissions are project-specific impact factors and as such cannot be depicted. They are of secondary importance for the SEA of the National Programme.

The measures and projects within the National Programme are associated with the following potentially relevant or potentially significant environmental impacts.

Site selection process and disposal especially of heat-generating radioactive waste

For the site selection process and for disposal of heat-generating radioactive waste, the environmental impacts of the following projects must be considered:

- surface exploration of several possible sites for a disposal facility;
- subsurface exploration of possible sites for a disposal facility (start-up, operation and closure of exploration mines, decommissioning and closure measures);
- transfer of the waste to be disposed of in the disposal facility for heat-generating waste from the sites of the storage facilities to the disposal facility;
- storage of the waste to be disposed of, in the disposal facility's receiving storage facility (construction, operation and decommissioning);
- conditioning of all waste to be disposed of in the disposal facility so that the waste acceptance requirements for disposal are met (construction, operation and cessation of operation);
- disposal (construction and operation of the disposal facility, closure of the disposal facility and post-closure phase)

The following evaluation makes a distinction between conventional impact factors in construction and dismantling, conventional impact factors in the operational phase, and radiological impact factors.

Conventional impact factors during construction and dismantling of facilities/installations and during transportation

Paving exploration areas as well as constructing buildings and erecting mining heaps for storage of incoming waste, conditioning, exploration and disposal cause land sealing which is a potentially significant environmental impact and as such must be compensated. When all the buildings and mining heaps are dismantled at a later date, this land surface will be unsealed again. The exploration areas are sealed only for the short period of time during which the surface exploration is carried out.

In addition to temporary land sealing, carrying out a surface exploration of a potential site for a disposal facility is associated with the following impact factors which cause potentially relevant environmental impacts that must be minimised in the course of the licensing procedures:

- air pollutants and noise within a range of several hundred metres

Building and demolishing the receiving storage facility and conditioning facility and building and closing the exploration mine and disposal facility may produce potential environmental impacts in the case of the following conventional impact factors:

- air pollutants - within a range of 700 m (construction of the exploration mine) or 1000 m (construction of the conditioning facility, receiving storage facility and disposal facility);
- noise emissions and vibrations, within a range of about 1000 m when protecting human wellbeing is the main concern;
- groundwater depletion;
- discharge of conventional wastewater generated by building projects (lowering of the groundwater level), mining (drainage, mining heap drainage);
- spatial impact of buildings and mining heap erected

Along the transportation routes for construction materials, conventional waste and excavated material, potentially relevant environmental impacts can occur within a range of about 100 m as a result of noise.

Conventional impact factors during the operation of mines and facilities

For mines for subsurface exploration and disposal, potentially relevant environmental impacts caused by lowering the groundwater level and by conventional wastewater resulting from discharge of groundwater, drainage and mining heap drainage have to be taken into consideration during operation and phase-out of operations and during closure of the disposal facility.

During operation of the conditioning facility, discharges of conventional wastewater must be taken into account.

During operation of the receiving storage facility, potentially relevant environmental impacts may arise as a result of heat being discharged into the ground. Measures to minimise the environmental impacts must be included in the licensing procedure.

Radiological impact factors

The site selection process for a disposal facility does not entail any radiological impact factors.

The disposal of heat-generating waste leads to the following potentially relevant environmental impacts with regard to radiologically relevant impact factors,:

- receiving storage facility: direct radiation and risks of incidents;
- conditioning facility: direct radiation, emissions of radioactive substances via the air and water pathways (discharges), risks of incidents;
- operation and closure of the disposal facility: risks of possible incidents.

Emissions of negligible amounts of radioactive substances or other pollutants from disposal facilities in the post-closure phase cannot be ruled out. They are, however, limited as a result of Safety Requirements Governing the Final Disposal of Heat-generating Radioactive Waste and the provisions of the Federal Water Act. Since this phase extends over an extremely long period of time of a million years and since it is not possible to predict with accuracy the development of the assets to be protected on which the potential environmental impacts will impact, the evaluations cannot be directly compared with those for the other projects. For that reason, no attempt to classify the environmental impacts into the commonly used evaluation categories will be made for the post-closure phase of a disposal facility.

Alternatively: shipment of spent fuel from research, development and demonstration reactors to a country where fuel for research reactors is supplied or manufactured

The impact factors that need to be taken into account for transportation – air pollutants and noise, direct radiation and accidental release of radioactive substances – do not lead to potentially relevant environmental impacts. The subsequent management stages – processing the fuel and disposal of the waste resulting from that – both of which take place outside Germany, are not within the remit of the SEA, because they are carried out under the regulatory regime of the receiving country.

Storage of spent fuel and waste from reprocessing

With regard to the environmental impacts associated with storage of spent fuel and waste from reprocessing, the following must be taken into account:

- the longer storage time for spent fuel and waste from reprocessing;
- extension of the permissible types of waste at decentralised storage facilities for waste from reprocessing operations; and
- storage of fuel from research, development and demonstration reactors

For the operational changes to existing storage facilities resulting from that, the following impact factors are considered: heat input, radioactive operational waste, direct radiation and risks of possible incidents. Within the SEA's overarching evaluation, no resulting potentially relevant environmental impacts have to be taken into consideration.

Management of radioactive waste retrieved from the Asse II mine and closure of the Asse II mine

Retrieval of the Asse II mine's radioactive waste requires the following projects:

- retrieval and conditioning of radioactive waste retrieved from the Asse II mine (operation of the Asse II mine to carry out the retrieval; construction, operation and dismantling of a conditioning facility);
- storage of the conditioned waste (construction, operation and cessation of operation);
- closure of the Asse II mine;
- transport of the waste from the storage facility to the disposal facility;
- disposal of the waste in the disposal facility according to the Site Selection Act; and
- optionally: disposal of the retrieved radioactive waste in the Konrad disposal facility

Conventional impact factors during the construction and dismantling of facilities and during transport

Construction of additional buildings for the retrieval operations, of a conditioning facility and of a storage facility lead to potentially significant environmental impacts as a result of land sealing, which must be compensated.

The construction and possibly also the dismantling of the interim storage facility and conditioning facility and the construction of facilities needed to retrieve radioactive waste from the Asse II mine may lead to potentially relevant environmental impacts for the following conventional factors:

- air pollutants within a range of about 1.5 km
- noise and vibrations within a range of about 1.5 km when protecting human wellbeing is the main concern
- air pollutants and noise from transport of construction materials, waste or excavated material within a range of about 100 m from the transportation routes
- lowering of the groundwater level and discharge of conveyed groundwater as conventional wastewater
- spatial impact of buildings

During construction of facilities for the retrieval of radioactive waste from the Asse II mine the following impact factors may lead to potentially relevant environmental impacts:

- air pollutants and noise (for the protection of human wellbeing) within a range of about 700 m;
- spatial impact of shaft buildings and possibly other buildings.

During the process of decommissioning the Asse II mine, the impacts lessen gradually.

Conventional impact factors during operation of facilities

During operation of the conditioning facility conventional wastewater is discharged.

During the retrieval operations no noteworthy conventional impacts occur that are relevant to the SEA's overarching perspective.

Radiological impact factors

With regard to radiological impact factors, the retrieval, conditioning and storage of radioactive waste from the Asse II mine lead to the following potentially relevant environmental impacts:

- retrieval operations: emissions of radioactive substances via the air pathway and risks of incidents;
- conditioning facility: direct radiation, emissions of radioactive substances via the air and water pathways, risks of incidents;
- storage facilities: direct radiation and risks of potential incidents;

Transport of waste does not cause any potentially relevant environmental impacts.

Based on the SEA's overarching considerations, the environmental impacts of disposal of radioactive waste retrieved from the Asse II mine in the disposal facility for heat-generating waste or optionally in the Konrad disposal facility are comparable. Potentially relevant environmental impacts arise during operation of the disposal facility as a result of emissions of radioactive substances via the air pathway and risks of potential incidents.

Management of depleted uranium from enrichment operations

Management of depleted uranium from enrichment operations comprises the following projects:

- conditioning of the waste according to the acceptance requirements for disposal (construction, operation and decommissioning);
- transfer of waste to the disposal facility;
- disposal of waste in a disposal facility according to the Site Selection Act; and
- optionally: disposal of waste in the Konrad disposal facility.

Conventional impact factors during construction and dismantling of facilities

Construction of a conditioning facility and storage facility lead to potentially significant environmental impacts as a result of land sealing, which must be compensated.

Construction and dismantling of the storage facility and conditioning facility may lead to environmental impacts for the following conventional impact factors:

- air pollutants and noise (for the protection of human wellbeing) within a range of about 1 km;
- noise resulting from transport of construction materials, waste or excavated material within a range of about 100 m from the transportation routes;
- lowering of groundwater level and discharge of piped groundwater as wastewater;

- spatial impact of buildings (storage facility, conditioning facility)

Conventional impact factors during operation of facilities

During operation of the conditioning facility conventional wastewater is discharged.

Radiological impact factors

With regard to radiological impact factors, storage and conditioning of non-reutilised waste from uranium enrichment lead to the following potentially relevant environmental impacts:

- storage: risks of potential incidents;
- conditioning facility: emissions of radioactive substances via the air and water pathways and risks of potential incidents;
- disposal of waste from uranium enrichment in a disposal facility according to the Site Selection Act or in the Konrad disposal facility leads to potential environmental impacts as a result of risks of incidents during operation of the disposal facility

Transport of the waste does not lead to any potentially relevant environmental impacts.

Feasibility of the measures, cross-border impact, hypothetical zero options and subsequent environmental assessments

The current findings of the evaluation of environmental impacts are based on precautionary considerations and assume that sensitive protection targets such as housing needs to considered. Measures to avoid or minimise impacts were not taken into consideration. For that reason, the potentially relevant environmental impacts detailed here will not necessarily occur when the National Programme’s measures and projects are carried out.

Taking protection targets that are actually affected into account and making use of potential for avoidance and minimisation, National Programme‘s measures and projects can be carried out in compliance with environmental objectives so that - with the exception of land sealing, which needs to be compensated – no significant environmental impacts remain.

Since virtually no site has been specified for the National Programme’s measures and projects, it is not currently possible to rule out the possibility of their occurring near to national borders. In this case, cross-border potential environmental impacts are possible within a distance to existing protection targets as far as distances have been identified.

In the SEA of the National Programme, hypothetical zero options, long-term storage of heat-generating radioactive waste, of waste that has been retrieved from the Asse II mine and of depleted uranium from enrichment, which is not reutilised, are investigated and with a view to their environmental impacts compared with the National Programme’s disposal plans. The hypothetical zero options of long-term storage would predominantly cause a worsening of the state of the environment by comparison with disposal as proposed in the National Programme.

Environmental Impact Assessments will be carried out for the National Programme’s measures and projects as required by the Act on the Assessment of Environmental Impacts (UVPG 2013). These assessments will consider the actual environmental components in the area under investigation to determine the required protection.

Any neighbouring countries that may be affected will be consulted in future licensing procedures as required under the Act on the Assessment of Environmental Impacts, if there are indications of cross-border environmental impacts.

List of abbreviations

AbwV	Abwasserverordnung (*Waste Water Ordinance*)
AtG	Atomgesetz (Atomic Energy Act)
AtVfV	Atomrechtliche Verfahrensverordnung (Nuclear Licensing Procedure Ordinance)
AVV Construction Noise	Allgemeine Verwaltungsvorschrift zum Schutz gegen Baulärm (General administration regulation for protection against construction noise)
BArtSchV	Bundesartenschutzverordnung (Federal Protection of Species Ordinance)
BBergG	Bundesberggesetz (Federal Mining Law)
BBodSchG	Bundesbodenschutzgesetz (Federal Ground Protection Law)
BBodSchV	Bundesbodenschutz- und Altlastenverordnung (Federal Ground Protection and Residual Pollution Ordinance)
BImSchG	Bundes-Immissionsschutzgesetz (Federal Emission Control Act)
BImSchV	Bundes-Immissionsschutzverordnung (Federal Emission Control Ordinance)
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
BNatSchG	Bundesnaturschutzgesetz (Federal Nature Conservation Act)
DCRL	Derived Consideration Reference Level
DIN	Deutsches Institut für Normung (German Institute for Standards)
DVGW	Deutscher Verein des Gas- und Wasserfaches (German Association of Gas and Water Specialists)
ERAM	Endlager für radioaktive Abfälle Morsleben (Disposal facility for radioactive waste Morsleben)

ESK	Entsorgungskommission (Nuclear Waste Management Commission)
EU	European Union
Euratom	European Atomic Energy Community
ewG	einschusswirksamer Gebirgsbereich (Containment-providing rock zone)
GGBefG	Gefahrgutbeförderungsgesetz (Hazardous Goods Transport Law)
HAA	Hochaktive Abfälle (Highly-Active Waste)
HDB	Hauptabteilung Dekontaminationsbetriebe (Central Decontamination Department of the WAK in Karlsruhe)
ICRP	International Commission on Radiological Protection
KrWG	Kreislaufwirtschaftsgesetz (Recycling Economy Law)
LAI	Länderausschuss für Immissionsschutz (State Committee on Emission Control)
LAWA	Bund/Länder-Arbeitsgemeinschaft Wasser (Federal/State Working Group on Water)
NaPro	National Programme
OGewV	Oberflächengewässerverordnung (Surface Water Ordinance)
PKA	Pilot-Konditionierungsanlage (Pilot Conditioning Plant)
RAL-UZ 53	Reichs-Ausschuss für Lieferbedingungen – Umweltzeichen 53 - Baumaschinen (Reichs Committee for Terms of Delivery - Environmental Mark 53 -Construction
SRS	Savannah River Site
SSR	Specific Safety Requirements
StandAG	Standortauswahlgesetz (Site Selection Act)
StrlSchV	Strahlenschutzverordnung (Radiaton Protection Ordinance)
SEA	Strategic Environmental Assessment
US	United States
UVP	Umweltverträglichkeitsprüfungen (Environmental impact assessments)

UVPG	Gesetz über die Umweltverträglichkeitsprüfung (Environmental Impact Assessment Act)
VSG	Vorläufige Sicherheitsanalyse Gorleben (Preliminary safety analysis, Gorleben)
WAK	Wiederaufarbeitungsanlage Karlsruhe (Reprocessing facility, Karlsruhe)
WHG	Wasserhaushaltsgesetz (Federal water act)

1. Introduction

Background

In accordance with the Council Directive 2011/70/Euratom of 19 July 2011establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, the Member States of the European Union are obliged to prepare, notify and regularly update a National Programme (National Programme) by 23 August 2015. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), as the responsible government authority, implements in this connection a Strategic Environmental Assessment (SEA) of the National Programme, with participation of the public, according to the instructions of the law for the environmental impact assessment /UVPG 2013/. The existing environmental report describes and evaluates the impacts of the measures represented in the National Programme on the environment. This document, as an extension to the National Programme, serves for the participation of the public.

Extent of consideration

Environmental impacts are detectable influences/emissions (e.g. of air pollutants, noise or land consumption) on the protected items defined in the UVPG (persons, human health, animals, plants, biological diversity, ground, water, air, climate, landscape, cultural assets and other physical assets, as well as interaction). The intensity and the duration of an environmental impact determine whether this is to be classified as below an insignificant limit, as potentially-relevant or as potentially significant.

The considerations in the SEA comprise the measures which are listed in the National Programme /NaPro 2015/ as planning or which result from corresponding plans as environmental impacts were already considered within the scope of the licensing procedures for already existing or approved measures respectively. The measures presented in the National Programme are partly realised in facilities (e.g. of disposal facilities and treatment plants), about whose sites and layout no decision has yet been made. Therefore no real areas under investigation with real environmental elements are in this respect representable in this SEA. Correspondingly, impact factors are described qualitatively or as a quantitative bandwidth. The environmental impactts are predicted on this basis and assessed with regard to compliance with general environmental objectives. For the assessment of the environmental impacts, assumptions are made regarding the involvement of subjects of protection and protected environmental elements.

The projects to be realised in future for the implementation of the objectives of the National Programme are assessed in detail in the following SEA's and environmental impact assessments (UVP). These assessments will then be implemented on the basis of concrete facility descriptions and sites, including the affected environmental elements in the investigation area, so that any further clarification of the planned generic qualitative approach is not necessary at the present time. Due to the degree of abstraction of this SEA, no main focal points of the environmental assessment are stipulated here with respect to subordinate SEA's and UVP's (pursuant to § 14 F Sect. 3 UVPG).

Procedural steps and participation

A draft of the National Programme as well as the scoping document for the SEA of the National Programme were published on 6 January 2015 by the BMUB. Pursuant to § 14f Sect. 4 Sentence 1 UVPG, the competent nuclear authorities of the Länder, as well as the recognised national active environmental organisations, were given the opportunity to make a written statement regarding the set framework of the investigation and the scope and the level of detail of the specifications to be recorded in the environmental report. On 29 January 2015 there existed an additional opportunity for them to have a verbal discussion.

The draft of the National Programme as well as the existing environmental report are made publicly available for public participation for a period of two months , in order to give the population an opportunity to comment on the planned measures. Taking into consideration the communicated comments and opinions, the representations and assessments of the two reports will be checked and considered in the revision of the National Programme.

2. Subject of the Strategic Environmental Assessment of the National Programme

The description of the test object represents the basis for the determination of the impact factors and for the description and evaluation of the environmental impacts based on them.

The test object for the SEA results from the measures listed in the National Programme for the management of radioactive waste in Germany. The considerations are limited to those measures, which are included in the National Programme as planning, as environmental impacts were already considered within the scope of the licensing procedures for already existing or approved measures (e.g. existing storage facilities for spent fuel, as well as construction and operation of the Konrad disposal facility) respectively. The planned measures are considered independently of whether they are also subject of legal stipulations, as well as the planning in the National Programme.

The description of the planned measures is further concretised for the environmental assessment by means of projects and project phases:

- Measures: The planning described in the National Programme are designated as measures.
- Projects: The essential parts of a measure are designated as projects. These can be e.g. facilities for certain waste management steps or defined exploration steps in case of the disposal or transport of waste between different facilities.
- Project Phases: Depending on the type of the project, different implementation steps are to be considered, which are hereinafter referred to as "project phases". In case of facilities which are to be newly realised, generally the project phases construction, operation and decommissioning/closure are to be considered in the environmental report. In case of projects which provide for the change or extension of the use of existing systems, the considerations are generally limited to the operating phase.

As far as a clarification of the measures of the National Programme is necessary for a representation of potential environmental impacts, plausible assumptions are taken as a basis in this report. These assumptions are solely made for the estimate of potential environmental impacts and are not a pre-stipulation for the later implementation of the measures of the National Programme.

Provided that in the National Programme for the implementation of an measure an alternative possibly to be tested is described in addition to the planning (e.g. the site for the disposal of the waste retrieved from the Asse II mine), the projects connected respectively are listed as options. With the description of the environmental impacts of options, a comparative consideration is implemented (as far as possible) according to the generic character of this SEA.

Based on the planning in the National Programme, the following planned measures are considered in the environmental report with regard to their environmental impacts:

- Site selection process and disposal of especially heat-generating waste, including the fuel assemblies from research, development and demonstration reactors
- Alternative: Shipment of the spent fuel from research, development and demonstration reactors to a country where research reactor fuels are supplied or manufactured Storage of spent fuel and waste from reprocessing
- Disposal of the radioactive waste retrieveed from the Asse II mine and closure of the Asse II mine
- Disposal of the depleted uranium from uranium enrichment providing for the case that it will not be reutilised

Below it is listed for each of these measures which projects and which project phases should be considered in the environmental report.

Site selection process and disposal especially of the heat-generating waste, including the spent fuel from research, development and demonstration reactors

The process related to the search and selection of a disposal facility especially for heat-generating waste is described in the Site Selection Act /StandAG 2013/. The steps defined there are considered in the SEA as projects. As an extension, the planning of the National Programme includes the construction of a receiving storage facility at the site of the disposal facility, which should be approved with the first partial license for the disposal facility. In this way, the precondition for the start of clearing the existing storage facilities is to be provided. According to the plans for the disposal facility, in case of all projects – as far as appropriate and possible- the host rock variants of rock salt, clay and crystalline rock designated in the Site Selection Act are to be considered. However, due to the generic qualitative character of the environmental report, considerations differentiating between host rocks are only implemented in individual cases, if, on the basis of currently available data with regard to certain impacts, considerable differences are to be expected which have a determining influence on the evaluation of the environmental impacts.

As well as spent fuel from nuclear power plants and the waste from the reprocessing, the considerations also include spent fuel from research, development and demonstration reactors, for which the National Programme provides the option of the disposal in the disposal facility for especially heat-generating waste to be constructed according to the Site Selection Act , if the shipment to a country where research reactor fuels are supplied or manufactured is not implemented. The quantities are small in comparison with the two other waste streams.

The considerations of environmental impacts through transportation of the different waste from the storage facilities to the disposal facility are implemented together in a generic approach for all waste and storage facility sites, since a differentiation of volumes, inventories and transport routes is not possible on the basis of the present planning status.

For the measures, the following projects and project phases are to be considered:

Measure: Site selection process and disposal especially of the heat-generating waste, including the spent fuel from research, development and demonstration reactors	
Projects	**Project Phases**
Surface exploration of several sites for a disposal facility	Implementation of all measures from the soil surface e.g. exploration drilling, measurements etc.
Subsurface exploration of sites for a disposal facility	excavation of exploratory mines Operation of the exploratory mine Cessation of the operation of exploratory mines, closure and close-off measures
Transfer of the waste to be emplaced in the disposal facility for heat-generating waste from the storage facility sites to the disposal facility site	transport to the receiving storage facility of the disposal facility
Storage of the waste to be disposed in the receiving storage facility of the disposal facility	Construction, operation and decommissioning of the receiving storage facility
Conditioning suitable for disposal of all waste to be disposed in the disposal facility for heat-generating waste	Construction, operation and decommissioning of the conditioning plant for the processing and packaging suitable for disposal
Disposal of the waste	Construction of the disposal facility Emplacement operation of the disposal facility Disposal facility close-off (closure and close-off measures, monitoring, dismantling of above-ground systems) Post-closure phase

Alternative: Shipment of the spent fuel from research, development and demonstration reactors to a country where research reactor fuels are supplied or manufactured

The shipment of the spent fuel from research, development and demonstration reactors to a country where research reactor fuels are supplied or manufactured is an alternative to the disposal in Germany according to the National Programme. For this measure, the following projects are considered:

Measure: Shipment of the spent fuel from research, development and demonstration reactors to a country where research reactor fuels are supplied or manufactured	
Projects	**Phases**
Transfer of existing and still produced spent fuel from research, development and demonstration reactors to a country where research reactor fuels are supplied or manufactured	The overall transport route to a country where research reactor fuels are supplied or manufactured, will be considered in generic form

The subsequent waste management steps in the recipient country (reprocessing and disposal of the resulting waste) are not the subject of the SEA, since they are implemented under the regulatory regime of the corresponding accepting state.

Storage of spent fuel and waste from reprocessing

For the spent fuel and waste from reprocessing, sufficient storage capacities exist in Germany. The measures listed below affect exclusively changes of the currently licensed operation of the existing storage facility with regard to the duration of the storage and the waste to be emplaced. Impacts through construction and decommissioning of facilities are therefore not to be considered.

The storage of spent fuel from nuclear power plants takes place at the sites of the nuclear power plants (on-site storage facility), as well as in the transport casks storage facilities in Gorleben, Ahaus and Rubenow. Due to the time schedule for the provision of a disposal facility according to the Site Selection Act /StandAG 2013/, a complete clearance of the storage facilities cannot be obtains within the licensed operating time. In the environmental report, the option of an extension of the storage times is therefore considered.

The vitrified fission product solutions to still be taken back from the reprocessing of spent fuel abroad are, in accordance with Article 2 of the Site Selection Act /StandAG 2013/, no longer to be kept in the transport cask storage facility Gorleben, but in on-site storage facilities. The planning to be considered in the environmental report refers to the operation of on-site storage facilities in which now- in contrast to the existing licenses- a total of 26 transport and storage casks with vitrified fission product solutions and vitrified operational waste are also to be stored.

Furthermore, storage capacities for the spent fuel from research, development and demonstration reactors are to be considered, for which the National Programme provides the option of storage and later disposal if a shipment to a country where research reactor fuels are supplied or manufactured is not implemented. The shipment to such a country is as an alternative described in Chapter 5.2.1.

Since the storage facilities are based on a comparable concept, the considerations for the environmental impacts of the three designated waste disposal measures are implemented in each case together for all storage facilities in a generic approach.

For the measure the following projects and project phases are to be considered:

Measure: Storage of irradiated fuel assemblies and waste from reprocessing

Projects	**Project Phases**
Extension of the storage time for spent fuel and waste from reprocessing in the existing, licensed on-site storage facilities and transport casks storage facilities	Operation
Extension of several existing on-site storage facilities for the storage of vitrified fission product solutions from the reprocessing of spent fuel	Operation
Extension of existing storage facilities for the storage of the spent fuel from research, development and demonstration reactors	Operation

Disposal of the radioactive waste retrieved from the Asse II mine and closure of the Asse II mine

In accordance with the act to to speed up the retrieval of radioactive waste from and the closure of the Asse II mine /Lex Asse 2013/, the waste is to be retrieved from the mine. The retrieved radioactive waste is to be conditioned on-site and stored in a storage facility that is to be newly constructed. For the disposal of the retrieved radioactive waste, the planning of the National Programme stipulates an emplacement in the disposal facility according to the Site Selection Act. The option of an extension of the Konrad disposal facility is not precluded and is to be examinedafter its commissioning, if necessary. The technical feasibility of an extension is assumed to be given. The emplacement of the retrieved radioactive waste in the Konrad disposal facility is therefore considered as an option in the environmental report. A consideration of impacts of an emplacement of the radioactive waste retrieved from the Asse II mine, on the verification of the long-term safety is not considered, either for the disposal facility according to the Site Selection Act or for the Konrad disposal facility.

For the measure, the following projects and project phases are to be considered:

Measure: Disposal of the radioactive waste from the Asse II mine and closure of the Asse II mine

Projects	Project Phases
Retrieval and conditioning suitable for disposal of the radioactive waste retrieved from the Asse II mine at the site of the retrieval	Retrieval of the radioactive waste, Construction, operation and decommissioning of conditioning plant for the processing and packaging of the retrieved radioactive waste
Storage of the conditioned waste	Construction, operation and decommissioning of the storage facility
Closure of the Asse II mine	Closure of the mine and dismantling of the above-ground facilities
Transfer of the waste to the disposal facility	Transport from the storage facility to the disposal facility
Disposal of the waste in the disposal facility according to the Site Selection Act	Consideration with the emplacement capacities of the disposal facility Operation of the disposal facility for the emplacement of the retrieved radioactive waste (emplacement operation)
Option: Disposal in the Konrad disposal facility	
Disposal of the waste in the Konrad disposal facility	Extension of the emplacement capacities of the Konrad disposal facility, Operation extension of the Konrad disposal facility for the emplacement of the waste retrieved from the Asse II mine

Disposal of the depleted uranium from the uranium enrichment

Providing for the case that it will not be reutilised, the depleted uranium that has been generated and will be generated in Germany as a result of uranium enrichment, as a precaution, is to be considered in the planning of the disposal facility according to the Site Selection Act. The option of an extension of the Konrad disposal facility is not precluded and is to be examined after its commissioning, if necessary. The technical feasibility of an extension is assumed to be given. The emplacement of the radioactive residues from uranium enrichment into the Konrad disposal facility is therefore considered in the environmental report as an option that is compared to the emplacement of the waste into the disposal facility according to the Site Selection Act. For disposal these residues are to be conditioned suitable for disposal and are to be transferred to the corresponding disposal facility site. Furthermore, it is to be assumed that, at the site of the conditioning plant or at the disposal facility site, storage capacities are to be constructed for the conditioned waste in order to enable the realisation of the conditioning independently of the emplacement management in the disposal facility.

For the measure the following projects and project phases are to be considered:

Measure: Disposal of the depleted uranium from uranium enrichment	
Projects	**Project Phases**
Transfer of the waste to the disposal facility	Transport from the storage facility to the disposal facility
conditioning suitable for disposal of the waste	Construction, operation and decommissioning of conditioning plant
Disposal of the waste in the disposal facility according to the Site Selection Act	Consideration at the emplacement capacities of the disposal facility, Operation of the disposal facility for the emplacement of the depleted uranium (emplacement operation)
Option: Disposal facility in the Konrad disposal facility	
Disposal of the waste in the Konrad disposal facility	Extension of the emplacement capacities of the Konrad disposal facility Operation extension of the Konrad disposal facility for the emplacement of the radioactive residues from uranium enrichment

3. Investigative framework, methodology and environmental objectives

3.1. Investigation area, probable development in case of non-implementation of the National Programme

The investigation area has a spatial and a time-related dimension.

In the spatial sense, the investigation area for the SEA of the National Programme is the environment around the planned measures and projects, within which the impact factors act on the environment (emissions). The measures planned in the National Programme are realised extensively at sites not stipulated to date in the region of the Federal Republic of Germany. Due to the lack of any site stipulations, a spatial delimitation to concrete areas under investigation, as well as a description of real environment components, are not possible. For the investigation of potentially significant environmental impacts, the occurrence of sensitive protected items or protected environment component parts in the investigation area is therefore assumed with the evaluation of the environmental impacts.

The time-related dimension of the investigation area is the consideration of the impact factors over the period of the action duration on the protected items. The relevance of environmental impacts depends, among other things, on whether the respective protected item is affected only short-term or on a long-term basis. Temporary impairments of protected items (e.g. through construction site noise) are to be classified as less serious in comparison with long-term impairments or actual losses of protected item functions (e.g. land consumption).

A probable development of the environment in case of non-implementation of the National Programme cannot be described quantitatively within the framework of the SEA, since the respective sites of the measures of the National Programme are not stipulated.

For the SEA of the National Programme, hypothetical zero variants are developed and described in Chapter 6.

3.2. Methodology for the evaluation of the environmental impacts

Procedural method for the registration and evaluation of the environmental impacts

Pursuant to § 14 g Sect. 1 UVPG in the SEA of a program, pursuant to § 2 Sect 5 UVPG, the probably significant environmental impacts on the protected items of the UVPG are to be determined (persons, including human health, animals, plants, biological diversity, ground, water, air, climate, landscape, cultural assets and other physical assets, as well as interaction between the above-designated protected items). The measures and projects of the National Programme listed in Chapter 2 are assessed. The assessment is implemented in three steps:

- In the first step, the impact factors (emissions/effects) are described which arise from the measures and projects of the National Programme to be tested.
- In the second step, the effects of the impact factors on the protected items of the UVPG - the environmental impacts - are described.
- In the third step, the evaluation is implemented of the environmental impacts with regard to compliance with the environmental objectives. Measures of avoidance and minimisation are represented.

In this SEA the description and evaluation of environmental impacts are implemented in each case for those protected items relevant from the comprehensive viewpoint of the SEA in accordance with UVPG. Protected items of the UVPG for which, within the framework of the comprehensive procedural method of this SEA, no significant involvement is identifiable with regard to the environmental impacts to be considered in each case, are not designated explicitly

Registration of the impact factors

The description the impact factors of the measures and projects of the National Programme is implemented by assessment of existing literature relating to project studies which indicate plausible comparability with the projects of the National Programme. Since there are currently no system-specific concepts of the projects of the National Programme available, a complete quantitative representation of the impact factors is not possible. The impact factors, as far as possible, are represented in the quantitative bandwidth of their appearence or described qualitatively.

In case of projects of the final storage of heat-generating waste (e.g. site exploration, disposal facility construction and operation), studies relating to planned systems abroad or to knowledge regarding the exploration of the site Gorleben, insofar as existing, are referenced. Provided that no plausible knowledge from relevant project concepts can be referred to for the description of impact factors of the disposal facility, portable knowledge from other projects, for example from mining projects, is used.

