ENVIRONMENT IMPACT ASSESSMENT REPORT ON

INVESTMENT PROPOSAL

CONSTRUCTION OF NATIONAL DISPOSAL FACILITY FOR LOW AND INTERMEDIATE LEVEL RADIOACTIVE WASTE – NDF

PART IV

DESCRIPTION, ANALYSIS AND ASSESSMENT OF THE POTENTIAL MAJOR IMPACT ON THE POPULATION AND ENVIRONMENT IN RADIOACTIVE AND NON-RADIOACTIVE ASPECT RESULTING FROM THE IMPLEMENTATION OF NDF, THE USE OF NATURAL RESOURCES, NOXIOUS EMISSSIONS AT NORMAL OPERATION AND EMERGENCY SITUATIONS, THE GENERATION OF WASTE AND CAUSE OF DISCOMFORT

Sofia, January 2015

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4.1 ATMOSPHERIC AIR

4.1.1 ASSESSMENT OF THE POTENTIAL IMPACT ON THE CLIMATE AND THE ATMOSPHERIC AIR

4.1.1.1 CLIMATE

The climate changes are a result of complex and continued processes that happened long ago in the distant space and depend mainly on the development of the modern geological age (planetary reasons) and on the solar activity as well.

The climate in every region is formed under the influence of the radiation, circulation and physicogeographical factors. The intensity of the sun radiation, its amount and inner-annual distribution have a major role for the climate formation. All these factors influence on the dispersing and transference of emissions in the air basin of a certain region. This is one of the reasons on which basis the World Meteorological Organization sets the years in relation to which can be done comparative analyses and assessments of the meteorological parameters for a certain region.

The realization of the investment proposal will not influence on the regime and spatial distribution of the values of the climatic elements of the adjacent territory of site “Radiana”.

No climatic changes are expected to occur as a result of the power of the nonradioactive emissions during the three phases: construction, operation and closing and the two types of disposal facilities – tunnel and trench.

4.1.1.2 NONRADIOACTIVE POLLUTION OF THE ATMOSPHERIC AIR

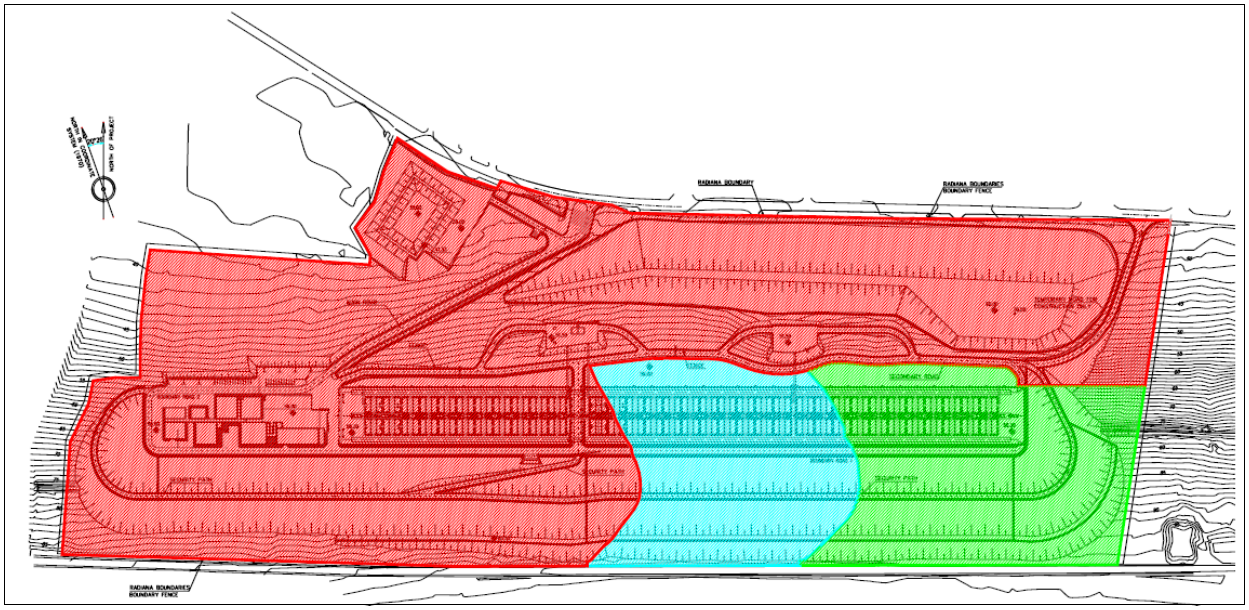
4.1.1.2.1 DURING CONSTRUCTION

The construction of NDF following the two alternative variants – tunnel and trench will be carried out in stages.

Two technologies for a realization of the disposal facility for low and intermediate level radioactive waste category 2a in a surface modular engineering disposal facility have been proposed: **TRENCH AND TUNNEL TYPE.**

- At the **TRENCH TYPE** the stages of the areas are as follows:

  → **Phase 1** – cleaning of a site with an approximate area of 343 300 m² which includes the territory for the Auxiliary buildings, the territory of the Platform for the Cages from Phase 1, the territory of the depot for ground masses and the access road in cases of failures (this road will be used as auxiliary during the construction of Phase 2 and Phase 3) - **Figure 4.1-1.**



- Phase 1, -Phase 2, - Phase 3

FIGURE 4.1-1 PLAN FOR THE CLEANING OF THE SITE IN PHASES 1, 2 И 3

→ **Phase 2** – cleaning of a site with an approximate area of 52 425 m² which includes the territory of the Platform for the cages from Phase 2 and the surrounding area.

- **Phase 3** – cleaning of a site with an approximate area of 70 400 m² which includes the territory of the Platform for the cages from Phase 3 and the surrounding area.
- At the **TUNNEL TYPE THE** areas with the necessary additional area for roads outside the site add up to a total of 475 000 m².

The disposal facility consists of 8 parallel tunnel constructions (galleries) for the disposal of the containers with radioactive waste (reinforced concrete containers). Each of the galleries is 1130 m long and the diameter is 6.5 m plus the thick supporting. The diameter of the excavation is 7.5 m. The tunnel constructions for the disposal of the reinforced concrete containers are arranged along the whole length of site “Radiana” with an orientation from west-northwest towards south-southeast – **Figure 4.1-4.**

At **stage I** should be built 3 tunnel galleries (**Figure 4.1-3**) and some maintaining perpendicular galleries – a transport stulm, a service gallery and a ventilating stulm. They are with a diameter – 3.7 m plus the thickness of the supporting. The diameter of the excavation is 5.5 m. An experimental stulm is built in addition and the total length of the mining constructions is 4 120 m for the servicing of the disposed reinforced concrete containers – **Figure 4.1-2**

At the operation stage (**stage II)** the mining constructions will be carried out only by the ventilating stulm so that they won’t influence the normal operation of the disposal facility. The constructions shall be carried out at a continuous operation mode while constructing and supporting the galleries with a big diameter where the packages will be disposed. **Figure 4.1-3.**

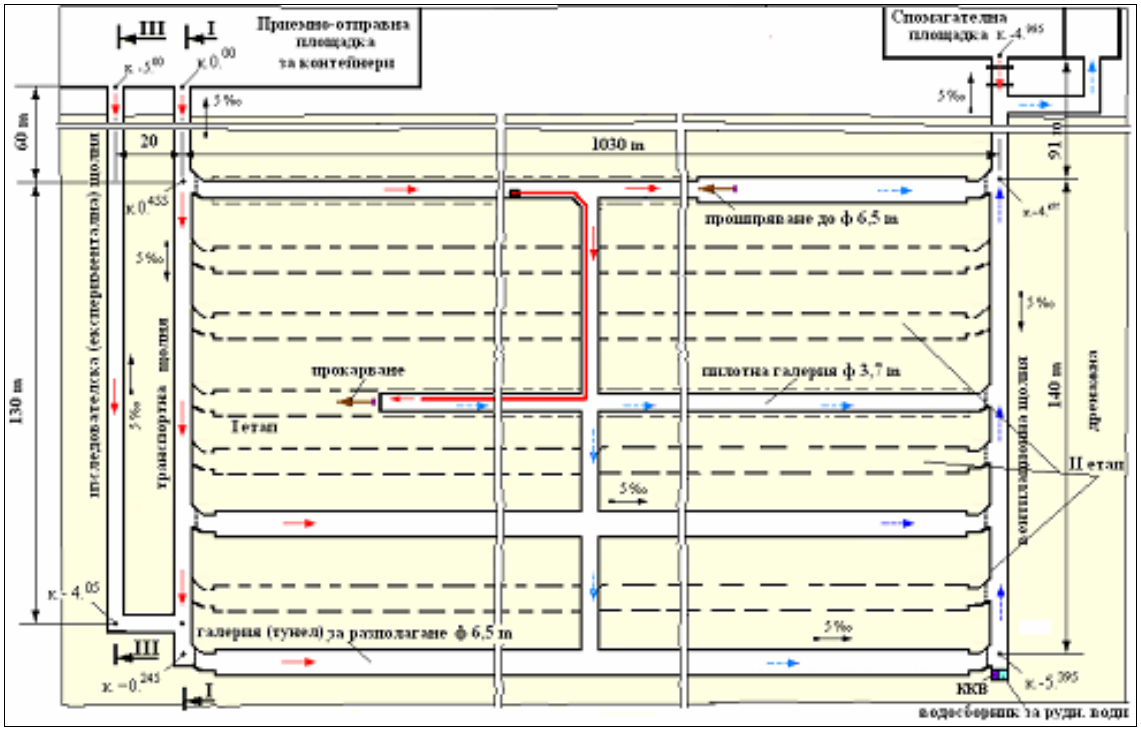


FIGURE 4.1-2 CONSTRUCTION OF NDF – PRE-OPERATION STAGE II

movement of vehicles
movement of air flow

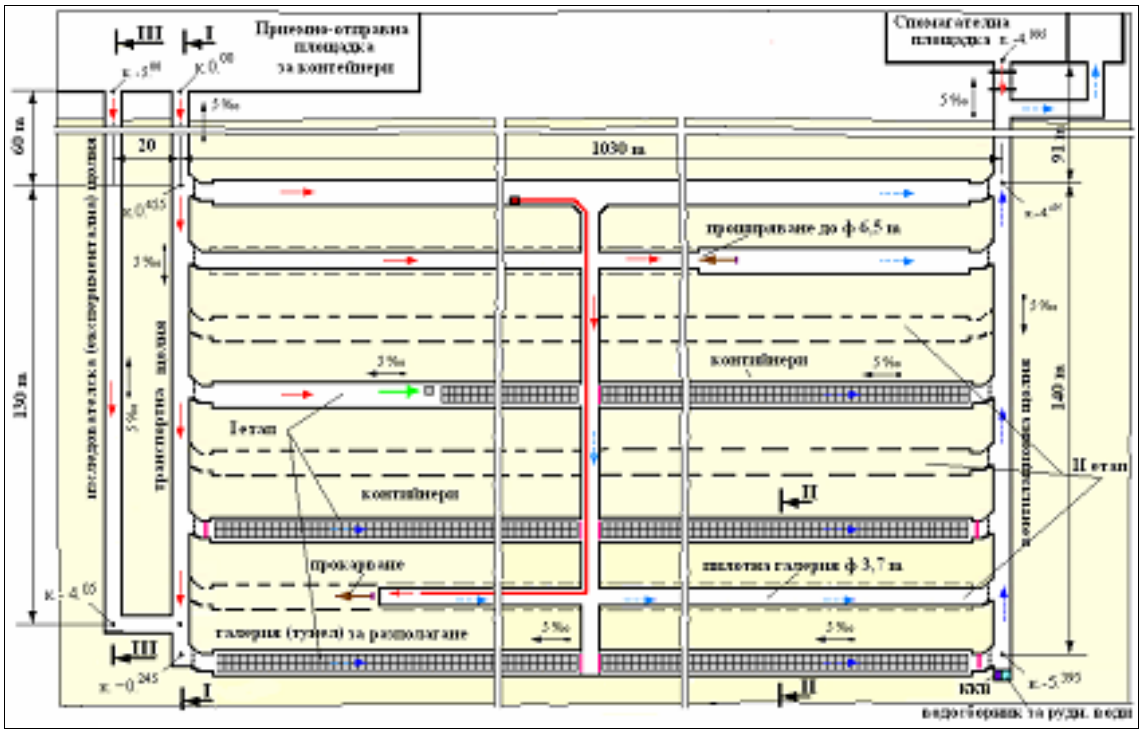


FIGURE 4.1-3 CONSTRUCTION OF NDF AT STAGE II OPERATION

movement of PTM
movement of vehicles
movement of air flow

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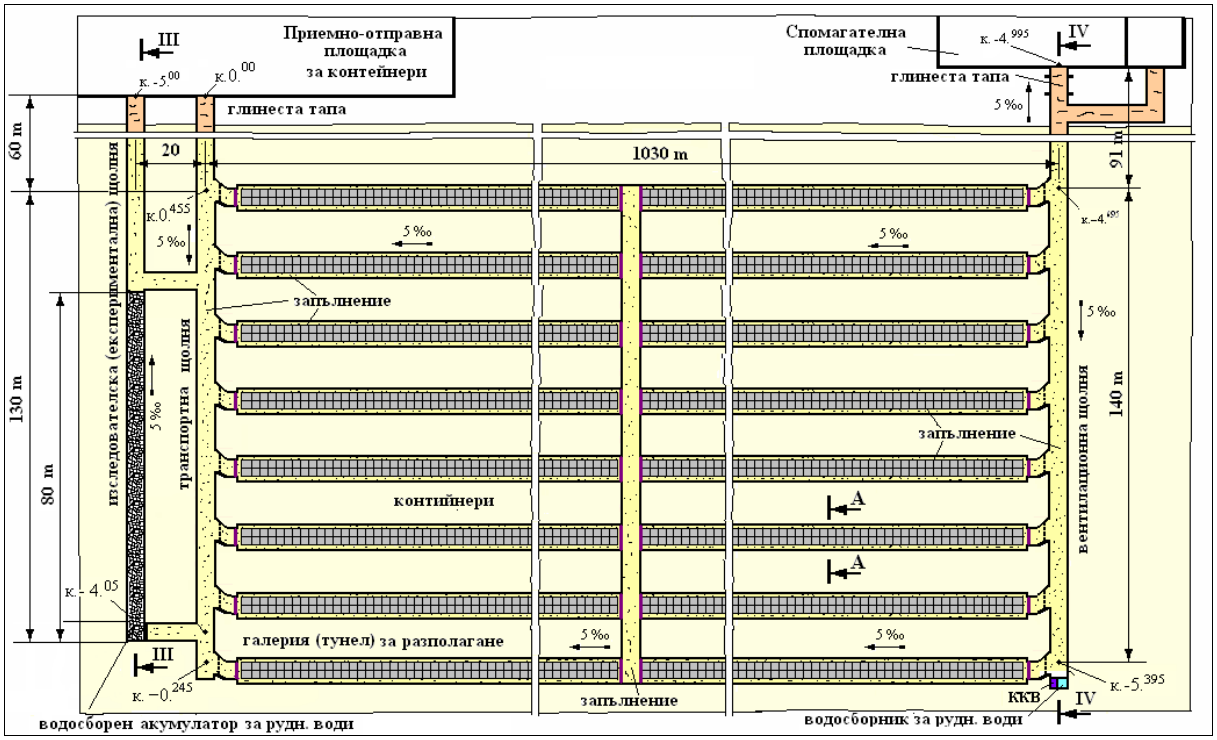

FIGURE 4.1-4 NDF POST OPERATION STAGE

4.1.1.2.1.1 Dust pollution – area sources

The expected dust emissions at the sites cleaning of the different modules of the NDF and the earth excavations are defined in accordance with the emission factors of **EMEP/EEA air pollutant emission inventory guidebook 2013, NFR** [1] код **2.A.5.b** - Construction and demolition:

$$\begin{Bmatrix} \text{общ прах} \\ \text{ФПЧ}_{10} \\ \text{ФПЧ}_{2.5} \end{Bmatrix} = \frac{\text{брой дни на определена дейност}}{365 \text{ дни}} \times \begin{Bmatrix} 0.162 \\ 0.0812 \\ 0.00812 \end{Bmatrix} [\text{kg}] \times \text{работна площ} [m^2]$$

For the trench and tunnel type repository for 1 working day during the different phases of the respective repository construction the dust emission are shown in **Table 4.1-1** .

TABLE 4.1-1 DUST EMISSION FOR ONE WORKING DAY

Stage	area	TSP	PM10	PM2.5
	m^2		kg	
Trench type	466 125	206.88	103.70	10.37
Tunnel type	475 000	210.82	105.67	10.57

The dust separation depends mainly on the meteorological conditions during the construction activities and the season when the constructions will be carried out, the climatic and

1 **NFR** (Nomenclature for Reporting) – nomenclature for reporting processes generation emissions. It allows the complete coordination and compliance among all national reportings under the Convention on Long-Range Transboundary Air Pollution (CLRTAP); before the Secretariate of the United Nations Framework Convention on Climate Change (UNFCCC) and the European Environment Agency (EEA).

meteorological factors (wind, humidity, temperature, atmospheric stability) the characteristics of the earth particles and many other conditions.

When is used an irrigation system for sustaining enough humidity the dust emission levels (controlled emissions) fall by 80%[2] under the formula:

$$E_C = E \times \left(\frac{100 - C}{100}\right),$$

where: E_C is the level of the controlled emission, E is the level of the non-controlled emission and C is the control efficiency in %.

CONCLUSION

At **the tunnel type** the dust impact of the earth excavation in the tunnels is minimal, because most of the construction activities are done inside (tunnel). Therefore the dust emissions are localized and limited in space by the outsets of the mining ventilation system.

At **the trench type** the construction dust impact comes from the outer non-organized construction area and Radian site islets but is also local and considerably low. - **Table 4.1-1** .