Portable knowledge is employed for the description of the impact factors of planned storage facilities from already realised storage facility projects.

In case of projects of the National Programme which are connected with a construction of facilities (e.g. disposal facility for heat-generating waste, conditioning systems and storage facility), as well as system and operational-related impact factors, relevant construction-determined impact factors are considered in overview. In case of projects which provide for an extension of the lifetime of existing systems, for example, the storage facility for irradiated fuel assemblies at nuclear power plant sites, operationally-caused impacts are considered exclusively. Systems and construction-related impacts, such as for example land consumption, were already considered with the licensing of the facilities.

The description of the impact factors for the planned measures and projects of the National Programme is implemented with focus on the most important impacts, according to the present status of knowledge, with regard to relevant impacts on the protected items of the UVPG.

Impact factors of a project which do not lead to environmental impacts in recognisable form right from the beginning, according to the comprehensive overview of this SEA, are not dealt with in the following description of environmental impacts.

Determination of the potential environmental impacts

Environmental impacts are detectable influences on protected items of the UVPG (emissions). The intensity, the scale and the duration of an environmental impact determine whether the environmental impact lies below an insignificant limit, leads to perceptible disturbances or to impairment of the protected item.

For the determination of the potential environmental impacts, the influences/emissions of the impact factors on potentially existing protected items are described qualitatively and, as far as possible, also quantitatively. The basic plausible relationships between impact factors and protected items are compiled for this purpose first of all (for example the impact of noise on persons). For the relevant relationships impact factor / protected item, the bandwidth of the intensity of possible environmental impacts is represented.

Environmental impacts of an impact factor which are represented as negligible, according to the comprehensive point of view of this SEA with the description of potential environmental impacts, are not dealt with in case of a following evaluation of environmental impacts of the respective project.

Evaluation of the potential environmental impacts

With the evaluation of the potential environmental impacts, it is assessed on the basis of assumptions relating to existing protected items whether the environmental objectives can be adhered to.

For the assessment of the environmental impacts through planned measures and projects of the National Programme, assumptions relating to sensitive protected items or protected environment components are made with the evaluation of impact factors with considerable influence potential on the environment (e.g. existing Natura 2000 sites or residential areas in the area of emissions). Statements are made, as far as possible and appropriate, concerning the distance between protected item and emissions, which can be taken as orientation values to avoid potentially-relevant environmental impacts and within which minimisation potentials are to be considered.

The evaluation of the environmental impacts is implemented according to three categories:

- **No potentially-relevant environmental impact.** The appearance of the respective impact factor is representable quantitatively to a large extent. The environmental impact is not relevant due to the low level of appearance of the impact factor or the low sensitivity of potential protected items. Compliance with the environmental objectives is not set in question.
- **Potentially-relevant environmental impact.** The impact factor can lead to significant entries in the environment (emissions). The scale of the environmental impact is dependent on the appearance of the impact factors and the involvement of possibly existing protected items. Taking into consideration minimisation potentials and considering the boundary conditions for the involvement of protected items, compliance with the environmental objectives can be assumed.
- **Potentially significant environmental impact.** Significant impacts on possibly-existing, especially-sensitive protected items or particularly-protected environment components cannot be excluded, so that compliance with the environmental objectives cannot be assumed.

The environmental impacts in the SEA of the National Programme to be generically considered are to be concretised with realisation of the relevant projects, within the framework of the prescribed environmental impact assessments. A more in-detail consideration of the environmental impacts is implemented in this case on the basis of defined system designs and sites.

3.3. Environmental objectives

In the SEA of the National Programme, with regard to the environmental impacts, the following protected items, pursuant to § 2 UVPG, are to be considered:

- Persons, including human health
- Animals, plants and biological diversity
- Ground, water, air, climate, landscape, cultural assets and other physical assets, as well as
- Interactions between the above-designated protected items

Environmental objectives are targets for the protection of the above-mentioned protected items. The environmental objectives are stipulated in the laws of the Federal Republic of Germany, the ordinances based on them, the subordinate legal regulatory works, as well as in the recognised publications. As a scale for the environmental objectives, specifications related to the protection objectives for the individual protected items, as generally qualitatively formulated in the regulatory works and in the literature or, provided that the determined influences on protected items can be quantified, actually stipulated values (e.g. precautionary and limit values) are employed.

The civil law relating to life and health anchored in Basic Law /GG 2012/ addresses the protected item person and human health.

With the evaluation of impact factors, the environmental objectives taken as a basis in each case (laws, ordinances, regulations) and evaluation criteria are represented.

Significant environmental objectives relating to the evaluation of conventional impact factors are anchored (among other things) in the following laws, ordinances and regulations:

- Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena (Federal Emission Control Act - BImSchG) including ordinances /BImSchG 2014/
- Law relating to the arrangement of the water budget (Federal Water Act - WHG) /WHG 2014/
- Law relating to protection against harmful ground changes and for the remediation of residual pollution (Federal Ground Protection Law - BBodSchG) /BBodSchG 2012/
- Federal ground protection and residual pollution ordinance (BBodSchV) /BBodSchV 2012/
- Law relating to nature conservation and landscape conservation (Federal Nature Conservation Act - BNatSchG) /BNatSchG 2013/
- Federal protection of species ordinance (BArtSchV) /BArtSchV 2013/

Significant environmental objectives and specifications relating to the evaluation of radiological impact factors are defined in the following laws, ordinances and announcements of the Federal Republic of Germany:

- Act on the peaceful utilisation of atomic energy and the protection against its hazards (Atomic Energy Act) /AtG 2013/
- Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance - StrlSchV) /StrlSchV 2012/
- Ordinance on the Procedure for Licensing of Installations pursuant to §7 of the Atomic Energy Act (Nuclear Licensing Procedure Ordinance - AtVfV) /AtVfV 2006/
- Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste /SaEndlwA 2010/

4. General considerations relating to impact factors, environmental effects and evaluation frameworks

This chapter gives an overview of all impact factors to be considered within the context of the projects of the National Programme.

The impact factors are of different relevance for the projects of the National Programme and for the project-specific considerations in Chapter 5 with regard to the frequency of their occurrence, as well as the environmental impacts to be expected. Correspondingly, the three following groups are differentiated between with regard to further handling of the impact factors:

1. *Project-specific impact factors (frequent)* which occur in numerous projects of the National Programme and which are described, as far as possible, in their band width for the individual projects of the National Programme:
   - Land consumption
   - Air pollutants
   - Noise and vibrations
   - Direct radiation
   - Emissions of radioactive materials via water (discharge)
   - Emissions of radioactive materials via air (discharge)
   - Incidents

For these impact factors, higher-level considerations of the associated environmental effects are detailed in Chapter 4.1and the evaluation framework is depicted. In this way, the basis is provided for the project-specific remarks in Chapter 5, which can thus focus on the quantification of the environmental effects and their evaluation in the respective project-specific context.

2. *Project-specific impact factors (special)* that occur only in individual projects of the National Programme:
   - Spatial impact
   - media input, blow-out and hydraulic shortcut
   - Radioactive operational wastes
   - Emission of radioactive substances or other pollutants from disposal facilities in the post-closure phase
   - Heat entry into the ground
   - Surface subsidence

For these impact factors, no general considerations are made, since they occur only in special projects. The description and evaluation of the environmental effects resulting from these impact factors is given in Chapter 5 in the respective project context.

3. *Non-specific impact factors* which cannot be described project-specific for the projects of the National Programme due to currently missing project plans, subdivided into non-specific impact factors *of relevant importance for an SEA* and non-specific impact factors of *subordinate importance*:

   Non-specific impact factors of *relevant importance for the SEA:*
   - Ground-water lowering
   - Conventional waste water

   Non-specific impact factors of *subordinate importance for the SEA*:
   - substances hazardous to water
   - Rainwater on circulation areas and roofs
   - Sanitary waste water
   - Conventional waste

- Light emissions
- Radon emissions

These impact factors are fully dealt with in Chapter 4.2.No further project-specific consideration will take place.

4.1. Frequent project-specific impact factors

4.1.1. Land consumption

Land consumption, in particular by sealing, arise from the construction of buildings, traffic and storage areas as well as through storage of substances and material (e.g. construction material, building materials, excavated material) on areas of land.

General environmental effects of land consumption

Land consumption leads to the loss of the buffering and cleaning function of the ground. As a result of the sealing of the ground, the exchange of media (air, water, nutrients, decomposition products) with the environment is suppressed so that the decomposition of biological substance to nutrients available in the ground to plants, as well as the buffering and the degradation of pollutants, are reduced to a large extent. The land consumption leads furthermore to the loss of the living space function of the ground for plants (e.g. fungi) and animals (e.g. earthworms) which live in the ground and which guarantee the media supply of the ground, in particular with air, through bio-turbation (mixing through by organisms).

A sealing of surface water bodies or parts of surface water bodies leads to the loss of the water body or water body part, including its function in the ecosystem.

With regard to the protection target "Animals and plants" land consumption of soil furthermore leads to the loss of the living spaces (e.g. deciduous wood, meadows) including their living communities that existed previously on the ground. Furthermore, protected species according to the Federal Protection of Species Ordinance or their breeding grounds can be affected in this case.

Provided that land consumption is implemented in a protection area (nature reserve, Natura 2000 sites, bird sanctuary area), a part of living spaces in the affected protection area disappears, which is placed under special legal protection due to its importance and/or rarity.

Evaluation framework for the environmental effects of land consumption

Land consumption is a significant impairment of nature and landscape, as specified by § 13 BNatSchG /BNatSchG 2013/. So as a rule, land consumption can be evaluated as significant environmental effects which are to be avoided, according to BNatSchG.

Significant impairments of nature and landscape, pursuant to § 13 BNatSchG, insofar as they are not avoidable through compensation and replacement measures, or insofar as this is not possible, are to be compensated by remuneration in money. The process relating to the compensation or replacement measures or the compensation by remuneration is implemented according to specifications of the federal state in which the interference occurs. The stipulation of compensation and replacement measures is implemented on the basis of an inventory stocktaking relating to the affected protected items. The land consumption is compensated according to its valence by unsealing or revaluation of other surfaces or by money. With the sealing of water bodies, the creation of new water bodies or measures of water body return to nature offer itself as a compensation. Thus a path exists for the realisation for projects with land consumption in spite of the significant environmental effects.

However, provided that particularly protected species or their propagation or rest places pursuant to § 44 BNatSchG are affected by land consumption, the interference is not permissible. The interference is feasible only if the exception prerequisites of § 45 Sect. 7 BNatSchG are fulfilled. For this, it is to be verified that there are compelling reasons of predominant public interest, including those of a social or economic nature. An exception to the prohibition of the intervention is permissible only if reasonable alternatives do not exist and the preservation status of the populations of a species does not deteriorate (§ 45 Sect. 7 BNatSchG). The process for the assessment of the exception prerequisites of § 45 Sect. 7 BNatSchG is stipulated in more detail in laws by the federal states.

For the realisation of land consumption, further requirements exist for the case that the land consumption is intended to be implemented in a Natura 2000 region, or if this region itself could be impaired by land consumption in the direct environment of a Natura 2000 region. In such a case, the compatibility of the project with the conservation objectives of the affected Natura 2000 region (FFH region), pursuant to § 34 BNatSchG, is to be assessed.

4.1.2. Air pollutants

With the projects of the National Programme, air pollutants are emitted particularly by the combustion engines of equipment, machines and vehicles used on construction sites, as well as by the operation of heating systems. In addition, dust drifts from construction sites and tips are possible.

General environmental effects through air pollutants

Particulate matter (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulphur oxides are particularly emitted by the employment of equipment, machines and vehicles used on construction sites, by the operation of facilities, as well as by the use of transportation vehicles. The same applies for the operation of heating systems. Pollutant emissions can lead to considerable negative effects on persons, animals and plants in the neighbourhood of sites and along the transportation routes, since they can be harmful to the health of persons and damage or impair plants and animals. In addition, a decrease of the regeneration function of sites by dust emissions can result. Salt dust emissions from mining heap or salt transports can impair the life function of soils and lead to a change of the species spectrum of the affected flora on a long-term basis. In case of a disposal facility in granite rock, it cannot be generally excluded that the excavated granite contains asbestos. If wind-blown dispersal of materials containing asbestos were not been prevented, this could lead to impairments in the health of persons and animals.

Evaluation framework for the environmental impacts of air pollutants

Precautionary aspects are to be considered in an SEA. For the evaluation, the possible environmental impacts of the projects of the national programme are compared to evaluation results of the environmental impact assessments for different storage facilities, for which precautionary aspects were considered. Thereby separation distances between project site and protected items are deducted for which it ca be expected that no relevant impacts on the protected items are to be expected, if these distances are exceeded. Within these separation distances, no further general conclusions can be made. In these cases, the evaluation has to take place for the individual case with more precise knowledge about the site and the environment.

For the evaluation, the sites/construction sites and the transport routes are to be differentiated between.

At the sites and on the construction sites, different vehicles, machines and equipment emitting air pollutants are employed in the different phases , for example hydraulic excavators, trucks, drilling units, concrete pumps, tower revolving cranes, jack hammers, ramming devices, drill hammers, motorised cranes and wheeled loaders. Some of these vehicles, machines and equipment are employed in continuous operation, e.g. hydraulic excavator, trucks, concrete pumps, tower revolving cranes. The remaining ones, e.g. jack hammers, ramming devices, hammer drills, are operated only temporarily. The highest amount of air pollutant emissions are to be expected

- during construction, operation and shutdown of the operation of the exploratory mines,
- during the construction of the receiving storage facility and the disposal facility, as well as
- during the construction or during extension of storage facilities,

for example caused by the emissions of the motors of machines, equipment and vehicles, caused by whirling up and wind-blown dispersal of dust as well as by wind-blown dispersal of tailings.

As minimisation options for these emissions of air pollutants e.g. the employment of machines and equipment with electric motors and the moistening of dust-emitting goods during loading and unloading can be used.

In the environmental impact assessments for different storage facilities it has been shown that, also taking into consideration precautionary aspects, at separation distances of more than one kilometre from the construction site, no relevant impacts result from the additional impact on persons and protection areas, if minimisation possibilities, e.g. the employment of machines and equipment with electric motors and the moistening of dust-emitting goods during loading and unloading, are used and if no sensitive facilities e.g. hospitals are present.

If the separation distance is less, possible impacts can be assessed and evaluated for individual cases only, since then for example wind speed and main wind directions also play a role.

If mining heaps (e.g. salt rock mining heaps) are covered or moisturised in order to minimise wind-blown dispersal, it can be assumed that at distances > 1 km no relevant impacts exist. In case of salt rock mining heaps, covering should be the preferred option so that the salt quantities that reach the ground and surface water bodies are minimised.

The emissions of heating systems during the operation of storage facilities, waste storage etc. cause no relevant impacts on protected items.

With regard to the transport routes, it has been shown in the environmental impact assessments for different storage facilities that the highest number of trucks is present during concrete work of the base slabs. According to the size of the facility it can certainly occur that there are 200 to 300 truck arrivals and departures per day. A somewhat lower amount is to be expected during removal of the excavated material and during haulage of material for soil improvement.

For the minimisation of the air pollution in small towns, as a rule these should be bypassed in case of high transport frequencies.

Along transportation routes outside of small towns, the additional pollution should not lead to any relevant impacts on persons, due to improved air exchange. Since there are no indications that animals react to air pollutants more sensitively than persons, no relevant impacts should result for them as well. Relevant acidification impacts or eutrophication cause by entries of sulphur dioxide or nitrogen oxides is not expected to occur as a consequence of the additional contamination, so that relevant impacts on plants are not to be expected.

For the protected items "persons" and "animals and plants", however, relevant impacts can possibly result if particularly narrow valleys are driven through. However, this can be assessed and evaluated for individual cases only based on more precise knowledge, for example about the localities and the meteorological conditions etc.

4.1.3. Noise and vibrations

General environmental impacts through noise and vibrations

Noise is caused by the employment of equipment, machines and vehicles on construction sites, by the operation of facilities and by exploration, as well as by the use of transportation vehicles. Noise emissions are caused in particular by the following projects of the National Programme:

- Disposal facility explorations
- Cessation of the operation of exploratory mines
- Construction of the disposal facility and
- Construction of buildings, such as the receiving storage facility or storage facilities.

Noise affects persons while awake and sleeping. Stress and an increased risk of cardiovascular diseases are caused by noise. Quiet and undisturbed night time rest are of high importance to health. Sensitive animal species also react to noise in form of stress, and they can be impaired in their communication by noise. Birds play a special role as an animal group with regard to the impacts on noise, since they communicate acoustically and with many species noise has a negative impact on breeding success, absorption of nutrients, protection against predators, hatching and flight characteristics /Garniel et al 2007//Reijen et al 1995/. The diurnal way of life of birds and their living space above 1 m from the ground cause that this animal group is exposed particularly to noise. Migrant birds react to noise intensively, since they are hunted objects outside of Germany and are affected acoustically. In addition birds, as a species-rich animal group, are represented in all living spaces with several species and numerous types of this animal group are strictly protected according to the Federal Protection of Species Ordinance.

Vibrations are caused in particular through pile-driving work, for example during road construction or during improvement of the building ground for the construction of buildings (e.g. receiving storage facility, storage facilities), and through blasting during subsurface exploratory work, as well as during construction of the disposal facility. They can have adverse impacts on sensitive animal species, on breeding birds, on resting migrant birds, as well as on bats in their quarters. In addition they can cause building damage.

Evaluation framework for the environmental impacts through noise and vibrations

For a general evaluation of the impacts of noise on persons the emission threasholds and limit values of TA Lärm /TA Lärm/, the AVV-Baulärm /AVV-Baulärm/ or the 16. BImSchV /16. BImSchV/ can be used. The emission threasholds of TA Lärm are for example:

- For core areas, village areas and mixed development areas 60 dB(A) by day and 45 dB(A) at night
- For general residential areas and small settlement areas 55 dB(A) by day and 40 dB(A) at night,

- For purely residential areas 50 dB(A) by day and 35 dB(A) at night, as well as
- For spa areas, hospitals and residential care homes 45 dB(A) by day and 35 dB(A) at night.

The above mentioned provisions and values, however, are not addressing the overall noise affecting a person. but they rather apply only to distinct sources of noise: TA Lärm applies to the noise of industrial and commercial facilities, AVV Baulärm applies to the noise of construction sites, 16. BImSchV contains regulations on the noise abatement for new projects for roads and railways. According to a statement by the interdisciplinary working group for noise impact questions at the Federal Office for Environment Protection, a sufficient protection against road traffic noise is reached only for a day value ≤ 35 dB(A) /BMU 1998/. Precautionary values can be taken into account by using the below designated separation distances.

For the evaluation of the impacts of noise on birds, the occurring bird species must be known, since their sensitivity to noise and thus the necessary separation distances from the noise source are very different. For birds therefore, no precautionary value is derived in the SEA of the National Programme. The consideration of the environmental impacts on birds will be implemented quantitatively in environmental impact assessments within the context of the licensing procedures for projects of the National Programme.

For an evaluation of noise, the site/construction site and the transportation routes are to be differentiated between. Experience relating to the environmental impact assessment of storage facilities for radioactive waste shows that, during the building phases with the highest noise emissions (e.g. ground replacement, soil compactation, large-scale concreting) the following rating levels/equivalent continuous sound levels can occur beyond certain separation distances:

- < 40 dB(A) from a separation distance of approx. 1.5 km,
- < 45 dB(A) from a separation distance of approx. 950 m,
- < 50 dB(A) from a separation distance of approx. 550 m.

Noise-reduction measures that, as a rule, can be applied on construction sites:

- Use of machines and equipment with electric motors
- Use of low-noise machines and devices according to RAL-UZ 53 /RAL-UZ 53/
- Installation of noise barriers and acoustic-insulation tents
- Piling up of noise protection embankments
- Use of sound screens and aprons
- Casing of construction machines
- Application of alternatives to pile-driving, e.g. vibrating in, boring and vibrating, pressing in.

With regard to animals that are sensitive to noise (e.g. birds), the above-designated measures for minimisation are also impactive. Furthermore, for the protection of breeding birds, noise-intensive activities can be implemented outside of the breeding times or be taken up before the nest building in order to enable evasion of sensitive species before the breeding time.

For transportation routes, experience relating to the environmental impact assessment of storage facilities for radioactive waste shows that, in case of 200 - 300 truck arrivals and departures per day, the following rating levels/equivalent continuous sound levels can occur at separation distances from the roadside as indicated below:

- > 60 dB(A) up to a separation distance of approx. 10 m,
- > 55 dB(A) up to a separation distance of approx. 30 m,
- > 50 dB(A) up to a separation distance of approx. 60 m,
- > 45 dB(A) up to a separation distance of approx. 100 m.

A minimisation of the noise pollution can be achieved if transports are not routed through small towns or along inhabited areas or regions with sensitive uses (e.g. spa areas, hospitals, residential care homes).

For birds, the first 100 m from the roadside represent an area with drastically reduced living space suitability (significantly reduced reproduction success) /Garniel et al 2007/. For bird species that are sensitive to noise, the area with clearly reduced living space suitability can comprise a distance of 500 m /Garniel et al 2007/. For the evaluation of the impacts of noise on birds along transportation routes, the occurring bird species must be known, since their noise sensitivity and thus the necessary separation distances from the roadside are very different depending on the species. Therefore no quantitative evaluation of the impacts of noise on birds along transportation routes is carried out within the context of the SEA of the National Programme.

For the minimisation of transport noise, as a rule, the following measures can be applied:

- Switching transports to rail
- Keeping sufficient separation distances to residential zones and protection areas
- Wide-ranging bypassing of breeding regions of protected or noise-sensitive bird species and regions with high resting and migrant occurrence,
- Construction of new roads with so-called quiet asphalt
- If present, the use of roads with so-called quiet asphalt
- The introduction of speed limits,
- Placing low-noise tires on the transportation vehicles.

The spreading of vibrations is dependent on the type of the ground, the underground, aquifers etc. It can therefore vary strongly within the smallest area. For a prognosis, precise knowledge of the underground is necessary.

As far as vibrations act on persons in buildings, the requirements are concretised in DIN 4150 Part 2 "Erschütterungen im Bauwesen; Einwirkungen auf Menschen in Gebäuden” (Vibrations in the building trade; influences on persons in buildings) /DIN 4150-2/, as well as in the LAI notes relating to the measurement, evaluation and decrease of vibration actions /LAI 2000/. In case of compliance with the requirements and provisional values laid down there, relevant impacts on persons should generally not occur in apartments and comparably used rooms.

Experience from environmental impact assessments for storage facilities for radioactive waste has shown that vibrations (for example during generation of vibration pot columns) do not act beyond the facility grounds. Relevant impacts on persons are therefore not to be expected during the construction of buildings.

There is as good as no precise knowledge available about the impacts of vibrations on animals. Only regarding bats, it is known that vibrations which are caused through construction measures, e.g. pile-driving, and blasting etc., can have direct and indirect impacts. They can become relevant in the bat colonies and in this case particularly in the winter quarters. Particularly problematic are vibrations which lead to disturbances and awakening during hibernation. Vibrations caused by the collapse of cave areas, tunnels and columns may result in the burial of entrances and exits and with that to partial or absolute habitat loss and can possibly also lead to high individual losses /BfN 2015/.

An assessment and evaluation is possible for individual casesl only, and with more precise knowledge about the range and strength of the vibrations, as well as about the site and, as appropriate, the species of the existing bat colony.

4.1.4. Direct radiation

General environmental impacts through direct radiation

The radiation acting on persons and environment outside of the planned systems during normal operation, which results from the radioactivity of the waste, is considered by the impact factor. Here, gamma and neutron radiation have to be taken into account. In living beings gamma and neutron radiation can cause biological effects. A lower threshold for the harmful impact of this radiation cannot be identified from a scientific viewpoint. For radiation protection objectives, the assumption is therefore usually made that no impact threshold exists and the probability of the occurrence of damage depends linearly on the level of the dose.

Impacts through direct radiation on persons as well as on animals and plants are possible. Other protected items are covered by these, since, in case of a sufficiently low dose for the protection of persons, as well as of animals and plants, no disadvantageous impacts on ground, groundwater and surface water, air or physical assets are possible.

Evaluation framework of the environmental impacts through direct radiation

For individuals of the population, the limit value of the effective dose, pursuant to § 46 Sect. 1 StrlSchV, is 1 mSv/a through radiation exposures from activities pursuant to § 2 Sect. 1 No. 1 StrlSchV. With the application of the Euratom basic standards /Euratom 2014/ the term activities is taken further; the dose limit value of 1 mSv/a is retained however.

It is international practice to define so-called de minimis doses clearly below authorised limit values so that below those de minimis doses no further considerations and regulations become necessary. In cases of clearance of materials the StrlSchV, as well as the Euratom basic standard /Euratom 2014/, takes an effective dose in the range of 10 µSv in the calendar year as a minimum dose as a basis.

A reduction of the direct radiation can be achieved by radiation shielding measures, an additional reduction of the dose through separation distance or through time restriction of the stay near the source.

With regard to the protection of animals and plants, as a measure for the evaluation of radiation exposures, the lower values of the DCRL (derived consideration reference level) according to ICRP 108 /ICRP 2008/ are suited, which should guarantee the protection of populations. The application of these values is recommended in /SSK 2013/.

4.1.5. Emission of radioactive materials via water (discharge)

General environmental impacts through the emission of radioactive materials via water

Generally there is no direct discharge of contaminated waste water from nuclear facilities and devices, rather any occurring water is collected first of all and then analysed. After determination of compliance with stipulated derived values or permissible concentrations of radionuclides, a discharge can be carried out into surface water. As a result of discharge to corresponding surface water, a radiation exposure of persons, animals and plants is possible. Exposure to radiation of protected items is limited by a sufficiently low dose for the protection of persons as well as animals and plants, so that no disadvantageous influencing of ground, base and surface water, air or physical assets occurs.

Evaluation framework of the environmental impacts of emissions of radioactive materials via water

For the discharge of radioactive materials with waste water, the limit values designated in § 47 StrlSchV apply for individuals of the population, among others an effective dose of 0.3 mSv/a. With the planning of plants, the radiation exposure for a reference person at the most unfavourable site has to be determined.

Also below dose limit values radiation injuries and environmental impacts cannot be excluded. Consequently a consideration is necessary for small radiation exposures (see Chapter 4.1.5). With regard to the protection of animals and plants, the criterion is the same as for direct radiation (see Chapter 4.1.4).

4.1.6. Emission of radioactive materials via the air (discharge)

General environmental impacts through emission of radioactive materials via the air

Provided that open radioactive materials are dealt with in a system or device, these materials can be carried by air and reach the environment with the exhaust air. In areas with higher room-air activity, these discharges can be reduced by suction exhausts and exhaust air ducting via filter sections. In the environment a radiation exposure of persons, animals and plants is possible. Exposure to radiation of protected items are therefore limited, because in the case of a sufficiently low dose for the protection of persons as well as of animals and plants, no disadvantageous influencing of ground, base and surface water, air or physical assets is possible.

Evaluation framework of the environmental impacts of emissions of radioactive materials via the air

For the discharge of radioactive materials with the exhaust air, the limit values designated in § 47StrlSchV apply for individuals of the population, among others an effective dose of 0.3 mSv/a. With the planning of plants, the radiation exposure for a reference person at most unfavourable site position has to be determined. In this case also, the same evaluation criteria are considered as for emissions via water (see Chapter 4.1.4).

4.1.7. Incidents

General environmental impacts through incidents

With the handling of radioactive materials releases as a result of incidents from internal events (e.g. container fall, fall from a height of loads, fire, leakage), by naturally occurring external events (e.g. earthquake, flood water) and by man-made external events (e.g. aircraft crash, gas cloud explosion) basically cannot be excluded. Within the framework of the licensing procedures for plants and devices in which radioactive materials are handled, incident analyses are implemented. In part incidents can be excluded by a corresponding plant design. In addition, the further investigation of incidents can possibly be dispensed with because they cannot lead to any release of radioactive materials. For incidents which can lead to a release of radioactive materials, the maximum possible releases are estimated and, on this basis, the radiological results determined based on Chapter 4 with the incident computation basics /SSK 2003/.

The relative content of released radioactive materials of the inventory depends on the level of the mechanical and/or thermal impact, as well as on the volatility of the radionuclides. In particular the conditioning of waste has a reducing effect on possible releases of radionuclides e.g. through integration into a concrete matrix, as well as their packaging. In particular with highly radioactive waste (for example irradiated fuel assemblies, vitrified waste canisters with waste from reprocessing of fuel assemblies) the extent of release of radioactive materials is suppressed by the resistance of the transport and storage containers against mechanical and thermal influences (e.g. falling of a container onto a fixed obstacle, fire).

Evaluation framework of the environmental impacts through incidents

As a incident planning value for the effective dose, 50 mSv is stipulated through § 49 StrlSchV. The value refers to the sum of the exposures in the period following the incident up to the reference person's age of 70 (resulting dose). The incident planning values, pursuant to § 49 StrlSchV, are also to be applied to on site storage facilities for irradiated fuel assemblies and final storage facilities. Pursuant to § 50 StrlSchV, incident planning values for such waste disposal plants and activities are stipulated for each single event, which require a license according to § 7 Sect. 1 AtG or § 6 AtG, as well as activities which require a license according to § 9 AtG or § 7 StrlSchV, in case of activities pursuant to § 7 StrlSchV, only as certain exemption limits are exceeded. As a result of a transitional provision (§ 117 Sect. 16 StrlSchV) until the coming into force of more detailed regulations, 50 mSv as a incident planning value is also to be employed in these cases as an effective dose (resulting dose).

Aabelow the fault-case planning values, radiation injuries and environmental impacts cannot be excluded, the consideration of a precautionary- oriented approach of these SEA evaluations should also be carried out when the fault-case planning value is fallen below.

4.2. Non-specific impact factors

In this chapter impact factors are considered which cannot be represented in a project-specific way due to currently missing concrete project planning. A differentiation is made between:

- Non-specific impact factors of relevant importance for the SEA and
- Non-specific impact factors of subordinate importance for the SEA.

Non-specific impact factors of relevant importance for the SEA

In this chapter impact factors are considered,

- which are not quantifiable, due to missing project planning in the measures and projects of the SEA of the National Programme, ,
- which can be of relevant importance for this SEA non-specific impact factors,.

The non-specific impact factors of relevant importance for this SEA are represented at this point with regard to their environmental impacts and their evaluation. The impact factors considered in this chapter are described with consideration of the impact factors of individual measures of the National Programme as far as possible, however, are not considered and evaluated further with regard to their environmental impacts. A project-specific consideration of environmental impacts of the impact factors evaluated in this chapter is implemented in concrete licensing procedures for individual measures and projects of the National Programme, based on the documents relating to the description of the projects then available.

Ground-water level lowering

Ground-water level lowering take place in case of **structural** or **mining structural** measures (construction shaft facility, excavating of shafts) in subsoil with aquifers. In order to drain subsoil, the ground water is pumped out into a water body or a storm sewer or seeped into the ground on site. Ground-water level lowering with **structural** measures is generally implemented temporarily over a period of not more than half a year. Ground-water level lowering from **mining structural** measures is implemented with the sinking of shafts temporarily over some months until the sealing work of the shafts internally has been concluded.

General environmental impacts through ground-water lowering

Ground-water level lowering can affect the protected items ground water, ground, plants, animals, bio-diversity, surface water and physical assets. As well as the sensitivity of the occurring protected items, the impacts are dependent on the range (area and depth of the pumping funnel), the discharge rate, the duration of the ground-water level lowering and the other water supply of the affected region.

With respect to fresh water as protected item a result of ground-water level lowering can be a degradation of the amount of fresh ground water and of its chemical quality, as well as consequential impacts for the ecosystem.