4.1.1.2.1.2 Construction machinery pollution – area sources

The area where the construction work will be carried out will be a source of exhaust emissions from the internal combustion engines (ICE) the machinery used.

The emission assessment is done under **Tier 2**[3] following the methodology of **EMEP/EEA air pollutant emission inventory guidebook 2013** for non-road mobile machinery (area emissions), SNAP code **0808**, and for carbon dioxide – under IPCC (**NFR**[4] code **1.A.5.b.iii**), in the exhaust of the ICE.

The necessary construction machineries for every type of the NDF construction – trench and tunnel is common to the two types of repository and is shown in **Table 4.1-2.**

TABLE 4.1-2 THE PLANNED MACHINERY

Machinery needed	ICE capacity [HP]	Hours of work [h]	Number
Dumper 20 t	350	7	1
Digging machine	560	7	1
Grader	250	7	1
Bulldozer	260	7	1
Loader	150	7	1
Chain excavator	300	7	1

The ICE exhaust for a working period of 100 working days at a 7-hour working shift is shown in

Table 4.1-3

[2] http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s00.pdf.

[3] In **EMEP/EEA air pollutant emission inventory guidebook** a methodology for the defining the emissions level are used methods with different complexity. They describe the basic activities while making an inventory of the emissions. The complexity level of the method is marked as Tier X, i.e. the higher the number X is, the more complex and precise the method is.

[4] **NFR** (Nomenclature for Reporting) – nomenclature for reporting processes generation emissions. It allows the complete coordination and compliance among all national reportings under the Convention on Long-Range Transboundary Air Pollution (CLRTAP); before the Secretariate of the United Nations Framework Convention on Climate Change (UNFCCC) and the European Environment Agency (EEA).

TABLE 4.1-3 CONSTRUCTION MACHINERIES EMISSIONS DURING THE BUILDING PERIOD

Construction machinery	Emissions [t/y]									
	Greenhouse gases			Basic and specific pollutants						$tCO_{2\text{-екв}}$
	CO_2	CH_4	N_2O	NO_x	SO_X	CO	NMVOC	$ФПЧ_{10}$	NH_3	
Tunnel and trench type	790.42	0.05	0.34	3.42	0.02	3.42	0.49	0.20	0.002	897.4

The total amount of greenhouse gases shown in CO_2-equivalent is 897.4 tons. The above mentioned emissions are emitted directly in the atmospheric air from the ICE machinery exhaust-pipes.

A considerable reduction of the pollutant emissions can be expected if during construction used machineries are meeting at least the standard requirements of EURO IV.

4.1.1.2.1.3 Transport activity pollution – linear sources

Their emission in kg/km are assessed under the methodology of **EMEP/EEA air pollutant emission inventory guidebook, 2013** for the basic pollutants from heavy-freight vehicles over 15 tons (**1.A.3.b.iii**) in item Transport

1. TUNNEL TYPE

According to the preliminary project during construction transportation of the unnecessary earth masses outside the site will be done by heavy-freight dumpers with loading capacity of $15m^3$ (40t). They will be transported to a certain dump. 73 runs per day are necessary for this.

The emission capacity of kilogram per 1 kilometer (kg/km) from the traffic of the respective road is shown in **Table 4.1-4** – row **1.**

2. TRENCH TYPE

The construction machinery and dumpers route passes through a second-class road (II-11, section Oryahovo-Mizia-Kozloduy-Lom which goes south of Kozloduy NPP and the NDF site and goes along the floodplain terrace of the Danube. That is how the traffic between the towns and the transit freight transport is moving out. An alternative route does not exist. That is why the means of transport schedule referring to the construction should be consistent to the rush hour of the traffic to Kozloduy NPP from 7:00 to 8:30 am and from 4:00 to 6:00 pm.

At a later stage the construction company should prepare a detailed transportation schedule based on the exact distances, production capacity of the excavators and the Lorries available.

In order to estimate how heavy the traffic is during the digging the following calculations might be done:

The unnecessary earth masses which will be transported outside Radiana site area[5] amount to 265 385 m^3. For 300 days the whole earth mass form Phase 1 will be dug. This will require 77 transportation runs for a day with loading capacity of $15m^3$ (40t).

Their emissions in kg/km are shown in **Table 4.1-4** – row **2.**

TABLE 4.1-4: EMISSION CAPACITY IN KILOGRAM PER 1 KILOMETER FROM THE RESPECTIVE REPOSITORY TYPE (KG/KM)

Repository type	CO	NMVOC	NOx	N_2O	NH_3	Pb	$PM_{2.5}$
Tunnel type	0.109	0.020	0.458	2.92E-04	2.12E-04	5.18E-07	9.49E-03
Trench type	0.115	0.021	0.483	3.08E-04	2.23E-04	5.46E-07	1.00E-02

[5] EQEB-11207-TD-OEC-R01

TABLE 4.1-4: CONTINUED

Repository type	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO_2	SO_2	benzene	tCO_2eq
Tunnel type	1.02E-07	4.45E-07	3.98E-07	6.57E-08	48.1	0.0002	0.00061	**0.049**
Trench type	1.08E-07	4.69E-07	4.20E-07	6.93E-08	50.8	0.0003	0.00064	**0.051**

A considerable reduction of the pollutant emissions might be expected if during construction are used machineries meeting the requirements of Regulation No **10/2004** (Official gazette 28 from 06.04.2004г.)[6], in compliance with Directive 2002/88/EC supplementing Directive 97/68 – measures for the reduction of emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery).

MODELING THE LINEAR SOURCES IMPACT

It is accepted that the vehicles pollution while moving along the road segments can be described as permanently operating linear sources.

In order to estimate the linear sources pollution under the European norms and the respective Bulgarian legislation is used Methodology for the determination of the diffusion of pollutant emissions from vehicles and their concentration in the ground atmospheric layer – program product **TRAFFIC ORACLE** (Order No РД 994/04.08.2003 of the Ministry of Environment and Water of Bulgaria). The program consists of two main modules - **DIFFUSION** and **EMISSION**[7]. The product gives statistical or type assessments of the pollution levels with a certain pollutant.

Module **DIFFUSION** is based on swift-flowing Gaussian model and calculates the pollution (concentrations) from the linear sources in the ground atmospheric layer by defining the expected climatic averages (average annual) concentrations using the annual “wind rose”. The concentration is presented in mg/m^3.

Module **EMISSION** estimates the values of the pollutant emission from the vehicle engines in g/(m.s) for a linear source. The modelling input parameters are:

→ The area for which the pollution is calculated is 12 500x7 250m (50 steps in west-east direction and 29 steps in north-south direction, each of them is 250 m).

→ The summer wind rose has been used for the study purposes (conservative assumption that the construction period is in summer – June, July and August) and the hourly meteorological file for 2012[8] - **Figure 4.1-5**, the average annual speed is 3.02m/s.

[6] Regulation № 10 from 24.02.2004 for the conditions and order of approving the type of of internal combustion engines for the non-road mobile machinery concerning the pollutants emissions (issued by the Minister of Agriculture and Forests published in Official gazette 28 from 6.04.2004 entering imnto force on 6.04.2004), last amended Official gazette 2 from 10.01.2014.

[7] European Topic Centre on Air and Climate Change, Long description of model 'TRAFFIC ORACLE' (http://pandora.meng.auth.gr/mds/showlong.php?id=158)

[8] EIAR „Construction new nuclear power from the latest generation at the site at Kozloduy NPP”, 2013.

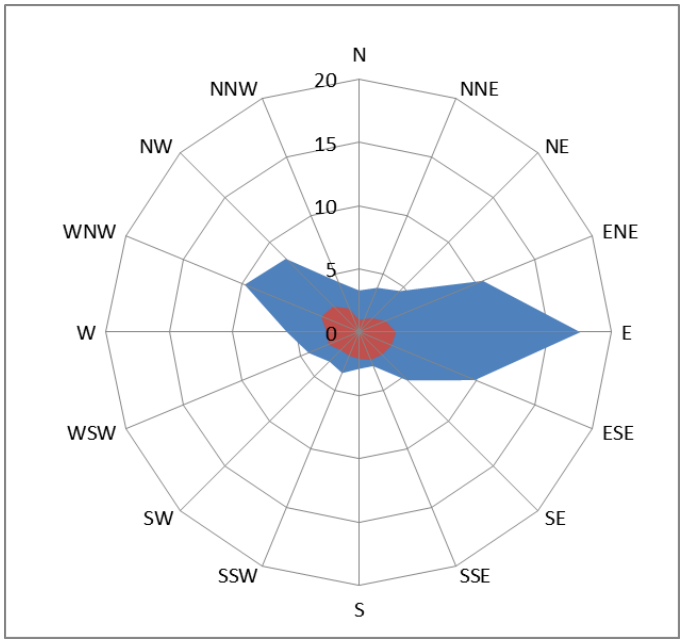

FIGURE 4.1-5: SUMMER WIND ROSE FOR 2012

The rose is typical for the Bulgarian Danubian regions: it's orientated towards the zonal transmission west-east and at the same time it follows the orientation of the huge river basin – the Danube around the Kozloduy NPP site (northwest-east) which has a considerable aeration impact. The average wind speed are within the interval of 1÷3.2 m/s, the winds from west-northwest have the highest speed (8 m/s), and those from north-northeast have the lowest speed (about 1.1 m/s). The winds from south-southeast have the lowest frequency (2.5%) and form south (2.9%), and those from east have the highest frequency – 17.5%.

→ The parameters necessary for every single source are:

- X_1, Y_1, X_2 и Y_2 – the co-ordinates at the beginning and end of the segment [m];
- the road width [m] and
- the emission [$g.m^{-1}.s^{-1}$] – are determined by :
  - The heavy-freight NDF traffic during the trench type construction – 77 runs daily (more unfavorable alternative compared ti 73 runs daily for the trench type repository).
  - The prognosticated data for the average 24-hour period intensity of the road traffic along road II-1 of the republican road network for 2020 for the six basic categories of vehicles: cars (8002), light duty trucks (1247), medium duty trucks (215), heavy duty trucks (57), buses (country) (312) and heavy duty with a trailer (202) – total 10 035 vehicles, has been received by the Road Infrastructure Agency [9] for ДПП-496 in the section Mizia-Kozloduy (**Chapter 3.1**, **Table 3.1-11**).

In

[9] Road Infrastructure Agency, 53-00-9813 from 20.08.2014.

Table 4.1-5 are shown the expected maximum pollutant concentrations for which there is an average annual norms (AAN) and annual lower assessment threshold (ALAT) according to the Bulgarian legislation.

TABLE 4.1-5: AVERAGE SEASONAL (SUMMER) CONCENTRATION FOR THE DIFFERENT POLLUTANTS

Pollutant	NO_2	Pb	FDP_{10}	SO_2	C_6H_6
AAN [µg/m^3]	40	0.5	40	50*	5
ALAT [µg/m^3]	26	0.25	20	-	2
Maximum concentration [µg/m^3]	7.36	0.0017	0.4725	0.4745	0.0821

**World Health Organization recommended norm.*

As it shown in

Table 4.1-5**,** there is no pollutant exceeding neither the AAN (in **red**), nor the respective ALAT (in **purple**) at average 24-hour period of automobile traffic concentration intensity for 2020. There are no transportation traffic exceeding.

On **Figure 4.1-6** is shown the ground pollution filed with nitrogen oxide only to complete the study of the pollution decomposition of the two traffics.

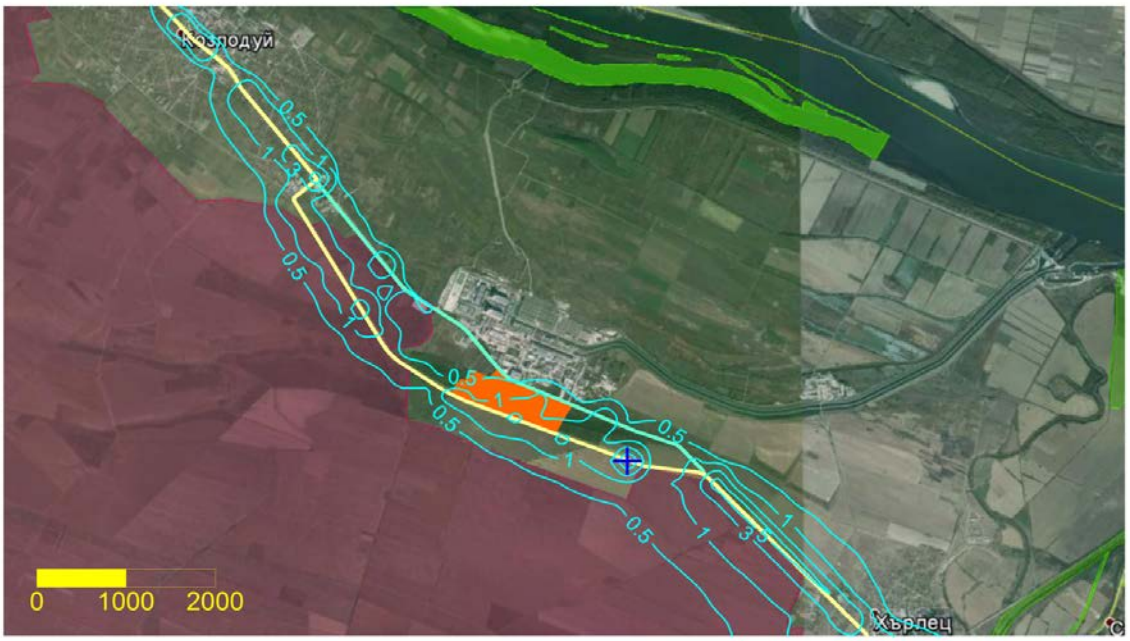

FIGURE 4.1-6: AVERAGE SEASON (SUMMER) POLLUTION WITH NITROGEN OXIDE ON THE LINEAR SECTION OF NATIONAL ROAD II-11 AND THE ROAD FROM THE TWO TRAFFICS REGARDED AS INTERNAL FOR THE PLANT

The maximum concentration of 7.36 µg/m^3 (marked by red cross) is over 5 times less than the AAN of 40 µg/m^3.

The gaseous linear emission won’t have impact on the atmospheric air quality during construction.

ASPHALT PLACING – AREA SOURCES

In compliance with the future technical projects for the NDF construction is provided asphalt covering not only of the technological areas but of the round and operation road too. The level emission of non-methane volatile organic compounds (**NMVOC),** total suspended particulate (**TSP)** and particulates up to 2.5 (**Particulates$_{2.5}$**) and up to 10 microns (**Particulates$_{10}$)** at placing asphalt mixture can be calculated by **Tier 1**[10] of methodology **EMEP/EEA air pollutant emission inventory guidebook, 2013** (**NFR 2.D.3.b - Road paving with asphalt**), where the emission factors are gram per ton placed asphalt.

TABLE 4.1-6 CONSTRUCTION MACHINERY EMISSION FOR THE CONSTRUCTION PERIOD

Activity: Asphalt placing	Placed asphalt	NMVOC	Total Particulates	Particlutaes$_{10}$	Particulates$_{2.5}$
			tons		
Phase I	4 817.52	0.077	67.45	14.45	1.93
Phase II	1 715.18	0.027	24.01	5.15	0.69
Phase III	1 381.54	0.022	19.34	4.14	0.55
	Total	0.127	110.80	23.74	3.17

The emission in the atmospheric air during construction will not have a considerable impact on the atmospheric quality of the region.

For the prevention against the above the standard pollution is necessary to stick to the traffic schedule of the vehicles serving the building site appropriate to the meteorological conditions (calm weather), i.e. to allow the atmosphere to use its natural capacity for self-cleaning.

4.1.1.2.2 OPERATION EMISSION

During the NDF operation the pollution of area particulates is not so remarkable. The gaseous emission will be considerably low compared to the average 24-hour period of intensity of the automobile traffic on road II-11 of the republican road network.

The exhaust emission of the machinery with ICE – the special means of transport which have diesel engines and of the operation of the ready-mix trucks s also considerably low.

4.1.1.2.3 CLOSURE EMISSIONS

The operation of the NDF will continue for 60 years. Planned gradual closure of the modules filled with RCCs. It is planned that the final closure of the facility shall last about 15 years and in accordance with the requirements of the nuclear legislation is subject to authorization by the NRA and a new assessment of the environmental impact.

After closure, the NDF will be set to 300 years of institutional control over part of which will be the implementation of programs for control on the condition of the facilities and radiation monitoring of the site, area for precautionary measures and surveillance area, security and access control which is within the site limits – within the area limits surrounded by an outer fence.

The impact of all kinds of emissions during closure will be lower than those during operation. And since the impact will be for a longer period of time they will not be important at all.

[10] In **EMEP/EEA air pollutant emission inventory guidebook** a methodology for the defining the emissions level are used methods with different complexity. They describe the basic activities while making an inventory of the emissions. The complexity level of the method is marked as Tier X, i.e. the higher the number X is, the more complex and precise the method is.

4.1.1.2.4 POTENTIAL IMPACT RESULTING FROM FAILURES AND INCIDENTS

4.1.1.2.4.1 Floods, fires and explosions

No floods are expected. There are no highly inflammable or explosive materials which can become a source of non-radiation harmful substances which as a result can affect the atmospheric air.

4.1.1.2.4.2 Natural disasters (such as earthquakes, floods)

Dangerous meteorological phenomena for Kozoduy NPP area and Raiana site are considered to be tornadoes and hails. The possibility of a tornado passing through the area within a year is estimated to 10^{-6}. During the period May 5th – July 31st form a statistic point of view hails for the NDF area are considered a chance phenomenon because of their large areas and time variations.

4.1.1.2.4.3 Stoppage or failure of the process or equipment

As a technology the storage process at the NDF is connected to a low possibility of equipment failure but even then it is not a volley source of non-radiation harmful substances which as a result can affect the atmospheric air.