Modifications of the ground water regime can influence the soils quality (e.g. as living space, filter and buffer etc.).

Ground-water level lowering can affect the availability of fresh water for plants (drought damage, dying) and thus also impair the biosphere of animals. Any involvement of protected animal and plant species according to BNatSchG, BArtSchV or EU law and their living spaces and/or particularly protected biotopes and protection areas with ground water-sensitive living species would be significant.

With regard to physical assets, ground-water level lowering can reduce forest commercial earnings from land and forest and cause subsidence cracks in buildings, roads and sewage pipes.

The discharge of pumped out ground water into surface water can have an impact on the quality of the surface water, if the water to be introduced e.g. does not correspond to the water quality of the surface water as a result of suspended matter.

Evaluation framework of the environmental impacts through ground-water level lowering

The following legal and technical standards are essential for the evaluation of the impact of ground-water level lowering:

Pursuant to § 6 Federal water act (WHG) /WHG 2014/, water bodies are to be managed sustainably with the objective that their functional and performance capability is maintained and improved as a part of the ecosystem and as biosphere for animals and plants. Impairment of land eco-systems and wetlands is to be avoided and, if unavoidable, is to be balanced with only a slight impairment as far as possible. Pursuant to § 9 of WHG, uses of the water body are the withdrawal, superficial conveying, superficial routing and conduction of ground water. Pursuant to § 8 WHG, these require permission or appropriation. Permission is to be refused, pursuant to § 12 WHG, if harmful, unavoidable or non-compensation-capable impacts of the water body are to be expected or if other requirements according to public-legal specifications (e.g. nature conservation law) are not met. Exceptions to the appropriation or permission exist, pursuant to § 46 WHG (among others), for the withdrawal, superficial conveying, superficial routing and conduction of ground water in small quantities for a temporary objective. This is specified more exactly in federal state law: thus for example in the Hesse Water Conservation Act /HWG 2010/ (§ 29) exceptions from the certification requirement on groundwater extractions exist if the drained surface does not exceed 1,000 m^2 or if the requisition quantity does not exceed 3,600 m^3 per annum.

The legal basis for the consideration of the protected items ground, plants, animals, bio-diversity, as well as physical assets are anchored in the appropriation and permission requirement of the WHG and the consideration of associated public-legal stipulations. This includes:

- The obligation to take precautions, pursuant to § 7 Federal Ground Protection Act (BBodSchG), against harmful ground changes
- The requirements of the Federal Nature Conservation Act (BNatSchG) /BNatSchG 2013/ relating to the avoidance and compensation of considerable impairments of nature and landscape as specified by § 13 BNatSchG,
- The obligations according to the polluter pays principle, pursuant to § 15 BNatSchG, for dispensing with avoidable interventions and the balancing and compensation of unavoidable interventions,
- The specifications pursuant to § 44 BNatSchG particularly for protected animal and plant species, including the exception prerequisites pursuant to § 45 BNatSchG and
- The requirement of verification of the Natura 2000compatibility in case of involvement of Natura 2000 regions through ground-water level lowering.

In the case of the evaluation of ground-water level lowering, against the background of the conditions (conveyed water quantity, scale of the sloping funnel, duration of the intervention), the qualitative and quantitative involvement of the protected items is to be evaluated subject to application of the above legal standards.

In case of **structural** ground-water level lowering, avoidance and minimisation possibilities consist, among other things, in measures being temporarily limited as good as possible. In addition, ground water extraction amounts as well as the extension of pumping funnel and catchment area can be minimised or be even avoided through combinations of different technologies (e.g. closed sheet piling boxes).

Mining-structural ground-water level lowering which arises from the sinking of shafts can be avoided or extensively minimised through freezing and injection processes. With freezing processes, a closed pipe system is inserted around the shaft area to be sunk using bores for a refrigerant. The ground water in the area of shaft sinking will freeze for so long until the shaft is generated and sealed off by cement-like substances in its interior. With the injection process, cement-like materials are injected via bores into the rock around the shaft. The area around the shaft becomes watertight after the setting of the injection materials in the rock /Sres 2009/, /DMT 2014/.

Definitive evaluation

Ground-water level lowering is a potentially-relevant environmental impact, which has to be checked and minimised in the licensing procedure of the respective project. The introduction of conveyed ground water is implemented as conventional waste water.

Conventional waste water

In different projects of the National Programme waste water is a by-product, which is routed into flowing water bodies. With **building projects,** waste water occurs in case of temporary ground-water level lowering. In **mining,** waste water is a result of ground-water level lowering e.g. for the sinking of shafts. Furthermore, drainage water results in mining itself. Drainage water penetrates into a mine via the sunk-through layers which are water-carrying, since any sealing of underground hollow spaces can never be completely implemented and sealing loses its effect by degrees through ageing. Sealing measures in mines must be constantly checked and improved as appropriate.

During the **operation of systems and mines** waste water occurs in case of cleaning processes, the conditioning of radioactive waste, the drainage of tips, as well as with underground drainage (drainage water), which is collected and after clarification treatment is routed into flowing water bodies via a receiving water body.

From the plan for the shutdown of the disposal facility for radioactive waste Morsleben /BfS 2009a/ the following information can be found with regard to the type and quantity of waste water disposed of via the water path: Shaft water is collected in the shafts, pumped to above ground and, via the Salzbach (Bartensleben) and/or local storm sewer (Marie), routed into the river Aller. In Bartensleben shaft water occurs with a long-standing average ingress rate of approx. 3,000 m^3/a. In the Marie shaft approx. 8,000 m^3/a on average occurs. The annual quantity of precipitation water occurring on the sealed surfaces of the Bartensleben mine is on average approx. 20,000 m^3 at a maximum amount of approx. 1 m^3/s (15 min. continuous rain). The material concentrations (dust and other contaminants) of the precipitation water routed from the sealed surfaces are very small.

General environmental impacts through conventional waste water

The waste water can be contaminated by the following conventional pollutants: Suspended matter, heavy metals, inorganic contaminants (e.g. chlorides, nitrates, sulfates) and organic contamination (e.g. faeces, bacterial contamination, nutrients, hydrocarbons). Before any introduction into a water body, waste water is cleaned to a large extent in corresponding systems (sewage treatment plants, sedimentation tanks and precipitation systems). Nevertheless, harmful contamination is present in the introduced waste water which can take effect directly on the protected item water and indirectly on the protected items animals, plants and persons, including human health. Contamination of surface water affects the biological or chemical water quality of the water body affected. Persons are affected by that indirectly, since changes to the chemical or biological water quality affect the usability of the water, for example as drinking water, irrigation water or bathwater. Changes to the water quality can affect for example the metabolism of plants and animals through oxygen-reduction processes in the water, changed salt concentrations or toxic materials, and impair the biosphere function of the water body according to sensitivity of the animal or plant species affected.

Evaluation framework of the environmental impacts through conventional waste water

The water laws control the requirements on the sewage disposal and their evaluation standards. Waste water is to be eliminated pursuant to § 55 WHG, so that the welfare of the society is not impaired. With regard to the requirements, direct and indirect introduction are to be differentiated between.

The direct routing of waste water into water bodies (direct introduction) requires permission pertaining to water laws. The basic requirements for issuing permission are laid down in § 57 WHG. According to this, permission may be granted only when

1. the quantity and harmfulness of the waste water is kept as small as possible, in compliance with the processes in question regarding the state of the art of the technology in each case,

2. the introduction is in agreement with the requirements on the water body features and other legal requirements and

3. Waste water systems or other facilities are set up and operated which are required in order to ensure compliance with the above requirements.

The determining minimum requirements according to the state of the art of the technology with the waste water introduction are concretised for certain origin areas through the Waste Water Ordinance (AbwV) /AbwV 1997/. The measures of the National Programme are to be assigned to the origin area of the waste disposal of radioactive waste. For this origin area, the Waste Water Ordinance does not include any explicit regulation. The state of the art of the technology must be determined in each individual situation, considering the requirements of the WHG and the Waste Water Ordinance.

Insofar as nothing other is stipulated in the appendices of the Waste Water Ordinance, the general requirements apply first of all (§ 3 AbwV). According to these, waste water may only be introduced into a water body if the pollutant freight is held to a level which is possible on an individual basis after testing the conditions: through the employment of water-saving processes with washing and cleaning procedures, indirect cooling, the employment of low-polluting operating and auxiliary materials, as well as the process-integrated return of materials. The reference of the AbwV to the state of the art of the technology makes it clear that the waste water ordinance includes more stringent requirements than contained in mining act, which refers only to the generally recognised regulations of safety technology (cf. § 55 Sect. 1 No. 3 BBergG).

The criteria of enclosure 1 of the WHG have to be referred to as an extension for the determination of the state of the art of the technology. For the area of the waste disposal of radioactive waste, the criteria for the employment of fewer dangerous materials (No. 2 of enclosure 1 WHG), comparable, processes successfully proven in operation, equipment and operational methods (No. 4), progress in the technology and in scientific knowledge (No. 5), type, effects and quantity of the respective emissions (No. 6), possible displacement effects on other environmental media (No. 10) and accident precautions (No. 11), are also to be taken into consideration.

The waste water discharge is to be measured by the applicable requirements on the water body features and the other legal requirements. The requirements on the discharge into surface water are to be considered in this case in particular.

With an discharge into surface water, the management objectives for above-ground water bodies pursuant to § 27 Sect. 1 WHG are to be considered. According to these, above-ground water bodies are basically to be managed so that a degradation of their ecological and their chemical status is avoided and so that a good ecological and a good chemical status is retained or achieved. The management objective describes both qualitative and time-related specifications for the respective water body. The ecological status is defined with first priority with reference to the occurrence of ground-water species-specific organism groups (invertebrate water-body animals, fish, aquatic plants). Details regarding this are found in the federal-legal surface water ordinance (OGewV) /OGewV 2011/, the state-legal stipulations for the consolidation of the WHG and the state Federal Water Act, as well as in the action-measure programs for the individual river region units. Of special importance are the quality components stipulated in OGewV and criteria for the evaluation of the ecological and chemical status (cf. Enclosures 3 to 7 of OGewV). The state-legal stipulations have been adapted to these specifications to a large extent.

For discharge of waste water into public or private waste water systems (indirect introduction), as well as the requirements of § 58 WHG, state-legal requirements also apply (waste water regulations in the state Federal Water Act, including the indirect introduction ordinances of the states issued on this basis)

Definitive evaluation

The discharge of conventional waste water into a surface water body is a potentially-relevant environmental impact which is to be checked and minimised in the licensing procedure of the respective project.

4.3. Non-specific impact factors of subordinate importance

In this chapter impact factors are handled definitively,

- which frequently appear with measures and projects of the National Programme - except for the post-closure phase of a disposal facility,
- which cannot be represented in a project-specific way for individual measures and projects of the National Programme, however, due to the comprehensive character of the SEA and currently missing project planning,
- which are negligible in total in their importance for the environmental evaluations of the SEA to be implemented here.

A project-specific consideration of environmental impacts of the impact factors evaluated in this chapter is implemented in concrete licensing procedures for singular measures and projects of the National Programme, based on the then available documents relating to the description of the projects.

Substances hazardous to water

Substances hazardous to water are handled in case of operation, maintenance and repair of vehicles, machines, systems and transport containers. The employment of liquid substances hazardous to water, such as e.g. refrigerant, oil and grease materials, fuels, cleaning fluids, dyes and paints is implemented in different ways and scope on construction sites for the construction and for the dismantling of systems, on sites for geological exploration, during the operation of nuclear facilities and in mines. With the construction of systems and in mines, large quantities of solid substances hazardous to water can furthermore be handled and installed, such as e.g. ready-mixed concrete and mortar. The handling and storage of substances hazardous to water are stipulated with regard to technical measures for the protection of ground and ground water in state-specific ordinances relating to the handling of substances hazardous to water. In case of application of these specifications, potential significant environmental impacts are to be excluded. The risk of a conventional contamination of groundwater and ground through accidental ingress of substances hazardous to water can basically be assumed. Risk evaluations with the derivation of measures to avoid and minimis risks (e.g. employment of collection troughs, limitation of the material type and amount of substance) are the subject of the licensing procedures of the projects of the National Programme. The requirements on the protection of groundwater and ground during installation of materials in building products are regulated in the EU Building Product Ordinance No. 305/2011 /EU-BauprodukteV 2011/, the building product act /BauPG 2012/, the respective state building codes and the licensing procedure for building products /DIBt 2011/.

The waste management of substances hazardous to water is implemented according to the specifications of the Recycling Management Act /KrWG 2013/ and its relevant ordinances. In nuclear facilities, substances hazardous to water can be contaminated radiologically with their employment as operating resources e.g. oil, cleaning fluids. The collection, conditioning and packaging of these substances hazardous to water is implemented as weakly-radioactive waste, subject to compliance with the requirements of the Atomic Energy Act and the Radiation Protection Ordinance. The occurring quantities of radioactive waste through the employment of substances hazardous to water as operating resources and cleaning fluids is small in facilities in which open radioactive waste is not dealt with e.g. storage facility or disposal facility, and with regard to the evaluation of risks, is the subject of the licensing procedure of the respective facility or device. On the high level of abstraction of the plans in the National Programme and the SEA of the National Programme, the handling of substances hazardous to water is not to be considered as a cause of potentially-relevant environmental impacts. The occurrence of liquid radioactive waste with facilities or devices in which open radioactive waste is dealt with, e.g. conditioning system, is considered in Chapter 5.1.5

Conventional waste

In case of all projects of the National Programme, conventional waste results which is subject to the regime of the Recycling Management Act /KrWG 2013/. With its acquisition, storage at the point of origin and waste disposal, the specifications of the industrial waste ordinance /GewAbfV 2012/, in particular as regards separation retention, are also to be considered. It can be assumed that the following waste types result:

- Commercial waste with all projects
- Excavated material with the construction of buildings (storage facility, incoming goods storage, social buildings, other buildings, e.g. for the conditioning) and the laying of supply lines
- Construction and dismantling waste (construction site mixed waste, building rubble) with construction and dismantling of buildings,

- Separately retained fractions, such as wood, iron and steel, plastics, glass, cable, paper and pasteboard, with all projects
- Special refuse, such as dyes and paint waste, adhesives and sealing masses, hydraulic oils, in particular in case of those projects within the framework of the site selection and disposal facility, storage facility of irradiated fuel assemblies and waste taken from waste reprocessing, as well as waste disposal from the Asse II mine
- Excavated material with the construction and operation of exploratory mines, with the construction and with the operation of the disposal facility, if it is not employed for backfilling again underground.

If the basic principles of recycling management (section 2 KrWG) and refuse disposal (section 3 KrWG), as well as the specifications with regard to separation retention and storage at the site of origin, as well as the order of priority with waste disposal (preparation for reuse, recycling, other utilisation, removal), are considered, it is not to be expected that relevant environmental impacts arise from the occurring conventional waste, even if the excavated material should include conventional pollutants due to pre-contamination or the excavated material was already contaminated. This waste is to be considered by the states in case of waste management planning pursuant to § 30 ff KrWG.

Rainwater on traffic areas and roofs

The discharge of rainwater that collects on traffic areas and roofs is implemented either by storm sewer, as appropriate with prior clarification, into the receiving water or via a percolation system for rainwater on the plant site. The rainwater occurring with projects of the National Programme is not differentiated with regard to conventional contamination (e.g. dust, nitrogen oxides, sulfur) from rainwater that results in cities and industrial areas. Salt dust emissions are dealt with in Chapter 4.1.2. During operation of nuclear facilities or devices according to specification, e.g. conditioning systems, there results radiological routing via the air. Approved discharge is implemented via a flue stack of large height, so that contamination can be excluded from rainwater at the site of the system or device. On the high level of abstraction of the SEA of the National Programme, rainwater coming off of traffic and roof surfaces is not to be considered as a cause of environmental impacts. The consideration of radiological emissions through routing via the air and water, as well as the consideration of fault-case risks are implemented in Chapters 4.1.4, 4.1.6 and **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Sanitary waste water

With all projects of the National Programme on site **conventional sanitary waste water** occurs. With temporary construction measures and project, such as the surface exploration of a disposal facility site, sanitary waste water would be collected in mobile sanitary systems and then disposed of in sewage treatment plants. In facilities (e.g. storage facilities, conditioning facilities, exploratory mines, disposal facilities) a connection of the sanitary line system of the facility to an internal sewage treatment plant or to a public sewage treatment plant is always to be assumed. The quantity of sanitary waste water depends on the number of employees. It can be assumed that, in comparison with the sanitary waste water occurrence from conventional industrial areas or cities, the waste disposal quantity of conventionally soiled sanitary waste water with projects of the National Programme, with regard to the SEA of the National Programme, do not lead to potentially-relevant environmental impacts.

In case of the handling of open radioactive materials in nuclear plants or facilities (e.g. conditioning system), an on-site separation of **sanitary waste water from control areas** of sanitary waste water outside of control areas can possibly be implemented. A contamination of the personnel is precluded in nuclear plants or facilities through measures of activity inclusion and avoidance of contamination entrainment, in accordance with the requirements of the Radiation Protection Ordinance /StrlSchV 2012/, so that contamination with radioactive materials of sanitary waste water through persons washing themselves or faeces do not occur. Independently of this, on requirement (contamination of persons), before a waste disposal of sanitary waste water from control areas it can be ensured, through radiological control-checks and separate waste disposal, that potentially-relevant environmental impacts through sanitary waste water possibly contaminated with radioactive materials do not occur. Within the framework of the SEA of the National Programme, no potentially-relevant environmental impacts exist comprehensively from control areas through sanitary waste water.

Light emissions

Light emissions can have disturbing effects on persons. Important effects are dazzle of affected persons and room brightening of residential, sleep, instruction, and work areas in the neighbourhood of sources of light. The impacts on persons reduce with increasing distance from the source of light.

Light emissions in particular concern the protected items animals, insects and birds. Insects are attracted and impaired in their nocturnal activity (food/partner search). Direct individual losses can occur in this case for insects through burning or the ingress into sources of light. Indirect individual losses can occur for insects by their distraction in the light within the framework of their nocturnal activity, where they collect insufficient food or do not find sex partners.

Birds, in particular also during bird migration, can lose their orientation through sources of light. As a result of collisions with sources of light or with buildings on which the sources of light are installed, individual losses can occur. The lighting of hatcheries can have as result that the hatcheries are not looked for at breeding time or that already begun breeding is given up through the disturbing effect of the light. Breeding losses can result in this case.

The basics for the evaluation of light emissions were decided on through the federal/state joint venture for emission-protection /LAI 2012/. There, emission directives are indicated both for cases of dazzle and for room brightening for different region types (e.g. health cure region, hospitals, residential areas, recreation areas, village regions, industrial areas). In case of compliance with these emission directives, considerable harassment of persons as specified by the Federal Emission Control Act is not expected.

The evaluation of the impacts of light on animals - in particular birds and insects - is to be carried out with reference to knowledge of the affected animal species, populations and existing living spaces. A particular role in this case is played as to whether the living spaces for particularly protected species would be affected by the lighting, according to the federal protection of species ordinance or Natura 2000 regions. With the evaluation of the impact of light emissions, individual losses are acceptable both in case of insects and birds. Not acceptable, and to be classified as significant environmental impacts, would be light emissions that result in populations - in particular specially protected species - being endangered in their conservation by losses. As a result of light alone, such significant environmental impacts will seldom occur with the projects of the National Programme, since the lighting of work and traffic areas is always targeted and comprehensive light impacts are not planned. However, in interaction with other impacts, such as e.g. air pollutants and noise, light emissions can make an additional contribution to the impairment of populations. Nuclear facilities are intensively illuminated at night for reasons of security (avoidance of the intrusion of third parties). The requirements on the protection of the facilities outweigh the requirements on the protection of the environment, since the protection of the facilities prevents releases of radioactive materials into the environment.

To avoid potentially significant environmental impacts through light, extensive minimisation possibilities exist through a suitable selection of the areas to be illuminated, the number of sources of light, as well as their inclination, height, shadowing and limitation of work to daytime. Those minimisation measures for light emissions designated to avoid disturbing impacts on persons are also applicable for the protection of animals. In addition, light impacts on insects and birds through suitable light spectra (sodium low-pressure lamps) and closed design implementation of the lamps can be considerably reduced (avoidance of the ingress of insects). For the protection of birds, the lighting of sleeping and breeding places is to be avoided. In addition, with potential involvement of birds during migration, in particular in case of high sources of light or sources of light which illuminate resting places, it is to be tested whether these can be switched off temporarily.

Radon emissions

During any mining construction activity (e.g. subsurface exploration, operation of an exploratory mine and a disposal facility, close-off of a disposal facility), radon emissions arise from the mine itself, from the tip and from the conveyed mountain water. The radioactive Radon-222 arises from the decomposition series of uranium 238 occurring in trace contents in the rock. Higher traces of uranium 238 and its decomposition products are included in granite and clay rock (with high local variations) than in salt rock. Increased radon concentrations through extreme exposure can increase the risk of lung cancer.

In particular employees are affected by an increased level of radon exposure. Minimisation possibilities for radon contamination for employees exist, e.g. through utilisation of suitable technical processes such as wet drilling, high-performance ventilation and working with respiratory protection. Contamination of the residents can basically be excluded. Measurements of the Federal Office for Radiation Protection /BfS 2009b/ have indicated an influence of mining construction activities on the radon concentration of the open air in direct proximity to the source (waste air shafts of mines in regions with a high content of uranium 238 in the rock). However, it can be assumed that no residential areas are in direct proximity to the waste air shafts of a mine or to the tip. With regard to the comprehensive point of view of the National Programme, radon emissions are evaluated as non-potentially-relevant environmental impacts. Impacts on the radon concentration of the atmosphere (protected item climate) are to be excluded due to the already existing high natural content of radon-222.

5. Description and evaluation of the environmental impacts

5.1. Site selection process and disposal especially of heat-generating waste, including the fuel assemblies of experimental, demonstration and research reactors

In this chapter the environmental impacts of the measure "Site selection process and disposal especially of heat-generating waste" are considered. Also included in this is the disposal of the fuel assemblies from experimental, demonstration, and research reactors in a disposal facility according to the Site Selection Act. The consideration is implemented separately for the following projects and project phases:

- Surface exploration of sites for a disposal facility

- Subsurface exploration of sites for a disposal facility
- Transfer of the waste from the storage facility sites to the disposal facility site
- Storage of the waste in the receiving storage facility of the disposal facility
- Conditioning of the waste for disposal at the disposal facility site
- Disposal especially of heat-generating waste

With the projects, the time-related phases of construction, operation and decommissioning or cessation of the operation with exploratory mines are considered in each case. For the project "Disposal especially of heat-generating waste", a separate consideration is implemented of the phases "Construction of the disposal facility", "Emplacement operation", "Closure of the disposal facility" and the "Post-closure phase" for the period after the closure of the disposal facility.

Within the individual chapters relating to the consideration of the environmental impacts of the above project, a representation of the activities on the site is first implemented. Then the impact factors are clarified and the potential environmental impacts described. Finally the potential environmental impacts are evaluated and measures for avoidance and minimisation represented. With the evaluation of the potential environmental impacts "frequent project-specific impact factors", the evaluation framework represented in Chapter 4.1 is referred to.

5.1.1. Surface exploration of sites for a disposal facility

In case of surface exploration, all geo-scientific and space-planning-based information items on the site are compiled. The surface exploration of evaluated international exploration programs is basically implemented through geophysical investigations and experimental boring /Goldsworthy et al to 2009/. The sinking of a mine is not implemented. On the basis of international experience relating to the exploration of disposal facility sites, with the preparation of requirements on an surface exploration for a selection method in Germany, it was determined that, with regard to different rock formations and configurations, no considerable differences exist in the exploration expenditure /Goldsworthy et al 2009/. At the site the following work is to be expected:

- With the construction, the installation of infrastructure (road connection, water and power supply, waste disposal), as well as the surface compacting for drilling sites, setup for the storage of drilling flushing, technical devices, as well as provisional dwellings and paths, are implemented.
- The exploration operation consists in particular of the implementation of deep boreholes, as well as seismic and hydrogeological investigations.
- On completion of the exploration work, exploratory borehole are closed according to the state of the art, all technical devices removed, the exploration place is built back and the land is restorated.

Until the completion of a site selection process which lasts several years technical devices can remain at the site, e.g. sealed surfaces.

Impact factors

It is assumed that, in case of surface exploration of a site for a disposal facility, several deep boreholes are implemented /NAGRA TB 1001 2010/. As a result of compaction of drilling places and access roads a **land consumption** between 10,000 m² and 40,000 m² is implemented /Thiele 2004/, /UBS 2012/, /NAGRA 2010/.

As a result of construction of the drilling places and technical systems, as well as in case of their later dismantling after the exploration, there arise with the employment of truck and construction machines emissions of **air pollutants and noise** which correspond in their scale to the emissions of a small construction site. The drilling operation leads in particular to acoustic emissions in the environment. The scale of motor vehicle movements and associated emissions is negligible during exploratory work.

During the surface exploration of a disposal facility site, risks exist of a **media entr**y through the drilling operation, a **blow-out** and an **hydraulic short-circuit.** In case of deep boring, drilling fluids, which can enter as media into the ground water are employed for different objectives (removal of the drill cuttings, cooling, lubrication). Drilling fluids consist mainly of water with different additives (clay minerals, salt, oils, polymers, tensides). With the employment of drilling fluids, in particular in case of too low pressure of the drilling fluids, the enrichment of gases and fluids from the substrate subsequent expansion (blow-out) can result /Dannwolf et al 2014/. As a result of exploration drilling through separated aquifers one after each other, the risk exists of a hydraulic short-circuit with which a replacement of ground water would be implemented between aquifers previously separated from each other.

In case of seismic measurements, short-term acoustic waves from vehicles or small blasting charges are guided underground. The resulting **sound levels and vibrations** are audible only in the direct environment and are therefore negligible with regard to any impacts on persons and animals, against the background of the comprehensive character of the SEA.

Hydrogeological explorations basically include the construction of ground-water measurement points, pump trials that lead to temporary **ground-water lowering** and, as appropriate, **media entry** in the form of tracers into the ground water. Ground-water lowering is described in Chapter 4.2. Ground-water lowering through pump trials is implemented temporarily for a maximum of a few days. The objective is not a drainage but the measurement of the impacts on the ground water level at corresponding ground-water measurement points. The duration, the amount of the ground-water lowering, as well as the quantity of ground water to be returned, are small. The employment of tracers is implemented in small quantity and in coordination with the responsible water authorities, subject to application of the legal regulations relating to the protection of the ground water. With regard to the comprehensive character of the SEA, no potentially-relevant environmental impacts exist through hydrogeological explorations.

Description of the potential environmental impacts

Land consumption

Land consumption in the order of magnitude of 10,000 m² and 40,000 m² act on the protected items ground, animals, plants and, as appropriate, living spaces of protected species, as well as their breeding grounds.

The sealing of a water body, within the framework of the surface exploration of a disposal facility site, is not assumed due to the associated expenditure for the underground compacting.

Air pollutants

Air pollutant emissions, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulfur oxides, are caused in particular through the operation of devices and machines during installation of the infrastructure, as well as with the dismantling and during land restoration. These emissions can have a health-endangering impact on persons, as well as a damaging or impairment impact on animals and plants.

Noise
Acoustic emissions are caused in particular by the operation of devices and machines during installation of the infrastructure, with the dismantling and during returning to nature, as well as through the drilling work. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their habitat.

Media entry, blow-out and hydraulic short-circuit
An entry of media into the ground or the ground water during drilling operation can lead to the contamination of both protected items, depending on the characteristics of the ingressed material and its quantity.

For the employment of drilling fluids and the chemical materials added in this case, requirements are stipulated in the regulatory work of the German association of Gas and Water Specialists Relevant regulations relating to the protection of the ground water against the ingress of drilling fluids can be found in the DVGW Specification Sheets 115 and 116 /DVGW 2008//DVGW 1998/. In addition, the entry of drilling fluids into the ground water is avoided through piping the borehole. For the protection of the ground and ground water by drilling fluids and other fluids handled at the drilling place, drilling places are sealed in Germany /Schilling 2012/.

Blow-out preventers are employed as a technical measure to avoid uncontrolled decompression in case of deep drilling. Blow-out preventers enable the targeted and controlled discharging of deep boreholes under pressure through valves into tanks /Uth 2012/. As a technical measure to avoid hydraulic short-circuits, deep bores are piped and cemented.

The protection of the ground water is controlled by the Federal Water Act /WHG 2012/. In § 48 of the WHG it is stipulated that measures, such as for example the introduction of materials into the ground water, requires a permit according to water laws. This is issued only if a disadvantageous change of the water condition is not to be expected. As an extension to this, in case of drilling, the requirements of the deep-drilling ordinances and the ordinances for the handling of substances hazardous to water are checked by the responsible government authorities of the respective state in which a bore is implemented. Therefore it can be assumed, within the framework of the investigation sinking to be carried out here, that risks such as a harmful ingress of drilling fluids into the ground water, a blow-out and a hydraulic short-circuit as potentially-relevant environmental impacts are not expected.

Evaluation of the potential environmental impacts

Land Consumption
The evaluation framework is represented in Chapter 4.1.1. The land consumption related to the surface exploration of a disposal facility site, provided that it is implemented on industrial areas or other or less valuable surfaces, is to be classified as a potentially significant environmental impact for which the obligation exists to provide balance or compensation.

Since, with a surface exploration of a site, the containment-providing rock zone searched must be encountered in sufficient size and homogeneity, the surface exploration can be implemented from different positions. Thus use-conflicts with human settlements, agriculture or nature conservation are to a large extent avoidable. In addition, experimental boring can be implemented slanted /NAGRA TB0224 2002/. Within the framework of the SEA of the National Programme, it can be assumed that an exploration can be avoided in protection areas or on surfaces with particularly protected animal and plant species. In addition, the possibility would exist of the resettlement of protected animal and plant species after checking the individual case.

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. In case of surface exploration, air pollutant emitting machines, devices and vehicles are employed in a scope such that relevant impacts on persons, animals and plants from a distance of not less than 100 m are no longer expected. Within a distance of some 100 m to the exploration operation, potentially-relevant environmental impacts can exist.

Noise
The evaluation framework is represented in Chapter 4.1.3. In case of surface exploration, machines, devices and vehicles are employed in a scope that is far less than, for example, with the construction of a storage facility. If no work is implemented in the night hours (20:00 hours to 07:00 hours), with the installation of the infrastructure as well as with the dismantling and during renaturation, no more relevant impacts should occur above a distance of some 100 m. In case of experimental drilling in Benken (Switzerland) /Macek 2001/ the noise emissions of the drilling operation - - were lower than 60 dB(A) for the day and 50 dB(A) for the night at the nearest residential area which was located at a separation distance of 700 m to the drilling site.

With regard to the impacts on animals - here birds - it can be determined that, with the existence of noise-sensitive bird species, the necessary separation distance to the drilling site is to be tested on an individual basis. As a result of noise, potentially-relevant environmental impacts can exist within a separation distance of some 100 m to the compacted exploration surface, which are to be considered within the framework of the practical implementation of a surface exploration against the background of the site-specific conditions.

5.1.2. Subsurface exploration of several sites for a disposal facility

The subsurface exploration consists of the phases "Construction of an exploratory mine", "Operation of an exploratory mine" and "Cessation of operation of an exploratory mine". The cessation of the operation of an exploratory mine would be implemented only in the case where the site does not remain in the site selection process or is not selected for the construction of a disposal facility or the exploratory mine is not used as part of the disposal facility. In case of use of the exploratory mine as a part of the disposal facility, the mine operation would be continued after implementation of a corresponding licensing procedure for the construction of the disposal facility.

5.1.2.1. Construction of an exploratory mine

In case of the subsurface exploration, the following project phases are implemented on the site:

- Excavation of a mine
- Construction of buildings, traffic routes, above-ground facilities and infrastructures
- Connection of the site with power and water supply
- Storing of excavated material on a mining heap
- Introduction of waste water from the mine and from the mining heap drainage to existing receiving waters, connection to the public network for the waste water drainage

It is assumed that the work for the construction of a disposal facility mine and for the exploration of the site require some years in each case /NAGRA TB02-02 2002/.

Impact factors

The **land consumption** for above-ground systems and infrastructures of an exploratory mine is estimated, according to existing results related to the exploratory mine in Gorleben /BfS 1990a/, with 50,000 m². In addition, approx. 60,000 m² of surface is used for the storage of the excavated material.

Noise, air pollutants and dust are emitted by the operation of the construction site at the exploration site (construction vehicles and machines), as well as by the truck traffic for the delivery of building material and for the disposal of excavated material. The disposal of the excavated material can be implemented on a mining heap specially placed near the disposal facility or an already existing tip. Disposal facility concepts of Switzerland assume a total excavated material of 420,000 m³ (loose) during driving of the mine, which is transported away over a period of five years with 30 trucks per day (12 m³/truck). For the construction of the above-ground systems and as material for supporting the mine, 90,000 m³ concrete would be transported to the site with seven trucks per day /NAGRA TB0202 2002/. In case of other host rocks, the quantity of excavated material and concrete possibly varies.

A spatial impact arises from the construction of the systems necessary for the subsurface exploration, as well as the mining heap.

Dependent on the hydrogeological initial situation of the site, a **ground-water lowering** can be required for the mine excavation and the sinking of shafts through layers carrying water. A ground-water lowering can be implemented temporarily until the sealing of the shafts, or over longer periods. Disposal facility concepts from Finland assume lowering depths 10 m to 60 m, which would lead to sloping funnels with radii from 0.5 to 2 km /Posiva 1999/.

Conveyed water with ground-water lowering, as well as percolating water of the mining heap drainage into a receiving water body, as other industrial water, e.g. water from a truck cleaning system, after previous processing (clarification, precipitation, deduction) is introduced as **conventional waste water.** The water of the mining heap drainage makes the largest contribution. During exploration of the salt stick in Gorleben an license existed for the daily introduction of 240 m³ saline surplus water into the Elbe.

The evaluation of the environmental impacts through **ground-water lowering** and the introduction of conveyed ground water as conventional waste water is implemented in Chapter 4.1.7, so that these impact factors are not further considered project-specifically in the following.

Description of the potential environmental impacts

Land consumption
Land consumption in the order of magnitude of approx. 110,000 m² (exploratory mine and mining heap) acts on the protected items ground, animals and plants. It cannot be excluded that a water body, protected species, or a protected area are affected from the land sealing.

Spatial impact
The above-ground systems for an exploratory mine are comparable in their spatial extension with a medium-sized industrial plant, however, far less than the actual disposal facility site. The rigs, stacks and, as appropriate, excavated material heap are the most visible system component part due to their height.

The spatial impact changes the appearance of an affected landscape and can reduce its regeneration function. The spatial impact is dependent on the subjective opinion of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism.

Air pollutants
Air pollutant emissions, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulphur oxides, are caused, as in case of construction sites, in particular through the operation of devices and machines during the construction of buildings and traffic routes. In addition are the transports between mine and mining heap. Additional emissions can arise from the heaping and wind borne discharge of fine-grained material from the heap surface. These emissions can have a health-endangering impact on persons, as well as a damaging or impairment impact on animals and plants.

Noise and vibrations
Acoustic emissions are caused through the same devices, machines and transportation vehicles which give rise to emissions of air pollutants. In addition acoustic emissions and vibrations can occur with blasting rock. Noise can increase the risk of cardiovascular illnesses in persons and can drive animals from their habitat. Vibrations can also affect persons and animals negatively and cause damage to buildings.

Evaluation of the potential environmental impacts

Land consumption
The evaluation framework represented is in Chapter 4.1.1. The land consumption of approx. 110,000 m² is to be evaluated as a potentially significant environmental impact.

Minimisation of impacts is possible in case of the site selection for an exploratory mine and the planning of the building development at the site (e.g. location of the mining heap, roadway management). In this case, protection areas or living spaces of protected species are to be avoided for a building development. Considering species-specific ecological requirements, there also exists the possibility of the resettlement of protected animal and plant species.

Spatial impact
The spatial impact of an exploratory mine on the landscape is a potentially-relevant environmental impact, which extends over several years until the dismantling of the above-ground systems on completion of the exploration operation concerned. An evaluation of the spatial impact can be implemented only based on graphic representations of the planned system in the landscape (photo montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape through the spatial impact of an exploratory mine aims at avoiding or reducing visual impacts from the environment. In this case, the relief of the landscape can be included, earth banks laid, shading of the system through forest implemented, or the colour design of the buildings adapted to the landscape.

As early as with the stipulation of the site for the subsurface exploration the possible spatial impact of the above-ground disposal facility systems should be considered, when the option exists that this could arise at the same site.

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. As a relevant variable for the evaluation of the environmental impacts through air pollutants, the number of transports per day, as well as the emissions of devices and machines on the construction site are to be considered. With the excavation of an exploratory mine, larger quantities in total of excavated material and building material are to be moved than would be the case for the construction of a storage facility employed

as a reference point in the evaluation framework, however, their amount extends over a long period. The number of transports per day is therefore of a similar order of magnitude or is possibly even less. The operation of devices and machines, as well as the transport traffic to the construction of buildings and traffic routes, are also less than in case of the construction of storage facilities. If the mining heaps are covered or if kept moist in order to minimise drifts, it can be assumed in total that, with a separation distance to the nearest residential zone of 700 m, no relevant impacts on persons occur. The same applies for the separation distance to the living space of animals, in particular protected species. Within a separation distance of 700 m to the project, potentially-relevant environmental impacts through air pollutants onto persons and animals can exist.

Noise and vibrations

The evaluation framework is represented in Chapter 4.1.3. For the evaluation of the impacts of noise with regard to the number of transports per day, as well as with regard to the above-ground operation of devices and machines, the considerations listed above under "Air pollutants" apply. If the separation distance to the nearest residential zone is more than 700 m, relevant impacts on persons are not to be expected. Noise through blasting is caused sporadically only, so that no relevant impacts are also to be expected at more than 700 m separation distance, unless the vibrations caused through blasting extend further. Within a separation distance of 700 m to the project, potentially-relevant environmental impacts can exist for persons through noise and vibrations.

With regard to the impacts on animals (here birds), it can be determined that, with the existence of noise-sensitive bird species, the necessary separation distance to the construction site is to be explored on an individual basis.

A test and evaluation of the impacts of vibrations on bats is possible only in the individual case, with more precise knowledge about the range and strength of the vibrations, as well as about the site and type of the bat colonies.

5.1.2.2. Operation of an exploratory mine

Impact factors

During the phase of the operation of an exploratory mine, transport-related emission of **air pollutants** occur to a slight degree, particularly through personnel transportation of the operating personnel and through transportation of materials between exploratory mine and mining heap. In addition, dust emissions are possible through drifts of material from the mining heap.

Relevant system-related emissions of **air pollutants and noise** during the operating phase of an exploratory mine are for example the heating unit, the operation of machines above ground and the ventilation/exhaust system.

Underground blasting work can cause **vibrations.**

During the operating phase of an exploratory mine it can be necessary to keep to a **ground-water lowering** possibly implemented during construction of the disposal facility. Disposal facility concepts from Finland assume lowering depths of 10 to 60 m, which would lead to sloping funnels with radii from 0.5 to 2 km /Posiva 1999/.

The evaluation of the environmental impacts through **ground-water lowering** and the introduction of conveyed ground water as conventional waste water are implemented in Chapter 4.1.7, so that these impact factors are not further considered project-specifically in the following.

During the operation of the exploratory mine, drainage water occurs which penetrates into the mine building in the area of layers carrying ground water at locations which are not yet sealed completely against ground water and are not filled. For a disposal facility in claystone in Switzerland in /NAGRA TB1301 2013/, resulting drainage water quantities were estimated. It is assumed as a precaution that, in a disposal facility according to the Site Selection Act, a quantity of 5 l/s (approx. 63,000 m^3 per annum) drainage water results during operation of the mine, conveyed to above ground and there introduced into the receiving water following possibly necessary clarification. For comparison: In the Konrad disposal facility, according to information from the operator /BfS 2015b/, approx. 22 m^3/d (approx. 8,000 m^3 per annum) pit water occurred in the year of 2013, in extraction mines, such as for example the former extraction mine Zeche Verein in the Ruhr District approx. 13,000 m^3 per day (approx. 4,800,000 m^3/a) /RAG 2015/. Environmental impacts through drainage water take effect as **conventional waste water** that is diverted into the receiving water. Conventional waste water also arises from the drainage of the tip during exploration operation.

The evaluation of the environmental impacts through **conventional waste water** is implemented in Chapter 4.1.7, so that this impact factor is not further considered project-specifically in the following.

Description of the potential environmental impacts

Air pollutants
The emitted air pollutants during operation of an exploratory mine correspond to those which are also emitted in case of its construction. In addition, the emissions of the heating plant occur. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations
With the operation of the exploratory mine, acoustic emissions are caused particularly through transportation vehicles, as well as devices and machines operated above-ground. In addition, acoustic emissions and vibrations can occur while blasting. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space. Vibrations can also affect persons and animals negatively and cause damage to buildings.

Evaluation of the potential environmental impacts

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. With the operation of the exploratory mine, the emissions will be far less per unit of time than during its construction, since for example considerably less transports from the mine to the mining heap occur. In total, it can be assumed that relevant impacts on persons, animals and plants are not to be expected, either along transportation routes or in the environment of the exploratory mine, if the mining heaps are kept covered or are kept moist.

Noise and vibrations
The evaluation framework is represented in Chapter 4.1.3. With the operation of the exploratory mine, the noise caused will be less than during construction of the exploratory mine, since

transports from the mine to the mining heap occur mainly separately and since many noise-causing activities occur underground. It can therefore be assumed that relevant impacts on persons, animals and plants are not to be expected along transportation routes.

Noise through blasting is caused sporadically only, so that no relevant impacts are to be expected unless the vibrations caused through blasting extend beyond the site.

The evaluation of the environmental impacts through vibrations depends on the involvement of the protected items. The separation distances of the nearest residential zone and/or other protected items such as animals from the respective vibration source are relevant in this case. An evaluation of the potentially-relevant environmental impacts arising is possible, subject to observation of the existing protected items with the existing legal regulations as an evaluation standard.

5.1.2.3. Cessation of the operation of the exploratory mine

The cessation of the operation related to the subsurface exploration of the site has to be implemented in accordance with the Federal Law (BBergG) /BBergG 2013/ on the basis of a concluding operating plan. In the concluding operating plan, the technical implementation and the time-related planning of the intended closedown are to be represented. In addition, verification of compliance with the prerequisites designated in the BBergG for the cessation of the operation is to be provided. In addition, specifications about a removal of the operational systems and devices or their otherwise utilisation are required.

With the cessation of operation of the exploratory mine, work is to be implemented with the objective of eliminating or reducing to a justifiable residual risk the possible hazards arisen through the exploration, as well as to again manufacture a usable environment which is ecologically intact to a large extent and in accordance with BBergG.

Flooding is a usual concept for the safekeeping of mines. The flooding is implemented, with shutdown of the drainage pumps, through natural supply flow of ground water into the mine e.g. in case of mines in flint clay or granite. In mines which were used for salt extraction, the mines are flooded with saturated saline solution in order to avoid unwanted dissolving processes. At the front end of the flooding, water-endangering materials, such as e.g. oils, greases and chemicals are removed from the mine. To avoid subsidence on the upper surface, likewise at the front end of the flooding, mining-mechanically unstable areas or hollow spaces are filled with suitable backfill materials. After the flooding, the close-off of the shafts is implemented which prevents a contamination of the ground water e.g. through saline solution.

The following project phases are implemented at the site, within the framework of the cessation of the operation:

- The dismantling of the operational devices and the backfilling of all hollow spaces, including the shafts, is implemented underground
- The dismantling of all buildings and mining heaps, as well as the recultivation, are implemented above-ground

Impact factors

During the closing down, backfill material is delivered, as appropriate, stored on a tip, as well as processed at the site, and inserted into the underground hollow spaces still remaining. In addition emissions of **air pollutants, noise and vibrations** arise from the dismantling work and the removal of building rubble and construction site waste.

Possibly occurring **conventional waste water** from the mining heap drainage and waste water occurring underground (drainage water) are reduced in comparison to the operation of the exploratory mine through the dismantling of the mining heap and is therefore not considered further.

A land restoration and adaptation to the total landscape, including surface unsealing are necessary with cessation of the operation. No relevant environmental impacts therefore arise.

Subsidence of the upper surface is reduced or minimised by the complete backfilling of all hollow spaces connected with the cessation of the operation.

During underground dismantling work, the backfilling of the hollow spaces and the close-off measures, for example with the dismantling of the shaft equipment, and the subsequent construction of the shaft close-off construction work, a **ground-water lowering** is to be carried out. The evaluation of the environmental impacts through **ground-water lowering** and introduction of conveyed ground water as conventional waste water is implemented in Chapter 4.1.7, so that these impact factors not further considered project-specifically in the following.

Description of the potential environmental impacts

The environmental impacts of the described impact factors are described in the previous chapters relating to the subsurface exploration and the operation of an exploratory mine. The cessation of the exploration operation leads quantitatively to less impacts than the driving of the exploratory mine. With cessation of the operation of the exploratory mine, however, the environmental impacts reduce by degrees, up to the land restoration of the site.

Evaluation of the potential environmental impacts

The described impact factors of air pollutants and noise, ground-water lowering and waste water are potentially-relevant environmental impacts of the cessation of the operation of the exploratory mine, whose minimisation is to be considered in the licensing procedure.

5.1.3. Transfer of the waste from the storage facility sites to the disposal facility site

Radioactive waste is hazardous material in the traffic-legal sense, from which hazards can arise in case of inappropriate handling and in case of transport accidents. In particular, persons who remain in the vicinity of such waste transportation because of their function or by chance can be exposed through the residual radiation arising from the radioactive waste and penetrating the cask wall construction (shielding). Furthermore, transport accidents with the possibility of an activity release and a radiation exposure of persons following from this and/or accident-caused environment contamination, basically cannot be excluded.

For protection against the hazards associated with this for the community, in particular for lives, health, physical assets and the environment, the transport of radioactive materials or waste is admissible only with special protective and precautionary measures /GRS 2010/.

According to safety regulations (e.g. para. 301 SSR-6, /IAEA 2012/) definitive for the secure transport of radioactive materials and/or waste, protection and security are to be optimised so that the level of the individual doses, the number of exposed persons and the probability of potential (accidentally-caused) exposures can be kept as low as is reasonably possible, considering economical and social factors, and that personnel doses are below the relevant dose limit values /GRS 2010/.

The regulations important for the secure transport of radioactive materials on public traffic routes are stipulated in the hazardous goods regulations of the law about the transport of dangerous goods (hazardous goods transport law - GGBefG) /GGBefG 2013/ and the legal ordinances issued based on this law. The transport of nuclear fuels and highly-radioactive waste and sources furthermore requires a transport license according to § 4 AtG and § 16 StrlSchV for other radioactive materials.

According to the amount of activity of the radioactive materials to be transported, radioactive materials can be transported with different packaging and according to a security concept graded to that. Basically the following package types come into consideration:

- Exempted package,
- Industrial package type 1 (IP-1),
- Industrial package type 2 (IP-2),
- Industrial package type 3 (IP-3),
- Type A package,
- Type B(U) package,
- Type B(M) package,
- Type C package,

where the activity of the radioactive materials transported in the packages increases, according to the list, usuallly from above to below. According to the package type, the amount of the activity to be transported in a package is limited, either by the transport specifications themselves or, in case of Type B and Type C packages, by their permission. Since Type B and Type C packages are part of accident-resistant packages, they have to be approved prior to utilisation according to the existence in the transport specifications of controlled test conditions determined through the responsible government authority. In addition, the transport specifications identify further test conditions for special utilisation, e.g., for the transport of UF_6 or fissile materials (from IP-2).

The transport of highly-radioactive or heat-generating waste is admissible exclusively with certified casks for transport by road, rail, inland waterway and sea. Type C packages are provided for a high activity inventory only for the air transport of radioactive materials. Up to now, transports have been implemented, with few exceptions, exclusively by rail. In case no direct rail connection exists to the storage facility, the last part of the transport is implemented by road. To date in Germany, about 130 Type B casks with irradiated fuel assemblies from power reactors or vitrified highly-radioactive fission product solutions from reprocessing in France have been transported over public traffic routes into central storage facilities. During the transport of waste into the receiving storage facility of a disposal facility, about 1400 casks of Type B will be used for transporting /NaPro2015/, as well as possibly some hundred casks with fuel assemblies from experimental, demonstration, and research reactors which have far smaller dimensions. Several casks can be transported within one transport procedure. Nevertheless, only one large cask per truck is possible during the transport via road.

Impact factor

While the transport of radioactive heat-generating waste, significant **air pollutant** as well as **noise and vibration** occurs as conventional influencing factors /GRS 2008/. Within the framework of the existing generic considerations of the SEA, however, it has to be considered that the number of transports of heat-generating waste amounts only some hundred transport procedures which are implemented staggered time-related over several years. Therefore no appreciable increase of the volume of transport results along the transport route - independently of the modes of transport. The designated conventional impact factors therefore do not have to be considered here.

In addition, the radiological impact factor **direct radiation**, dependent on the characteristics of the radioactive material to be transported, as well as the used transport cask, has to be considered. The potential relevance of these impact factors depends in this case primarily on the selected mode of transport, as well as the necessary number and duration of the transports.

Furthermore, the impact factor **direct radiation and release of radioactive materials due to transport accidents** has to be considered with regard to the resulting radiation exposures on the population.

Description of the potential environmental impacts

Direct radiation

The impact factor "Direct radiation" is relevant in an examination area of a few hundred meters around the transportation routes, as well as the access roads and above-ground systems of a disposal facility. The dose resulting from direct radiation is dependent on the activity and nuclide composition of the sources and can be minimised in accordance with the ALARA principle by increasing the separation distance, reinforcement of the shielding and/or reduction of the retention time. For persons of the population, the exposure through direct radiation is limited to their stay along the transport sections and the duration the pass-by travel at the person. By sufficient separation distance and shielding, impacts on persons and the environment can be reduced or avoided /GRS 2008/.

Direct radiation and release of radioactive materials due to transport accidents

In case of the accident-resistant casks to be employed for the transport of heat-generating waste, it is to be verified, within the framework of the licensing procedure that, even with the check criteria stipulated in the transport specifications, any exceeding of the permissible limit values of radiation exposure through the release of radioactive materials does not result. Different accident scenarios and following stressing are assumed in this case. An external exposure through direct radiation for persons of the population through gamma and neutron radiation can be avoided through admission prevention to the accident site, and is therefore considered only for persons occupied with the recovery.

Evaluation of the potential environmental impacts

Direct radiation

The limit values already stipulated nowadays for the dose rates on the cask surface are applied for the direct radiation due to transports. The radiation exposure for residents can be minimised by changing transportation routes and reducing standstill times during transports. Transports with radioactive hazardous goods have been implemented for a long time subject to compliance with the limit values and the minimisation requirement, so that potentially-relevant impacts on the human health are not to be expected /GRS 2008/.

Direct radiation and release of radioactive materials due to transport accidents
For those employees involved with the recovery after an accident which cannot be excluded, it can be ensured, through the use of dosage rate measuring devices and direct read-off capable personnel dosimeters, that the exposure for individuals of the population through direct radiation of the casks does not exceed the limit values permissible in accordance with the Radiation Protection Ordinance. Since such transport accidents are in addition rather unlikely, potentially-relevant impacts are not to be considered within the framework of the considerations of the SEA.

5.1.4. Storage of the waste in the receiving storage facility of the disposal facility

The receiving storage facility at a site for a disposal facility according to the Site Selection Act serves for the time-related buffering of the irradiated fuel assemblies delivered in transport and storage casks and the waste from reprocessing. In this way, the prerequisite is created to begin with the clearance of the existing storage facility. Furthermore, this waste should be conditioned disposal facility-related and packed into suitable disposal casks at the disposal facility site. Depending on the disposal facility concept, the transport and storage casks could possibly be used as a final storage cask. The National Programme provides the authorisation of the receiving storage facility with the first partial licence for the disposal facility /NaPro 2015/. It is assumed that the receiving storage facility has approx. 500 storage places for transport and storage casks with spent fuel and waste from reprocessing, which enable a staggered relocation from the storage facility. The following project phases are implemented at the site:

- The construction includes the construction of the receiving storage facility, including maintenance building, and a road for the by-pass and infrastructure connections at the disposal facility site over an assumed period of two to three years.
- During operation transport casks are accepted, emplaced into the receiving storage facility and successively brought to the conditioning system in-house. Acceptance, emplacement and relocation of transport casks are implemented with radiological control-checks (dosage rate measurement, wipe test) and control-checks of the casks for sealing and external damages. If required, external repairs can be implemented in a cask maintenance station (e.g.exchange of lifting trunnions, welding of a welded lid, change of the secondary cover).
- On completion of the operation of the receiving storage facility site, the building, can be taken from atom-legal supervision and can then be conventionally dismantled or used in another way after corresponding tests. Radioactive contamination or activations of the building parts which would have to be disposed of as radioactive waste are not to be expected. Therefore a dismantling would be realisable in about two years.

Impact factors

The **land consumption,** in analogous conclusion to the size of the transport cask storage in Ahaus and the site storage facility /BfS 2015a/, is estimated to approx. 10,000 m², of which about three-quarters is taken up with the surface of the warehouse and a quarter with surfaces for accesses and other infrastructure.

As a result of an estimated building height of 20 m and a building length of about 200 m, a **spacial impact** arises.

Emissions of **air pollutants and sound** arise from truck traffic and construction machines during construction and during a dismantling of the receiving storage facility. From knowledge related to the construction of the site storage facility /BfS 2015a/, the truck amount during the building phase is estimated at 20-40 trucks per day. At peak times a daily amount of 125 trucks has to be expected in the short term. During the operation of the receiving storage facility, supply vehicles and hall cranes are operated in case of emplacement and relocating procedures. The air pollutant and sound emissions associated with that are not relevant against the background of the comprehensive character of the SEA of the National Programme.

Dependent on the site, a **groundwater depletion for a** limited time of some months, has to be possibly considered during foundation engineering for the storage facility building. A local depletion of the groundwater of a maximum of a few meters, depending on the hydrological conditions at the site, generates a submersible funnel with a range of a few meters to a few hundred meters around the construction shaft.

The abstraction of groundwater as **conventional waste water** would be implemented into a flowing water body located nearby or into the storm sewer or as ground drainage on site.

The evaluation of the environmental impacts through **groundwater depletion** and the abstraction of groundwater as conventional waste water is implemented in Chapter 4.1.7, so that these impact factors are not further considered project-specifically in the following.

During the operation of the receiving storage facility, **heat dissipation** arises in the substrate, which results in the heating of the ground around the receiving storage facility and the heating of the ground water. For the site storage facility in Germany, heating of the ground near the buildings by some degrees (approx. 5 K) and heating of the ground water by up to 15 K, are predicted /BfS 2015a/. The heat dissipation into the ground and the ground water, implemented through heat-generating waste in a receiving storage facility of a disposal facility, since the receiving storage facility has significantly more cask installation places than a site storage facility, will affect a large spatial area. On the other hand, the thermal output to be considered per cask is less due to the decay characteristic of the radioactive inventory than at the time of the license of the site storage facility.

The operation of the receiving storage facility leads to the emission of **direct radiation** (gamma and neutron radiation). The storage and utilisation of other radioactive materials (e.g., test radiation source) is not relevant with regard to direct radiation.

As a result of, e.g., cask maintenance during operation, liquid and solid radioactive residues occur. Based on licensed values of existing storage facilities, it can be assumed that, after the free measurement of all occurring radioactive residues, about 200 l liquid **radioactive operational waste** and 50 kg solid **radioactive operational waste** can result annually.

The operation of the receiving storage facility is not linked with the **emission of radioactive materials via the air (discharge)** of radioactive materials, since the transport casks are technically sealed using two cover seals and are not opened in the receiving storage facility. Provided one of the cover seals fails, this can be renewed or a welded lid can be welded on.

The operation of the receiving storage facility includes risks through possible **incidents**.

Description of the potential environmental impacts

Land consumption

Land consumption in the order of magnitude of 10,000 m² leads to the loss of the functions of the ground, as well as the living space for animals and plants on the surface. It cannot be excluded that protected species or a protection area are affected by the sealing of a water body.

Spatial impact
The building of the receiving storage facility is associated with the ensemble of the disposal facility. Spatial impacts of the disposal facility site are considered in Chapter 5.1.6.1.

Air pollutants
With the construction and with the dismantling of the receiving storage facility, air pollutants, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulfur oxides are emitted on the construction site, as well as along the transportation routes. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations
Noise is caused during construction and with the dismantling of the receiving storage facility on the construction site, as well as along the transportation routes. Noise is to be considered concerning its impact on persons and animals. Vibrations can occur during building ground improvement, for example during the manufacture of vibration pot columns and affect persons and animals negatively, as well as cause damage to buildings.

Heat dissipation
The physical and chemical characteristics of the ground are not impaired by heating by a few degrees. A heat dissipation into the ground below the receiving storage facility and around the receiving storage facility affects the living space function of the ground. Ground organisms whose temperature tolerance is exceeded cannot use this living space.

The influence of the climate and the mixing through of the groundwater oppose the heat dissipation into the ground water. The heating of the groundwater affects the following characteristics of the groundwater: Viscosity, oxygen solubility, carbonate precipitation, pH value, mobilisation of organic molecules and heavy metals, as well as composition of the living communities /Griebler et al 2014/. A heating of the groundwater by 10 K leads to a doubling or tripling the speed of the physiological processes in microorganisms /RIT 1977/. Changes of the metabolism of the microorganisms interact with impacts of the heating of the ground water on its physical and chemical characteristics.

Direct radiation
The receiving storage facility at a site for a disposal facility for heat-generating waste is primarily the greatest emitter of direct radiation.

Radioactive operational waste
The quantity of radioactive operational waste occurring during operating time of the receiving storage facility is small in comparison to the radioactive waste of the conditioning system. It is to be assumed from this that a central processing of the occurring radioactive operational waste is implemented at the site, which mainly occurs within the framework of the conditioning. The environmental impacts through radioactive waste occurring on the site are therefore considered in Chapter 5.1.5.

Incidents
The layout of the receiving storage facility against impacts of internal and external events is the subject of the verification process and tests in the concrete licensing procedure.

Evaluation of the potential environmental impacts

Land consumption

The evaluation framework is represented in Chapter 4.1.1. The land consumption of approx. 10,000 m² is to be evaluated as a potentially significant environmental impact. The obligation for compensation and for balancing exists.

Possibilities of the minimisation of the intervention, in particular with regard to protected species and protection areas, occur primarily during selection of the overall site for the above-ground systems of a disposal facility, including the receiving storage facility.

Air pollutants

The evaluation framework is represented in Chapter 4.1.2. The construction of the receiving storage facility is directly comparable, with regard to the possible impacts, with the construction of storage facilities. The volume of items transported, which is higher in total due to the size, is compensated by the longer building time.

Beyond a separation distance of one kilometre, no potential relevant impacts on persons and protection areas are to be expected through the additional contamination of the construction site operation, if minimisation possibilities, e.g., employment of machines and devices with electric motors and moistening of dusty goods during loading and unloading, are used, and no sensitive facilities, e.g., hospital, are existing.

If small towns are bypassed and the route does not lead through particularly narrow valleys, also no potentially-relevant impacts on persons, animals and plants are to be expected through the additional contamination from transports, even at peak times.

Within a separation distance of 1 km to the project and on transportation routes of the project-caused traffic, potentially-relevant environmental impacts can occur, which are to be considered within the framework of the UVP.

Noise and vibrations

The construction of the receiving storage facility is directly comparable, with regard to the possible impacts, with the construction of storage facilities. The volume of items transported, which is higher in total due to the size, is compensated by the longer building time.

According to the listings related to the evaluation framework in Chapter 4.1.3, impacts on persons, in particular at a separation distance of less than 1 km, can be considered as potentially-relevant environmental impacts.

Vibrations, for example during the generation of vibration pot columns, do not extend beyond the system grounds, so that no relevant impacts on persons and animals are to be expected.

If small towns are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g., health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.

The potentially-relevant environmental impacts are to be determined concretely in a project-specific UVP of the project, and considered with regard to possible minimisation.

Heat dissipation

The heating of the ground around the receiving storage facility affects the living space function of the ground. A heat dissipation into the ground is decreased through the influence of the seasonally fluctuating air temperature. By means of a compensation measure related to the land consumption, living space losses of the ground caused by the construction of the receiving storage facility are already considered. The ground around the receiving storage facility, and its probably existing by-pass, is shaped by anthropogenic effects at the end of the construction measures, so that a heating of the ground (on condition that this is only in the range of a few degrees) can be evaluated as a non- potentially-relevant environmental impact, within the framework of the SEA of the National Programme.

Fluctuations of temperature of the ground water by 10 K within the temperature range of 6°C to 16°C do not lead to changes of the chemical water quality /Possermiers et al 2014/. /Griebler et al 2014/ assume that temperature increases of about 4 K lead to significant changes of the eco-system functions of the ground water. A value of 4 K is to be applied as a trifle threshold for a heating of the ground water, according to present status of the science.

It basically cannot be excluded that the heat dissipation induced by the receiving storage facility into the ground water exceeds 4 K. Therefore potentially-relevant environmental impacts through heat dissipation cannot be excluded. Measures for the minimisation, e.g., through the installation of thermal-insulating layers in the base slab of the receiving storage facility, could become necessary. In addition, the installation areas of the casks could be implemented in the receiving storage facility so that air circulates below the casks, so that a direct heat dissipation into the substrate does not take place.

Direct radiation

The evaluation framework is represented in Chapter 4.1.4. The emission of the direct radiation of the receiving storage facility is checked through measurement-technical verification. The limit values of the Radiation Protection Ordinance are to be adhered to.

Concrete measures for minimisation with regard to real dwell times of persons classified as not exposed to radiation on the site of the disposal facility, and of persons in the publicly accessible area, can be realised. Within the framework of the SEA of the National Programme, the direct radiation of the receiving storage facility is evaluated as a potentially-relevant environmental impact.

incidents

The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Within the framework of the licensing procedure, these potentially-relevant environmental impacts are to be considered on the basis of a incident analysis.

5.1.5. Conditioning for disposal at the disposal facility site

Before the emplacement in a disposal facility according to the Site Selection Act, the heat-generating waste must be treated and/or be repacked in a large-scale-technical system with corresponding throughput.

The existing Pilot Conditioning Plant Gorleben (PKA), with a planned throughput of 35 Mg heavy metal per annum, was constructed in order to prove and to demonstrate the conditioning of irradiated fuel assemblies and heat-generating waste for the disposal facility. The system was planned for the maintenance and service function for transport and storage casks (acceptance and repair of a defective casks) /BMUB 2014/. Against the background of the boundary conditions defined by the Site Selection Act, the concepts relating to the conditioning and emplacement, depending on the future disposal facility formation, must possibly be adapted in part or newly developed. The following project phases are implemented at a disposal facility site:

- The construction of the conditioning system includes the construction of the building and the manufacture of the infrastructure connections to the disposal facility site over an assumed period of 2 to 3 years.
- During the operation, the transport and storage casks are taken successively from the incoming goods storage and opened in a hot cell of the conditioning system using a remote-control method. The fuel assemblies can be dissembled in order to enable a more dense packing in the disposal casks. The acceptance of the transport and storage casks and the issue of the disposal casks for emplacement is associated with radiological control-checks (dosage rate measurement, wipe tests) and control-checks of the casks for sealing and external damages.
- With regard to the shutdown of the conditioning plant, the listings made for the receiving storage facility apply accordingly. However, radioactive contamination and possibly also activations of building parts cannot be excluded in this case, which would have to be disposed of as radioactive waste. Therefore a dismantling would take some years, similar to the dismantling of other nuclear facilities.