4.1.1.2.4.4 Road accidents

At the NDF site there are no conventional vehicles that can cause road accidents.

In the Kozloduy NPP area and Radiana site the traffic of the specialized vehicles is carried out according to strictly prepared schedules and routes. The speeds are low and the possibility of road accidents is zero.

The following measures should be foreseen. During the different periods of the IP implementation they will ensure the observing of the requirements of the operation legislation regarding the impact on the atmospheric air quality and the health of the people working at the site and in the nearby towns and villages. .

1. In order to reduce the exhaust harmful emissions into the atmosphere and to minimize the negative impact on the atmospheric air in the region and the ensuring of safe working conditions, health protection of the staff and the population during the construction periods, operation and closure is necessary to:
    - To limit the traffic of heavy duty vehicles through towns and villages. If this is inevitable, then it should be done fast and freely at a steady speed (without stops and slowing down). This will provide a stable temperature regime of the operating engine and the pollutant emission levels are very slow;
    - The construction and transport machinery should be n a good working order;
    - The machinery and vehicles should meet the requirements of Regulation № 10/2004 (Official gazette, 11/2004) measures for the reduction of emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery.
2. The vehicles should not be overloaded with earth masses and ballast. These materials should not be scattered, crushed and smashed because later on they will become additional sources of particulate emissions.
3. The vehicles should be covered while transporting the dug earth, building materials, building waste, etc.

4. Irrigating the construction areas if necessary.
5. Shortly after the completion of the construction activities the storage areas for the bulk materials should be cleared (recultivated).

4.1.1.3 CONCLUSION

Regarding the component “atmospheric air” in non-radiological aspect the building of two types of repositories (tunnel and trench) during construction has almost the same impact importance – very low. Neither of them is with a potential risk from anthropogenic air pollution with the conventional pollutants in the IP area. The emission impact and the pollutant concentrations are considerably under the permissible norms limits. The impact is of **short duration, temporary and with a limited range and is reversible** for the atmosphere**.** The level of the impact for the protection of human health and the ecosystems is very low.

The additional emission load (cumulative impact) is expected form the transportation traffic in discussed area with an impact level which is quite lower. **No cumulative impact is expected on other environmental components – soils, flora and fauna, health and hygienic conditions.**

No impact is expected during operation, closure and the following instruction control.

No transboundary impact is expected regarding the conventional pollutants.

On the grounds of the above mentioned statement regarding the favorable climatic and meteorological characteristics of the region and the fact that there are no serious industrial pollutants in the region, can be concluded that it is not expected that the quality of the atmospheric air will change for the worse in the area at the realization of the NDF.

4.1.2 ASSESSMENT OF THE POTENTIAL POLLUTION OF THE ATMOSPHERIC AIR IN RADIOLOGICAL ASPECT

4.1.2.1 DURING CONSTRUCTION

It is not expected atmospheric air pollution with radioactive substances during construction – the construction of a national disposal facility for low and intermediate level radioactive waste is carried out on a clean terrain and the building technology of the two disposal alternatives – tunnel and trench has nothing to do with radioactive pollution.

4.1.2.2 DURING OPERATION

At the NDF site no radioactive materials will be processed, no matter hard or liquid because this might be a potential source of gaseous radionuclides or aerosols.

In the disposal for low and intermediate level radioactive waste are disposed only **conditioned RAW** which are included in a hard matrix and packed in reinforced concrete containers (outside Radiana site which secure “zero” radionuclide emission into the area.

At the moment at site Radiana is implementing the Program for pre-operation/exploitation radiological monitoring of the component “air” (№ ТК.Д-142-D3/2012, НХ-ПЕМ-ПМ-001) in order to analyze the site radioecological status and to determine if there is conformity with the regulatory framework in the field.

If there is a proven necessity during the NDF operation period while working out a Program for operation radioactive monitoring of the NDF, the Monitoring of the radioecological status of the site atmospheric and the NDF controlled zones should be revised and updated.

4.1.2.3 DURING CLOSURE

The closure of tunnel and trench type repository is also not a source of gaseous radionuclides or aerosols because the closing procedures will not damage the package with the immobile RAW matrix.

During the period of institutional control the disposed RAW are placed in the repository structure (reinforced concrete repository cells trench type or concrete tunnels for the tunnel type repository) and are covered by protective multbarrier coating and the loess reversed covering on the site with a trench type of repository or with the geological environment natural massif at a tunnel type repository which eliminates the passing of radionuclides into gases or aerosols into the atmospheric air.

4.1.2.4 CONCLUSION

No impact is expected on the radioecological situation resulting from the realization of the IP neither at the construction stage nor during the repository operation. The conditioned RAW packages (reinforced concrete containers) and the other NDF engineer barriers guarantee the non-distribution of the radioactive substances and the environment protection from radioactive contamination. No change in the national gamma background and the atmospheric radioactivity in the region resulting from the NDF implementation.

The IP implementation for NDF Radiana is not a source of radiation contamination of the atmospheric air during the implementation of the “tunnel” and “trench” type repository.

4.2 WATERS

4.2.1 SURFACE WATERS

4.2.1.1 NON-RADIOLOGICAL ASPECT

The site Radiana where the NDF will be located is situated in the vicinity of Kozloduy NPP between two roads, on the north – a road, controlled by Kozloduy NPP and regarded as internal for the plant, and on the south – a section of second-class road (national road II-11), connecting the village of Harlets, Mizia and the town of Kozloduy. The site is positioned 3.3 km south-east from the regulatory line of town of Kozloduy, 4.3 km north-west from the construction boundaries of the village of Harlets and about 4.2 km south-west from the right bank of the Danube River. It covers an area of approximately 46 hectares, roughly rectangular in shape. The site is situated at the slope between the first and sixth loess terraces with displacement between them of about 60 m (from elevation +35 m to elevation +94 m) and is located between the second and sixth loess terraces in the floodplain terrace on the right bank of the Danube River. No natural water objects flow through this terrace.

Because of the Radiana site characteristics (located on the north slope of the second terrace of the Danube River) the surface rain waters drain away in north direction towards Kozloduy NPP and the river. According to the River Basin Management Plans of the Danubian region for a water basin management river in the country the Danube River is a surface water object with the name the Danuve River RWB01and a water body with a code BG1DU000R001. The river has the greatest importance for the NDF.

4.2.1.1.1 DURING CONSTRUCTION

The State Enterprise IP “RAW” for the construction of NDF includes the construction of a **module repository** for the disposal of low and intermediate level radioactive waste, category 2a

in accordance with the Provision for the safe management of radioactive waste[11]. It is a **multibarrier engineering surface repository**. The NDF multibarrier isolation system will include four engineering barriers and a natural one (based on Radiana site characteristics which are described in details in part 1 of the present Report.

At Radiana site both for the two types of surface repository – the tunnel and the trench one will have to be organized temporary site for earth masses storage, bulk materials, ready steel, concrete, reinforced concrete and other construction elements, fuel and lubricating oil, temporary offices, feeding water-supply network and sewage and household waste water for purification, as well as facilities directing the rain water, site fencing.

For both repository types there will be 3 oil-water separators at the working site for the specialized mechanization. Thanks to them there will be no oil products pollution (the waste waters will be collected in scraped pits).

During the construction site preparation for the two discussed technology alternatives – tunnel and trench type repository will be implemented the project for the replacement of the water supply system which provides the drinking water for the NPP and the villages Harlets and Glozhen. It is a property of Water Supply and Sewerage – Vratsa OOD and it will be at the border of the site and the read internal to the plant in accordance with the Spatial Development Plan witch a detour stipulated in it which will provide the supply for the NDF. The project for the moving of the part of the irrigation canal M-1 passing the site will be implemented. This canal is part of Shishmanov Val irrigation system.

According to the Investment proposal the two repository types will be built gradually – at three phases.

At the first stage for both repository types will be built service infrastructure such as Water Supply and Sewerage, rain drainage systems, drainage systems including the drainage system under the slope and the surface waters drainage systems around the cells, electric and other auxiliary buildings and installations. At this stage:

→ For the **trench type** repository will be constructed the first platform with its systems of galleries, infiltration control system and preparatory works for the construction of the catchment basin for surface waters/ rain waters basin,

→ For the tunnel **type** – three tunnels, a transportation gallery, a service and ventilation gallery will be built.

At the second stage the following facilities will be built:

→ For the **trench type repository**: platform №2, together with the adjoining gallery and the infiltration control system;

→ For the **tunnel type repository** – 3 tunnels for disposal together with the adjoining infiltration control system.

At the third stage the following facilities will be built:

→ For the **trench type repository**: platform №3, together with the adjoining gallery and the infiltration control system;

→ For the **tunnel type repository** – the last three disposal tunnels together with the infiltration control system.

On **Figure 4.2-1** is shown an exemplary plan of the three stages for the object completion as a surface multibarrier trench type facility.

[11] Regulation on safety RAW management, Official gazette 76 from 30th August 2013.

At the site there will be an opportunity to provide the respective mechanical transport by detouring from the existing road infrastructure as well as enough space to separate the necessary construction area and its infrastructure that will service the construction of the two repositories – trench and tunnel type.

In accordance with the Investment proposal the numbers of workers and employees of the construction and assembly works Contractor will be 75 people on average for the two types of repository.

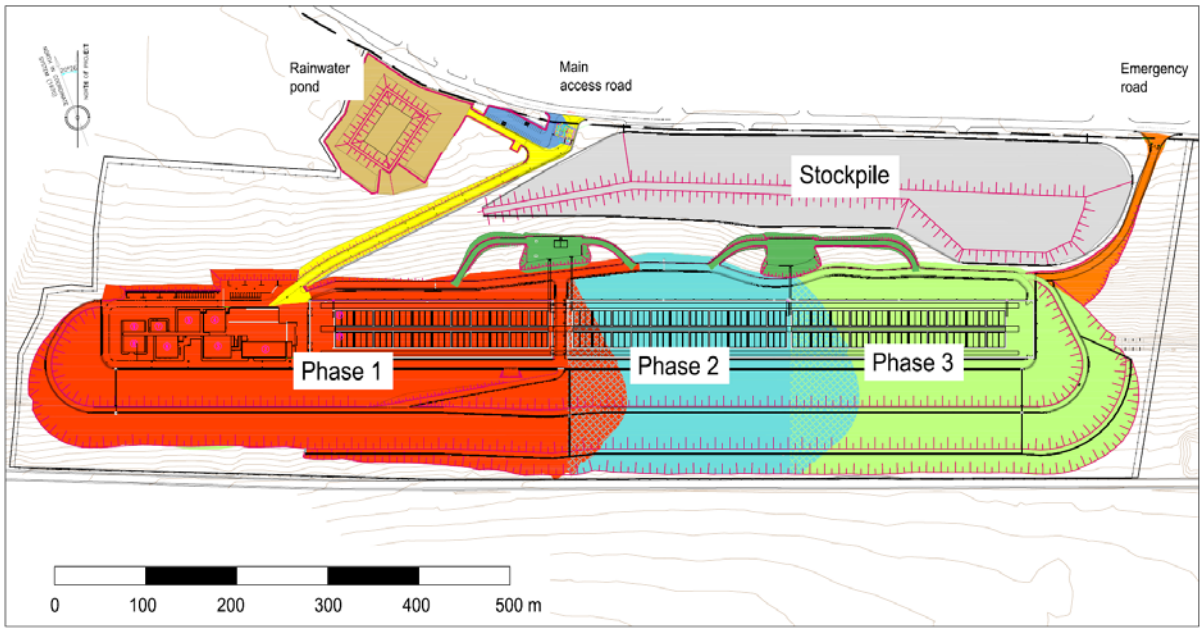

FIGURE 4.2-1 RADIANA SITE – PLAN OF THE STAGES

4.2.1.1.1.1 Water supply system

There is no constructed or existing water supply system at the site. In accordance with the IP and the Spatial Development Plan for the object (part Water Supply and Sewerage) the water supply will be done by connection to the drinking water-main for Kozloduy NPP. The connection point from the street water-main is near the border checkpoint.

From this point where the main water meter unit has been installed during construction an underground pipe will be placed conducting 3,90l/s of water. The water is distributed for the buildings supply (2.23l/s) and for other needs – construction needs (1,67l/s).

During the construction of the two types of repository at a water supply norm of $Q_{ср.д.}^{об}$ = 110 l/d for the workers and employees will be necessary about $Q_{ср.д.}^{об}$ = 110x75 = 8m^3/day and average annual consumption of about $Q_{ср.г.}^{об}$ = 8.25 x 250 = 2 062.5 m^3/y drinking water.

Technological needs water including that for irrigation when the weather is dry, washing of the transportation means, technological watering of the cast concrete and other “wet” processes will be $\leq$ 1 500m^3/y and will be specified in the next designing and implementing stage in accordance with the accepted construction technology and the repository type.

A site network for firefighting needs will be constructed. The measured amount of water is 15.0l/s. The time to extinguish a fire will be 3h. The water for the outer fire extinguishing will be provided by a pumping station located in the Technical building and fire needs reservoir for the trench type repository. The system will be supplied with water from the site water supply network for drinking water.

4.2.1.1.1.2 Sewerage

There is no built existing sewerage at the site. For both types of repository the sewerage will be divided – for domestic sewage and for rain waters. During construction works the sewerage will be constructed from materials providing high level of water-tightness which will not allow any pollutants to enter the underground waters and the bowels of the earth.

- ***Domestic sewerage and sewage wastewater***

During construction chemical toilets will be used for the wastewater from the workers' life cycle. At the next designing phase the opportunity for building a temporary connection or a scraped pit to the nearby Kozloduy NPP sewerage will be specified. All the normative requirements will be met.

The wastewater will come from 75 people. In accordance with the IP the expected polluting flow during construction for the two types of repository will be:

Q Average per day	8.0 m^3/d;
Biochemical oxygen demand$_5$/BOD	1.5 kg/d;
Chemical oxygen demand/COD	3.0 kg/d;
Insoluble substances /SS	1.8 kg/d;
Nitrogen total/Nt	0.28 kg/d;
Phosphorus total/Pt– 0.04kg/d	0.05 kg/d.

- ***Rain drainage***

During construction the rain water will be generated from rain, snow melting, if it is necessary to drain the construction excavations from rain water, from the auxiliary buildings and facilities for the two types of repository, rom the working sites cleaning and from other general construction activities. The insoluble substances (sand, dust and others) will be stored in deposit shafts.

For both types of repository there will be draining protective rain drains to protect the site from slope waters during construction. For the tunnel type repository this protection is necessary for the construction part which is connected to the auxiliary buildings and for the trench type of repository – for the whole construction front.

For the trench type of repository the construction of protective rain drainage and draining system is important because the conventional construction technologies are applied and the construction will be done on the surface.

For the tunnel type of repository the mining construction methods are applied and the problem about the facility protection from rain water is not so important. The rain water will drain freely down the terrain.

In the next design stage the expected amounts of rain during construction will be specified in accordance with the preferred technology – trench or tunnel type. The Concrete technical parameters of the draining facilities and where they will lead to will be specified at the next phase in accordance with the regulations such as the conditioned clean rain water.

4.2.1.1.1.3 Conclusion for the impact expected during construction

As a result of the analysis the expected impact on the component "surface waters" in non-radiation aspect during construction of the NDF for both types of repository has almost equal importance – very low.

The expected impact DURING CONSTRUCTION is of **short duration, temporary and with a limited range without cumulative effects**. The impact level is **quite** low if all thee normative requirements are met.

4.2.1.1.2 DURING NORMAL OPERATION

NDF will be a separate structural section within SE RAW – specialized section “NDF”: The NDF staff will consist of 64 people working one shift only excluding the police officers.

4.2.1.1.2.1 Trench type repository

The repository will be placed on the consolidated Pliocene clay. It will not reach the level of the underground waters. It will consist of 66 disposal cells for the RAW packages placed on three identical platforms. Each of them will contain 22 cells. The disposal cells will be monolithic oblong reinforced concrete constructions.

The cells will be constructed on a loess-cement cushion 5 m thick placed from elevation +50 m to elevation +55 m. Sidelong of the disposal cells the loess-cement cushion will be thicker – 6.3 m in order to cover the edges of the foundation slab (from elevation +50 m to elevation +56.3 m). The loess-cement cushion is designed to increase the thickness of the unsaturated area. There will be constructed the drainage galleries under each parallel row of disposal cages regarding the protection of the surface and underground waters using the infiltration control system.

Every cell will be protected by e mobile roof until it is filled. The mobile roof allows the RAW packages to be protected from the rain water before the placement of the cover slab.

The repository empty cells before filled with waste will be protected from the atmospheric impact by installing covering panels which will be waterproofed.

The specific characteristic of the trench type of repository in accordance with the IP will be the additional construction of a deep drainage which will collect rain water, penetrating through the slope surface. It will be collected by draining pipes under the south and north edge of the loess-cement cushion and will be directed to the rain water site network.