Impact factors

The building has the following dimensions approximately: 125 m (length), 70 m (middle width) and 20 m (height) and with that a **land consumption** of approx. 8,750 m² /NUKEM 1984/.

A spatial impact arises from an estimated building height of 20 m and a building length of 125 m.

Emissions of **air pollutant and noise** arise during construction and during a dismantling of the receiving storage facility from truck traffic and construction machines. From knowledge relating to the construction of site storage facility /BfS 2015a/ the truck amount is estimated during building phase with 20-40 trucks per day. At peak times a daily amount of 125 trucks is to be expected in the short term. During operation of the conditioning plant, supply vehicles, as well as hall cranes, are operated for cask transport. The air pollutant and sound emissions associated with that are not relevant in the context of the higher-level considerations in the SEA.

A conditioning plant is placed some meters below the ground surface (approx. 10 m) /NUKEM 1984/, so that during foundation engineering a **ground-water lowering** at the site is to be assumed. The ground-water lowering would be implemented temporarily over some months. A local lowering of the groundwater level by maximum a few meters, depending on the hydrological conditions at the site, can generate a sloping funnel with a range of a few meters to a few hundred meters around the construction pit.

The introduction of conveyed ground water as **conventional waste water** would be implemented into a flowing water body located nearby or into the storm sewer or as ground drainage on site.

The evaluation of the environmental impacts through **ground-water lowering** and the introduction of conveyed ground water as conventional waste water is implemented in Chapter 4.1.7, so that these impact factors are not further considered project-specifically in the following.

The operation of the conditioning plant leads to the emission from **direct radiation** (gamma and neutron radiation). The storage and utilisation of other radioactive materials (e.g. test radiation sources and radioactive operational waste) is not relevant with regard to direct radiation.

Radioactive operational waste results from the conditioning operation. In this case it involves wiping cloths, cleaning cloths, protective clothing, filter cartridges of the ventilation and exhaust gas systems, parts of the component scrapping and cemented liquid waste /NUKEM 1984/. This waste is packed, conditioned and stored until its disposal. In addition, waste also comes from the transport dispatch in the incoming goods storage. In case of a dismantling of the conditioning system, small quantities of radioactive waste occur, in comparison with the overall masses occurring in total during decontamination, which are to be provided with a final storage. In comparison to the total amount of the quantity of radioactive waste considered in the National Programme, the quantity of radioactive waste occurring at the disposal facility site and the following dismantling is small, so that a further consideration of environmental impacts is not implemented.

With the operation of a conditioning plant there results the **emission of radioactive materials via the air (discharge**). In /NUKEM 1984/ emissions from a conditioning system for irradiated fuel assemblies were estimated, where a throughput of 1,311 fuel assemblies a year and a defect rate of 1% of the rods were assumed. A dismantling of rods was not assumed. Under the designated conditions, the following routing into the ambient air was estimated:

Nuclide	Inventory [Bq/a]
H-3	2.6E11
Cobalt-60	7.7E6
Nickel-63	1.9E6
Krypton-85	9.3E13
Iodine-129	9.8E5
Caesium 137	2.7E6
Plutonium-239	9.3E3

The capacity of the conditioning system taken as a basis in /NUKEM 1984/ would be sufficient for the conditioning of the heat-generating waste, so that derived values in the designated order of magnitude can be assumed for further consideration.

During the operation, radioactive liquids result, basically decontamination liquids for the major part with cobalt-60 and caesium-137. Highly-active liquids should be provided to the radioactive waste, the remainder after collection, possibly cleaning and measuring, routed away as an **emission of radioactive materials via the water path (discharge).** About 550 m³/a occur /NUKEM 1984/. The limit values of StrlSchV apply for the discharge. The discharge of radioactive materials includes a discharge as material-linked discharge and, due to additional conventional materials (e.g. residue of cleaning substances), as **conventional waste water**. The evaluation of the impact factor conventional waste water is implemented in Chapter 4.1.7 and is not further considered project-specifically in the following.

The operation of the conditioning plant includes risks of possible **incidents**.

Description of the potential environmental impacts

Land consumption

Land Consumption in the order of magnitude of 8,750 m² leads to the loss of the ground function, as well as the living space for animals and plants on the affected surface. It cannot be excluded that protected species and a protection area are affected by the sealing of a water body.

Spatial impact

The conditioning plant is associated with the ensemble of all buildings of the disposal facility. Spatial impacts of the disposal facility site are considered in Chapter 5.1.6.1.

Air pollutants

During construction and with the dismantling of the conditioning plant, air pollutants, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulfur oxides are emitted on the construction site, as well as along the transportation routes. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations

Noise is caused during construction and with the dismantling of the conditioning plant on the construction site as well as along the transportation routes. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space. Vibrations can occur in case of work for on building ground improvement (e.g. manufacture of vibration pot columns) and affect persons and animals negatively, as well as cause damages at buildings.

Direct radiation

In the comparison to the receiving storage facility (cf. 5.1.4) the emission of direct radiation through the conditioning system is less, since in the plant only a few casks with heat-generating waste are handled simultaneously. The direct radiation basically affects persons in the system and on the company grounds.

Radiological emissions via the air and water

As a result of the emissions of radioactive materials, radiation exposures of persons, animals and plants are possible. Other protected items are covered by these, since, in case of a sufficiently low dose for the protection of persons, as well as of animals and plants, no disadvantageous influencing of ground, base and surface water, air or physical assets is possible.

Incidents

Incident-caused releases of radioactive materials through influences of internally (cask fall, load fall, fire etc.) as well as from externally (earthquake etc.) cannot be excluded, in particular if a handling of open radioactive materials is implemented during conditioning.

Evaluation of the potential environmental impacts

Land consumption

The evaluation framework is represented in Chapter 4.1.1. A sealed surface of approx. 8,750 m^3 is to be evaluated as a potentially significant environmental impact. The obligation exists to provide balance or compensation.

Possibilities of the minimisation of the intervention, in particular with regard to protected species and protection areas, exist above all during selection of the overall site for the above-ground systems of the disposal facility, including the conditioning devices.

Air pollutants

The evaluation framework is represented in Chapter 4.1.2. The construction of the conditioning system is comparable with regard to the possible impacts with the construction of storage facilities. The volume of items transported, which is higher in total due to the size, is a relative factor because of the longer building time.

Beyond a separation distance of one kilometre, no potential relevant impacts on persons and protection areas are to be expected through the additional contamination of the construction site operation, if minimisation possibilities, e.g. employment of machines and devices with electric motors and moistening of dusty goods during loading and unloading, are used, and no sensitive facilities, e.g. hospital, are existing.

If small towns are bypassed and the route does not lead through particularly narrow valleys, also no potentially-relevant impacts on persons, animals and plants are to be expected through the additional contamination from transports, even at peak times.

Within a separation distance of 1 km to the project, potentially-relevant environmental impacts can exist which are to be considered within the framework of the UVP of the project.

Noise and vibrations

The construction of the conditioning plant is comparable with existing experiences relating to the construction of storage facilities. The volume of items transported, which is higher in total due to the size, is a relative factor because of the longer building time.

According to the listings related to the evaluation framework in Chapter 4.1.3, impacts on persons, in particular at a separation distance of less than 1 km, can be considered as potentially-relevant environmental impacts.

Vibrations, for example during the generation of vibration pot columns, do not extend beyond the system grounds.

If small towns are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g. health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.

The potentially-relevant environmental impacts are to be determined concretely in a project-specific UVP of the project, and considered with regard to possible minimisation.

Direct radiation

The emission of the direct radiation of the conditioning plant is checked through measurement-technical verification. The limit values of the Radiation Protection Ordinance are to be adhered to.

Concrete measures of the minimisation with regard to real dwell times of persons at the site of the conditioning plant, who are classified as not exposed to radiation, and by persons in the publicly accessible area, can be realised. Within the framework of the SEA of the National Programme, the direct radiation of the conditioning system is evaluated as a potentially-relevant environmental impact.

Emission of radioactive materials via the air and water

For the operation of a conditioning plant, discharge values are stipulated which cover the expected discharge actions and guarantee compliance with the limit values of the Radiation Protection Ordinance. The discharge values, on condition of a throughput of 1,311 fuel assemblies a year, a defect rate of 1% of the rods and on condition that the dismantling of the fuel rods is not implemented, would not be higher than the discharge values for nuclear power plants in operation in Germany. It can therefore be assumed that, in case of similar chimney height and similarly large fenced-in ground site, the emission through a future conditioning plant for heat-generating waste are significantly under the dose limit values. The expected discharge actions with the exhaust air can be reduced through improved filter technology for aerosol-shaped radionuclides and iodine 129. In case of discharge with the waste water, the discharge value can be selected so that the dose limit values are adhered to and then all waste water, which cannot be routed away, is further cleaned or supplied to the disposal facility after processing.

In case of compliance with these specifications, in accordance with the investigations in /Kueppers et al 2012/ for the long-lived radionuclides relevant here, it can be assumed that the dose limitation for persons, in accordance with the Radiation Protection Ordinance, covers potential disadvantageous effects on populations of animals and plants. A further reduction of the potential environmental impacts in particular, as a precaution, is possible in case of suitable site selection (separation distance to residential zone, separation distance to sites with long-term stay of persons, size of the receiving water body).

The discharge actions of the conditioning system via air and water are a potentially-relevant environmental impact, whose minimisation possibilities are to be considered within the framework of the license.

Incidents
The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. A conditioning plant includes incident risks against which precautions are to be taken. Within the framework of the licensing procedure, the minimisation of incident risks as a source of potentially-relevant environmental impacts is to be considered on the basis of a risk analysis.

5.1.6. Final storage in particular for heat-generating waste

5.1.6.1. Construction of the disposal facility

The construction of the disposal facility according to the Site Selection Act is implemented in the region of an already explored underground site. Further buildings are erected in this case, as well as traffic spaces and infrastructures being extended or newly installed. The site is provided with a railway siding.

Since it cannot necessarily be assumed that the disposal facility can be constructed by further extension of the already existing exploratory mine as a result of the subsurface exploration (cf. for example the planned disposal facility at the French site Boer), it is preventatively assumed that a completely new mine will be excavated, analogous to the procedure outlined in Chapter 5.1.2.1. It is assumed that the construction of the disposal facility will be realized over a period of about 10 years.

Impact factors

At the site further **land consumption** arises from the areal extension of the buildings. For the above-ground system an extension of the land consumption up to 80,000 m^2 is to be assumed /NAGRA TB1101 2011a/. In addition an areal extension of up to 200.000 m^2 for the mine dump could be assumed.

Emissions of **air pollutants and noise** are caused by intensive traffic movements for the delivery of building material and for the removal of excavated material. Further air pollutant and noise emissions arise from the operation of construction machines and vehicles. The Swiss disposal concept assumes an excavation volume of 400,000 m^3 during the tree-year constructional phase of the disposal facility, which is transported away to waste dumps with 50 trucks per day (12 m^3/truck). The delivery of building material (65,000 m^3 of concrete) with 8 trucks/day /NAGRA TB0202 2002/ should be performed. The amount of excavated material will depend on the host rock and geological conditions. The estimated excavation volume with regard to four proposed siting in the Swiss Opalinus Clay varies by a factor of 2 and lies between 1 million m^3 to 2 million m^3 of solid material /NAGRA TB1101 2011b/.

The construction of buildings with a height of 25 m and a building front of some hundred meters beings perhaps visible /NAGRA TB0202 2002/, two stacks and two pits with heights of 40 m to 60 m, as well as the construction of a mining heap, lead to a spatial **impact** on the landscape.

During the constructional phase a temporary **ground-water lowering may** be necessary. The pumped ground water, as well as percolating water from the mining heap drainage, will reach a recipient water body after prior treatment (clarification, precipitation and settlement) as **conventional waste water** or will be seeped into the ground on site. The assessment of the environmental impacts through **ground-water lowering** and the **injection** of pumped ground water as conventional waste water is performed in Chapter 4.1.7, so that in the following these impact factors are not considered project-specific any further.

During construction of the disposal facility, drainage water will be collected in the excavations depending on the hydrogeological situation (in particular in crystalline rock) with respect to base-aquiferous layers in spite of sealing measures. For a disposal facility in the claystone in Switzerland /NAGRA TB1301 2013/, accumulated drainage water quantities were estimated. It was assumed preventatively , that in a kept-open disposal facility according to the Site Selection Act, a quantity of 5 l/s (approx. 63,000 m³ per annum) drainage water will accumulate , will be pumped to above ground and , after necessary clarification, will be injected into the recipient. Drainage water is dealt with in Chapter 4.1.7 with the impact factor **conventional waste water** and is therefore not further considered project-specifically in the following.

Description of the potential environmental impacts

Land consumption

The land consumption affects the ground, the groundwater recharge, as well as plants and animals which live on the affected surfaces. It cannot be excluded that, on the site of the disposal facility, small water bodies also are existing and protected animal or plant species are affected.

Air pollutants

Air pollutant emissions, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitrogen oxides and sulphur oxides, are caused in particular through operation of devices and machines during the construction of buildings and traffic routes, through driving movements between mine and mining heap during excavation of the disposal facility, as well as along the transportation routes during delivery of building material and during removal of excavated material. Wind-drifts from the mining heap are also possible. These emissions may have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations

Noise is caused through the operation by devices and machines during the construction of buildings and traffic routes, through the driving movements between mine and mining heap during excavation of the disposal facility, by rock-blasting and by transport along the routes for delivery of building material and removal of excavated material. Vibrations can occur by blasting of rock and during ground improvement, for example during operation of vibration pot columns. Noise may increase the risk of cardiovascular diseases for persons and may exile animals from their living space. Vibrations may affect persons and animals negatively and cause damage to buildings.

Spatial impact

The impact of the disposal facility on the landscape accumulates from the single impacts of the buildings of the disposal facility, as well as the buildings of the incoming goods storage (cf. Chapter

5.1.4) and the conditioning (cf. Chapter 5.1.5). The overall site of the disposal facility has the size of an industrial area and also effects on the landscape corresponding to this.

A spatial impact changes the appearance of an affected landscape and can reduce their regenerative function. The spatial impact is dependent on the subjective opinion of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism.

Evaluation of the potential environmental impacts

Land consumption

The evaluation framework is represented in Chapter 4.1.1. The land consumption of about 280,000 m² in total is a considerable impairment of nature and landscape and therefore is to be evaluated as a potentially significant environmental impact. The obligation for balance and compensation exists.

Possibilities of minimizing the intervention, in particular with regard to protected species and protection areas, exist above all in the selection of the overall site for a disposal facility. Use conflicts can be examined as early as during specification of the sites for an exploratory mine.

Air pollutants

The evaluation framework is represented in Chapter 4.1.2. As a relevant variable for the evaluation of the environmental impacts through air pollutants, the number of transports per day as well as the emissions of devices and machines on the construction site are to be considered. With the construction of a disposal facility with its above-ground and underground systems, considerably larger quantities of excavated material and building material in total are to be moved than is the case, for example, with the construction of a storage facility, however their amount is distributed over a considerably longer period. The emissions caused by the machines and devices on the construction site per day will likewise be in the same order of magnitude as, for example, with the construction of an storage facility. In total, the emissions of air pollutants per day are comparable with the construction of storage facilities, however, will occur over a far longer period. In addition, there are still the dispersals from the mining heap if this is not covered or kept sufficiently moist.

In total it can be assumed, with a separation distance of more than 1 km, that no relevant impacts on persons and protection areas are to be expected through the additional contamination of the construction site operation, based on a comparison with results of environmental impact assessments for storage facilities, if minimisation possibilities, e.g. employment of machines and devices are used with electric motors and the moistening of dusty goods during loading and unloading is carried out, and no sensitive facilities, e.g. hospitals, are present. If small towns are bypassed and the transportation routes do not lead through particularly narrow valleys, also no relevant impacts on persons, animals and plants are to be expected through the additional contamination, even at peak times.

Air pollutant emissions during construction of a disposal facility can lead, within a separation distance of 1 km, to potentially-relevant environmental impacts for which minimisation possibilities are to be considered in the licensing procedure.

Noise and vibrations

The evaluation framework is represented in Chapter 4.1.3. For the evaluation of the impacts of noise with regard to the number of transports per day, as well as with regard to the above-ground operation of devices and machines, the considerations listed above under "Air pollutants" apply. It is therefore to be assumed that the noise pollution with the construction of the disposal facility will be approximately in the same order of magnitude as, for example, during the construction of an storage facility, however, will persist over far longer period.

In total, based on a comparison with results of environmental impact assessments for storage facility, it is to be assumed that a separation distance of 1 km suffices in order to adhere to the emission directives applicable for persons at peak times. This appraisal is based on the assumption that - with some from exceptions - the construction site is operated by day only.

If small towns are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g. health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.

Vibrations, for example caused by vibration pot columns, do not extend beyond the system grounds, so that no relevant impacts on persons and animals are to be expected.

Noise through blasting is caused sporadically only, so that at 1 km separation distance no relevant impacts on persons are to be expected, unless the vibrations caused through blasting extend further. An examination and assessment of the impacts of vibrations on bats is possible only in the individual case with more precise knowledge about the range and strength of the vibrations, as well as about the site and type of the bat colonies. Within a separation distance of 1 km to the project, potentially-relevant environmental impacts through noise and vibrations can exist, whose possible minimisation is to be considered on the basis of the site-specific knowledge.

Spatial impact

The spatial impact of a disposal facility site on the landscape is a permanent potentially-relevant environmental impact, which should be considered as early as within the framework of the specification of the sites for a subsurface exploration. During the construction of the disposal facility, the landscape is already characterised by the previously constructed exploratory mine. An evaluation of the spatial impact can be implemented only if it is based on graphic representations of the planned system in the landscape (photo montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape which is caused by the spatial impact of a disposal facility aim at avoiding visual relationships from the environment of the disposal facility. In this case, the relief of the landscape may be included, earth banks may be laid, shading of the system through trees implemented or the colour layout and design of the buildings adapted to the landscape.

5.1.6.2. Emplacement operation of the disposal facility

During the emplacement operation of a disposal facility, the already conditioned waste casks are transferred into the disposal facility and installed there in the emplacement areas. For the disposal facility according to the Site Selection Act, no stipulation currently exists for a disposal facility concept, such as e.g. boreholes, route section or underground storage. In case of the host rocks granite, clay and salt, with the installation of the waste casks, geotechnical barriers are generated which have different scope and differentiate in material. The material for the generation of such geotechnical barriers (e.g. clays or sands and/or the respective host rock) must be delivered during operation of the disposal facility and generally stored initially on above-ground storage surfaces. The installation of the material is performed successively and in parallel with the emplacement of the waste casks.

During the emplacement operation of the disposal facility, radioactive waste is delivered in suitable casks, transported underground and emplaced. Environmental impacts through the delivery of the radioactive waste are described and evaluated in Chapter 5.1.3.

Dependent on the disposal facility concept during the emplacement operation of the disposal facility, emplacement areas are possibly closed off completely for the mechanical stabilisation of the mine, as soon as these are filled with waste. The backfill material (clays, sands and/or the respective host rock) can either be withdrawn from mining heaps erected during the excavation of the mine on the above-ground company premises, or alternatively be delivered successively by truck or rail transport. It is processed in above-ground facilities and then brought underground and installed in situ. Any installation of material must be implemented qualified and documented.

The emplacement operation of the disposal facility, according to the Site Selection Act, should begin approx. by the year 2050. The duration of the operating time is currently not defined and will depend t on the selected emplacement concept /NaPro 2015/. As a result of the extensive emplacement activities in the disposal facility, and through the requirements to be considered here on the radiation protection of the personnel (operational radiation protection), the activities are implemented at the site of the disposal facility uniformly without special operational peaks.

Impact factors

During emplacement operation of the disposal facility, transport-related emissions of **pollutants and noise** may result through the delivery of the mining heap materials or alternative materials to be backfilled. In addition, there is transportation of the operating personnel. The disposal concept of Switzerland assumes that, during operating time of a disposal facility, approx. nine railway wagons weekly will be readied for dispatch with radioactive waste and installed in the disposal facility and approximately one truck per week delivers backfill material /NAGRA TB0202 2002/.
According to the disposal facility concept taken as a basis in the preliminary safety analysis Gorleben (VSG) /GRS 2012/ (horizontal drift emplacement of the heat-generating radioactive waste in salt) approx. 585,000 m³ of crushed salt in total is calculated for backfilling of the layering sections and cross-cuts. The crushed salt to be employed is obtained mainly from the excavated material from the exploration and construction phase, which is emplaced on the disposal facility premises on a mining heap. This means that the transport of the crushed salt is limited to the area of the facility premises provided that no additional material is required.

Relevant system-related emissions of **air pollutants and noise** during the emplacement operation consist, e.g. in the heating unit, the operation of machines above ground and the ventilation/exhaust system.

Underground blasting work may cause **vibrations.**

During the emplacement operations, according to the disposal facility concept, it may be necessary to keep to a **ground-water lowering** during construction of the disposal facility. According to disposal facility conceptions in Finland, during construction of a disposal facility depression funnels of 0.5 to 2 km radius arise around the system with a lowering depth of the groundwater level of 10 to 60 m. The size of the depression funnel depends on the mining construction requirements and the hydrogeological conditions on site. After cessation of the ground-water lowering, several years pass by in case of large lowering depths, as this is required in Finland due to the initial hydrogeological situation, until the initial level of the ground water has levelled off /Posiva 1999/, so that arising impacts occur on a long-term basis. The pumped ground water, as well as percolating water from the mining heap drainage, should be injected into a recipient after prior treatment (clarification, precipitation, settlement) as **conventional waste water.**

During emplacement operation, depending on the hydrogeological situation (in particular granite), drainage water can result, which is to be disposed of as **conventional waste water.** In this case it basically involves shaft water, which can result in spite of sealing of the shafts, air humidity from the ventilation which condenses in the mine area, as well as formation water which was included with the formation of the rock or in fissures. In particular in case of a crystalline host rock, pit water can result, which connects with the hydrosphere via fissures. On the basis of site-independent considerations for the evaluation of impacts on the ground water during operating time of a disposal facility in the clay rock in Switzerland /NAGRA TB1301 2013/, it is assumed as a precaution for a disposal facility in Germany that a quantity of 5 l/s drainage water occurs during retention. The water is collected, transported to above ground and after possibly implemented chemical clarification and settlement of suspended matter, injected into a recipient (approx. 63,000 m^3 per annum). As a comparison: in the Konrad disposal facility, according to specification of the operator /BfS 2015b/, in the year 2013 approx. 22 m^3 per day pit water would accumulate (approx. 8,000 m^3 per annum), in extraction mines, such as for example the former extraction mine Zeche Verein in the Ruhr District approx. 13,000 m^3 per day (approx. 4,800,000 m^3/a) /RAG 2015/.

The impact factors **ground-water lowering** and **conventional waste water** are handled in Chapter 4.1.7 and therefore are not further considered project-specifically in the following.

A incorporation of **heat** into the surrounding rock is associated with the final storage of radioactive heat-generating waste. This impact factor is further considered for the period after close-off of the disposal facility in Chapter 5.1.6.3.

Emissions of radioactive materials via the air (discharge) may lead to environmental impacts on the protected items persons and animals.

A dose resulting from **direct radiation** is dependent on the activity and nuclide composition of the sources and may occur with the emplacement operation of a disposal facility during handling (in-house transport and emplacement work) of the casks (see Chapter 5.1.4).

Within the framework of the safety verification for a disposal facility, it is to be demonstrated that relevant **incidents** do not lead to any releases which exceed the existing limiting values, in accordance with Radiation Protection Ordinance, during emplacement operation. Relevant incidents during emplacement operation, against which the disposal facility is to be designed, are e.g. above-ground and underground incidents with mechanical influence (cask drop), fires or external events. Layout against these incidents is achieved by the technical characteristics of the system itself, and by the integrity of the cask. Considerations relating to above-ground incidents do not differ,in this case, from fault-case verification having been maintained for site storage facilities or treatment plants for nuclear materials. In addition, underground incidents may not endanger the long-term safety of the disposal facility e.g. through incident as a result of a solution influx during operation and after shutdown.

With the supply of the disposal casks for the emplacement, with the emplacement process itself as well as with the dismantling of underground radiation protection areas, e.g. in case of the close-off of the individual underground storage chambers, as well as in case of decontamination procedures, solid and liquid **radioactive operational waste** (e.g. wiping cloth, cleaning fluids, fine filter meshes, etc.) arises. The quantity and composition of this waste during the emplacement operation can be compared with decontamination waste from research facilities.

In case of laboratory work and decontamination measures, **radioactive waste water** will result underground and above-ground. In a disposal facility, water is used for the cleaning of casks for radioactive waste, with added detergents. This water is processed regularly and maintained in the circuit. It may be assumed that only a few cubic meters of liquid radioactive waste will result annually /NAGRA TB1301 2013/ and are to be disposed of as radioactive operational waste.

Description of the potential environmental impacts

Air pollutants
Air pollutant emissions, such as fine-grain dust (PM_{10}, $PM_{2.5}$), nitric oxides and sulphuric oxides, are caused by the operation of devices, machines and transportation vehicles, as well as by the heating plant, the ventilating system and the ventilation. Dispersals from the mining heap are also possible. These emissions may have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations
Acoustic emissions are caused by devices and machines operated above-ground, as well as by transportation vehicles. In addition, acoustic emissions and vibrations during blasting activities may occur. Noise may increase the risk of cardiovascular diseases in persons and drive animals from their living space. Vibrations may also affect persons and animals negatively and cause damage to buildings.

Emission of radioactive materials via the air (discharge)
In a disposal facility for radioactive waste, locked waste casks exclusively are handled. According to selected disposal facility and cask concept, emission of radioactive materials from the waste casks can result. According to the Radiation Protection Ordinance, releases are permissible up to an effective dose of 0.3 mSv/a (§ 47 StrlSchV).

Direct radiation
Exposure through direct radiation in direct proximity to the waste casks basically concerns the persons remaining there and, as appropriate, any animals present there. The emplacement operation of a disposal facility covers only one handling of individual casks. , however, and most handling procedures are implemented additionally underground. An exposure of protected items through direct radiation during emplacement operation can virtually be excluded by this. An evaluation of environmental impacts within the framework of the SEA is not necessary.

Incidents
Incidents, such as fire or explosions, may lead to unforeseen releases of radioactive materials into the environment and therefore have impacts on the protected items persons, animals, plants, ground, water, climate and air, as well as cultural and material goods. The dose resulting from potential incidents for individuals of the population depends on the source term, the event sequence and meteorological conditions, as well as on precautionary measures to avoid incidents and/or for the limitation of potential radiological impacts.

Radioactive operational waste
With the emplacement operation of a disposal facility, solid and liquid radioactive waste results. This must be collected to be conditioned, buffered and emplaced, as well as to be transported in-house. Liquid radioactive operational waste should be solidified in an in-house conditioning system and solid operational waste should be correspondingly packed. For all radioactive operational waste, a verification process as well as a product inspection are to be implemented. The waste is then to be provided to the disposal facility.

Evaluation of the potential environmental impacts

Air pollutants

The evaluation framework is represented in Chapter 4.1.2. During the emplacement operation, the transport-related pollutant and dust emission through the delivery of the mining heap material to be filled, or alternative materials such as e.g. bentonite, correspond to approximately the total number of necessary transports during construction of the disposal facility. However the transports of the mining heap material during emplacement operation are distributed over a long period (some decades), so that peak loads are avoided. Since the volume of items being transported is small per unit of time and the emissions at the site are also small per unit of time, potentially-relevant impacts on persons, animals and plants are not to be expected, either along the transportation routes or in the environment of the site, if aerial dispersals from the mining heap are minimised by covering or moisture retention, also during emplacement operation.

Noise and vibrations

The evaluation framework is described in Chapter 4.1.3. Activities causing noise occur during the emplacement operation in small scope only. No relevant noise emissions are caused by the heating plant, the ventilating system and the exhaust. Transports of mining heap or construction materials are extended over a long period and are therefore small per unit of time. In total, it can therefore be assumed that relevant impacts for persons and animals through noise are neither caused by the emplacement operation, nor at the site or along the transportation routes.

Noise through blasting is caused sporadically only, so that no relevant impacts are to be expected unless the vibrations caused through blasting extend beyond the disposal facility site.

The evaluation of the environmental impacts through vibrations depends on the involvement of the protected items. The separation distances of the nearest residential zone or other protected items such as animals from the respective vibration source are relevant in this case. An evaluation of the arising potentially-relevant environmental impacts is possible, subject to observation of the existing protected items with the existing legal regulations as an evaluation standard.

Emission of radioactive materials via air (dispersal)

For the emission of radioactive materials to be expected, significant environmental impacts are not to be expected - on the basis of experience from the emplacement operation in other systems (e.g. storage facility, Morsleben disposal facility). Potentially-relevant environmental impacts basically cannot be excluded on the basis of currently existing knowledge about the measure. A more precise evaluation can be implemented only when the emplacement concept has been concretised.

Incidents

The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. The risk for incidents can be minimised by limiting, the maximum release-capable inventory with handling. For example, this can be achieved for the fire incident, in that the treated inventory is limited by a stipulation regarding a maximum quantity of the casks per in-house transport unit and the quantity of the treated cask units per storage procedure is limited.

The evaluation of the environmental impacts through incidents with nuclear facilities is based on the results of the safety-technical evaluation. The evaluation criteria for "Safety" are employed according to the state of the art of science and technology. Numerous incidents, which play a role with more complex systems (e.g. with storage of spent fuel assemblies irradiated in a fuel-cooling installation), can be excluded by the handling of closed waste casks in a disposal facility. By means of precautionary measures, incidents are therefore either to be avoided or, insofar as this is not possible, the radiological impacts are to be limited through corresponding measures. The risk for incidents in connection with the emplacement operation is somewhat comparable with other systems for the handling of radioactive waste, in which open radioactive materials are not dealt with. Significant impacts of a disposal facility on the environment as a result of incidents are therefore unlikely. Since corresponding verifications are still to be carried out in the licensing procedure, it is assumed here that potentially-relevant environmental impacts due to radiological incidents may exist.

Radioactive operational waste

The radioactive operational waste which arises with the operation of a disposal facility is conditioned and stored up to its disposal. The evaluation standards for the handling and dealing with radioactive waste are the stipulations of the Radiation Protection Ordinance (StrlSchV). Potential environmental impacts correspond to the environmental impacts of this type in case of medium-sized research laboratories, and are evaluated here as not being relevant in relation to the primary waste flows.

The quantity of waste water to be initially classified as radioactive is estimated, for example, for the Swiss disposal facility for HAA at maximum of 100 m^3 during the entire operating time /NAGRA TB1301 2013/. Here, the waste water is either cleared after measuring or cleaned if required (e.g. with centrifuge or evaporator) or disposed of as radioactive operational waste after a decisive measurement. The evaluation standards for handling and dealing with radioactive waste are the stipulations of StrlSchV. Residues from the sewage treatment are collected and delivered for conditioning with the objective of final storage. Compared to the comprehensive consideration of the SEA within the National Programme, occurring radioactive operational wastes are not relevant environmental impacts.

5.1.6.3. Closure of the disposal facility

The closure of the disposal facility, within the framework of the decomissoining, serves for the objective of assuring the isolation of the radionuclides in interaction with the containment-providing rock zone and the technical and geotechnical barriers included in that.