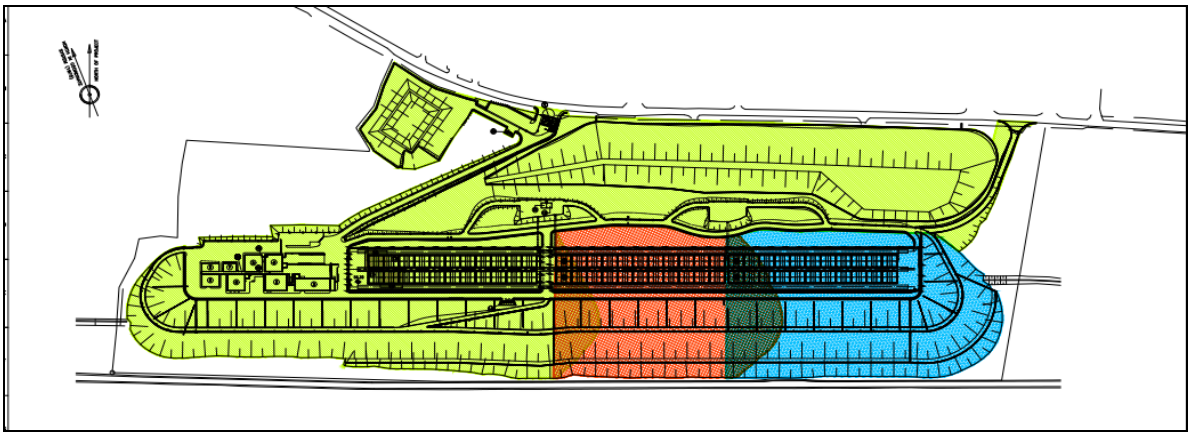

FIGURE 4.2-2 OVERVIEW OF A TRENCH TYPE REPOSITORY

On **Figure 4.2-2** up to **Figure 4.2-5** are shown the overview of the trench type repository, longitudinal section through the cells from Platform 1 where can be seen the passable gallery and the infiltration control system, as well as the cross section through a repository cell.

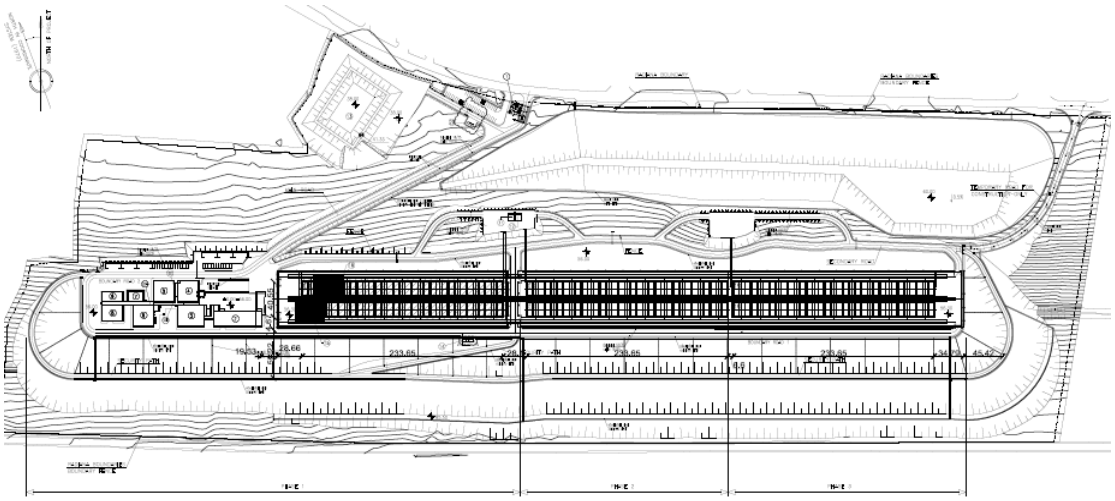

FIGURE 4.2-3 OVERVIEW OF PLATFORM 1 FROM A TRENCH TYPE REPOSITORY

The opportunity for constant and visual control of this system will provide its designed function and if there is a possible leakage in a particular cell it will be located. This will enable the operation for immediate actions to solve the problem. The infiltration control system will include a pipeline connection of the pipes of each cell including the control vessel which has a sampling device and can measure the capacity. The waters will be collected in a collecting reservoir. It should be noted that during the cell operation period the water access and the water collecting by the infiltration control system will be averted by the mobile roof above the cell. After the cell is filled the water access will be averted by the placed covering panels and the roof slab as well as by the placed and maintained waterproofing.

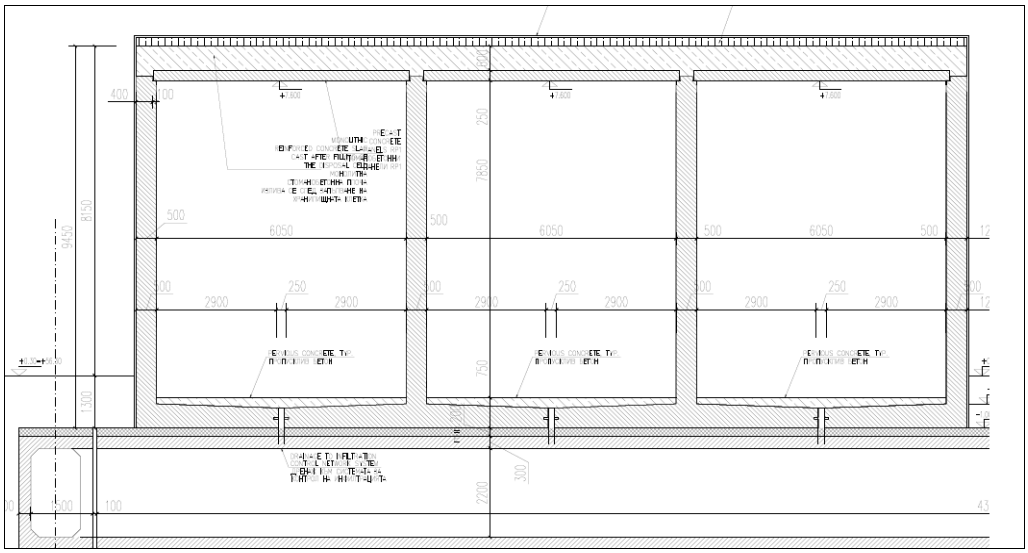

FIGURE 4.2-4 LONGITUDINAL SECTION THROUGH THE CELLS WITH THE PASSABLE DRAINAGE GALLERY

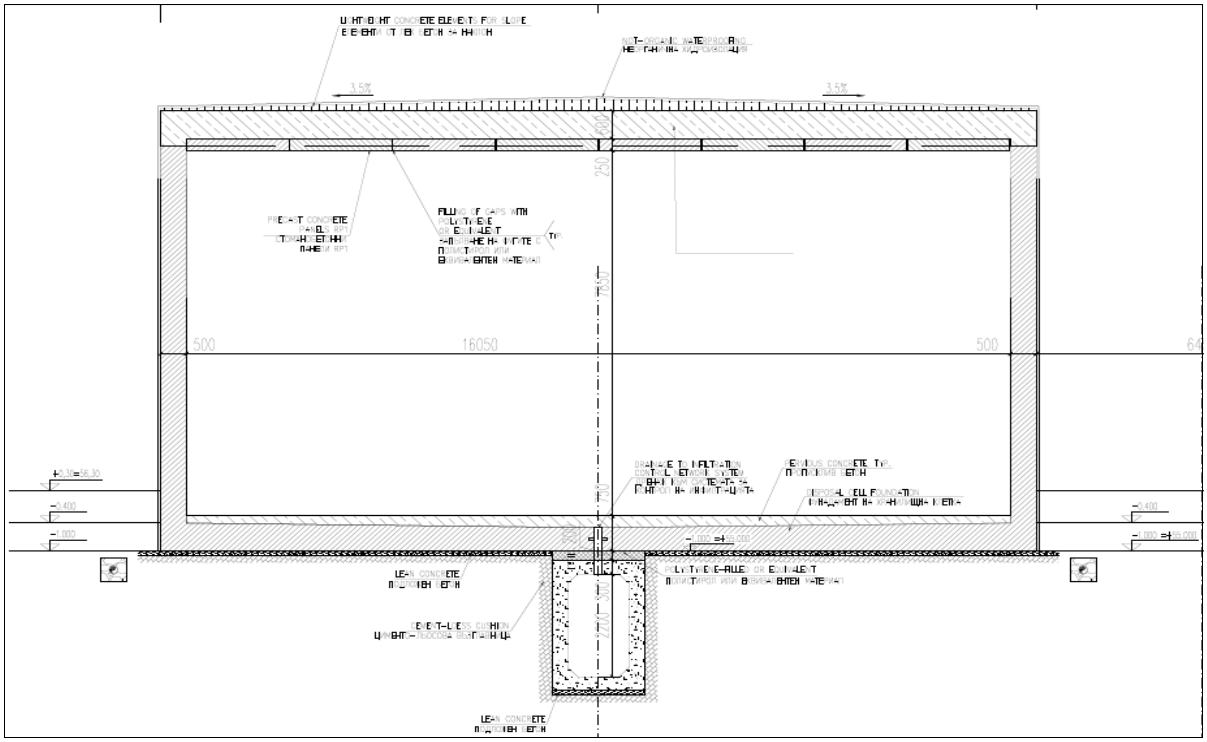

FIGURE 4.2-5 CROSS SECTION THROUGH A CELL WITH THE PASSABLE DRAINAGE GALLERY

4.2.1.1.2.2 Tunnel type repository

The construction and technological characteristics of a tunnel type of repository are based on the underground parallel tunnel constructions (galleries) with a big section and length of 1130 m the access to them will be provided by horizontal disclosing stulms with a small diameter. The tunnel constructions will be placed in the same plane which is 250 m under the terrain surface.

The repository will consist of 8 tunnel constructions for the placing of the reinforced concrete containers of RAW. The tunnel constructions for the placing of the reinforced containers will be along the whole length of Radiana site parallel to the road. The tunnel constructions service will be done by 3 perpendicular servicing galleries –transportation stulm, service gallery and a ventilation stulm. An experimental stulm will be built in addition.

The tunnels for the RAW placing will be with waterproofed multilayer reinforced concrete supporting. At the bottom part of the tunnels will be built a concrete slab with drainage ditches which are part of the water catching system - **Figure 4.2-6.**

Under the concrete slab will pass pipes for the potentially polluted waste waters. The drainage waters from the ditches and the eventually polluted waters form the pipes will be controlled separately and will be discharged in separate reservoirs located on the site where will be built the mining construction complex. The reservoirs will be supplied with sampling devices. Before the placing of the RAW the waters will be considered as clear mining waters and will be discharged into the clear water reservoir. After the placing of the RAW containers the waters will be considered as potentially polluted and will be discharged into the contaminated water reservoir.

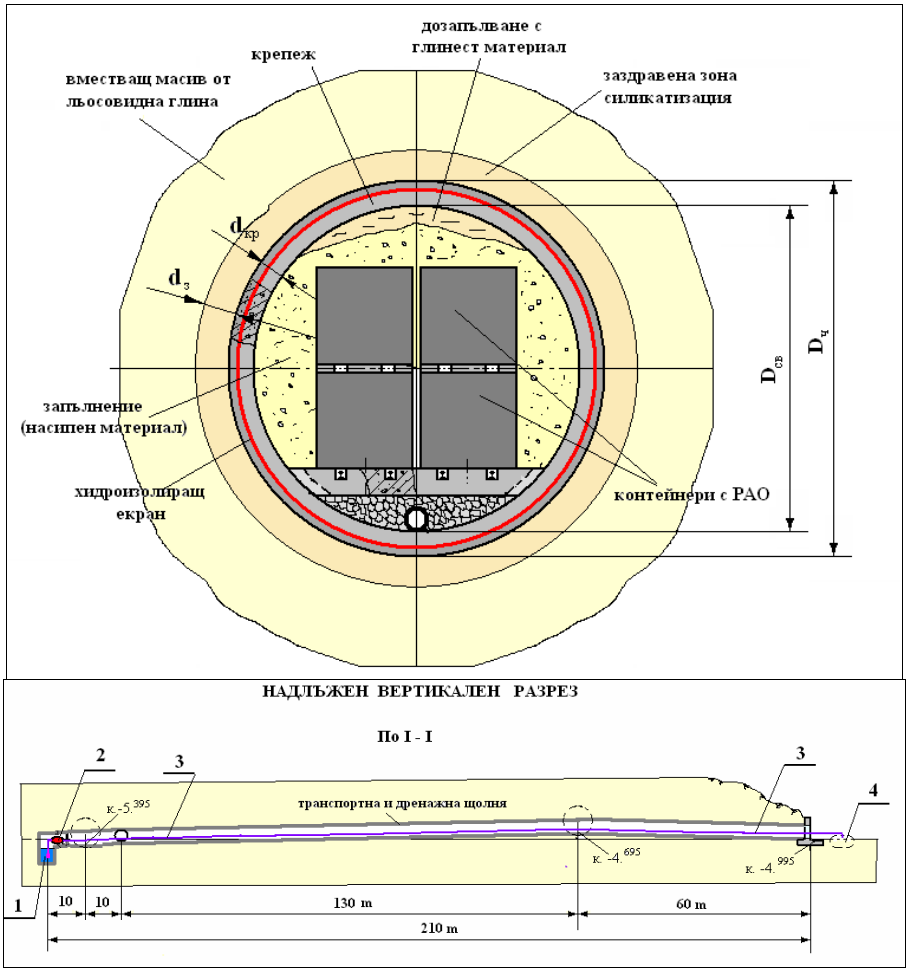

FIGURE 4.2-6 CROSS AND LONGITUDINAL SECTION OF A TUNNEL TYPE OF REPOSITORY

The waters from the pipeline system will be considered as potentially polluted and will be controlled for radioactive contamination. As it is stated in chapter 1 of the present EIAR of the NDF the radioactive waste will not be processed. In the cases when there is a radioactive contamination the waters will be transported to RAW – Kozloduy for processing. The clean waters will be directed to a rain water basin and will be controlled.

Auxiliary buildings and facilities will be built on the surface. They will be on two sites with different purposes. The so called site “Zapad” includes technological facilities for the radioactive waste management and servicing buildings and facilities which will be the same for the two radioactive waste disposal methods described in **Chapter 1.** The specific characteristic of the placement of the RAW in a tunnel technology is a charging station for the remote controlled hoists and the lamp-cabin – a charging station for the electric lamps used by the staff and the construction workers.

At the site “Iztok” will be built the mining construction complex, the mining ventilation system and the water catching system. It includes a charging station for accumulator locomotives, a workshop for the construction machinery maintenance, compressor ventilation installation, a site for reloading of the dug earth masses, a gantry crane.

During the operation period of a tunnel type repository the access of the surface waters to the tunnels and its collecting by the infiltration control system will be averted by the earth massif located above the tunnels. The underground waters level at Radiana site is under elevation 50. That is why no water flow is expected in the underground tunnels placed at elevations 50÷62 m. At the same time the tunnels will play the role of drainage and there will flow the waters form

the geological environment surrounding the tunnels. This process will end after the filling of the empty space in the tunnel with filling materials and the construction of clay stoppers on both sides of every tunnel of RAW. But since the infiltration control system will be removed before the filling operation the only way for controlling will be the total amount of water flowing into the reservoir.

4.2.1.1.2.3 4 Amounts of water used during the operation of the NDF

- ***Drinking water and water for domestic use***

The drinking water for the workers and the staff during the operation of the NDF will be used for both types of repository in accordance with the IP where:

→ The drinking water and that for domestic use for a total of 64 people (for 250 working days) - Q = 64x45 l/d/1000 = 2.88 m^3/d; Q= 720 m^3/y;

→ Only the operation and maintenance workers will have a shower (for 250 working days) - Q = 40x 60 l/d/ 1000 = 2.40 m^3/d; Q= 600 m^3/y;

Total drinking water consumption is Qcp = 2.88+2.40 = 5.28 m^3/d; Q= **1320 m^3/y**.

- ***Industrial water***

The industrial water will be used for both types of repository in accordance with the IP:

→ Water for outer washing of specialized transportation (ST) – the opportunity for circulation use of the water after local purifying in the oil-water separator and filter will be specified) - Q = 2 ST x 300 l/washing x 52 weeks =31.2 m3/y;

→ Water for deactivation with reagents of working surfaces, ST, washing laboratory equipment and others, maximum Q. = 5 m3/y.

Total water consumption after the commissioning of the plant is expected to be - Q = 1320 + 31.2 +5 = 1 356.2 m^3/y about **1 400 m^3/y**.

- **Fire water**

In accordance with the regulations for the water consumption for outdoor firefighting of the Building complex is 15.0 l/s fire water for the trench type repository. The IP provides water supply firefighting installation for indoor firefighting for all the objects of the Building complex. The fire water will be provided through a pump station located in the Technical building. According to the design solution the necessary water amounts for outdoor and indoor firefighting will be kept in an underground reinforced concrete reservoir with emergency rations 181.5m3. The reservoir is intended to serve only the needs of firefighting.

The expected **total amount of industrial water up to 1 500 m^3/y**.

4.2.1.1.2.4 Sewerage

In accordance with the IP for both types of repository the sewerage will be separated – for waste waters and rain water - **Figure 4.2-7** .

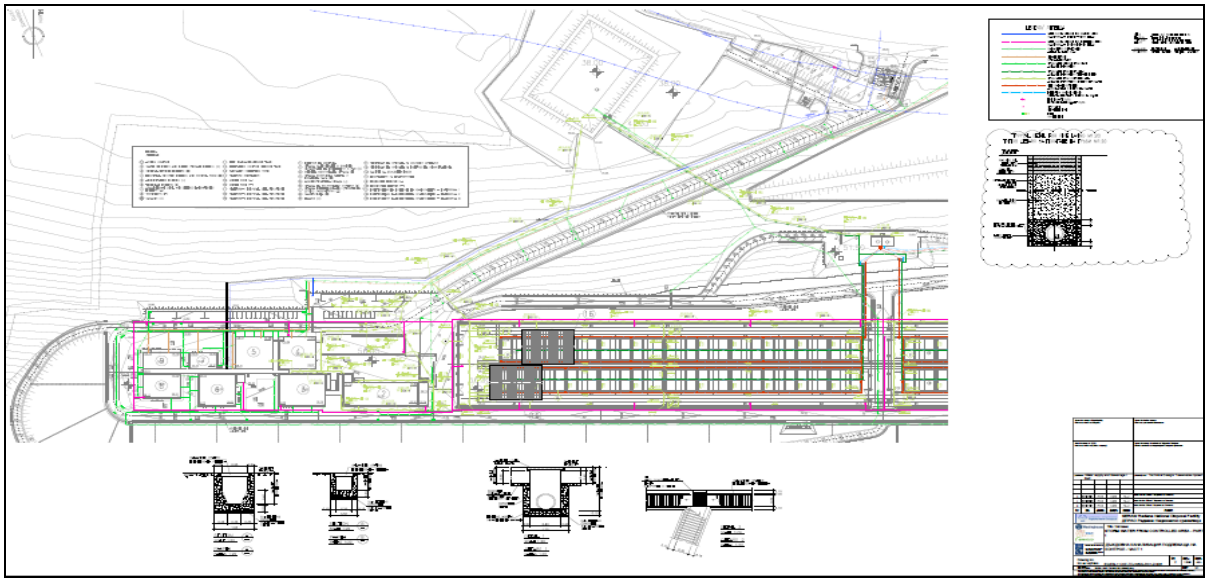

FIGURE 4.2-7 SITE SEWERAGE OF THE NDF AND RAIN DRAINS DETAILS FOR TRENCH TYPE REPOSITORY

- ***Domestic sewerage and non-radioactive domestic waste waters***

During the operation period for both types of repository will be formed domestic waste waters (non-radioactive) from 64 people staff (production staff and administration). For every building there will be sewerage. All sewerage waters form the buildings will be collected and directed to the site domestic sewerage of the repository which will be connected to the existing sewerage of Kozloduy NPP.

The waste waters during the operation period will be formed by 64 people (equal to 22 residents);

Q Average per day	6-7 m^3/d;
BOD_5	1.3 kg/d;
COD	2.6 kg/d;
Insoluble substances /SS	1.5 kg/d;
Nitrogen total/Nt	0.25 kg/d;
Phosphorus total/Pt– 0,04kg/d	0.04 kg/d.

The expected load of domestic sewerage water formed from the life cycle of the workers and employees for both types of repository is quite small compared to the load carried by the accepting sewerage of the NPP.

- ***Rain drainage and drainage***

According the IP on the site territory will be built drainage. Its diameter and route will be specifically defined at the next stage of the investment project in accordance with the approved storage technology of RAW.

At the **trench type** facility which will be underground there is no rain drainage for the protection of the tunnels from the rain. The water will freely on the surface. The rain drainage will be used to drain the site where will be located the buildings, facilities, roads and the roofs of the buildings which will be directed towards the rain water reservoir. At this type of repository the bottom concrete slab will be built in the tunnels. It will be with drainage ditches which will be

part of the waters management system. Under the concrete slab there will be pipes directing the potentially polluted water. The drainage ditch water and the potentially polluted water of the pipelines will be managed separately and will be discharged in different reservoirs located on the surface, at the so called “Iztok” site and will be equipped with sampling devices. Before the start of the placing of the radioactive waste the waters will be conditionally considered clear mining waters and will be discharged in the clean water reservoir and after being controlled will be directed towards the rain water reservoir. After placing the containers of radioactive waste the waters will be considered as potentially polluted and will be discharged into a reservoir for contaminated water. In order to make the water flow easier the galleries are slightly tilted - 5 $‰_0$. The placement of the contaminated water reservoir at “Iztok” site is contrary to the requirements of the nuclear legislation for the separations of the flows “clean materials” from the flows “radioactively contaminated or potentially radioactively contaminated” which is set by the tilt of the disposal galleries. The tilt follows the natural tilt of the layer where the tunnel is built and therefore leads towards the ventilation (drainage) stulm.

The designed pipeline system will not allow any monitoring on its condition and no defects or failures will be found during the 60-year operation period. The pipeline system will be built from standard materials providing its smooth operation during the 60-year operation period.

In order to protect the modules of the **trench type** repository gratings will be built on both sides and drainage for the surface rain and snow waters - **Figure 4.2-8**. The street flows will collect the rain water from the site roads and will be directed to a catchment area – rain water basin where its quality will be controlled. The rain water from the roofs of the servicing buildings and facilities will be discharged in the rain site drainage too. The rain water from the slopes outside the platforms will be collected through open canals located on the upper and lower terrain border. The so called deep drainage system will be built. It will collect rain water infiltrated through the surface soil (outside the disposal cells). During operation it will be directed to a deep drainage reservoir with a volume V= 100 m^3 where will be checked before running it to the rain water basin. These drainages will stop the water reaching the sunken constructions of the cells during operation. Outside the platforms the deep drainages turn into a pipe placed into an open trench parallel to the infiltrated water control network until they reach the reservoir where the water will be monitored. According to the IP the site rain drainage for this type of repository will be open concrete canals with rectangular and trapezium-shaped section and draining pipes. The rain water system will direct the flow to a catchment area – rain water basin where its quality will be controlled before running it into the reservoir. At the next designing stage the discharge location of these waters will be specified in accordance with the regulatory framework and the technical capacity of the existing infrastructure.

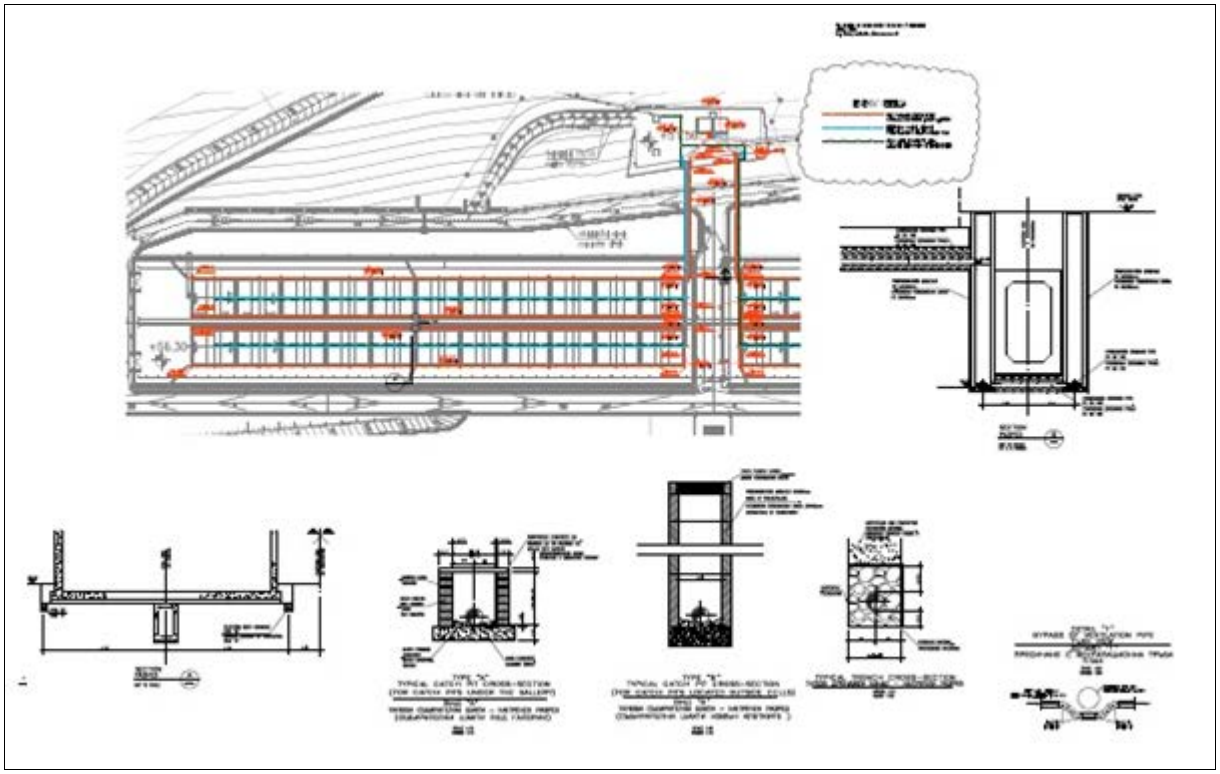

FIGURE 4.2-8 PIPE NETWORK FOR COLLECTING DEEP DRAINAGES FROM PLATFORM 1

According to the IP the maximum rainfall for 24 hours will be 90 mm (L/m²), and the maximum rainfall expected from 5-minute rain is 45 mm for an hour (L/m²h). The maximum water flow from the melting snow is considered less than the maximum water flow from the rainfall. The sections of the open drains and pipes depend on the respective catchment areas.

The rain water drainage network has determined dimensions in according to the catchment area, the accepted intensity of the rain measured - i=313 l/s/ha and the respective flow coefficient for the different types of surface for every catchment area – concrete covering, asphalt covering and green areas. The measured water amount is calculated on the basis a pick rainfall with a probability once in three years in accordance with the regulatory framework for deigning and the meteorological statistic data for the region including Radiana site. It is expected that the maximum measured water amount will be $q_{op.} = 2\ 156$ l/s. At the next designing stage the rain drainage of the repository will be specified in terms of technical parameters and water amounts in accordance with the final master plan of the site.

The rain system and the drainage will provide an opportunity for a permanent monitoring of the rain water quality and the drainage rain water eventually entering through the infiltration control system.

- ***Infiltrated water control system***

There will be such a system for both types of repository with specific characteristics determined by the respective type.

In accordance with the IP during the operation period of the **trench type** repository the potentially polluted waters will be caught by longitudinal canals (grooves) where the rails of the hoist are installed. At every 50 m the waters will be discharged into a pipeline system built under the concrete foundation where will be located the containers of radioactive waste. The pipeline system will be lead through a ventilation stulm towards a collecting reservoir located at the

ventilation stulm face. At “Iztok” site there will be a building with a contaminated water tank. The pipeline system will be built so that it can be controlled from which section of the repository can come contaminate water. It will be developed in the project at the next designing stage when be designed technical means for control of the exit of every pipeline.

The water from the pipeline system will be considered as potentially contaminated and will be checked for radioactivity contamination. As it is mentioned in **Chapter 1** of the present report there will be no processing of radioactive waste at the NDF. If there is radioactive contamination the water will be transported for processing to RAW-Kozloduy. Clear water will be directed to a clear water reservoir and after checking it to the rain water basin.

The designed pipeline system will not allow any monitoring on its condition and no defects or failures will be found during the 60-year operation period. The pipeline system will be built from standard materials providing its smooth operation during the 60-year operation period.

The monitoring of the water condition which will be used to define the condition of the radioactive waste packages. The monitoring will be of a short period only during the filling of a certain tunnel considering the IP closing conception. After the closure of a certain tunnel during the repository operation there will be monitoring only over the waters coming from the tunnel; but the condition of the packages and the engineering barriers (supporting, reinforced area) in the different tunnel compartments will not be controlled.

During the operation period of a tunnel type repository the access of the surface water to the tunnels and its collecting by the infiltration control system will be averted by the earth massif over the tunnels. The underground water level at Radiana site is under elevation 50 so no flow of underground water is expected when the tunnels are place at elevations 50÷62 m. At the same time the tunnels play the role of drainage and there will flow the water from the geological environment surrounding the tunnels. This process will end after the filling of the empty space in the tunnel with filling materials and the construction of clay stoppers on both sides of every tunnel of RAW. But since the infiltration control system will be removed before the filling operation the only way for controlling will be the total amount of water flowing into the reservoir.

The infiltration control system for the **trench type** repository will ensure the collecting and monitoring of the rain water penetrating through the permanent protective covering of the disposal cells as well as waters penetrated as a result form incidents or failures and has contacted the packages of radioactive waste.

The infiltration control network will be separate from the rain water collecting network.

During operation this system will collect water which might eventually appear in the cells and it will be monitored.

The infiltrated water network will have the following function:

- ✓ To collect the infiltrated waters in the disposal cells and to direct them towards the controlling reservoir.
- ✓ Do provide a surveillance method of the engineering barriers efficiency through:
  - → Measuring the infiltrated waters by checking the water density of every closing slab of the disposal cells (i.e. the barrier efficiency at a filled and closed disposal cell) as a check of the water penetration prevention – second barrier;
  - → Measuring the concentration of the water volume activity as a check of the package of RAW efficiency while retaining the radionuclides – first barrier.

This system is mainly connected to the machineries safety in radiological aspect.

According to the IP the infiltrated water control system will be operating during the phases of construction, operation and industrial control for 300 years and it will require minmum maintenance. It will allow an easy opening of the infiltrated water in the storage cells. In order to serve their functions the system pipelines will be places in an accessible gallery, called a gallery of the infiltrated water control system.

The collected waste waters in the collecting reservoir will be checked for radioactivity before being released from the reservoir and directed towards the rain water basin. The waste water activity will have to be under the fixed limits. In case the water is over the limits it will be transported outside the object site in order to be processed at RAW-Kozloduy.

The infiltrated water control network has the **following characteristics:**

- ✓ The infiltrated water control network pipelines will be installed in underground accessible galleries with unbroken tilt towards the controlling reservoir for infiltrated water. The gravitation will provide the flowing of the controlled water.
- ✓ Between the galleries and the end controlling reservoir there will be a section of a servicing reinforced concrete rectangular canal. It will provide the servicing access when necessary.
- ✓ The controlling reservoir volume is 100m^3, of the infiltrated water network and will be located at the system lowest point.
- ✓ In the underground galleries for the infiltrated water control parallel to the pipes of the infiltrated water control network will be traced pipelines for collecting rain water. During the pre-operation period of the cells their drainages are connected to this pipeline for collecting rain water. The transfer of the pipeline from a cell to the infiltrated water control water network will be done shortly before the filling of the cell with packages of RAW.

⇒ **Before the cell is being put into operation**

Before the beginning of the filling of the disposal cells with packages of RAW they are covered with ready-made concrete panels, the so called covering panels which reduce the amount of rain water penetrating into the cells. The water collected at the drainage of the bottom slab of the disposal cells which have no contact with radioactive waste.

The cell drainages before being put into operation are connected to a rain water pipeline traced parallel to the pipes of the infiltrated water control network. This is a temporary connection. Before every disposal cell being put into operation its drainage is transferred from the temporary rain water pipe to the pipe of the infiltrated water control system.

The pipeline collecting rainwater directs the water to a basin collecting g rain water.

⇒ **Cells being filled with packages of RAW**

The cell drainage will be connected to the pipes of the infiltrated water control network.

The cell will be protected from rain water with a mobile roof and therefore no water collected by the infiltrated water control network will enter it.

⇒ **Cell during closure**

The mobile roof is moved at a position above the next disposal cell when the cell is filled with packages; the upper reinforced concrete slab is constructed and covered with waterproofing coating.

Possible source of water collected by the infiltrated water control network:

→ The water from capillary effects and a result from the condensation and evaporation processes inside the cell on its concrete surface and the packages of RAW. These effects are a result of the temperature differences between the cell walls and the walls of the packages of RAW. As a visible result water might appear in the cells. It will be collected by the infiltrated water control system;

→ Small amounts of (if there are any) infiltrated water might appear as a result from rainfalls. The temporary waterproofed covering will be inspected. It is easily accessible and can be repaired during the operation phase of the facility. Large amounts of the rain water falling above the cell will be finally directed towards the rain water collecting system.

➢ ***Rainwater collection pond***

As per the IP, the rainwater pond will be a structure intended for both types of repositories. It will collect the rain runoff over a period of 24 hours from platforms 1, 2, and 3, including from the roof over the cells, mobile roofs, unencased and empty cells, onsite roadways and the site ringroad, as well as water from the infiltration control system and the deep drainage system for collection of filtered surface water at trench type repositories, and the rainfall collection system of service buildings and facilities roofs, the clean drainwater tank, and site roadway ditches at tunnel type repositories.

The rainwater collection pond will be of open type, where water from different sources will be collected and tested before being discharged.

The rainwater collection pond will be a reinforced concrete structure shaped like a truncated pyramid situated within the site. As per the IP, the rainwater collection pond will be 3.33m deep, and its walls will have an incline of 1:3 or 33,0%. The dimensions of the bottom are 30x50m, and at the top the dimensions are 50x70m. The maximum depth of the water is 2.50m. The maximum volume of the collected rainwater will be = 5 530 m 3.

The rainwater collection pond will have one overflow spillway at 2.50 m from the bottom. In addition, at the bottom, an outfall sewer is to be provided with a stainless steel plug valve, situated in a reinforced concrete shaft, as shown in the following Figure 4.2 9. When the valve is open, the water collected in the pond is directed to the main stormwater sewer.

The discharge pipe is characterized by Ø400mm, inclination I = 1.0%, and maximum water flow quantity Q = 260.0 l/s, at which the pond can be completely drained on average within 6.0 h.