A difference is made between filling and close-off measures in the emplacement areas and those in the remaining areas of the disposal mine, e.g. shaft adits, connection and access routes and infrastructural areas. A disposal facility concept is assumed, with which a backfilling of the already loaded emplacement sections and/or emplacement boreholes is carried out in parallel with the emplacement of the waste casks. Also the geotechnical barriers such as drift and borehole sealings for the separation of the remaining mine are also constructed during emplacement operation. The closure of the disposal facility considered here refers to the phase after the emplacement operation, in which already large parts of the underground installations are demounted and drifts in the emplacement areas are backfilled and closed off (Chapter 5.1.6.2).

During the close-off of a disposal facility, central access areas become completely backfilled and closed off. The material, such as e.g. clay, sands, crushed salt and gravel, is stored at the site of the disposal facility on one or several mining heaps (also included here is the excavated material from the exploration and construction phase) and/or delivered, and conveyed successively into the disposal facility for the backfilling of voids.

After close-off of all underground areas of the disposal facility, above-ground buildings are dismantled after radiological appraisal, control-check and clearance measurements or are used as desired. The conventional dismantling of buildings is generally implemented in short periods with storage of dismantling waste material, as appropriate, a concrete and building rubble recycling through mobile systems on site is implemented and the following removal of the dismantling waste materials carried out for re-utilisation or waste disposal.

A small part of the buildings at the site of the disposal facility will be used for the registration, processing and documentation of data within the monitoring process over an indefinite period of time. It may be assumed that, in the far future, no obvious remnants will remain on the earth's surface indicating the former existence of a disposal facility in the deep geological formations below.

Impact factors

During the close-off phase of the disposal facility, backfill material is delivered, processed on demand and conveyed to the voids of the disposal facility. With this, there results transport-related emissions of **air pollutants**.

According to the disposal facility concept (developing horizontal drift emplacement of the heat radioactive waste in salt) taken as a basis in the preliminary safety analysis Gorleben (VSG) /GRS 2012/ 575,000 m³ in total of crushed salt were calculated for backfilling the lateral drifts and cross-cuts on the emplacement base level and exploration-level, and for the infrastructural areas 340,000 m³ of gravel. Not included are the backfill quantities which were already inserted during emplacement operation for the emplacement sections and cross-cuts. The crushed salt to be used would be obtained mainly from the excavated material from the exploration and construction phase, which is emplaced on a mining heap of disposal facility site. This means that the transport of the crushed salt would be limited to the area of the company grounds provided that no additional material is required. The gravel would have to be delivered from outside.

Further vehicle transports result from the removal of the remounted, dismantled underground and above-ground installations. In addition, supply transports of e.g. fastening material, top soil and plants in the phase of the recultivation of the site, will result. The time period and volume for these transports will be far less than the schedule taken as a basis and the volume transported for backfilling the disposal facility. In this way, less air pollutant and dust emissions also result from vehicles.

In the close-off phase of a disposal facility, emissions of **air pollutants and noise** through motor vehicle and construction machines with the filling and close-off measures, dismantling work, recultivation and installation of pieces of equipment and measuring instruments and/or precautions for the environmental monitoring, are to be expected. The highest contamination of noise and air pollutant emissions results during above-ground dismantling work. However, the dismantling in comparison to the backfilling and, with that, also other phase such as exploration construction and emplacement operation are implemented in a relatively short period.

Conventional waste water will result in case of **ground-water lowering** which must be maintained dependent on the hydrogeological situation of the site during underground filling measures and with the dismantling of the shaft equipment and the construction of the shaft seals. In addition, "mine water" can occur as fissure or formation water. A significant contribution to the total waste-water quantity arises from the mining heap water which escapes from the mining heap in case of rain. Industrial water e.g. from truck cleaning systems and from sanitary areas, plays a minor role in comparison to the waste water that arises from the mining construction processes qualitatively and quantitatively. The impact factors **ground-water lowering** and conventional waste water are handled in Chapter 4.1.7 and therefore do not have to be subsequently considered project-specific.

An incorporation of **heat** into the surrounding rock is associated with the final storage of radioactive heat-generating waste. This impact factor is further considered for the period after close-off of the disposal facility in Chapter 5.1.6.4.

During the closure of a disposal facility **vibrations** can result e.g. from deploying and compaction measures of the replacement material, as well as with the above-ground dismantling work. The scale of possible vibrations is classified as small in comparison to the establishment phase with possible pile-driving work and blasting.

In the course of the close-off phase of the disposal facility, with respect to the impact factors **land consumption** and **spatial impact** through dismantling of the mining heap, reconstruction measures and recultivation of the company grounds the sealed surfaces and buildings are reduced successively. Such positive impacts are not considered any further.

Subsidence of the surface is reduced and/or minimised by the complete backfilling of all rooms during the closure of the disposal facility. Requirements on the long-term safety verification assume that the containment-providing rock zone, over the verification time period of approximately 1 million years, will achieve its function as a barrier. This excludes major sub-surface collapses and displacements which become noticeable on the earth's surface.

During the underground dismantling work, the backfilling of the rooms and the close-off measures e.g. with the dismantling of the shaft equipment and the subsequent construction of the shaft seal , a **ground-water lowering** will have to be carried out. This impact factor, as well as the associated injection of pumped ground water as **conventional waste water,** are dealt with in Chapter 4.2 and do not have to be considered any further.

Emissions of radioactive materials via aeolian dispersal (discharge) which would be transported via air may lead to environmental impacts on the protected items persons and animals.

Incidents to be considered during the closure of the disposal facility are e.g. above-ground and underground incidents, such as fires or external events. In addition, e.g. incident-caused solution influx or damage of the shaft seal with regard to the long-term safety of the disposal facility, are to be considered.

With the dismantling of radiation protection areas, as well as with the decontamination procedures, solid and liquid **radioactive operational waste** (e.g. wiping cloths, cleaning fluids, fine filter meshes, etc.) arise. An estimate for the shutdown of the ERAM has indicated that approximately 180 m^3 solid metallic radioactive waste will result. Furthermore, up to 30 m^3 solid radioactive mixed waste from ventilation-technical systems and up to 20 m^3 solid radioactive mixed waste in the form of cleaning cloths, protective clothing, working equipment, laboratory devices and material from decontamination and dismantling measures, will result /BfS 2009a/. Within the framework of the ERAM closure, it was estimated that approximately 30 m^3 liquid operational radioactive waste will result, which have to be conditioned in compliance with the disposal facility. This case refers to waste water from the decontamination of systems and equipment /BfS 2009a/.

Description of the potential environmental impacts

Air pollutants

Air pollutant emissions, such as fine-grain dust, nitric oxides and sulfuric oxides, are caused, in particular by the operation of devices and machines for the dismantling of the buildings (e.g.

incoming goods storage), by traffic between disposal facility and mining heap, as well as traffic on the transportation routes during delivery of e.g. gravel and during removal of e.g. building rubble and excavated material. Aeolian dispersal from the mining heap is also possible. These emissions can have health-endangering effects on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations
Noise is caused by the operation of devices and machines for the dismantling of buildings (e.g. incoming goods storage), by traffic between disposal facility and mining heap, as well as traffic on the transportation routes during delivery of e.g. gravel and during removal of e.g. building rubble and excavated material. Vibrations can occur through compaction measures during closure of the disposal facility and with the dismantling of buildings. Noise may increase the risk of cardiovascular diseases for persons and may drive animals from their living space. Vibrations may affect persons and animals negatively and may cause damage to buildings.

Subsidence of the surface
Impacts on the protected items ground, water and cultural and physical assets can be related to the subsidence of the surface.

As a result of the backfill measures, within the framework of the closure of the disposal facility, subsidence of the surface is avoided to a large extent. Therefore there are no potentially-relevant environmental impacts.

Emissions of radioactive materials via air (aeolian dispersal, discharge)

In a disposal facility for radioactive waste closed waste casks are handled exclusively. According to the selected disposal facility and cask concept, the emission of radioactive materials from the waste casks may result. According to the Radiation Protection Ordinance, discharge is permissible up to an effective dose of 0.3 mSv/a (§ 47 StrlSchV).

Incidents
Dependent on the type of potential incidents, all protected items such as persons, animals, plants, ground, water, climate and air, as well as cultural and material goods, may be affected.

Radioactive operational waste
The operational waste which arises during the closure of a disposal facility is conditioned and stored up to its disposal. Resulting radioactive waste water can be conditioned and disposed of as operational waste. The evaluation standards for the handling and dealing with radioactive waste are the stipulations of StrlSchV. As far as a discharge of radioactive waste water would become necessary, which is not be assumed concerning the small expected quantities, the discharge of waste water is implemented on the basis of authorised values according to the determinations of StrlSchV. Relevant environmental impacts are not to be expected.

Evaluation of the potential environmental impacts

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. In case of the closure of the disposal facility, extensive activities (backfilling and close-off of the disposal facility, dismantling of buildings, loading and unloading of transportation vehicles) occur at the site, in case of which the devices, machines and vehicles employed cause emissions. In addition the aeolian dispersal s from the mining heap can occur if it is not covered or kept sufficiently moist. Considerable truck traffic will result on the transportation routes, since e.g. gravel transports and e.g. excavated material and

building rubble must be transported away. In total, for the air pollutants resulting from the close-off of the disposal facility, it can be assumed that, with a separation distance of more than 1 km, no potential relevant impacts on persons and protection areas through the additional contamination of the construction site operation are to be expected when minimisation measures , e.g. the employment of machines and devices with electric motors and the moistening of dust-emitting goods during loading and unloading, are used and if no sensitive facilities e.g. hospitals are present.

If residential areas are bypassed and if the transportation routes do not lead through particularly narrow valleys, no potentially-relevant impacts on persons, animals and plants are to be expected through the additional contamination, too, even at peak times.

Air pollutant emissions in case of the close-off of a disposal facility can lead, within a separation distance of 1 km, to potentially-relevant environmental impacts, for which minimisation measures are to be considered, as appropriate.

Noise and vibrations

The evaluation framework is represented in Chapter 4.1.3. In case of the closure of the disposal facility, extensive activities (backfilling and close-off of the disposal facility, dismantling of buildings, loading and unloading of transportation vehicles) occur at the site, in case of which the devices, machines and vehicles employed cause noise. Considerable truck traffic will result on the transportation routes, since e.g. gravel transports and e.g. excavated material and building rubble must be transported away. The vibrations occurring as a result of compaction measures during the closure of the disposal facility and during dismantling of buildings will probably not have any impacts beyond the extent of disposal facility site and therefore will not cause any relevant impacts on persons and animals.

In total, in case of the close-off of the disposal facility as regards noise-causing impacts, it can therefore be assumed that a separation distance of 1 km will suffic in order to avoid potentially-relevant environmental impacts for persons at the peak times. This appraisal is based on the assumption that (exceptions aside) the lot is operated by day only.

If residential areas are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g. health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.

For the evaluation of the impacts on birds along the transportation routes, the occurring bird species must be known since their noise sensitivity, and thus the necessary separation distances from the road, differ very much.

Within a separation distance of 1 km to the project, potentially-relevant environmental impacts by noise may exist. Site specific expertise is required for evaluation and possible minimisation.

Emission of radioactive materials via air (discharge)

For the possible emission of radioactive materials, significant environmental impacts on the basis of experiences from the emplacement operation in other systems (e.g. storage facility, Morsleben disposal facility) are not to be expected. Potentially-relevant environmental impacts basically cannot be excluded on the basis of currently existing knowledge about the measure. A more precise evaluation can be implemented only when the emplacement concept has been concretised .

Incidents
Within the framework of the security verification for a disposal facility, incidents during closure are to be analysed. Relevant incident scenarios during the disposal facility close-off consist of above-ground and underground incidents, such as e.g. fires or external events. As a result of the design of the disposal facility, compliance with the fault-case planning values must be guaranteed. Potential incidents are to be considered within the licensing procedure and are to be evaluated as potentially-relevant environmental impacts within the framework of the SEA of the National Programme.

5.1.6.4. Period after closure of the disposal facility

After closure f of the disposal facility, the radioactive waste should remain isolated from the biosphere permanently. This must be verified in the licensing procedure for the period of one million years. A permanent monitoring of the disposal facility cannot be assumed.

Impact factors

The final storage of heat-generating waste leads to an incorporation of **heat** into the rock and - on a long-term base - to the heating of protected items in the biosphere. The soil on the earth's surface above a disposal facility 800 m deep in salt rock would warm up locally after 500 to 1000 years by a maximum of 2 K /Müller 2002/. A Finnish study for the final storage in granite rock predicts a heating of the local surface of 6 K /Posiva 1999/.

For consideration of the environmental impact, it is assumed that a slight **emission** of radioactive materials with**in the post-closure phase** could result from the containment-providing rock zone on a long-term base. The Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste stipulate which nuclear law-based safety level has to be verified for achieving the requirements for a disposal facility for heat-generating radioactive waste in deep geological formations /SaEndlwA 2010/.

Correspondingly, release scenarios for emissions of **other pollutants** from the disposal facility **in the post-closure phase** are to be considered, too, since the finally-stored heat-generating waste has harmful material characteristics e.g. as heavy metals.

Description of the potential environmental impacts

Incorporation of heat
Changes of the retention characteristics of the rock through incorporation of heat with regard to releasing capabilities of radionuclides and of natural materials from the environment of the disposal facility and with regard to changes of groundwater flows, are the subject of the long-term safety analysis /SaEndlwA 2010/.

Heating of the ground and ground water of the upper surface may affect the microclimate of the living spaces, if this impact factor reaches the relevant interval of a temperature rise of some K. Present knowledge on heating of the ground and also the ground water by 2 or 6 K within the ground water is in the range of the currently scientifically discussed trifle thresholds of about 4 K (cf. Chapter 5.1.4). The heat entry is limited locally. According to the state of the art of the scientific knowledge, a long-term heating of the surface can be evaluated as a non-relevant environmental impact in the range of 4 K.

Within the framework of a licensing procedure for a disposal facility, the heating of the surface has to be predicted against the background of the site-specific conditions and evaluated with regard to environmental impacts.

Emissions of radioactive materials or to other pollutants from final storage facilities in the post-closure phase

In case of final storage, an inclusion of the waste in geological formations which keeps the radioactive materials away from the biosphere permanently is striven for. For less probable developments in the post-closure phase, it is to be verified that the additional effective dose for the persons affected by that, caused through the release of radionuclides which come from the embedded radioactive waste, does not exceed 0.1 millisievert per annum. More stringent requirements apply for probable developments.

The final storage must ensure that releases of radioactive materials from the disposal facility increase the risks resulting from natural radiation exposure on a long-term basis only very little.

Generally, released radioactive materials and other pollutants may have impacts on the protected items ground water, persons, animals and plants.

Evaluation of the potential environmental impacts

With the evaluation of environmental impacts in the post-closure phase of a disposal facility, it is to be considered that this phase extends over an extremely long period of one million years. The evaluations are therefore not directly comparable with the evaluations carried out for other projects.

Methods for the evaluation of the long-term safety of a disposal facility exist. They also consider the handling of inevitable uncertainties for prognostical purposes, i.e., the forecast of the development of the disposal facility over the long period. Any prognosis for the actual development of existing protected items is not possible, however, so that the evaluation is turned temporarily to current potentially-existing protected items.

Based on these constraints, for the post-closure phase of a disposal facility, dividing the environmental impacts into the usually employed categories as non-relevant, potentially-relevant or potentially significant, is dispensed with. However, significant impacts are not to be expected.

Emissions of radioactive materials or other pollutants from final storage facilities in the post-closure phase

Radioactive materials

Within the framework of the SEA of the National Programme, the potential environmental impacts through assumed releases of radioactive materials on the protected items persons, including human health, animals and plants, as well as water, are considered.

For a disposal facility according to the Site Selection Act, it is to be verified that, in case of releases which cannot be excluded, the exposure of individual persons of the population for probable developments leads only to an additional effective dose in the range of 10 microsievert per annum (µSv/a). Independently of whether a release into the biosphere is actually implemented and whether in the far future persons are therefore affected, the dose to be verified corresponds of the internationally recognised minimum dose that was stipulated with an annual individual dose in the area of 10 µSv/a as a minimisation limit for the protection of persons. Thus no potential environmental impacts on persons would occur with a successful verification in accordance with this dose criterion. For less probable developments of a disposal facility according to the Site Selection Act, it would have to be indicated that a possible release additionally contaminates individuals of the population with not more than 0.1 millisievert per annum (mSv/a) /SaEndlwA 2010/. Independently of whether such releases actually occur, this value is below, by the factor of 10, the present limit value pursuant to § 46 of the Radiation Protection Ordinance of 1 mSv/a for individuals of the population. In this way it is ensured that future generations are not more exposed than present generations. In addition, the following has to be considered:

- That it involves possible releases in case of less probable developments, therefore with developments of the geological substrate that unfavourably affect the retention of radionuclides
- That it involves potential releases and potential radiation exposures ng from these , which occur, according to present appraisals, with a low probability only, and which are thus different from an actual radiation exposure from a present activity
- That the dose criteria according to /SaEndlwA 2010/ do not serve as a limit value for the modelling of a dose, rather, due to the existing imponderables for individuals in the far future, as a standard value for the verification of the quality of the long-term safety verification.

In the containment-providing rock zone, according to /SaEndlwA 2010/, the formation of secondary waterways must be excluded, which would lead to the influx or discharge of pollutant-contaminated liquids and which may not participate in the hydrogeological cycle outside of the containment-providing rock zone with interstitial water existing in the containment-providing rock zone. In addition, it must be demonstrated for clay and salt rocks that mechanical stresses and liquid pressures from the cap-rock , as well as the incorporation of heat resulting from the emplacement of the radioactive waste, do not impair the integrity of the containment-providing rock zone.

The verification of the long-term safety of a disposal facility, according to the Site Selection Act, is implemented in accordance with the Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste /SaEndlwA 2010/, above all by verification of the integrity of the containment-providing rock zone as a barrier over a period of one million years. The preliminary safety analysis Gorleben has shown that a verification can basically be carried out for compliance with the limit values. However, the necessary verification is yet to be carried out within the framework of the site selection process and/or the subsequent licensing procedure for the disposal facility.

Other pollutants

Pursuant to § 48 Sect. 2 WHG /WHG 2014/, materials may only be stored or emplaced in such a way that a disadvantageous change in the ground water composition is not to be worried about. This requirement is concretised by the insignificance threshold concept of the German Working Group on water issues of the Federal States and the Federal Government (LAWA) /LAWA 2002//LAWA 2004//LAWA 2006/. The insignificance threshold concept is based on the evaluation of the human and eco-toxicological characteristics of conventional materials and stipulates peak values for concentrations in the ground water. In case of compliance an anthropologic influencing of the ground water can be excluded.

As a result of the consideration of human and eco-toxicological criteria, in case of compliance with the insignificance threshold values, both environmental impacts on the ground water as well as on persons, human health, as well as plants and animals, are to be excluded. The insignificance threshold values should be adhered to as early as before any entry into the ground water from materials in the ground or placed there. If the geogenic background values of a ground water body exceed the insignificance threshold values of the LAWA, the background values of the ground water existing on site in each case may be applied instead of the insignificance threshold values.

Provided that a complete inclusion of the conventional pollutants is not verifiable for a disposal facility according to the Site Selection Act, all conventional pollutants to be emplaced in the disposal facility are to be inventoried, within the framework of the long-term safety verification, with regard to their solubility and transport characteristics /Alt et al 2009/. Conventional pollutants of the disposal facility inventory, for which the verification can be provided that, due to their solubility and transport characteristics, these do not reach an aquifer outside of the containment-providing rock zone, are not considered further with regard to their effects /Alt et al 2009/. Provided that material in a disposal facility, in case of solution influx , reaches only solution concentrations which fall below the insignificance threshold values for the protection of the ground water of the State Joint Venture Water (LAWA), environmental impacts on the ground water of the biosphere are not given (including impacts on persons, human health, animals and plants).

Materials of a disposal facility's inventory, for which a discharge from the containment-providing rock zone (ewG) cannot be excluded and, with their discharge from the ewG, exceed existing or derived insignificance thresholds of the LAWA, are to be considered with regard to their migration to the ground water of the biosphere. The aquifer is to be stipulated in this case, in which for the precautionary protection of the ground water of the biosphere, the existing or derived insignificance thresholds of the LAWA are to be adhered to /Alt et al 2009/. Generic investigations relating to the inventory of a disposal facility for heat-generating waste indicates that the verification of the non-exceedance of the insignificance thresholds can be provided /Alt et al 2009/. However, the future long-term safety verification of the disposal facility planned in the National Programme for heat-generating waste is a determining factor yet.

5.2. Alternative: Shipment of the spent fuel from experimental, demonstration, and research reactors into a country in which fuel assemblies for research reactors are provided or manufactured

As an alternative to the disposal of the fuel assemblies from experimental, demonstration, and research reactors, the transport of the spent fuel into a state in which fuel assemblies for research reactors are appropriated or manufactured, is to be considered. The focus of this SEA is on the phase of the transfer of the fuel assemblies into a corresponding country. The subsequent waste disposal steps in this country (reprocessing and final storage of the waste resulting from this) are not the subject of the SEA, since they are implemented under the regulatory regime of the corresponding accepting country.

For the return of irradiated fuel assemblies with highly concentrated uranium from US inventories, which were initially supplied to foreign research reactors, there are available environmental impact assessments on the SRS complex (Environmental Impact Statements) of the US authorities /DoE 1996/, /DoE 2000/ and /DoE 2013/. The emission of radioactive materials as well as the risks of radiological incidents were not further considered here.

The transport of the fuel assemblies into a country in which fuel assemblies for research reactors are provided or manufactured, would be implemented in the event case with the same transport casks as heat-generating waste, in accordance with Chap. 5. 1. 3, i.e., in case of an assumed shipment with Type B casks.

With the transport of the spent fuel, the casks are first of all taken from the storage facility by road and, as appropriate, shipped by sea. The corresponding impact factors and potential environmental impacts on this transport route do not differentiate considerably from the transport of the spent fuel into the disposal facility.

Impact factors

The impact factors with the transport of radioactive heat-generating waste within Germany are dealt with in Chapter 5.1.3. In case of the transport of the spent fuel into a country in which fuel assemblies for research reactors are provided of nmanufactured, transport by sea is to be considered, in addition to transport by road and rail.

In the same way as the transport of radioactive heat-generating waste, in accordance with Chap. 5.1.3, basically the conventional infuencing factors **air pollutant and dust emissions**, **noise** and **vibration** are to be considered**.** Due to the small number of transports in the event case - independently of the transport mode - the designated conventional impact factors are not further considered here.

In addition, the radiological influencing factors of **direct radiation** (gamma and neutron radiation), as well as **the release of radioactive materials due to accidents** are considered. The characteristics of the radioactive material to be transported, as well as the employed transport cask - in this case Type B cask - have to be considered in this case.

Description of the potential environmental impacts

Air pollutant and sound emissions
The volume and the number of casks of the transported waste from experimental, demonstration, and research reactors are considerably less than those of the radioactive waste considered in Chapter 5.1.3. A further consideration of the air pollutant and sound emissions resulting from the transports is therefore not necessary.

Direct radiation
In Germany, emissions of direct radiation are controlled by the Radiation Protection Ordinance. Due to the relatively small number of casks and the separation distance of persons of the general population to these casks usually realised, potentially-relevant impacts within the framework of the SEA are not to be considered.

Release of radioactive materials due to accidents
The transport is implemented in accident-resistant Type B(U) casks which, on the one hand, have to guarantee sufficient shielding of the strongly radiating materials and, on the other hand, must resist certain loading in order to be approved as accident-resistant transport casks. In case of transport-related accidents during ship transport, a release of radioactive materials therefore cannot be assumed, provided that the underlying check criteria are not exceeded (cf. Chapter 5.1.3).

5.3. Storage of spent fuel and waste from reprocessing

In this Chapter the environmental impacts of the measure "Storage of spent fuel and waste from reprocessing" are considered. The consideration is implemented for the following projects and project phases:

- Extended storage time for spent fuel and waste from reprocessing
- Extension of the permissible waste types of decentralised storage facilities for the retention of waste from reprocessing
- Storage of spent fuel from experimental, demonstration, and research reactors

The project phase "Operation" is considered in the projects, respectively. For the projects "Extension of the permissible waste types from site storage facilities for the retention of waste from reprocessing" and "Storage of the spent fuel from experimental, demonstration, and research reactors", a consideration of the project phase "Transport to the storage facility" is implemented in addition.

Within the individual chapters for the consideration of the environmental impacts of the above-mentioned project, at first a representation of the project phases at the site is implemented. Then the impact factors are clarified and the potential environmental impacts are described. Finally the potential environmental impacts are evaluated and measures of the avoidance and minimisation represented. With the evaluation of the potential environmental impacts of numerous impact factors, reference is made to the evaluation framework represented in Chapter 4.1.

5.3.1. Extended interim storage period for spent fuel and waste from reprocessing

The storage facility for spent fuel and waste from reprocessing has a licence for 40 years respectively. The first licence will expire in 2034. In accordance with the plans in the National Programme, a disposal facility for heat-generating waste should start operation around 2050. As a result, there exists the necessity to further store the spent fuel and waste from reprocessing. A necessary authorisation for the storage over a limited period is expected. Some years prior to expiry of the existing licence, the licensing procedures are to be initiated with an application for a further storage.

At the site, the following work is implemented during the extended operation:

- In the case of emplacement and relocation, tests of the casks are performed. Radiological control-checks (wipe test, dosage rate measurement) and control-checks of the casks for sealing and external damages are implemented in this case. Provided that required, external repairs can be implemented in a cask maintenance station (e.g., exchange of lifting trunnions, welding of welded lids, exchange of the secondary cover).
- Within the framework of regular tests, repairs are implemented on the system (building, crane, emergency power supply etc.).

Impact factors

The environmental impacts described in this chapter refer to a limited period. Aspects of a long-term storage facility are described in Chapter 6.

The storage facility operation leads to the emission of **direct radiation** (gamma and neutron radiation). The direct radiation decreases with reference to a fully occupied storage facility, with the extension of the storage facility duration, since short-lived radionuclides fade away. Since, with reference to the previous operation, no additional environmental impacts through the direct radiation are to be provided for, a further evaluation is dispensed with, within the framework of the SEA. The storage and utilisation of other radioactive materials (e.g., test radiation sources) is also not relevant with regard to direct radiation.

In case of cask maintenance during the operation, liquid and solid radioactive residues arise. It is assumed that, after the free measurement of all occurring radioactive residues, about 10 l of liquid **radioactive operational waste** and 1 to 3 kg of solid radioactive waste result annually /BfS 2015a/. With reference to the previous operation, no change of the type and quantity of occurring radioactive waste would arise from a longer storage time, so that no additional environmental impacts through the radioactive waste are to be provided for. Therefore no further consideration is implemented within the framework of the SEA of the National Programme.

An extended storage time, as in the case of the previous operation of the storage facility, is **not** linked with the **emissions of radioactive materials** since the transport casks are technically sealed using two cover seals (license prerequisite) and are not opened in the receiving storage facility. In case that one of the cover seals fails, this can be renewed or a welded lid can be welded on.

During an enlarged storage time, **heat dissipation** into the substrate still arises, which leads to the heating of the ground around the receiving storage facility and to the heating of the ground water. For the site storage facility in Germany, heating of the ground (with maximum storage facility occupation and maximum thermal output of the casks) as well as the buildings by a few degrees (approx. 5 K) and heating of the ground water of up to 15 K, are predicted /BfS 2015a/. In the course of time, the casks cool down, so that less heat enters into the underground. Since, with reference to the previous operation, no additional environmental impacts through the longer storage through heat dissipation are provided for, a further evaluation is dispensed with, within the framework of the SEA.

The extended storage facility operation - as well as the present operation of the storage facility - includes the risk of **incidents**. Within the framework of the licensing procedures necessary for a longer retention, it is checked whether, through an extension of the storage facility time, impacts on the incidents to be considered and their evaluation result. From the comprehensive viewpoint of the SEA of the National Programme, no changes of the incident risks are therefore to be considered for an extended storage time with respect to the previous storage facility.

Evaluation of the potential environmental impacts

With reference to the previous operation, no additional environmental impacts are to be considered through an extension of the storage time of heat-generating waste at their previous sites by a limited period of approx. 20 years, against the background of the comprehensive consideration in the SEA. Within the framework of the outstanding licensing procedures, potential environmental impacts are to be clarified on the basis of the situation.

5.3.2. Extension of the permissible waste types of site storage facilities for the retention of waste from reprocessing

The vitrified wastes still to be returned from reprocessing in the European foreign country should be emplaced, not into the storage facility Gorleben, rather they should be brought into an site storage facility not yet determined in detail and be stored there up to the acceptance readiness of an receiving storage facility at the site of a disposal facility. For this, the casks of the design type CASTOR® HAW28M are provided. The existing transport cask storage facility should not be either modified or structurally extended, nor should the permissible activity inventory altered for the reception of this waste flow. The environmental impacts of the occurring transports are negligible in the existing context of the SEA, since it involves only a small number of transports which do not lead to relevant emissions.

The delivery of the wastes from reprocessing is implemented on the basis of existing obligations. The Federal Government of Germany, with respect to the French and the British government in an exchange of notes from the years 1979 and 1990/1991, has confirmed the right of these two states to send back to Germany the waste occurring from reprocessing of German fuel assemblies and other products /BMUB 2014/.

At the site, the following work is implemented:

- During the operation, transport and storage, casks are accepted and emplaced in the storage facility. Acceptance, emplacement and relocation of these casks are implemented with radiological control-checks (wipe test, dosage rate measurement) and control-checks of the casks for sealing and external damage. Provided that required, external repairs can be implemented in a cask maintenance station (e.g. lifting lug change, welding of a jointing cover, change of the secondary cover).
- According to the traffic-legal certification of the cask CASTOR®HAW28M, this can be conveyed only with intact primary cover as "Sealed encapsulation" /ESK 2014/. If the primary cover sealed system of these casks fails, the restoration of the double-cover system with a jointing cover can be achieved for the storage operation. Before a transport to the disposal facility, however, a certification-consistent status must be restored. In order to restore the transport capability in case of the failure of the primary cover, in accordance with /ESK 2014/, the construction of a hot cell may be required, in order to open the cask and to renew the primary cover. This could be arranged in the existing storage facility or would have to be done in a separate building possibly constructed for that. From the viewpoint of the Nuclear Waste Management Commission (ESK) /ESK 2014/, there exists only a small probability that a failure event occurs during storage time with regard to the primary system of a cask CASTOR®HAW28M. Therefore the requirement for the construction of a hot cell is also rather unlikely. The construction, operation and the dismantling of a hot cell would lead to conventional and radiological impact factors. Due to the comprehensive character of this SEA, the construction and operation of a hot cell is not considered further. Nevertheless, this aspect is to be checked in the licensing procedure.

The environmental impacts for the fully occupied site storage facility in each case were examined as early as in the respective UVP. In the following, only those impact factors are described which can occur in addition through the storage of the waste from the reprocessing or which can change through that.

Impact factors

As a result of the wastes from the reprocessing, the **heat entry** into the underground can change, which leads to the heating of the ground around the storage and to the heating of the ground water. For the site storage facility in Germany, heating of the ground (at maximum storage occupation and maximum thermal output of the casks), as well as the buildings, by a few degrees (approx. 5 K) and heating of the ground water of up to 15 K are predicted /BfS 2015a/.

The wastes from reprocessing lead to the emission of **direct radiation** (gamma and neutron radiation) in the storage facility operation.

The storage of the waste from reprocessing includes the risk of **incidents**.

Description of the potential environmental impacts

Heat entry
A heat entry into the ground and the ground water below the storage facility and around the storage facility affects the living space function of the ground and the ground water, and can thus also have feedback impacts on the characteristics of the ground water (cf. Chapter 5.1.4).