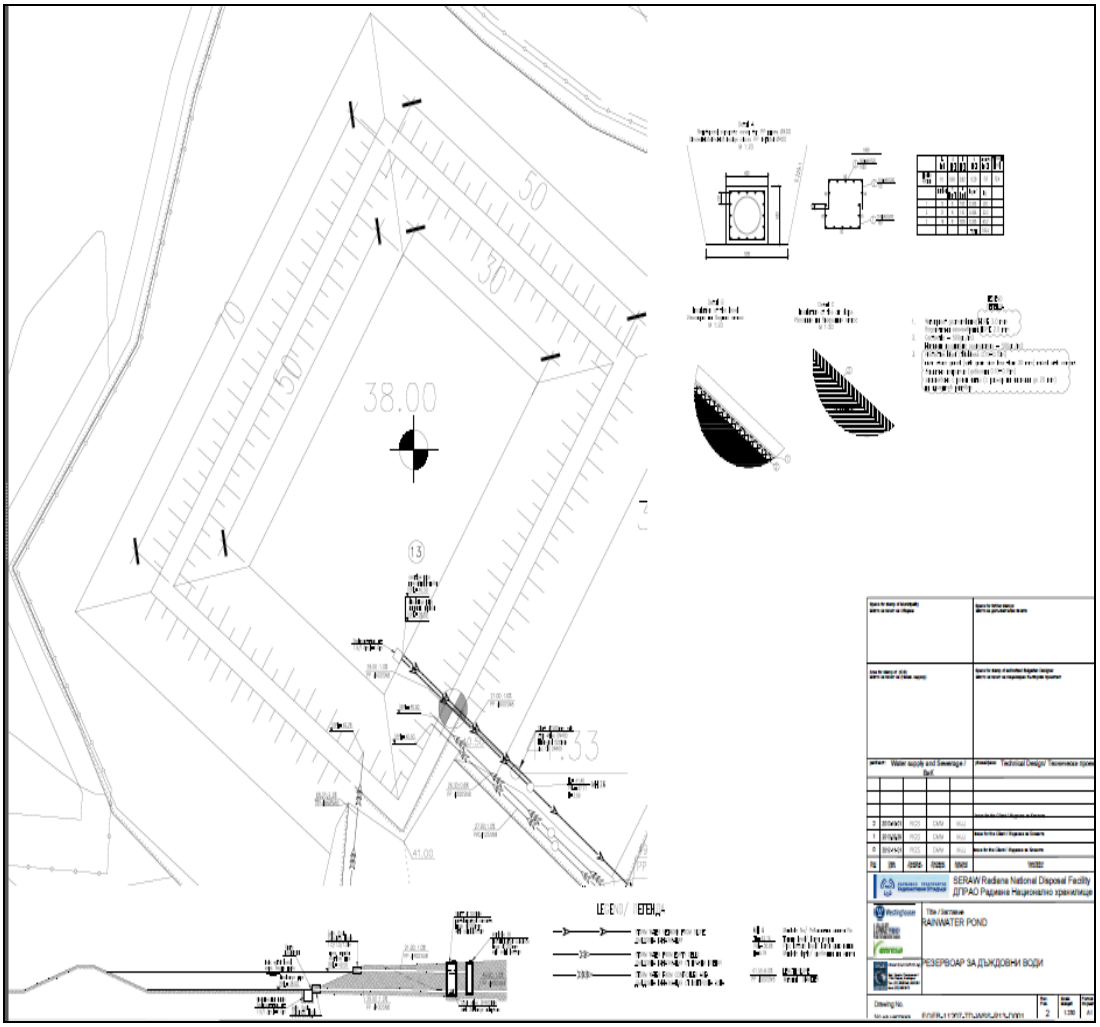

FIGURE 4.2-9 RAINWATER COLLECTION POND

4.2.1.1.2.5 Conclusions regarding the anticipated non-radioactive impact during operation

The environmental impact on surface water during normal operation is identical for both trench and tunnel type repositories.

The quantity of sanitary waste water from workers and employees is negigable in relation to the collection – combined sewer system of Kozloduy NPP for both types of repositories.

Rainwater is to be collected by a stormwater sewer system suitable for the respective type of repository. A drainage sysem for infiltrated surface water is to be constructed, as well as an infiltrate control system. The infiltrate control system of the trench type repository provides better water quality control during operation and site construction works, which is a significant advantage.

The water will go through a retention basin which is intended to hold the runoff at maximum rainfall, and following a control test this is discharged into the receiver. The place of discharge will be specified in the next design phase as per the regulatory framework. This basin allows for raintwater quality control prior to its discharge.

The analysis of repository operations indicates that the anticipated impact on surface water may be as follows:

Impact scope – local.

Impact type - direct, negative, very low impact level, limited if reguations and safety measures are observed.

Impact characteristics – continuous, long-term, no cumulative effect, regional sensitivity, irreversible, but negligibly weak.

There is no expected cross-border non-radioactive impact on surface waters.

4.2.1.1.3 IN EMERGENCY SITUATIONS

Emergency situations may arise as a result of onsite events, events caused by human activity outside the site, natural events and/or processes.

There are no natural water basins on the site. There are various emergency situations envisioned within the scope of the investment proposal which are related to the constructed water supply and sewarage system, for example:

- Collapse / settlement of the foundatons and failure of the sanitary and/or stormwater sewer. This impact will be negative, direct, low-level within the site, reversible;
- Infiltration of relatively little quantities of sanitary and rain water, containing undissolved substances in case of poor construction works quality. Negative, indirect, secondary, very low-level within the site;
- Outside flood.

There is no expected impact resulting from:

- Failure of the sanitary and/or rainwater sewers as there will be measures taken to strengthen the foundations and the pipes will be suitable for the respective conditions, and placed within a concrete tunnel in accordance with construction requirements;
- Infiltration of sanitary and rain water as the project construction technology to be implemented for these utilities does not allow for such;
- Not possible as there are no bodies of water within the site. The site is located at the second non-flood terrace of the Danube at a significantly higher altitude than even the highest river level forseeable in case of failure of the Iron Gates dam.

4.2.1.1.4 AFTER CLOSURE AND DURING INSTITUTIONAL CONTROL

In accordance with the provisions of the applicable nuclear energy legislation[12,13] the radioactive waste repository is closed as per the closure design, the closure procedure, the safety assessment, which are to be approved by the Nuclear Regulatory Agency following an additional safety assessment upon closure, as well as the development of post-operational monitoring programmes – Figure 4.2 10. In accordance with the Investment Proposal, closure activities will be performed within 15 years. Followed by a 300-year institutional control period.

[12] Regulation on Safety of Radioactive Waste Management, SG. 76 of 30th August 2013.

[13] Regulation on the procedure for issuing licenses and permits for safe use of nuclear energy, promugulated in SG 41/18.05.2004, amended in SG 76/5.10.2012.

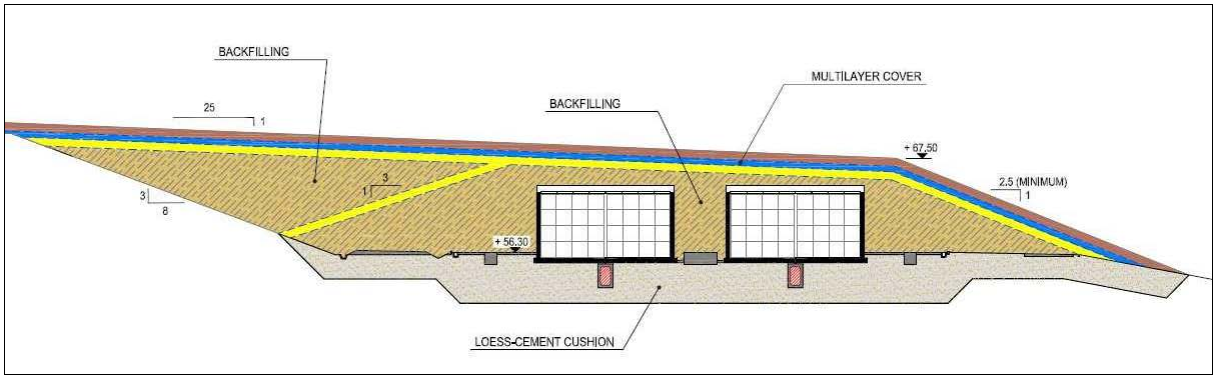

FIGURE 4.2-10 TRENCH TYPE REPOSITORY AFTER THE CLOSURE PERIOD

The NDF closure process and the respective requirements are described in detail in Chapter 1 of the EIAR. This section provides information on the specifics related to the closure of both types of repositories.

As per the IP, the trench type repository will be closed in stages by filling and sealing the tunnels during operation, dismounting the respective tunnel drains. Tunnels will be filled, after which the quipment will be dismounted from the ventilation and transport galleries. Galleries will be backfilled. At the entrance of each gallery clay seals will be constructed with the last reinforced concrete barrier placed at the gallery entrance.

The most important aspect for the water component is the filling of the space between module walls and the radioactive waste. This is to be done in a manner which guarantees that all gaps are filled, as any spaces would in time be filled with water seeping through the walls.

Backfilling is to be carried out in two stages. First, the entire space is filled using the primary backfill material. A certain period passes in order to utilize the processes of self-packing and settling, after which the remaining space is filled with clay material.

Water which may find its way into the repository or such generated by the dewatering of the backfill and packing materials will be lead to the ventilation gallery face where there is a concrete tank of sufficient capacity, containing an absorbant.

As per the IP, the filling design has been tested in standard mining galleries, but has not been applied to long tunnels, containing radioactive waste. The next project phase will clarify the issues related to the additional filling of free spaces with clay material following the self-packing and settling of the primary backfill material, and design solutions will be proposed to this end.

In view of the specifics of the facility, control over rainfall runoff passing through the tunnels housing radioactive waste is impossible which does not allow for the drawing of direct conclusions with regard to the condition of underground galleries.

The proposed design solution is a new technology which has never before been used for the disposal of radioactive waste. All tunnel-type repositories throughtout the world have been constructed in hard rock at a significantly greater depth using different structural designs.

As per the IP, the closure of the cells in the trench type repository will include the filling with gravel of the minimal free space between the arranged RCCs, placing roof panels on top, constructing a roof slab and waterproofing it. After the cell is filled with RAW containers, it is filled with gravel, premade concrete panels are placed on top of its walls and it is closed/sealed with a waterproof roof slab. This will be carried out under the mobile roof which protects the containers and the closure operation from any rain.

After the operating period of the repository of 60 years, it is to be closed completely. The final closure of a trench-type repository is based on a multi-layered encasement ensuring low filtration and infiltration rates – significantly lower than those in the natural environment, thus minimizing any possibility of humidity reaching the repository. Figure 4.2 11 shows a diagram of the multi-layered encasement as per the IP.

In addition to the multi-layer encasement, during the closure of the repository, a drainage system is constructed at the base of the site's south slope, dewatering the slope without letting the water reach the waterproof clay bed. The system utilizes a drainage ditch filled with clean gravel covered with suitable materials ensuring its structural integrity.

The protective multi-layer encasement will consist of the following layers as shown in the figure:

(1) Topsoil with shallow-root vegetation – grass. The layer is 10 cm thick. Its hydraulic conductivity is 10^{-2} m/s;

(2) Antierosion layer of gravelly clay with a thickness of 40 cm and hydraulic conductivity of 10^{-2} m/s, laid in layers;

(3) Compacted loess base with a thickness of 50 cm and hydraulic conductivity of 10^{-7} m/s, laid in layers;

(4) Protective layer of gravel and boulders, 40 cm thick with hydraulic conductivity of 10^{-1} m/s, designed to provide protection from mechanical damage and to direct any water into the drainage system;

(5) Geotextile 1 cm in thickness with hydraulic conductivity of $10^{-4} \div 10^{-3}$ m/s, physically separating the upper and lower drainage layers;

Main drainage layer, directing the moisture that reaches it to the drainage system. It consists of the following three layers, each 10 cm in thickness:

(6) Layer of sand with hydraulic conductivity of 10^{-3} m/s;

(7) Layer of coarse sand or fine gravel with hydraulic conductivity of 10^{-2}m/s;

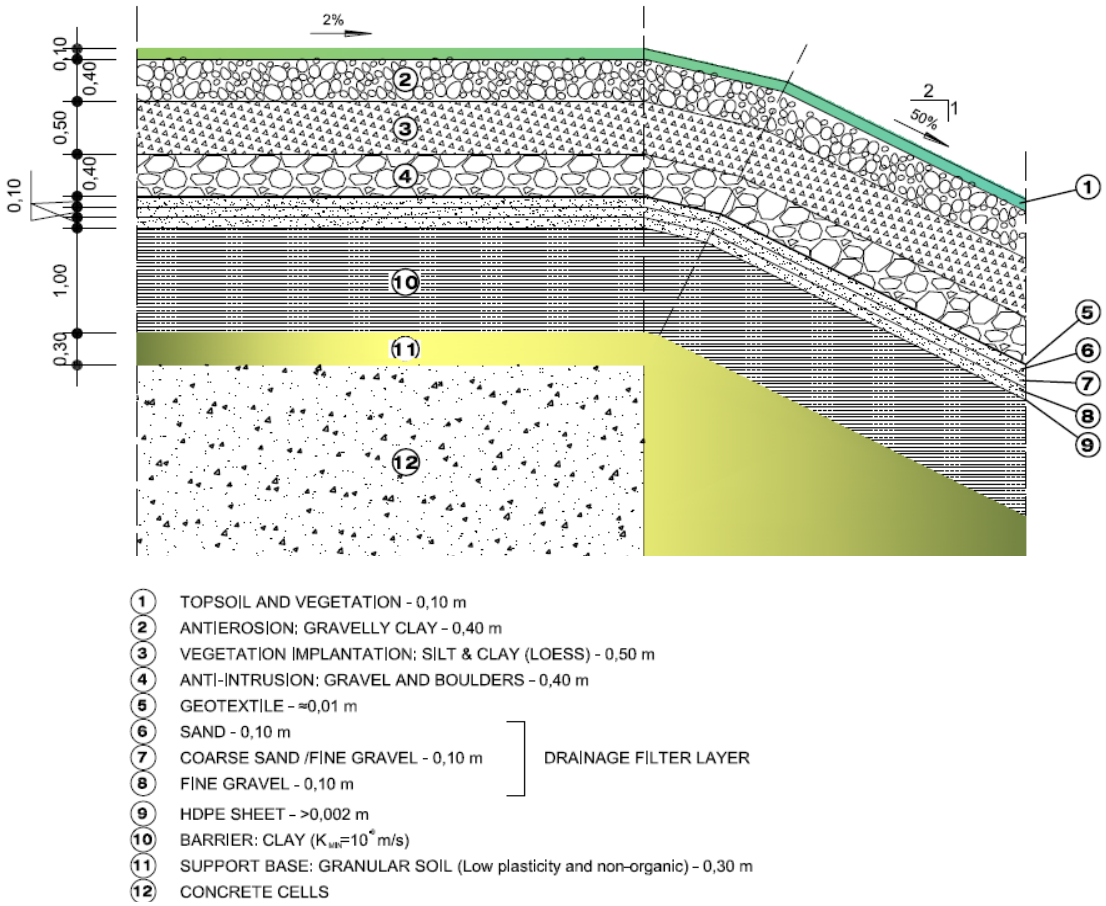

FIGURE 4.2-11 PROTECTIVE MULTI-LAYER ENCASEMENT FOR A TRENCH TYPE REPOSITORY

(8) Layer of fine gravel with hydraulic conductivity of 10-1 m/s

(9) Waterproof layer of high density polyethylene sheets or betonite clay composite with a thickness of 0.2 cm and hydraulic conductivity of 10-11 m/s, dividing the upper primary drainage filter layer from the lower sealing clay layer;

(10) Main waterbed of the waterproof clay with a thickness of 100 cm and hydraulic conductivity of 10-9 m/s

(11) Support base consisting of low plasticity materials with a thickness of 30 cm and hydraulic conductivity of 10-5 m/s. The base is entirely sandy-clay with fine gravel;

(12) Concrete cell with hydraulic conductivity of 10^{-8} m/s.

The drainage layers described above take the infiltration water to ditches along the north boundary of the site, which are subject to monitoring and control.

The designed protective multi-layer encasement guarantees a very low filtration rate – no higher than 10-9 m/s and very low infiltration rate – less than 1.5 L/m2 per year.

The construction activities related to the multi-layer protective encasement and the backfilling will be audited along with the infiltrate control system and the galleries designed for a service life of 375 years.

This ensures that the radioactive waste will be safely isolated from people and the environment, following the closure of the trench type repository. Rainwater will be drained way from the multi-layer protective encasement. Only very small quantities may infiltrate through the protective encasement. Complete control over the repository is ensured. Even if some small

amount of moisture reaches the repository, this would be captured by the infiltrate control system.

During the institutional control period, a radiation monitoring program and an environmental monitoring program will be implemented. The observed parameters will be chosen carefully without placing a burden on future generations.

The goals of the monitoring will be to ensure early detection of systems failure, which may cause unacceptable effects on people and the environment. What is more, it may be used to predict the behaviour of the encasement system.

The IP provides for complete control over the condition of encased radioactive waste and the repository structure using the abovementioned infiltration control system, which is to be designed for a service life of 375 years. Trench type repositories do not require any repair works to infiltration control galleries other than the maintenance of the waterproof encasement. The duct system for any infiltrated water as described above will be constructed using standard elements, allowing for easy maintenance and replacement, if necessary.

The condition of the multi-layer encasement will be controlled visually and using the geodetic control and drainage control methods, which will be part thereof.

The technology for disposal of radioactive waste in trench type repositories is an up-to-date technology which is well-known and widely used. Contemporary trench type repositories have been implemented into a number of developed countries with well-developed nuclear energetics.

The non-radiation monitoring of the facility, which is related to surface waters, will include the state of the multi barrier protective cover, the drainage system and the quality of water in it, as well as periodical inspection of the galleries of the infiltrate control network, the meteorological conditions, hydrology and hydrogeology, etc. The monitoring programme can be modified if necessary in case of unexpected observations or changes in the legislative requirements. The final monitoring will be elaborated during the stage of closure of the facility and the final report on its safety analysis.

- ***Quantities of water used during the NDF closure***

Number of the workers and personnel during closure – The personnel, required during the NDF closure, is expected to be approximately 40 people.

Water will be used for *drinking and household needs* of the workers and the servicing personnel during the NDF *closure*.

→ Potable and household water for about 40 people (for 250 work days) - Q = 40x 110 l/d/ 1000 = 4.4 m^3/d; Q= 1100 m^3/y;

→ Water for technological purposes:

- Water for cleaning of special transport vehicles (STV). It will be specified the possibility to use reclaim water after local cleansing in a mud and oil catcher and a filter). Q = 1500 m^3/y;
- Water for fire-precaution purposes 8 l/s.

- ***Quantities of water used during the period of institutional control after the NDF closure***

Water will be used for *drinking and household needs* of the workers and the servicing personnel during this period for 15 people (for 250 working days) - Q = 15 x 110 l/d/ 1000 = 1.65 m^3/d Q= 420 m^3/y

- Water for technological purposes up to Q = 5 m^3/y
- Water for fire-precaution purposes 6 l/s.