Direct radiation
As a result of the wastes from reprocessing, the emission of direct radiation (gamma and neutron radiation) can be changed in the storage facility operation. The basic impacts of direct radiation are represented in Chapter 4.1.4.

Incidents
The storage is implemented in solid transport and storage casks. A release of radioactive materials is not to be assumed due to a cask fall, the fall of loads onto the cask or a fire. As a result of influences with terrorist background, releases of radioactive materials would be possible. In this way, the risks do not differentiate considerably from those of the storage of irradiated fuel assemblies themselves. From a comprehensive viewpoint of the SEA, no significant change of the incident risk is given with respect to the storage facility authorised to date, so that this aspect does not have to be further considered within the framework of the SEA.

Evaluation of the potential environmental impacts

Heat entry
For the evaluation it is important whether, through the heat-generating wastes from reprocessing, in addition to the heat entry considered already in the UVP of the site storage facility for a fully occupied storage facility, heat can be entered. This is estimated in the following.

In total, 21 casks with heat-generating waste from reprocessing are still to be sent back. Which cask type is employed for this is not known. The type CASTOR®HAW28M is therefore assumed here as a model. The maximum thermal output of a CASTOR®HAW28M is 56 kW /GNS 2010/. A thermal output of 1176 kW results from this for all 21 casks. If it is assumed that, in case of a distribution of the waste to be sent back, not more than 7 casks per storage facility are emplaced, so that a maximum thermal output of 392 kW to be emplaced results. The authorised maximum thermal output of the storage facility extends from 2 to 6 MW.

With the earliest-possible, time-related, staggered termination of the use of atomic energy in Germany, according to /BfS 2015c/, not all authorised emplacement spaces are required. Thus the authorised thermal output is not exhausted.

The heating of the ground and the ground water through the emplacement of sent-back, heat-generating waste in site storage facility within the framework of the SEA of the National Programme are not potentially-relevant environmental impacts, since no significant exceeding of the already considered heat entry is to be expected.

Direct radiation
The evaluation framework is represented in Chapter 4.1.4. The emission of the direct radiation of the storage facility is checked through measurement-technical verification. The limit values of the Radiation Protection Ordinance are to be adhered to.

Concrete measures of the minimisation with regard to real dwell times of persons at the site or persons in the publicly accessible area can be realised. Within the framework of the SEA, potentially-relevant environmental impacts due to direct radiation are not to be assumed.

5.3.3. Storage of the fuel assemblies from experimental, demonstration and research reactors

In accordance with the plans of the National Programme, the storage of the fuel assemblies from experimental, demonstration and research reactors, with the objective of the final storage or the relocation to a country in which fuel for research reactors is manufactured, is to be considered. For this, the fuel assemblies which currently still remain in the wet storage of the research reactors must be transferred in dry transport and storage casks and transported into an existing storage facility. The storage facility should not be structurally extended for that. Rather the existing storage spaces should be used.

The irradiated nuclear fuel is located in the wet storage facilities of the research reactors in Berlin, Garching and Mainz. 479 casks are already emplaced (dry storage facility) in the storage facility Ahaus, Juelich and the Nord storage facility. In total an occurring quantity of 10 to 12 Mg heavy metal is expected /NaPro 2015/.

The impacts from the transports are negligible in the existing context.

During the operation of the existing storage facility for research, experimental and demonstration reactors, transport casks are accepted and emplaced. Acceptance, emplacement and relocation of transport casks are implemented with radiological control-checks (wipe test, dosage rate measurement) and control-checks of the casks for sealing and external damage. Provided that required, external repairs can be implemented (e.g. lifting lug change).

The environmental impacts for the available storage facilities have already been assessed within the framework of the licensing procedures. In the following only the possible impact from the additional waste inventory on is described.

Impact factors

Heat entry into the underground arises from the waste. Since, in comparison with the storage of fuel assemblies from power operation, the heat entry into the ground resulting from storage of fuel assemblies from research, experimental and demonstration reactors, is negligible with regard to environmental impacts. A further consideration is therefore not implemented within the framework of the SEA.

The wastes of the research, experimental and demonstration reactors lead in the storage facility operation to the emission of **direct radiation** (gamma and neutron radiation), however, which is covered with the considerations in the already existing license. Basically, environmental impacts from direct radiation are represented in Chapter 4.1.4. The small quantity of predicted waste from research, experimental and demonstration reactors does not require any in-depth consideration of environmental impacts through direct radiation against the background of the comprehensive consideration of the SEA of the National Programme.

The storage includes the risk of **incidents** for which, however, precautions have already been taken in the existing license of the storage facility. A further consideration is therefore not necessary within the framework of the SEA of the National Programme.

5.4. Management of the Asse II mine´s radioactive waste and closure of the Asse II mine

The management of the radioactive waste retrieved from the Asse II mine includes the following projects and project phases

- Retrieval and final storage-related conditioning of the radioactive waste from the Asse II mine
- Storage of the conditioned radioactive waste
- Closure of the Asse II mine

- Transfer of the radioactive waste into the disposal facility
- Disposal of the retrieved radioactive waste in the disposal facility according to the Site Selection Act
- Option: Disposal of the retrieved radioactive waste in the Konrad disposal facility

5.4.1. Retrieval and conditioning of the radioactive waste from the Asse II mine

Due to the law relating to the acceleration of the Retrieval of radioactive waste and the closure of the Asse II mine /Lex Asse 2013/, the waste from the Asse II mine should be retrieved and conditioned on site.

5.4.1.1. Retrieval of the radioactive waste from the Asse II mine

The planning status of this project is in an early phase of the application. Currently the so-called fact investigation is taking place, which is accompanied by required investigations relating to market availability and technical prerequisites of the necessary recovery technology and feasibility studies for the basic procedural method during Retrieval. The recovery is probable implemented using remote-handling special machines. By the setting-up of underground double door systems , it should be guaranteed that the dose limit values laid down in the German Radiation Protection Ordinance (RPO, StrlSchV) are adhered to while the handling of the radioactive waste.

Present estimates assume that, with the retrieval, at least 90,000 Mg of non-conditioned waste will result, a waste volume of approx. 175,000 to 220,000 m³ therefore results after the conditioning for the later disposal facility /BfS 2014/.. /.

The low-level and medium-level radioactive waste is currently stored in a total of 12 chambers at the 725 m and the 750 m levels. Exclusively medium-level radioactive waste is currently stored in a chamber at 511 m depth. The Retrieval is subdivided into the following phases:

- Sinking of the shaft Asse 5 and construction of infrastructures for the connection of the shaft (traffic routes, double door systems, packing plants, ventilation, current access etc.) to the site
- Recovery of the radioactive waste

According to present know-how, the Retrieval cannot be begun before 2033 and will take several decades /BfS 2014/.

Impact factors

For the construction of the shaft Asse 5, as well as further buildings and infrastructures, a **land consumption** is implemented. For this environmental assessment, a maximum surface to be sealed is assumed, which corresponds to the construction of the above-ground systems of an exploratory mine (estimated at maximum 50,000 m²).

As a result of the construction of a pithead building, as well as possibly further buildings, a **spatial impact** exists.

For the impacts **air pollutants,** as well as **noise and vibrations,** it is assumed during the building phase of Shaft 5 that they occur maximally in the scope as they are approximately expected by exploratory mines during construction.

The sinking of the shaft should be implemented with the freezing process, however **ground-water lowering** is not excluded, in particular during generation of the pilot shaft /DMT 2014/. The introduction of conveyed ground water would be implemented as **conventional waste water.**

The evaluation of the environmental impacts through **ground-water lowering** and the introduction of conveyed ground water as **waste water** is implemented in Chapter 4.1.7, so that these impact factors are not further considered project-specifically in the following.

The Retrieval operation will lead at best to unimportant air pollutants and noise, since the work is mostly underground or is supposed to occur in closed halls. Air pollutants should be retained as far as possible in this case, through the filtration of the exhaust air.

The Retrieval operation does not lead to **direct radiation**, which is relevant within the framework of the SEA, since the activities are implemented underground. Above-ground, packed containers are handled only in Overpacks. The direct radiation in case of the storage facility and conditioning is considered in Chapter 5.4.1.2 and 5.4.1.2.

During the Retrieval, the ventilation of the working areas and possibly also the opened storage chambers is required. Due to this, an increased quantity with respect to the present status of gaseous radionuclides is routed away as **emissions of radioactive materials via air** into the environment. With the recovery work underground, dust which is contaminated radioactively can arise in significant quantity. Particles and suspended matter can be separated out in filtering systems with a high level of efficiency (> 99.9%).

Risks of possible **incidents** exist during underground Retrieval operation.

Description of the potential environmental impacts

Land consumption
Land consumption through construction of a shaft, as well as possible further traffic surfaces leads to the loss of the ground function, as well as the living space for animals and plants on the affected surface.

Spatial impact
A spatial impact changes the appearance of an affected landscape and can reduce its regeneration function. The spatial impact is dependent on the subjective opinion of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism.

Air pollutants
Air pollutant emissions, such as fine-grain dust, nitrogen oxides and sulfur oxides, are caused by the operation of devices and machines in the mine, as well as during construction of buildings and traffic routes. In addition are possibly the driving movements between mine and mining heap. Wind-drifts from the mining heap are also possible. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise
Noise is caused through the same devices, machines and transportation vehicles as the emissions of air pollutants. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space.

Emissions of radioactive materials via air (discharge)
Previous estimates have indicated that the legal dose limit values, pursuant to § 47 StrlSchV, could be exhausted up to approximately a quarter /DMT&TUEV 2009/.

Incidents
Releases of radioactive materials are on principle possible with the opening of chambers, from handling faults with a waste recovery, through fire or explosion etc.

Evaluation of the potential environmental impacts

Land consumption
The evaluation framework is represented in Chapter 4.1.1. The land consumption for the pithead building and, as appropriate, further traffic spaces and building, is to be evaluated as a potentially significant environmental impact.

Minimisation of impacts is possible for buildings and traffic spaces during stipulation of the surfaces. Protection areas or living spaces of protected species would have to be avoided as a site. Considering species-specific ecological requirements, as appropriate, the possibility also exists of the resettlement of protected animal and plant species.

Spatial impact
The spatial impact of the pithead building as well as possibly further buildings to be constructed on the landscape is a potentially-relevant environmental impact. An evaluation of the spatial impact can be implemented only based on graphic representations of the planned system in the landscape (photo montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape through the spatial impact of an exploratory mine aims at avoiding or reducing visual impacts from the environment. In this case, the relief of the landscape can be included, earth banks laid, shading of the system through forest implemented, or the colour design of the buildings adapted to the landscape.

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. Emissions of air pollutants will be caused in the same order of magnitude as with the present open-retention operation of the Asse II mine and during construction of an exploratory mine. If mining heaps are covered in order to minimise wind-drifts, it can be assumed in total that, with a separation distance to the nearest residential zone of 700 m, no potentially-relevant impacts on persons and animals will occur.

Noise
Noise is caused in the same order of magnitude as with the present open-retention operation of the Asse II mine and during construction of an exploratory mine. If the separation distance to the nearest residential zone is more than 700 m, as with the construction of an exploratory mine, potentially-relevant impacts on persons are not to be expected.

For the evaluation of the impacts of noise on birds, the occurring bird species must be known, since their noise sensitivity and thus the necessary separation distances are very different.

Emissions of radioactive materials via air (discharge)
The actual level of the discharge and the maximum dose of discharge values authorised with exhaustion can be estimated only with improved progress of knowledge about the status of the waste to be retrieved, as well as concrete development and planning of the recovery technology. The cases of discharge can be reduced by ventilation-technical measures. For the Retrieval, it is to be ensured that the dose limit values, pursuant to § 47 StrlSchV, are adhered to. For the emissions

of radioactive materials, potentially-relevant environmental impacts within the framework of the SEA cannot be excluded.

Incidents

In the licensing procedure, a incident analysis is to be implemented in which a sufficient provision is verified in case of malfunction. The fault-case planning value can be stipulated in this case by the approving authority on an individual basis /Lex Asse 2013/. Within the framework of the SEA, potentially-relevant environmental impacts are therefore not to be excluded.

5.4.1.2. Conditioning of the retrieved radioactive waste at the site of the Retrieval

Conditioning of the retrieved radioactive waste is necessary. The site of the conditioning is not currently stipulated. For this report, however, it is assumed that this is implemented at the site of the Retrieval.

- During the building phase, the construction of the conditioning plant and storage for buffering is implemented for stocking the incoming waste and conditioned waste for further transport, as well as the infrastructures (road connection, power etc.). As appropriate, further buildings are constructed for system backup, maintenance work and personnel.
- During the operation, contamination-free overpacks are delivered externally to above ground, radiological measurements implemented and the waste packed renewed after a possibly implemented separation. Ready-conditioned waste containers are provided to transport units in the output buffer storage for a transfer into the actual storage facility (cf. Chapter 5.4.2).
- The closure of the conditioning plant basically corresponds to its construction with regard to impact factors.

Impact factors

The area requirement of the building is 2.350 m^2 /GNS 2011/ in accordance with planning concept. Depending on whether the storage facility and the conditioning system are constructed together or separately from each other at the site of the Retrieval, significant deviations from the concept can exist.

With the construction and dismantling, emissions of **air pollutants** as well as **noise and vibrations** result. During the operation of the system, air pollutants and dust emissions, as well as noise, are not relevant. During construction, measures for **ground-water lowering** and **waste water introduction** can be necessary.

Spatial impact arises from the building.

With the construction of a conditioning system, temporary **ground-water lowering** and introductions of conveyed ground water as **conventional waste water** cannot be excluded. These impact factors are considered in Chapter 4.1.7 so that no further details are necessary here.

In the conditioning plant, the daily handling is implemented of a small content of the overall inventory of all waste of approx. $3.9 \cdot 10^{14}$ Bq Alpha activity, as well as approx. $2.3 \cdot 10^{15}$ Bq Beta/gamma overall activity /TUEV 2013/. During the conditioning, impacts through **direct radiation**, **emissions of radioactive materials via air and water (discharge)**, as well as risks of possible **incidents,** are to be considered. For the discharge via the entrained air and the waste water, as well as with regard to incident risks, analogous conclusions can be drawn on the basis of experience with conditioning devices. A large conditioning system for radioactive waste, with negligible thermic development, is currently operated through the main department

Decontamination Operations (HDB) of WAK GmbH in Karlsruhe. The discharge of radioactive materials via water includes a discharge as material-linked routing and, due to additional conventional materials (e.g. residue of cleaning substances), as **conventional waste water**. The evaluation of the impact factor **conventional waste water** is implemented in Chapter 4.1.7 and is not considered project-specific any further.

Resulting **radioactive operational waste** is stored after a conditioning up to the disposal, and is of subordinate importance for the considerations in the SEA.

With a dismantling of the conditioning system, small quantities of radioactive waste, in comparison with the occurring overall construction masses in total, occur during decontamination which are to be conveyed to a disposal facility. The occurring quantities are not relevant for the considerations of the SEA.

Description of the potential environmental impacts

Land consumption
Land consumption in the order of magnitude of 2,500 m² leads to the loss of the ground function, as well as the living space for animals and plants on the affected surface. It cannot be excluded that protected species and a protection area are affected by the sealing of a water body.

Spatial impact
A spatial impact changes the appearance of an affected landscape and can reduce their regenerative function. The spatial impact is dependent on the subjective opinion of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism.

Air pollutants
During construction and with the dismantling of the conditioning system, air pollutants, such as fine-grain dust, nitrogen oxides and sulfur oxides are emitted on the construction site, as well as along the transportation routes. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations
Noise is caused during the construction and with the dismantling of the conditioning system on the construction site, as well as along the transportation routes. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space. Vibrations can occur during building ground improvement, for example during manufacture of vibration pot columns, and affect persons and animals negatively, as well as cause damage to buildings.

Direct radiation
The direct radiation from a conditioning system with possible buffer storage for the waste from the Asse II mine, at a distance a few 100 m behind the system fence, is already less than 10 µSv per year /Steag 2014/.

Emissions of radioactive materials via air (discharge)
In /Frank 2014/ the stipulated authorisation values for those radionuclides routed away with the exhaust air, are indicated (among others) from seven different areas of the HDB. For the seven HDB areas (among others) the following discharge actions are authorised (the major part occurring on the combustion plant): 8.0E13 Bq/a for H-3, 1.5E12 Bq/a for C-14, 1.8E12 Bq/a for rare gases (without Rn-222), 2.6E8 Bq/a for I-129, 4.5E7 Bq/a for long-lived alpha-emitters and 2.1E10 Bq/a for long-lived beta-emitters. Discharge actions of radioactive materials in this order of

magnitude can take as a basis an evaluation of possible environmental impacts of the system for the conditioning of the radioactive waste from the Asse II mine.

Emissions of radioactive materials via water (discharge)
Highly-active liquids are provided to the radioactive waste, the remaining waste water is routed away within the framework of the corresponding license.

Incidents
As a result of influences from internally (container fall, load fall, fire, leakage etc.), as well as from externally (earthquake etc.), risks exist for fault-caused releases of radioactive materials.

Evaluation of the potential environmental impacts

Land consumption
The evaluation framework is represented in Chapter 4.1.1. The land consumption of approx. 2,350 m² is to be evaluated as a potentially significant environmental impact.

Minimisation of impacts during site selection is possible. Protection areas or living spaces of protected species would have be to avoided as a site. Considering species-specific ecological requirements, as appropriate, the possibility also exists of the resettlement of protected animal and plant species.

Spatial impact
The spatial impact of the building on the landscape is a potentially-relevant environmental impact. An evaluation of the spatial impact can only be implemented based on graphic representations of the planned system in the landscape (photo montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape through the spatial impact of an exploratory mine aims at avoiding or reducing visual impacts from the environment. In this case, the relief of the landscape can be included, earth banks laid, shading of the system through forest implemented, or the colour design of the buildings adapted to the landscape.

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. The construction of the conditioning system is, with regard to the possible impacts at other sites, comparable with the construction of residue treatment centres. The employed machines and devices are probably comparable. A matching with the results of environmental-relevance studies for the residue treatment centres indicates the following:

- Above a separation distance of 1 km, through the additional contamination of the construction site operation, no potentially-relevant impacts result through the additional contamination of persons and protection areas when minimisation possibilities, e.g. the employment of machines and devices with electric motors and the moistening of dust-emitting goods during loading and unloading, are used and are no sensitive facilities e.g. hospitals are present.
- If small towns are bypassed and the route does not lead through particularly narrow valleys, also no potentially-relevant impacts on persons, animals and plants are to be expected through the additional contamination from transports, even at peak times.

Within a separation distance of about 1 km to the construction site of a conditioning system, potentially-relevant environmental impacts can occur, for which the possible minimisation measures are to be considered.

Noise and vibrations

With regard to noise and vibrations, a direct comparability likewise exists with environment relevance studies relating to the construction of residue treatment centres. A matching results in the following:

- It is assumed (aside from exceptions) that the construction site is operated during the day only, a separation distance of 1 km should suffice in order to avoid potentially-relevant environmental impacts on persons at peak times. As a precaution, additional noise-reduction measures can be taken (see Chapter 4.1.2).
- Vibrations, for example during the generation of vibration pot columns, do not extend beyond the system grounds, so that no potentially-relevant impacts on persons and animals are to be expected.
- If small towns are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g. health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.
- For the evaluation of the impacts on birds along the transportation routes, the occurring bird species must be known, since their noise sensitivity, and thus the necessary separation distances from the road, are very different.

Within a separation distance of approx. 1 or 1.5 km to the construction site, potentially-relevant environmental impacts on persons can exist. Within 100 m distance to the transportation routes potential environmental impacts on persons can exist in residential areas or other sensitive facilities (e.g. hospitals).

Direct radiation

The evaluation framework is represented in Chapter 4.1.4. The emission of the direct radiation of the conditioning system and the buffer storage is a potentially-relevant environmental impact, which is limited through measurement-technical verification, with realisation of measures for the minimisation, to such an extent that the limit values of the Radiation Protection Ordinance are adhered to. Possibilities of the minimisation exist in particular through structural screening measures.

Emissions of radioactive materials via air (discharge)

Discharge of radioactive materials as they are implemented from the above-detailed example of a large conditioning device into the environment for the significant undershooting of the permissible dose limit values. Prerequisite in this case in particular is a sufficiently dimensioned chimney height. Potentially-relevant environmental impacts exist which are to be considered in the licensing procedure.

Emissions of radioactive materials via water (discharge)

In case of discharge with the waste water, the discharge value can be selected so that the dose limit values are adhered to and then all waste water, which cannot be routed away, is further cleaned or supplied to the disposal facility after processing. Potentially-relevant environmental impacts exist, which are to be considered in the licensing procedure.

Incidents

The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. A conditioning system includes incident risks against which precautions are to be taken. Within the framework of the licensing procedure, the minimisation of incident risks as a source of potentially-relevant environmental impacts is to be considered on the basis of a risk analysis.

5.4.2. Storage facility of the conditioned radioactive waste

The site for the storage of the conditioned radioactive waste from the Asse II mine is currently not stipulated. The project is to be subdivided into the following phases:

- During the building phase, the construction is implemented of the storage facility with traffic routes for the connection to the public road network, as well as further buildings for the purpose of emplacement, system backup and maintenance of containers, as well as for the accommodation of personnel.
- During the storage facility operation, the successive emplacement of containers, the storage of the containers with implementation of control work and the relocation of the containers for the transfer into a disposal facility, are implemented.
- The closure of the storage facility basically corresponds to the construction of the storage facility with regard to impact factors. After prior free measurement the buildings are demolished conventionally or used in another way.

Impact factors

Due to the enlargement of the volume (see Chapter 5.4.1.2) through conditioning of the retrieved radioactive waste, the requirement results for the storage of disposal facility-related containers with a total volume of approx. 175,000 to 220,000 m^3 /BfS 2014 /. The building volume of the storage facility is accordingly 1.3 million m^3. In case of a building height of about 15 m, a building surface of approx. 85,000 m^2 then results. Considering further surfaces for traffic spaces, infrastructure such as office building and security systems, approx. 100,000 m^2 is assumed for the entire **land consumption**

A spatial impact in the surrounding landscape arises from the storage facility building.

If the storage facility were to be dimensioned so that it could accept all Asse II mine´s radioactive waste, it would be approx. twenty times larger than, for example, storage facilities for radioactive waste, as they are constructed in the course of the dismantling at the site of nuclear power plants. Therefore it is assumed that the impacts through **air pollutants,** as well as **noise and vibrations** (construction and transport noise) per unit of time, while not proportional, however, are higher by 1.5 to 2 times.

With the construction of an storage facility, temporary **ground-water lowering** and introductions of conveyed ground water as **conventional waste water** cannot be excluded. These impact factors are considered in Chapter 4.1.7, so that no further details are necessary here.

Direct radiation arises from the stored radioactive waste.

No relevant **emissions of radioactive materials** result in normal operation, so that a further consideration of this potential impact factor is not necessary within the framework of the SEA of the National Programme.

The risk of **incidents** exists.

Description of the potential environmental impacts

Land consumption

Land consumption in the order of magnitude of 100,000 m² leads to the loss of the ground function, as well as the living space for animals and plants on the surface. It cannot be excluded that protected species or a protection area are affected by the sealing of a water body.

Spatial impact

The spatial impact changes the appearance of an affected landscape and can reduce its regeneration function. The spatial impact is dependent on the subjective opinion of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism. Air pollutants

With the construction and dismantling of the storage facility, air pollutants, such as fine-grain dust, nitrogen oxides and sulfur oxides, are emitted on the construction site, as well as along the transportation routes. These emissions can have health-endangering impacts on persons, as well as damaging or impairment impacts on animals and plants.

Noise and vibrations

Noise is caused during the construction and with the dismantling of the storage facility on the construction site, as well as along the transportation routes. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space. Vibrations can occur during building ground improvement, for example during the manufacture of vibration pot columns, and affect persons and animals negatively, as well as cause damage to buildings.

Direct radiation

The direct radiation from a possible storage facility for the radioactive waste from the Asse II mine at less than 100 m behind the system fence is already less than 10 µSv per year /Steag 2014/.

Incidents

Incident-caused releases of radioactive materials through influences of internally (container fall, load fall, fire etc.) as well as from externally (earthquake etc.) are possible.

Evaluation of the potential environmental impacts

Land consumption

The evaluation framework is represented in Chapter 4.1.1. The land consumption of approx. 100,000 m² is to be evaluated as a potentially significant environmental impact.

Minimisation of impacts is possible during site selection. Protection areas or living spaces of protected species would have to be avoided as a site. Considering species-specific ecological requirements, as appropriate. the possibility also exists of the resettlement of protected animal and plant species.

Spatial impact

The spatial impact of the building on the landscape is a potentially-relevant environmental impact. An evaluation of the spatial impact can only be implemented based on graphic representations of the planned system in the landscape (photo montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape through spatial impact aims at avoiding or reducing visual impacts from the environment. In this case, the relief of the landscape can be included, earth banks laid, shading of the system through forest implemented, or the colour design of the buildings adapted to the landscape.

Air pollutants
The evaluation framework is represented in Chapter 4.1.2. From the matching with environmental impact assessment studies related to storage facilities, it is indicated that, over a separation distance of 1.5 to 2 km, no potentially-relevant impacts on persons and protection areas are to be expected through the additional contamination of the construction site operation, if the minimisation possibilities, e.g. the employment of machines and devices with electric motors and the moistening of dust-emitting goods during loading and unloading, are used and are no sensitive facilities e.g. hospitals are present.

If small towns are bypassed and the route does not lead through particularly narrow valleys, also no potentially-relevant impacts on persons, animals and plants are to be expected through the additional contamination from transports, even at peak times.

Within a separation distance of 1.5 to 2 km to the construction site, potentially-relevant environmental impacts can exist through air pollutants.

Noise and vibrations
The evaluation framework is represented in Chapter 4.1.3. A matching with the results of the environmental impact assessments for storage facility, considering the increased machine and device employment, as well as the increased volumes of items transported, results in the following:

- It is assumed (aside from exceptions) that the construction site only is operated during the day, a separation distance of 1 km should suffice in order to avoid potentially-relevant environmental impacts on persons at the peak times. As a precaution, additional noise-reduction measures can be taken.
- Vibrations, for example during the generation of vibration pot columns, do not extend beyond the system grounds so that no potentially-relevant impacts on persons and animals are to be expected.
- If small towns are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive facilities (e.g. health cure region, hospitals, care institutions), relevant impacts on persons are generally not to be expected.
- For the evaluation of the impacts on birds along the transportation routes, the occurring bird species must be known, since their noise sensitivity and thus the necessary separation distances from the road are very different.

Within a separation distance of about 1.5 km to the construction site and 100 m to the transportation routes, potentially-relevant environmental impacts on persons can exist.

Direct radiation
With regard to direct radiation, potentially-relevant environmental impacts exist.

Incidents
The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. In the licensing procedure a incident analysis is to be implemented, in which sufficient provision in case of malfunction is verified. Potentially-relevant environmental impacts cannot be excluded within the framework of the SEA.

5.4.3. Closure of the Asse II mine

On completion of the Retrieval of the radioactive waste, the actual closure of the Asse II mine is implemented according to Atomic Law. The concrete closure planning will depend significantly on whether and which radioactive and chemical toxic contamination remains in the mine after the Retrieval /BfS 2014/.

This means that a concrete closure planning will first be possible at a later time after the retrieval phase of radioactive waste. For the retrieval phase, a period of several decades is assumed.

The following specifications relating to the closure concept and the activities for a closure procedure are to be considered under the above boundary condition:

In the course of the stabilisation measures decided on, the backfilling of the mine is pursued continuously. The so-called ridge-gap backfilling, as well as further measures, are included here, where hollow spaces (staple shafts, routes, etc.) in the mine no longer required are filled with special concrete.

The closure of the Asse II mine considered here refers to the phase after the retrieval of the radioactive waste, in which the underground devices are dismantled and the still existing mine filled in and closed off. In the closedown phase, the central access areas and the remaining hollow spaces, as well as the shafts, are filled in and closed off.

The closure of the Asse II mine is concluded with the safekeeping of the mine and subsequent above-ground dismantling and recultivation work /ARCADIS 2012/.

It is assumed that the following project phases are implemented at the site within the framework of the shutdown:

- The dismantling of the operational devices and the backfilling of all hollow spaces, including the shafts, is implemented underground
- The dismantling of all buildings, insofar as these are not under monument protection, and tips is implemented above ground, as well as the recultivation.

Impact factors

During the shutdown of the Asse mine, backfill material is delivered and possibly stored on a tip, as well as processed at the site, and filled into the hollow spaces still remaining underground. As a result, **air pollutants and dust emissions,** as well as **noise** and **vibrations,** arise from the dismantling work and the removal of building rubble and construction site waste. The air pollutant emissions through vehicles, including rail-mounted transport, are estimated as less due to the short closedown phase, the far smaller scope of the filling and close-off measures, as well as dismantling work, in comparison to the close-off of a disposal facility according to the Site Selection Act.

Possibly occurring **conventional waste water,** including tip waste water, are reduced in comparison to the operation of the Asse II mine through the dismantling of tips during shutdown and are not considered further here.

The **landscape change,** including **surface unsealing of** the shutdown, is a return to nature and adaptation to the total landscape. No relevant environmental impacts arise here.

Subsidence of the upper surface is reduced or minimised by the complete backfilling of all hollow spaces connected with the closedown phase.

Emissions of radioactive materials in normal operation or with incidents are not to be provided for during the shutdown of the Asse II mine.

With the dismantling of underground radiation protection areas, as well as with decontamination procedures, solid and liquid **radioactive operational waste** (e.g. wiping cloth, cleaning fluids, fine filter meshes, etc.) arises.

Description of the potential environmental impacts

The environmental impacts of the impact factors described are described qualitatively in the prefixed chapters for the retrieval of the waste from the Asse II mine. The closure of the Asse II mine leads quantitatively to less impacts than the retrieval, as well as the storage facility of the radioactive waste retrieved from the Asse II mine, since in particular large building projects are not implemented and the ground can be renatured.

Evaluation of the potential environmental impacts

The described impact factors air pollutants and noise, as well as radioactive operational waste, are potentially-relevant environmental impacts of the closure of the Asse II mine, which are to be evaluated in the licensing procedure.

5.4.4. Transfer of the radioactive waste into a disposal facility

In case of further considerations relating to the handling of the radioactive waste retrieved from the Asse II mine, it is assumed that these are conditioned at the site of the retrieval. According to location of the storage facility for the conditioned waste, a transport into the storage facility first takes place and then from there to the disposal facility. Within the framework of the generic considerations of the SEA, a common consideration of these transport procedures is implemented here. Radiation exposures of the population are considered in this case during transport and for the case of assumed transport accidents.

The impact factors represented in Chapter 5.1.3 basically also apply for the transport of waste described here with negligible thermic development, however, are extended by the Point "Release of radioactive materials".

In accordance with the study "Retrieval of the radioactive wastes from the Asse II mine" /BfS 2014/, approx. 21,000 Konrad containers must be transported away (containers authorised for the Konrad mine) from the storage facility of the Asse II mine. With a transport capacity of 2 containers per truck assumed in the study, and a maximum number of 1,250 transports per annum (25 weekly), a transport duration of approx. 8-9 years is to be expected.

Impact factors

The relevant impact factors are described in Chapter .5.1.3

For the conventional impact factors **air pollutants,** including **noise and vibration,** as well as for the radiological impact factor **direct radiation,** the listings relating to the environmental impacts and their evaluation according to Chapter 5.1.3 basically apply, since, also in case of the transfer of the Asse waste into a disposal facility, it involves only of a small number of transport procedures with 25 transports weekly.

Deviating considerations result relating to the impact factor **release of radioactive materials** due to accidents, since it cannot be excluded that, following a transport accident, radioactive materials are freed from the transport container into the environment.