4.2.1.1.5 NON-RADIOACTIVE WASTE WATER

4.2.1.1.5.1 During the NDF Closure

During the NDF closure will be generated household wastewater from 40 workers with the following pollution load**:**

The pollution load during the period of closure will be generated by 40 people (14 equivalent inhabitants):

Q av. /day	4.0 m^3/d;
BOD_5	0.8 kg/d
COD	1.6 kg/d;
Indissoluble substances /SS	1.0 kg/d;
Nitrogen/Nt	0.15 kg/d;
Phosphorus/Pt	0.03 kg/d.

Rain surface waters from the site will be eliminated in accordance with the legal requirements.

4.2.1.1.5.2 During the Period of Institutional Control

Household wastewater will be generated by 15 workers.

The pollution load during the operation period is generated by 15 people (5 equivalent inhabitants):

Q av. /day	1.5 m^3/d;
BOD_5	0.3 kg/d
COD	0.6 kg/d;
Indissoluble substances /SS	0.4 kg/d;
Nitrogen/ Nt	0.06 kg/d;
Phosphorus /Pt– 0.04kg/d	0.014 kg/d.

It can be prognosticated that the pollution of household and faeces wastewater will be significantly reduced compared to the period of operation. Rainwater will flow freely away on the surface.

Scope of the impact – local.

Type of the impact – direct, negative, with low level of impact.

Nature of the impact – continuous, long-term, reversible after closure.

4.2.1.1.5.3 In case of emergency situations in non-radiation aspect

It expected:

- infiltration of relatively small volumes of household and faeces water and rain water, which contain indissoluble substances;
- external flood.

It is not expected:

- collapse of the earth foundation;
- it is not possible because water bodies do not pass through the site. The site is located on the second flood terrace of the Danube River, and it is at a significantly higher level than it.

The necessary measures are foreseen during the design and construction of the water and sewage infrastructure, the different facilities and communications. A quality protection of the water ecosystem and prevention of health risk for the workers and the population in the region is ensured in case of strict control and effective water management of the various stages of the NDF implementation (design, construction, maintenance of the equipment during operation, and closure), respectively prevention of pollution exceeding the allowable limits set by the legal requirements.

4.2.1.2 GROUND WATER IN RADIATION ASPECT

4.2.1.2.1 DURING CONSTRUCTION

The lack of radioactive sources during the construction *excludes the radiation impact on the surface waters.*

4.2.1.2.2 DURING OPERATION

During the NDF operation the lack of distribution of radioactive substances and protection of the environment, including the surface waters, is ensured in the design by:

→ the package of the conditioned RAW and the rest of the engineering barriers, which maintain their integrity and the design characteristics, regardless of the repository type – trench or tunnel;

→ the construction of the cells with RAW with a loess-cement cushion below them for the trench type of repository and the fixation of the mine constructions for tunnel type of repository, which are practically waterproof and ensured against radiation leaks;

→ the constructed drainage systems in the storage cells for RAW containers for trench type of repository and in underground constructions for tunnel type of repository, as well as in the reservoirs for collection of water from drainages located at the areas for storage and management of radioactive waste in the Main servicing building, in the Building for acceptance and temporary storage of packages with RAW, etc.

The presented information allows to conclude that during the NDF operation for both trench and tunnel type of repository, is not expected a change of the radiation indications of surface waters beyond the background levels, which are typical for the region.

Currently, it is implemented a Programme for pre-operation radiological monitoring of the foreseen zones and points of the surface waters in the vicinity of the Radiana site (№ ТК.Д-142-D3/2012, НХ-ПЕМ-ПМ-001/01) in order to analyse the radioecological status of the site and the environment, and to establish conformity with the normative base in the field, which will continue during the operation period after it is revised.

4.2.1.2.3 DURING CLOSURE

Upon normal evolutionally scenario of development during the NDF closure, it is not expected a change in the radiation indicators of the surface waters beyond the background levels, which are typical of the region, because the loss of functionality and the amortization of the packages with RAW, for the engineering barriers and concrete constructions, exclude leakages and migration of

radionuclides in the geosphere, respectively in the ground waters and then to the water receiving body the Danube River

To continue the implementation of the programme for pre-operation radiological monitoring of the foreseen zones and points of the surface waters in the vicinity of the Radiana site (№ ТК.Д-142-D3/2012, НХ-ПЕМ-ПМ-001/01).	**C**	Analysis of the radioecological status of the surface waters and to establish conformity with the normative base in the field.
To be elaborated and implemented a Programme for operational radiological monitoring of the surface waters from the NDF.	O and Cl	Control over the radioecological status of rain and waste waters at the site, which are discharched in the drainage collector and the Danube River, and establishment of conformity with the normative base in the field.

After the NDF closure, the Programme for operational radiological monitoring of the NDF should be revised and updated, and its implementation continues for a certain period of time to prove lack of impact upon implementation of the necessary measures for prevention of contamination and safety of the population in the area.

4.2.1.2.4 CONCLUSION

Changes in the quality contents of the water receiving body – the Danube River, are not expected in radiation aspect during the construction, operation and closure of the NDF. This applies both to the stage of construction and to the operation period of the repository. The package of the conditioned RAW (RCCs) and the other engineering barriers of the NDF guarantee non-distribution of radioactive substances and protection of the environment from radioactive contamination. The quality of the water receiving body – the Danube River, and of the other water bodies in the region will not be changed, and will maintain their typical background values.

The implementation of IP for Radiana NDF is not a source of radiation contamination of surface waters both for „tunnel“ and „trench“ type of repository.

4.2.2 GROUND WATERS

The analysis of the geological and lithographic structure and the hydro-geological conditions shows that a receptor of an impact from the implementation of the investment proposal is the water saturated zone in the geological section of the Radiana site and its vicinity, which is a common ground filtration flow, formed by the hydraulically connected parts of the ground water bodies “Porous groundwater in Neogene - Lom-Pleven depression” identified by code BG1G00000N2034, Porous groundwater in Quaternary - between the rivers of Lom and Iskar” identified by code BG1G0000Qpl023 and “Porous waters in the Quaternary – Kozloduy lowlands” identified by code BG1G0000Qal005. The ground flow is directed from the south-southwest to the north-northeast towards the non-flood and the flood terrace of the Danube River, i.e. from the ground water bodies BG1G0000Qpl023 and BG1G00000N2034 to the SWB BG1G0000Qal005. Its feeding is south from the site and above (through infiltration of atmospheric precipitation through the unsaturated zone from Aeolian deposits in its boundaries). The drainage is carried out northeast from the site through the construction water intake facilities (shaft and pipe wells) and the main drainage canal, through which all waters coming from the

south into the Kozloduy valley, i.e. in the low floor terrace of the Danube River, are lead (with pumping) in the Danube River.

The potential impacts during the different stages of implementation of the investment proposal can be only generated by activities, which are directly or indirectly related to the receptor.

4.2.2.1 HYDROLOGICAL MODEL

The model is a simulation of the structure of the impact receptor – the ground flow in the vicinity of the site, and the simulation takes into account the specific hydro-geological situation and all external impacts, including the hydraulic conditions for infiltration of pollutants under the bottom of the NDF.

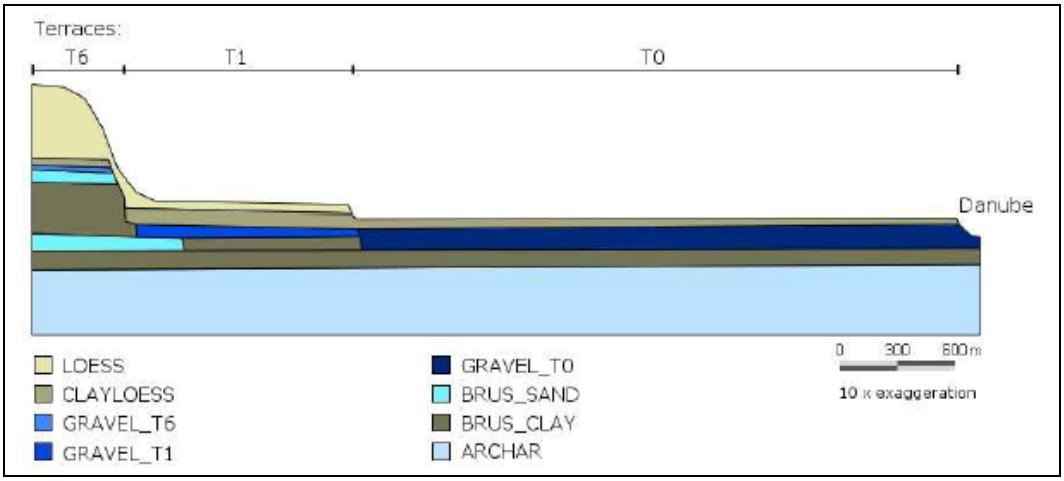

FIGURE 4.2-12 CONCEPTUAL MODEL OF THE HYDROGEOLOGICAL UNITS AT THE RADIANA SITE ACCORDING TO ISAR REV.2, ELABORATED IN ACCORDANCE WITH PROFILE I - I (M_{BEP} 1: 1000 / M_{XOP} 1:10 000)

It is constructed through a two-dimensional model with programme code FEFLOW 6.0. eight hydro-geological units are distinguished in it, and they are shown in **Figure 4.2-12**: loess complex, clay loess and sand clay from the alluvial terraces, gravel with sand-clay filler from alluvial terrace T_6, gravel with sand filler from alluvial terrace T_1, gravel from flood terrace T_0, sand from the Brusar formation, clay from the Brusar formation and sand from the Archar formation.

The input parameters for filtration coefficient and porosity are shown in **Table 4.2-1Table 4.2-1**.

TABLE 4.2-1 CONDUCTIVITY AND POROSITY OF THE HYDRO-GEOLOGICAL UNITS

Hydro-geological units	**Loess**	**Clay loess and sand clay**	**Gravel from terrace T_6**	**Gravel and sand from terrace T_1**	**Gravel from terrace T_0**	**Sand from the Brusar formation**	**Clay from the Brusar formation**	**Sand from the Archar formation**
Filtration coefficient, m/d	0.24	0.025	7.6	20	20	1.0	0.002	0.15

Porosity	0.49	0.41	0.32	0.30	0.30	0.36	0.38	0.37

The prognosis is made under the presumption that the ground flow is formed south to the site by the Danube River in the output conditions, established by the elaborated filtration model of the water balance at the Radiana site in the Interim report on the safety analysis (IRSA) [14], as follows: lateral feeding of the ground flow from the south, vertical feeding from infiltration of rain waters and drainage of the ground flow to the north of the site at terrace T_1, which is estimated at 15.5 l/s.

The structure of the ground flow is modelled under two boundary conditions: discharge in a drainage channel in the base of terrace T_1 and discharge without drainage channel (in the Danube River). The infiltration feeding is assumed to be $1.7631x10^{-10}$ m/s, which corresponds to about 10% of the average annual value of precipitation.

Boundary conditions of the model with a drainage channel are shown in**Figure 4.2-13.**

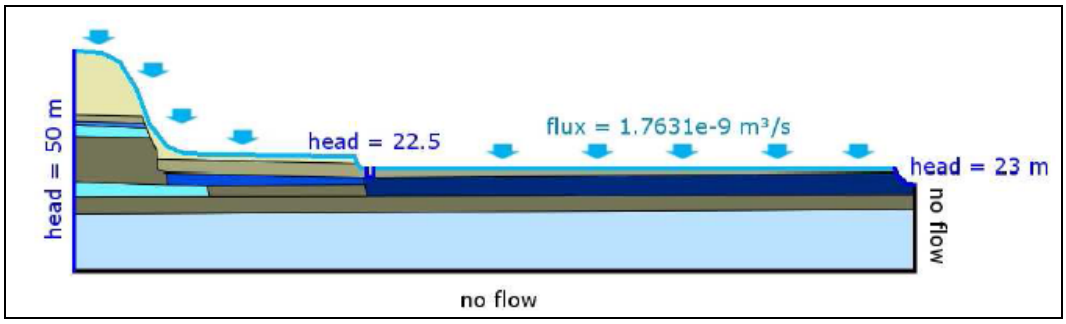

FIGURE 4.2-13 BOUNDARY CONDITIONS OF THE MODEL WITH A DRAINAGE CHANNEL (NATURAL CONDITIONS)

The direction of the flow and the distribution of filtration speeds during discharge in the drainage channel are illustrated in **Figure 4.2-14.**

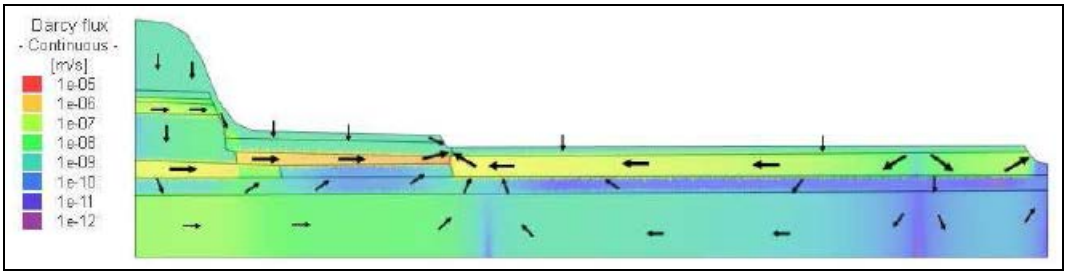

FIGURE 4.2-14 SPEED DISTRIBUTION AND FLOW DIRECTION IN THE MODEL WITH A DRAINAGE CHANNEL

The modelling results in the balance of the received and drained water amounts, and it is shown in **Table 4.2-2.**

TABLE 4.2-2 INFLUX AND FLOW-OFF AT BOUNDARY CONDITION WITH A DRAINAGE CHANNEL

Boundary	Influx m^3/d	Flow-off m^3/d
Area infiltration	0.735	-
South boundary	0.480	0.002
Watercourse of the Danube River	-	0.089

[14] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013г.

Drainage channel	-	1.124
Total	1.215	1.215

The boundary conditions of the model without drainage channel are shown in **Figure 4.2-15**.

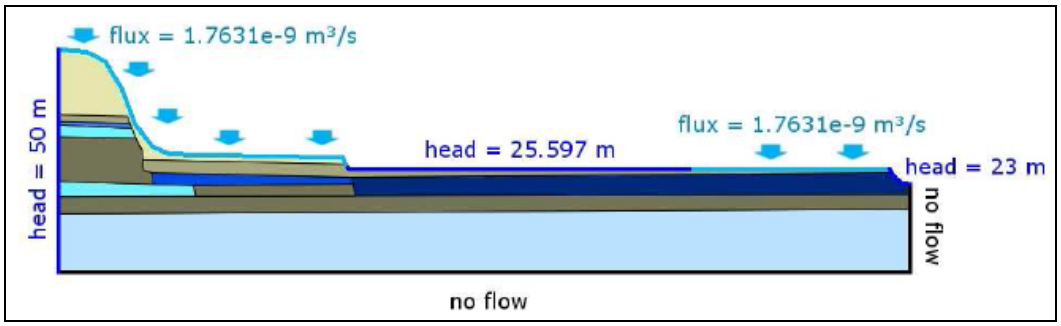

FIGURE 4.2-15 BOUNDARY CONDITIONS OF THE MODEL WITHOUT A DRAINAGE CHANNEL (POTENTIAL FUTURE SITUATION)

The direction of the flow and the distribution of filtration speeds during discharge in the Danube River are shown in **Figure 4.2-16**.

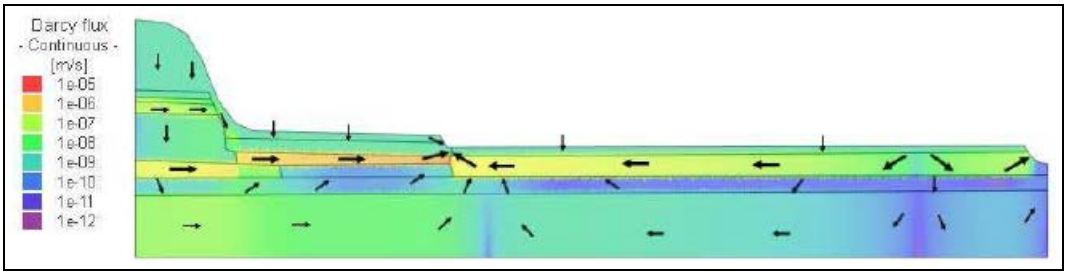

FIGURE 4.2-16 SPEED DISTRIBUTION AND FLOW DIRECTION IN THE MODEL WITHOUT A DRAINAGE CHANNEL

The modelling results in the balance of the received and drained water amounts, and it is shown in**Table 4.2-3.**

TABLE 4.2-3 INFLUX AND FLOW-OFF AT BOUNDARY CONDITION WITHOUT A DRAINAGE CHANNEL

Boundary	Influx m^3/d	Flow-off m^3/d
Area infiltration	0.402	-
South boundary	0.489	0.0004
Watercourse of the Danube River	-	0.324
Swamping in T_0	0.176	0.742
Total	1.067	1.0664

In conclusion, it should be noted that the results from the model with a drainage channel, which imitates the natural conditions without anthropogenic impact, show good correspondence to the measured water levels.

The potential impacts during the different implementation stages of the investment proposal can only be generated by activities, which are directly or indirectly related to the impact receptor (the ground flow), whose structure is simulated through the described hydro-geological model.

4.2.2.1.1 DURING CONSTRUCTION

Trench type of repository

For the NDF construction is adopted an approach for stage construction, which consists of three phases. First will be built the auxiliary facilities and the first set of 22 cells for disposal of the packages; they will be located at the northwest part of the site and their construction will create a fully fit disposal facility, which meets all requirements and design criteria, but without the total number of cells. During the second and third stage the facility will be expanded in its central and southeast part to reach its full capacity. The construction of stages 2 and 3 will take place during the end of the facility filling, respectively at stages 1 and 2.