Description of the potential environmental impacts

Release of radioactive materials due to accidents
Radioactive emissions can take effect on the protected items person, animal, plants, ground, water, climate and air, as well as cultural and material goods.

Evaluation of the potential environmental impacts

Release of radioactive materials due to accidents
For the impact factor accidents, the investigation area concerns a maximum surrounding area, dependent on the meteorological conditions at the time of the release, so that any exceeding of the permissible radiation exposure of persons of the population can be excluded. Standard parameters of the spreading of air pollutants are employed for the determination of the maximum separation distance. On the basis of the activity concentration theoretically measured there, the radiation exposure is determined.

For persons of the population who remain in the environment of the transport, an additional radiation exposure can be avoided through admission prevention to the accident site.

With the utilisation of non-accident-resistant transport containers for weak and medium-radioactive waste, the impacts of radioactive materials freed in the incident are limited through the quantity of the transported radioactive inventory, in accordance with the transport specifications. Within the framework of the SEA, potentially-relevant environmental impacts are therefore not assumed.

5.4.5. Disposal of the retrieved radioactive waste in the disposal facility according to the Site Selection Act

The radioactivity to be emplaced, in case of a emplacement of the radioactive waste retrieved from the Asse II mine, in addition to the heat-generating waste, is in relation negligible here, however, the waste container volume to be finally stored is larger.

To what extent the necessary volume of disposal facility hollow spaces is enlarged through the radioactive waste from the Asse II mine, is hard to quantify without detailed planning. As a result of the different material composition, a spatial separation can be necessary.

Impact factors

From containers with radioactive waste retrieved from the Asse II mine, **direct radiation,** small in relation to the remaining radioactive waste to be finally stored, is emitted. Additional precautions against direct radiation in the environment of the disposal facility are therefore not necessary.

Emissions of radioactive materials from the containers are possible, in particular with **incidents**.

Description of the potential environmental impacts

Emissions of radioactive materials via air
According to nuclide spectrum, conditioning and packaging of the waste, radioactive materials can be released from the containers. Such releases are to be estimated in the licensing procedure. If necessary, protective measures are to be provided (additional requirements on the containers or on the ventilation-technical devices at the disposal facility).

Incidents
Possible radiological impacts of incidents with radioactive waste retrieved from the Asse II mine are dependent on the layout of the containers employed for the disposal facility, as well as on the release capability from the waste matrix. For both aspects, no stipulations have yet been made. In corresponding licensing procedures, incident analyses are to be carried out on the basis of the then concretised boundary conditions and the results evaluated with regard to the environmental compatibility. Within the framework of the SEA of the National Programme, it can be determined, based on comparison with other waste, that a secure handling is basically technically realisable.

Evaluation of the potential environmental impacts

Emissions of radioactive materials via the air
The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Radioactive emissions via air are to be considered in the license as potentially-relevant environmental impacts

Incidents
The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Incident risks are to be considered in the license as potentially-relevant environmental impacts

5.4.6. Option: Disposal of the retrieved radioactive waste in the Konrad disposal facility

The plan-stipulated volume of the shaft Konrad disposal facility for the emplacement of weak and medium-radioactive waste is 303,000 m^3. The emplacement of the radioactive waste retrieved from the Asse II mine into the Konrad disposal facility is not considered here. A renewed plan identification procedure related to the extension of the emplacement capacity would be necessary.

Impact factors

Direct radiation arises from containers with radioactive waste retrieved from the Asse II mine.

In normal operation, releases of radioactive materials from the containers are possible, which make a contribution to the **emissions of radioactive materials via air** of the Konrad disposal facility.

Risks of **incidents** exist.

Description of the potential environmental impacts

Direct radiation
From containers with radioactive waste retrieved from the Asse II mine, probably a similar dosage rate is emitted as from other containers to be emplaced in the disposal facility. The precautions taken in the plan for the shaft Konrad disposal facility /BfS 1990b/ against direct radiation in the environment of the disposal facility are to be considered as providing cover, since a longer operating time of the disposal facility, however, not a more extensive storage of containers at the disposal facility, is to be assumed. An evaluation with regard to environmental impacts is not necessary.

Emissions of radioactive materials via air (discharge)
In /BfS 1990b/ values were applied for the discharge of radioactive materials with the waste ventilation air which were stipulated on the basis of waste-product-dependent and nuclide (groups)

dependent release rates from waste containers. Against the background of the emplacement of the waste from the Asse II mine, the authorised emissions of radioactive materials via the air need a verification.

Incidents

Possible radiological impacts of incidents with radioactive waste retrieved from the Asse II mine depend on the layout of the containers employed for the disposal facility, as well as on the release capability from the waste matrix. For both aspects, no stipulations have yet been made. In corresponding licensing procedures incident analyses are to be carried out on the basis of the then concretised boundary conditions and the results evaluated with regard to the environmental compatibility. Within the framework of the SEA of the National Programme, it can be determined, based on comparison with other waste, that a secure handling is basically technically realisable.

Evaluation of the potential environmental impacts

Emissions of radioactive materials via the air

The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Radioactive emissions via the air are to be considered in the license as potentially-relevant environmental impacts.

Incidents

The evaluation framework is represented in Chapter Fehler! Verweisquelle konnte nicht gefunden werden.. Incident risks are to be considered in the license as potentially-relevant environmental impacts.

5.5. Disposal of the depleted uranium from the uranium enrichment

In the following chapter, the disposal of the depleted uranium from the uranium enrichment is considered for the case that a further utilisation of these residues is not implemented. During the enrichment of uranium, depleted uranium (tails) is generated. The tails have been considered to date as recyclable material, since generally for the extraction of feed or product material, a renewed enrichment or a utilisation in fast-breeder reactors would be possible. If such expectations are not fulfilled, the material is to be consigned to disposal at a disposal facility in controlled manner /Urenco 2002/.

At the enrichment facility of Urenco Deutschland GmbH in Gronau, there exists an open storage for natural uranium in the form of feed and for depleted uranium in the form of UF_6 in transport and storage containers, and a warehouse for the storage of the depleted uranium in the form of uranium oxide (U_3O_8). The corresponding waste management steps therefore do not have to be considered here.

An utilisation of the depleted uranium from uranium enrichment is not considered here, since it does not present a disposal of radioactive waste.

Provided that the depleted uranium is not utilised, a disposal as radioactive waste is implemented in the project phases as represented below:

- conditioning suitable for disposal of the waste
- Transfer of the waste to the disposal facility
- Disposal according to the Site Selection Act
- Option of disposal in the Konrad disposal facility

5.5.1. Conditioning suitable for disposal of the waste

The waste from the uranium enrichment must be conditioned before its disposal so that it meets the acceptance criteria of the corresponding disposal facility. The regarding criteria have not been stipulated to date for this type of waste. Within the framework of the SEA of the National Programme, it is assumed conservatively that a conditioning with processing of the U_3O_8 is implemented and, for this, a conditioning plant will be constructed, operated and decommissioned.

Impact factors

With the construction of the conditioning plant, **land consumption** is implemented. Analogous to the land consumption for the construction of the plant for the conditioning of the waste from the Asse II mine (cf. Chapter 5.4.1.2) a surface from approx. 2,500 m^2 is assumed.

A spatial impact is generated from the building in the surrounding landscape.

With the construction and later decommissioning occurs the emission of **air pollutants** as well as **noise and vibrations.** During the construction, activities for **lowering** of **ground-water level** and **waste water discharge may** be necessary.

The operation of the conditioning plant does not result in either relevant air pollutant and dust emissions or relevant noise emissions.

During the construction of a conditioning plant, temporary **groundwater depletion** and **waste water discharge** of conveyed groundwater cannot be excluded. These impact factors are considered in Chapter 4.1.7, so that no further details are necessary here.

The operation of the conditioning plant leads to the emission of **direct radiation** (gamma and neutron radiation) which, however, is not relevant outside of the building and therefore does not have to be considered further. During the conditioning, **emissions of radioactive materials via the air** cannot currently be excluded. During decontamination work, contaminated waste water can be generated, which is collected and possibly routed into a receiving water holder, so that **emissions of radioactive materials via water** occur. The discharge of radioactive materials via water, as a material-bound discharge and due to additional conventional materials (e.g. residues of cleaning substances), includes a discharge as **conventional waste water**. The evaluation of the impact factor conventional waste water is implemented in Chapter 4.1.7 and is not considered project-specifically further on.

The operation of the conditioning plant includes risks of **direct radiation or release of radioactive materials due to incidents**.

Generated **radioactive operational waste,** as well as possibly generated radioactive waste during a decommissioning of the facility, are disposed likewise and are therefore of subordinate importance.

Description of the potential environmental impacts

Land consumption

Land consumption in the magnitude of 2,500 m^2 leads to the loss of the ground function as well as of the living space for animals and plants in the affected area. It cannot be excluded that water bodies, protected species and a protected area are affected by the sealing.

Spatial impacts
Spatial impacts change the appearance of an affected landscape and can reduce its regeneration function. Spatial impacts are dependent on the subjective feeling of the observer, it acquires an additional weighting with a high number of affected residents or visitors. The observability of the site is particularly relevant in regions characterised by tourism.

Air pollutants
With the construction and decommissioning of the storage facility, air pollutants, such as fine dust, nitrogen oxides and sulfur oxides, are emitted on the construction site, as well as along the transportation routes. These emissions can be health-endangering for people persons, as well as damage and impair animals and plants.

Noise and vibrations
Noise is caused during the construction and the decommissioning of the storage facility on the construction site, as well as along the transportation routes. Noise can increase the risk of cardiovascular illnesses in persons and drive animals from their living space. Vibrations can occur during ground improvement, for example during the making of vibrated stone columns, and affect persons and animals negatively, as well as cause damage to buildings.

Emissions of radioactive materials via the air (Discharge)
In relation to other already operating conditioning plants, far less discharge of radioactive materials is to be expected, since U_3O_8 is relatively non-volatile and can be filtered over an exhaust air filtration system.

Emissions of radioactive materials via water (Discharge)
More active liquids are disposed of as radioactive waste, the remaining waste water is discharged within the scoop of the corresponding loicense.

Incidents
As a result of influences from inside (container crashing, load crash, fire etc.) as well as from outside (earthquake etc.), incident-related releases of radioactive materials are possible.

Evaluation of the potential environmental impacts

Land consumption
The evaluation framework is represented in Chapter 4.1.1. The land consumption of approx. 2,500 m² is to be evaluated as a potentially significant environmental impact.

Minimisation of impacts during site selection is possible. Protection areas or living spaces of protected species would have to be avoided as a site. Considering species-specific ecological requirements, if applicable, the possibility to resettle protected animal and plant species also exists.

Spatial impact
The spatial impact of the building on the landscape is a potentially relevant environmental impact. An evaluation of the spatial impact can only be carried out by graphic representations of the planned installations in the landscape (photo-montages) considering all relevant lines of vision.

Minimisation of impacts on the landscape through spatial impacts aims at avoiding or reducing visual links with the surroundings. Though, the relief of the landscape can be embraced, mounds can be laid, shading of the installation through forest can implemented, or the colour design of the buildings can be adapted to the landscape.

Air pollutants

The evaluation framework is represented in Chapter 4.1.2. The construction of the conditioning plant is, with regard to the possible impacts, comparable to the construction of residue treatment centres at other sites. The employed machines and devices are presumably comparable. A comparison to the results of surveys of environmental relevance for the residue treatment centres results in the following:

- Above a separation distance of 1 km, no potential relevant impacts on persons and protection areas are to be expected through the additional burden of the construction site operation, if the minimisation possibilities, e.g. the employment of machines and devices with electric motors and the moistening of dust-emitting goods during loading and unloading, are used and no sensitive facilities e.g. hospitals are present.
- If localities are bypassed and the route does not lead through particularly narrow valleys, even at peak times no potentially relevant impacts on persons, animals and plants are to be expected through the additional burden, too,.

Within a separation distance of about 1 km to the construction site of a conditioning plant, potentially relevant environmental impacts can occur, for which possible minimisation measures are to be considered.

Noise and vibrations

With regard to noise and vibrations also a direct comparability to surveys of environmental relevance of the construction of residue treatment centres exists. A comparison results in the following:

- If it is assumed (aside from exceptions) that the construction site is operated during the day only, a separation distance of 1 km should suffice in order to avoid potentially relevant environmental impacts on persons at peak times. As a precaution, additional noise-reduction measures can be taken (see Chapter 4.1.2).
- Vibrations, for example during the generation of vibrated stone columns, do not extend beyond the installation site, so that no potentially relevant impacts on persons and animals are to be expected.
- If localities are bypassed and the transports are routed at more than 100 m separation distance to inhabited regions or sensitive areas (e.g. spa areas, hospitals, nursing establishment), potentially relevant impacts on persons are not to be expected.
- For the evaluation of the impacts on birds along the transportation routes, the occurring bird species must be known, since their noise sensitivity, and thus the necessary separation distances from the road, are very different.

Within a separation distance of approx. 1 or 1.5 km to the construction site, potentially relevant environmental impacts on persons can exist. Within 100 m distance to the transportation routes potential environmental impacts on persons can exist in residential areas or other sensitive areas (e.g. hospitals).

Emissions of radioactive materials via the air

Provided that discharges of radioactive materials occur during conditioning, these would lie clearly below admitted dose limit values. The discharges are to be considered in the licensing procedure as potentially relevant environmental impacts.

Emissions of radioactive materials via water
In case of the discharges with waste water e.g. from container flushing, the discharge value can be selected so that the dose limit values are adhered to. Potentially relevant environmental impacts exist, which are to be clarified within the framework of the licensing.

5.5.2. Disposal of the waste in the disposal facility according to the Site Selection Act

At a disposal facility, according to the Site Selection Act, heat-generating waste is mainly dealt with. In addition, packages with U_3O_8, or another chemical form favourable for disposal, would have to be emplaced in case of disposal of the waste from uranium enrichment. The activity of the waste from uranium enrichment is negligible with respect to the activity of spent fuel and other high active waste.

To what extent the necessary volume of disposal cavities enlarges through the waste from uranium enrichment is difficult to quantify without detailed planning. The non-heat-generating waste from the uranium enrichment could, under certain circumstances, be emplaced in areas which otherwise would not be usable, in order to limit the thermal stress in the disposal facility. A spatial separation from the heat-generating waste is in all likelihood necessary.

Impact factors

Containers with waste from uranium enrichment emit **direct radiation,** which is negligible in relation to the remaining waste to be disposed. Additional precautions against direct radiation in the surroundings of the disposal facility are therefore not necessary.

During normal operation no relevant **emission of radioactive material** from the containers with waste from uranium enrichment is to be expected. On the other hand, during **incidents** releases from the containers can be possible.

Description of the potential environmental impacts

Incidents
Possible radiological impacts of incidents with waste from uranium enrichment depend on the layout of the containers employed for disposal, as well as on the release-capability of the uranium from the waste matrix. For both aspects, no stipulations have yet been made. Potential environmental impacts are therefore to be considered.

Evaluation of the potential environmental impacts

Incidents
Uranium possesses a very low specific activity so that, for a relevant potential impact, a relatively large airborne mass would have to be released. In corresponding licensing procedures, accident analyses are to be carried out on the basis of the then specified boundary conditions and the results have to be assessed with regard to the environmental compatibility. Within the framework of the SEA of the National Programme, it can be determined, based on comparison with other waste, that a secure handling is basically technically feasible, however, incident risks require consideration in the licensing as potentially relevant environmental impacts.

Incidents
The evaluation framework is represented in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. During the licensing procedure an accident analysis is to be conducted.

5.5.3. Transfer of the waste to the disposal facility

The transfer of the radioactive waste from uranium enrichment is performed essentially based on the transport of weak to medium active waste as described in Chapter 5.4.4. Both the impact factors, as well as the description and assessment of the potential environmental impacts are along the lines of Chapter 5.4.4.

5.5.4. Option: Disposal of the waste in the Konrad disposal facility

The officially approved volume of the Konrad disposal facility for the emplacement of weak and medium-radioactive waste is 303,000 m^3. The emplacement of the depleted uranium into the Konrad disposal facility is not considered in this occasion. A renewed planning approval process relating to the extension of the emplacement capacity would be necessary.

Impact factors

Containers with radioactive waste from uranium enrichment emit d**irect radiation** is . During normal operation, no relevant **emissions of radioactive materials** are emitted by the containers with waste from uranium enrichment. On the other hand, during **incidents** releases from the containers can be possible.

The radiological impact factors refer to potential impacts per operating year or in case of an incident. An extension of the emplacement duration in the Konrad disposal facility therefore cannot have any new potential environmental impacts.

Description of the potential environmental impacts

Direct radiation
Containers with waste from uranium enrichment (depleted U_3O_8) emit a small dosage rate in relation to other waste flows which are planned for the Konrad disposal facility. The precautions taken in the planning for the Konrad disposal facility /BfS 1990b/ against direct radiation in the surroundings of the disposal facility therefore provide significant coverage with regard to containers with U_3O_8.

Emissions of radioactive materials via air and water (discharges)
With an additional emplacement of the waste from the uranium enrichment into the Konrad disposal facility, no additional potentially relevant environmental impacts through discharges of radioactive materials with the exhaust air must be assumed. The same applies with regard to discharges of contaminated waste water.

Incidents
Possible radiological impacts of incidents with waste from uranium enrichment depend on the layout of the containers employed for disposal, as well as on the release-capability of the uranium from the waste matrix. For both aspects, no stipulations have yet been made. Potential environmental impacts are therefore to be considered.

Evaluation of the potential environmental impacts

Incidents
Uranium possesses a very low specific activity so that, for a relevant potential impact, a relatively large airborne mass would have to be released. In corresponding licensing procedures, accident analyses are to be carried out on the basis of the then specified boundary conditions and the

results have to be assessed with regard to the environmental compatibility. Within the framework of the SEA of the National Programme, it can be determined, based on comparison with other waste, that a secure handling is basically technically feasible, however, incident risks require consideration in the licensing as potentially relevant environmental impacts.

6. Hypothetical zero alternatives

The consideration of the zero alternatives is necessary, according to § 14 g Sect. 2 No. 3 UVPG, within the scope of the SEA. For the SEA of the National Programme, potential environmental impacts of hypothetical "zero alternatives" are described and compared with those of the planned measures of the National Programme. The "zero alternatives" do not represent any reasonable planning alternatives for the National Programme. However, the zero alternatives can provide a standard of comparison for the planned measures and planning alternatives for the SEA, and thus serve as a reference point for an illustration of the environmental impacts of the planned measures and planning alternatives. Therefore zero alternatives are described which are in contrast to the actual objective of the National Programme, the disposal of all radioactive material in deep geological formations. The hypothetical zero alternative assume the continuation of the present handling of already existing and in the future generated radioactive waste, under the assumption that the basically objective of the National Programme - the waste disposal of all types of radioactive waste in deep geological formations - would not continue to be pursued. The zero alternatives therefore include an above-ground keeping of the radioactive waste as long-term storage. The following zero alternatives are defined and compared with planned measures of the National Programme with regard to environmental impacts:

Hypothetical zero alternatives	Planned measures of the National Programme
Long-term storage of all heat-generating radioactive waste	Disposal of all heat-generating radioactive waste, including the spent fuel from research, development and demonstration reactors
Long-term storage of the radioactive waste retrieved from the Asse II mine	Disposal of the radioactive waste retrieved from the Asse II mine in a disposal facility
Long-term storage of the radioactive residues from uranium enrichment	Disposal of the radioactive residues from uranium enrichment in a disposal facility

The consideration of the zero alternatives of a long-term storage with the planned measures of the National Programme for the disposal in deep geological formations is carried out over the same period of 1 million years. Hypothetical scenarios of a different disposal of radioactive waste, after a limited storage of, for example, 1000 years, are not considered, since other technologies are not available for the waste management of radioactive waste and the actual objective of the comparison is an illustration of the environmental impacts of the planned measures of the National Programme. The comparison is carried out qualitatively according to the following criteria:

- Potential emissions of air pollutants and noise
- Potential land consumption
- Potential radioactive emissions of the operation and during the post-closure phase
- Potential releases of radioactive materials through events (e.g. incidents)

6.1. Zero alternatives "Long-term storage of all heat-generating radioactive waste"

The hypothetical zero alternative "Long-term storage of all heat-generating radioactive waste" describes a dry storage in closely sealed metallic casks. Since there are no binding regulations for a long-term storage of heat-generating waste, for the representation of the zero alternative reference is made to the recommendation of the Nuclear Waste Management Commission (ESK) " Guidelines for dry cask storage of spent fuel and heat-generating waste " /ESK 2013a/, which, however, refers to the time-limited storage in the magnitude of the time periods licensed to date.

For a long-term storage of heat-generating waste, along the lines of /ESK 2013a/, the following protection objectives apply in the long-term:

- Safe inclusion of the radioactive material,
- Safe adherence of sub-criticality and
- Avoidance of unnecessary radiation exposure, limitation and control of radiation exposure of the operating personnel and the population

Derived from this, the following requirements would result which are to be permanently fulfilled:

- Storage of the waste in sealed casks and corresponding buildings for the control and limitation of the radiation exposure
- Precautions against incidents and avoidance of theft and a targeted attack by third parties
- Regular renewal of the casks and conditioning of the waste (approx. every 100 to 300 years /NERAS 2010/)
- Ensuring the personnel, administrative, technical and financial prerequisites for the realisation of an active storage of the waste

<u>Boundary conditions for a simplified comparison:</u>

A long-term storage that would be carried out over a period of the post-closure phase of a disposal facility would be carried out forabout 1 million years at approx. 16 sites (13 on-site storage facilities at all former nuclear power plant sites and three transport cask storage facilities).

For the renewal of the casks and conditioning at intervals of 250 years, it is assumed that the heat-generating waste would be transported from the respective storage facilities in Germany to a central conditioning plant, which would be newly constructed based on the changed technical requirements each time (conditioning at a single site appears more effective, since otherwise new plants would have to be constructed each time at all storage facility sites between the individual conditioning intervals). A period of far longer than 40 years, during which casks for heat-generating waste retain their transport capability, can currently not be stipulated due to lack of experience in licensing. To simplify matters, it is assumed that the casks retain their transport capability between the conditioning intervals

	Zero alternative long-term storage of heat-generating waste	Planned measures site selection act and disposal of heat-generating waste
Land consumption	Storage facility: **80,000 m² approx. 1 million years** Conditioning plant: **10,000 m² approx. 1 million years**	Site selection: **430,000 to 730,000 m² approx. some years** Disposal facility: **approx. 300,000 m² approx. some decades**
Air pollutants and noise	Emissions from **numerous** building projects (68,000 building projects: 16 storage facilities and 1 conditioning plant each to be newly constructed every 250 years)	Emissions from the building projects relating to the site exploration and disposal
Radiological emissions	Direct radiation through **numerous transports** (approx. 4,000) to the conditioning plant Emissions through **numerous** conditioning intervals (approx. 4,000) (Limit value: 1 mSv/a)	Direct radiation through **one-time transport** of all waste to the disposal facility Emission through **one** conditioning procedure (Limit value: 1 mSv/a)
Potential releases	incident planning value: **50 mSv resulting dose** **Risks** of theft and a targeted attack **over 1 million years**	Maximum objective of the demonstration **0.1 mSv/year** at less probable events **Risks** of theft and a targeted attack **over some decades**

The comparison shows that the zero alternative "long-term storage" would lead in the short term to less land consumption and less emissions through air pollutants and noise than the site selection and disposal. On a long-term basis, however, the zero alternative, in case of the selected conventional impact factors, would lead to a predominant degradation of the status of the environment.

With regard to radioactive emissions on the basis of existing limit values or verification objectives, the zero alternative "long-term storage" would lead to a predominant degradation of the status of the environment.

Geological developments are processes over extremely long periods, which would affect both storage facilities and a disposal facility. Storage facilities could react to that, unlike a disposal facility, provided that the personnel, administrative, technical and financial prerequisites for that are met. Climatic changes, e.g. ice ages, which could be caused both naturally and anthropogenically, would only affect long-term storage in the biosphere.

Since it cannot be excluded that Germany will be affected on a long-term basis by social crises or war-time events, it cannot be presupposed that the personnel, administrative, technical and financial prerequisites for the realisation of an active storage of the heat generating waste (long-term storage) would be met on a long-term basis. Therefore, in case of a long-term storage of the heat-generating waste, a complete release of the inventory into the biosphere must be expected.

6.2. Zero al "long-term storage of all radioactive waste from the Asse II mine and all residues from uranium enrichment"

The hypothetical zero alternative "long-term storage of all radioactive waste from the Asse II mine and long-term storage of all residues from uranium enrichment" describes storage in steel containers. Since there are no regulations for the long-term storage, the description of the zero alternative reference is made to the recommendation of the Nuclear Waste Management Commission (ESK) for the storage of radioactive waste with negligible heat generation /ESK 2013b/, which explicitly regulates the time-limited storage. Along the lines of /ESK 2013b/, the following protection objectives would apply in the long-term:

- Safe inclusion of the radioactive material and
- Avoidance of unnecessary radiation exposure, limitation and control of radiation exposure of the operating personnel and the population.

Derived from this, the following simplified requirements would result which would have to be fulfilled:

- Storage of the waste in sealed containers and corresponding buildings for the control and limitation of the radiation exposure
- Precautions against incidents and avoidance of theft and a targeted attack by third parties
- Regular renewal of the containers to avoid corrosion
- Ensuring the personnel, administrative, technical and financial prerequisites for the realisation of an active storage of the waste

<u>Boundary conditions for a simplified comparison:</u>

The comparison of the zero alternatives "long-term storage of the radioactive waste from the Asse II mine and the waste from uranium enrichment" with the disposal is carried out under the assumption of a disposal in the disposal facility according to the Site Selection Act. With regard to container renewal, it is assumed that long-term storage is executed at low humidity, dryly conditioned containers and high-quality interior container coverings, so that a container service life of 100 years is supposed. It is assumed that the maintenance of the buildings corresponds to the effort of new construction at intervals of approx. 250 years. Both the disposal and the long-term storage require at the beginning a conditioning of the waste with comparable emissions, so that this is not considered.

	Zero alternative "long-term storage of the radioactive waste from the Asse II mine and the waste from uranium enrichment"	Planned measures for disposal of the radioactive waste retrieved from the Asse II mine and the waste from uranium enrichment in the disposal facility
Land consumption	Two long-term storage facilities and two facilities for new packaging: **300,000 m² over approx. 1 million years**	Two storage facilities : **200,000 m² over several decades**
Air pollutants and noise	Emissions from **numerous** building projects (16,000 building projects (two long-term storage facilities and two facilities for new packaging are constructed every 250 years)	Emissions of the construction and the operation **of a storage facility for the radioactive waste from the Asse II mine** and the waste from the uranium enrichment each
Radiological emissions	Direct radiation through the long-term storage over **1 million years** Emissions through numerous new packaging processes of the waste (Limit value: **1 mSv/a**)	Direct radiation through storage over **some decades** After that, disposal (Verification objective **0.1 mSv/a**)
Potential releases	Limit value for incidents: **50 mSv resulting dose**	Maximum objective of the demonstration **0.1 mSv/year** in case of less probable events

The comparison shows that the zero alternative "long-term storage of the radioactive waste from the Asse II mine and the residues from uranium enrichment" to the disposal facility, with regard to conventional and radiological impact factors, would lead to a degradation of the status of the environment.

7. Additional specifications

In this Chapter, transboundary potential environmental impacts and difficulties in the listing of the specifications are represented.

A separate representation of measures for minimisation and compensation is dispensed with, since this is already implemented with the evaluation of the environmental impacts of the individual projects of the National Programme.

7.1. Transboundary potential environmental impacts

The sites of the measures and projects of the National Programme are currently not stipulated. A delimitation to certain regions within Germany has also not been implemented yet. Therefore currently sites are also conceivable close to the border. For the following impact factors, transboundary potential environmental impacts cannot be exclude with regard to precautionary aspects.

- Air pollutant and dust emissions, as well as noise emissions through construction sites of larger facilities (e.g. storage facility) within a separation distance of about 1.5 km to the border

- Air pollutant and dust emissions, as well as noise emissions, through transport of construction materials, waste or mining heap material with management of the transportation routes within a separation distance of about 100 m to the state border
- Air pollutant and dust emissions through the operation of facilities in direct proximity to the border
- Routing of waste water with conventional and radioactive material contents into the underflow of the receiving water adjacent to a state border
- Spatial impact through constructed buildings or mining heaps in proximity to a border with direct visual conditions outside of Germany
- Incident risks with the operation of nuclear plants within Germany
- Accident risks during Germany-internal transport of radioactive waste in the area of Germany borders, with the back-supply of waste from reprocessing over neighbouring states of Germany and during transport of fuel assemblies from experimental, demonstration and research reactors on the region of a neighbouring state

The potential environmental impacts represented do not occur automatically within the indicated separation distances since, with the specifications, precautionary aspects are considered and measures for avoidance and minimisation can achieve a considerable reduction of the impacts. Such measures for avoidance and minimisation, however, cannot be prepared until project-specific knowledge is available and has been stipulated as binding. In addition, it was assumed here that directly on the state border to Germany on the region of a neighbouring country, sensitive protected items, such as e.g. residential zones, are affected.

With the realisation of the measures and projects of the National Programme, environmental impact assessments are implemented according to the law relating to the environmental impact assessment of the Federal Republic of Germany (UVPG) /UVPG 2013/. The affected neighbouring states participate in the future licensing procedures, according to the specifications of the UVPG.

7.2. Difficulties in listing the specifications

In this SEA the measures of the National Programme relating to waste disposal of radioactive waste were assessed with regard to the construction, the operation and the shutdown by facilities for which no concrete designs and sites are stipulated. The indicated bandwidths for impact factors are therefore based only on estimates from present knowledge about facilities for the processing, storage and disposal of radioactive waste. Due to sites being currently not stipulated, the real status of the environment in each case cannot be considered. Thus, for example, an evaluation of noise through construction measures and transports with regard to animals, where birds represent the relevant animal group here, is dispensed with because currently there is a lack of knowledge about the sites and affected species there. The system designs and sites currently not stipulated have caused that this evaluation relating to environmental impacts could be implemented only qualitatively - frequently as a potentially-relevant environmental impact. Due to the missing stipulations, with the evaluation of numerous impact factors there were therefore no arguments available quantitatively in order to be able to exclude significant environmental impacts as early as in the SEA.

In the SEA of the National Programme, interactions of building projects being implemented simultaneously in spatial proximity to each other could not be considered. In addition, possibly existing legacy contamination could not be considered at future sites due to their not being stipulated.

In the SEA of the National Programme, measures for the avoidance and minimisation of environmental impacts are designated in each case. No liability currently exists, however, due to missing consolidation relating to the systems and sites about the realisation of measures for avoidance and minimisation.

The difficulties represented in the listing of the specifications of the facilities do not exist in case of the implementation of the measures and projects of the National Programme, since both the facility-engineering aspects as well as the planned site of the systems are stipulated for the then required licensing procedure.

With regard to the evaluation of possible environmental impacts in the post-closure phase of a disposal facility, the very long period over which this phase extends is to be considered. The processes relating to the evaluation of the long-term safety of a disposal facility, which consider the handling of uncertainties in the forecast of the development of a disposal facility over the necessary period of verification of 1 million years, are dealt with qualitatively in Chapter 5.1.6.4 of this SEA. An existing verification of the long-term safety of a disposal facility for heat-generating waste cannot be referenced currently, since this verification can be implemented only with consideration of the site selected for the disposal facility, the regional geology and the host rock-specific disposal facility concept.

Due to these boundary conditions, the arrangement of the environmental impacts for the post-closure phase of a disposal facility into the categories usually employed as not relevant, potentially-relevant or potentially significant, is dispensed with.

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