The construction activities during stage 1 will include[15]:

→ preparation of the construction site: removal of existing plants and roots, dislocation of communications, fencing of the construction site, construction of temporary roads, drainage ditched and deposition of the humus layer, etc.

→ excavation works at the site for the RAW containers platform from stage 1, rain water collection reservoir, loess-cement cushion, etc.

→ deposition of the excavated earth masses within the boundaries of the site and outside it;

→ construction of a loess-cement cushion with a thickness of 5 m;

→ excavation and concrete works for construction of a building for accepting and temporary storage of containers with RAW, of auxiliary buildings, of a platform for the cells for stage 1, of a network of galleries for infiltration control; of a system for deep drainage (shafts, pipelines, a reservoir), of fire-precaution system, of temporary construction zones for offices, temporary storage of materials and construction machines, of laying electrical and telecommunication cables, etc.

The construction during stages 2 and 3 will be similar to the one during stage 1 without the already construction auxiliary buildings and facilities, which will be used during the whole operation period.

An impact on the quantity and chemical status of ground waters, caused by the described construction works, could be generated by:

4.2.2.1.1.1 In non-radiation aspect:

On the quantity status of ground waters: change in the hydro-dynamic regime as a result of:

→ *Drainage of construction excavations and/or change of the flow direction:* all excavations, including the biggest one, which is for the platform of the containers with RAW, will be made above the water level of the receptor – the water saturated zone below the repository modules.

Therefore, it is not expected ground waters to come into the excavations, drainage is not necessary and change of the flow direction is excluded, i.e. *an impact on the quantity status* of ground water *is not expected*.

→ *Water intake for drinking, construction and other purpose*: The necessary water quantity for the NDF located on the Radiana site will be supply from:

[15] Westinghouse, DBEtec, Enresa, EQE Bulgaria Ltd, 2013. Technical design. Part: Organization and implementation of construction

- supply of potable and household water: through a connection from the domestic water pipeline for Kozloduy NPP within the allowable water intake from the Kozloduy intake system (which includes three shaft wells with horizontal rays of Ranei type), in accordance with the Permit for water intake № 11510229/05.01.2009 issued by BDWMDR, with a holder „Water and Sewage“ Ltd – Vratsa;

- for construction and other purposes (water for concrete preparation, dust elimination during excavation and embankment works through irrigation and wetting, cleaning of transport and construction machines, cleaning of temporary construction sites, etc.): through supply with auto cisterns.

These activities *are not expected to have an impact on the quantity status* of ground waters, because the intake of potable and household water is regulated in accordance with the requirements of the Waters Act and Regulation №1/2007[16], and it does not cause changes of the hydro-dynamic regime of ground waters. Also, usage of ground water is not foreseen for construction and other purposes.

On the chemicals status of ground waters: infiltration of relatively small volumes of domestic and faeces waters and of rain waters, which contain undissolved substances and petroleum products (from accidental leakage of oils, fuel and other pollutants), of wastewater generated by cleaning of the construction site, the transport vehicles, construction machines and facilities, etc. Such an eventual impact, in case it occurs during the construction period, will most probably be limited to partial infiltration in the unsaturated zone below the repository, which is made of practically waterproof clay sediments, without reaching the level of ground waters.

There are no hydro-dynamic prerequisites for impact on the chemical status of potable water, because:

→ as it can be seen from the hydro-dynamic map of the Radiana site[17] – **Figure 3.2-13** in Part III of the EIA, the filtration flow of ground waters at and in the vicinity of the Radiana site is directed from southwest to the northeast;

→ the construction activity does not affect the natural hydro-dynamic regime of the ground waters, i.e. it does not change the direction of the filtration flow;

→ the water intake facilities for potable and household water supply, which are the closest to the Radiana site, are located a big distances from the site and are far away beyond the ground waters direction of movement (Kozloduy water intake system is about 10 km away to the northwest, and the water intake facilities at the villages of Harlets, Glojene, Butan, Kriva bara, etc. are 2÷13 km away to the southeast and south).

On the basis of the above-mentioned reasons and as a result of the foreseen design measures and facilities for organized collection and elimination of atmospheric precipitations, and the treatment of waste waters (embankments and /or drainage ditches along the slope for catching and elimination of rain water outside an excavation for the modules, drainage system in the fundament of the excavated slope, rain water reservoir, rain water drainage system at the platform with the RAW containers with oil catchers for collection and filtration of water polluted with petroleum products, recultivation and landscaping of the scopes, etc.), it can be concluded that it *is not expected an impact on the chemical status of ground waters, including potable waters.*

[16] Regulation № 1/10.10.2007 on research, usage and protection of ground waters (promulgated SG, 87/2007, last amended and supplemented SG 28/2013)

[17] Gerginov, P., 2014. Hydro-dynimic map in the vicinity of the Radiana site.

4.2.2.1.1.2 Radiation Aspect

The lack of radioactive sources during the construction *excludes radiation impact on ground waters.*

Tunnel type of repository

According to the preliminary studies, conducted by „Minproekt“[18], the repository will consist of eight lengthwise tunnels set by transverse to the slope servicing outlining mine construction (opening groves), which have a direct outlet at the surface. Three alternatives are discussed for location of the mine constructions in a vertical section, respectively at levels of approximately 40, 50 and 62 m. The depth from the surface upon storage of the containers at a level of about 40 m is between 32 m to about 50 m in a clay massif (layer 5) and water intake sand lenses and seams (layer 6) lenses of the Brusar formation, above which are the Quaternary alluvial formations of terrace T_6 (layers 3 and 4) and the loess complex (layers 1 and 2). The thickness of the massif during storage of containers at levels of about 50 and 62 is about 25÷35 m and will mainly include Aeolic formations (layers 1 and 2, partially layers 3, 4 and 5).

The construction activities will include:

→ preparation of the construction site for the auxiliary buildings and facilities, for the ventilation system, etc. at and in the vicinity of the outlet for the opening groves: cleaning of existing plants and roots, dislocation of communications, fencing of the construction site, construction of temporary roads, drainage ditches, and deposition of the humus layer, etc.

→ running, fixing, hydro-insulation and reinforcement first of the opening groves and then on 8 lengthwise tunnels for storage of the RAW containers;

→ implementation of preceding tamponage for expected crossing of water intake zones;

→ deposition of the excavated mine mass within the boundaries of the site and outside it, if necessary;

→ excavation and concrete works for construction of a ventilation system, a building for accepting and temporary storage of containers with RAW, of auxiliary buildings, of fire-precaution system, of temporary construction zones for offices, temporary storage of materials and construction machines, of laying electrical and telecommunication cables, etc.

→ An impact on the quantity and chemical status of ground waters, caused by the described construction works, could be generated by:

4.2.2.1.1.3 Non-Radiation Aspect:

On the quantitative status of groundwater: change in hydrodynamic regime due to

→ *water inflow into the mine workings.* Option deployment of tunnels elevation about 40 m of the mine workings, particularly longitudinal tunnels could be in the water-bearing sand layers and lenses in the midst of clays Brusarski Formation. At the intersection is the possible water flow, possibly accompanied by a collapse of rock and damage in the fastening and, as a result, compromising the tunnel in poor performance of the envisaged faster wicking. Therefore, the realization of this opportunity to build a tunnel type of repository is inappropriate.

[18] „Minproekt“ Ltd, 2009. Pre-design (pre-investment) research for construction of a National disposal facility for low and intermediate level radioactive waste. Construction and mine and technological part.

The water level of the site "Radiana" is below grade 50 and therefore is not expected water inflow from groundwater in tunnels when mounted on levels 50 ÷ 62 m, i. e. *is not expected to impact on the quantitative status of groundwater*;

→ *abstraction for drinking, construction and other needs:* it will be identical to that described above for the trench type repository. In view of this is not expected to impact the quantitative status of groundwater, as water abstraction for drinking purposes is regulated in accordance with the requirements of the Water Act and Ordinance №1 / 2007 and does not change the hydrodynamic regime of groundwater waters.. Furthermore, for construction and other purposes not intended use of groundwater.

On chemical status of groundwater: infiltration of relatively small volumes of domestic wastewater, storm water containing suspended solids and petroleum products (by accidental release of oil, fuel and other pollutants) of wastewater from cleaning the construction site, vehicles, mnno-mining and construction machinery and equipment and others. Such possible contamination, if allowed under the preferred option for the construction of the mine workings above elevation 50 m, will most likely be limited to partial penetration in unsaturated zone in the repository, изградена от практически водоупорни глинести седименти, без да достига до нивото на подземните води.

There are no prerequisites for hydrodynamic impact on the chemical state of the drinking water for the reasons set out above for the trench type repository.

Of those grounds, and as a result of the proposed project measures and facilities for organized collection and removal of atmospheric precipitation and purification of polluted waters (drainage ditches along the slope to capture and divert rainwater out of the mouths of revealing Galleries and sites of the ventilation system, auxiliary buildings and facilities, drainage channels in the tunnels below the containers with radioactive waste for disposal of contaminated and potentially contaminated water, etc.) results, *that is not expected to impact the chemical status of groundwater, including drinking water.*

4.2.2.1.1.4 Radiation aspect

The absence of radioactive sources during construction exclude *radiation effects on groundwater*.

4.2.2.1.2 DURING NORMAL OPERATION AND EMERGENCY SITUATIONS

4.2.2.1.2.1 During normal operation

➢ **In the non-radiation aspect:**

Impact on the quantitative and chemical status of groundwater during normal operation, both trench and tunnel type of repository is basically identical and may be derived from the following:

✓ *on the quantitative status of groundwater***:** change in hydrodynamic regime due to water abstraction for drinking and other purposes.

The water supply of the NDF site "Radiana" provides via a link from drinking tap NPP "Kozloduy" to the extent permitted abstraction from an intake system "Kozloduy" (three-shaft wells with horizontal beams type "Raney"), under permit issued by BDUVDR abstraction № 11510229 / 05.01.2009 held by the "Water Supply and Sewerage" Ltd. - Vratsa. Regulated water abstraction from existing water sources and the absence of own water intake facility, do not give change in the hydrodynamic regime of groundwater, therefore *is not expected to impact on the quantitative status of groundwater, including drinking water.*

- ✓ *on chemical status of groundwater:* infiltration of relatively small volumes of domestic wastewater and storm water containing suspended solids and contaminants (from the accidental release of oil, fuel and other pollutants). Such possible contamination will most likely be limited to partial penetration in unsaturated zone under repository built of virtually waterproof clay sediments, but not to the level of groundwater.

  There are no prerequisites for hydrodynamic effects on the chemical condition of drinking water, as:

  → filtration flow of groundwater in and around the site "Radiana" as seen hydrodynamic card near the site " Radiana"[19] - **Figure 3.2-13** in Part III of the EIA is directed from southwest to northeast;

  → implementation of the Project, both during construction and over the period of the normal operation of the repository does not affect the natural hydrodynamic regime of groundwater, i. E. Not change the direction of filtration flow;

  → closest to the site "Radiana" abstraction facilities for drinking water supply are located at large distances from it are far beyond the direction of movement of groundwater (water intake system "Kozloduy" about 10 km northwest, water intake structures in the villages Harlets , Glojene, Bhutan, curve bar and more. 2 ÷ 13 km southeast and south).

In view of the foregoing considerations, and implemented measures and facilities for organized collection and removal of atmospheric precipitation and purification of polluted waters *is not expected to impact on groundwater, including on potable water.*

4.2.2.1.2.2 Radiation aspect

During the period of about 60 years of operation of the NDF proliferation of radioactive substances and environmental protection, including groundwater project is guaranteed by:

→ packaging of conditioned waste and other engineering barriers that maintains its integrity and design features regardless of the type of storage - trench or tunnel;

→ construction of cells for RAW with loess-cement cushion beneath them in trench type repository and the fastening of the mine workings in tunnel type repository that are practically waterproof and secured against radiation leakage;

→ constructed drainage systems in the cells for storage of containers with radioactive waste in trench type repository and underground workings of tunnel type storage and tanks to collect water from the drainage of the storage and management of radioactive waste in the main service building, in the building for the reception and temporary storage of packaging waste, etc..

Apparent from the above that during the operation of the NDF, as in trench and tunnel type in the repository, no change is expected radiological indicators of groundwater, including drinking water, beyond the typical background levels for the region.

4.2.2.1.2.3 In emergency situations

In principle, emergency situations may arise as a result of:

→ natural processes and phenomena;

→ external events caused by man outside the store;

[19]Gerginov, P., 2014. Hydrodynamic map in the area of “Radiana”site.

→ - internal events occurring at the site of the repository.

Differentiation principle possible within the scope of the project emergency and assess the potential impact of those which may be relevant to groundwater is given in **Table 4.2-4**.

TABLE 4.2-4 ASSESSMENT OF POTENTIAL IMPACTS FOR EMERGENCIES

emergency events	**emergency events**	**Assessment of potential impacts on groundwater**	
		In non-radiation aspect	In the radiation aspect
Natural processes and phenomena			
Tectonic processes and phenomena: not proven active faults and are not expected endogenous changes in the earth, respectively, and in the state of groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Earthquake: estimated maximum expected earthquake area Mmax = 5,0 is not able to generate changes in the natural regime of groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Surface erosion, could be expressed in the formation of shallow furrows and gullies on the surface.	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
External flooding: it is not possible, since the site is located more than 15 ÷ 20 m above the estimated maximum water levels in the river. River generated by the destruction of the water supply system "Iron Gate" and prolonged downpours. Groundwater level under such conditions is practically invalidated terrace T6	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
External events caused by human activity			
Explosion of the tank, external fire, vibration ground, interruption of external water supply and others. - Not affect the condition of groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
internal events			
Accident during transportation of containers with RAW weak radioactive consequences without impact on groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Leaks from pipes or tanks - pollution of land and groundwater big project is off	trench	Not expected impact	Not expected impact
	tunneling		

Damage to water, does not affect the status of groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Internal fire: will quickly be detected and extinguished	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Falling heavy objects, potentially damaging the containers with RAW minimal contamination that does not reach the groundwater	trench	Not expected impact	Not expected impact
	tunneling	Not expected impact	Not expected impact
Human error (falling containers in accidents, moving and other actions): minimal contamination that does not reach the groundwater	trench	Not expected impact	Not expected impact
	тунелен	Not expected impact	Not expected impact

4.2.2.1.3 DURING CLOSURE

The purpose of the closure is to safely isolate radioactive waste from the environment and people by filling the empty space between the packaging waste and installing protective screens against the flow of waterThis should be accompanied by a safety assessment of the repository during the period of institutional control and implementation of post-operational monitoring.

The life cycle phase of closing of the NDF is estimated at about 15 years, followed by institutional control continued 300 years.

In the phase of closing will be completed dismantling of buildings and facilities, which are not necessary for the next institutional control, and building a system for closure of the repository.

In trench type repository closure system will include backfilling the space between the cells around them, building a multi-barrier engineering, drainage system for precipitation, monitoring and reclamation and re-planting.

In tunnel type repository closure system will include filling the space around the containers with loess-cement mud or loose granular material immediately after storage of containers in each gallery or in several galleries. After the final filling of underground workings mouths revealing Galleries with access to the surface is sealed.

These activities are similar, but to a lesser extent, the described activities during construction and operation, hence the similar absence of negative impact on the quantitative and chemical status of groundwater including on potable water. therefore:

4.2.2.1.3.1 In the non-radiation aspect:

Not expected to impact the quantitative and chemical status of groundwater and water sources for drinking water supply, as:

→ will not be built on its own intake structure and water is carried out by existing water supply network in Vratsa Water Ltd, which supplies the town of Kozloduy NPP Kozloduy;

→ in trench type repository too insignificant infiltration of potentially contaminated rainwater will be limited to partial penetration in land cover and concrete slabs over the cells, and domestic wastewater (for unexpected damage to the sewer system) - to partial penetration in the unsaturated zone, but not to the level of groundwater;

→ in tunnel type repository authors of conceptual design indicate that practically excludes infiltration filled mines due built around watertight fasteners reinforced zone by cementation or silicification. World experience shows that in tunnel facilities injecting grout can be applied to the filtration coefficient of soil types > 1.10^{-2} m/s. In the case loess has a coefficient of filtration $1.10^{-5} \div 10^{-6}$ m/s and under these conditions can be applied only silicification. In loess this method is only the surface of the equipment with a small area like effect results in removal of the collapse and partial reduction of water permeability. No construction experience to perform in silicification loess in tunnel facilities. It should be borne in mind that the injection of sodium silicate solution can lead to increased bacterial microflora in the Earth's environment (incl. Groundwater), such cases were observed in the construction of the subway in Milan.

4.2.2.1.3.2 Radiation aspect:

No change is expected radiological indicators of groundwater outside the typical background levels for the region, due to a multi-system provided. This is confirmed by the conservative scientific assessments which excludes leakage and migration of radionuclides in the geosphere, respectively, and in groundwater at normal evolutionary scenario of development during the closure of the NDF.

In the radiation aspect there is a difference between the two types of technology for disposal (tunneling and trench) in the period after closure of the repository in the long run. It is conditioned by the fact that the artificial multi barrier protective coating is characterized by a very low coefficient of filtration 10^{-9} m/s and extremely low values of the coefficient of infiltration - in the 1,5 L/m^2 a year. This applies to the issue of IP NDF "Radio", but those are the design characteristics of protective coatings of other modern storage currently in use, and as such are the real characteristics of already closed repositoriesThese characteristics also be monitored during the period of institutional controlWhile the repository tunnel type these values are much higher - the natural barrier is characterized by a coefficient of filtration $5.8x10^{-6}$ m/s and a coefficient of permeation 60-120 L/m^2 a year.

	To continue the implementation of the program for pre-service radiological monitoring of the site "Radiana" in the part in monioring of lifting and drinking water (№ TK.D-142-D3 / 2012, HX-PEM-PM-001/01).	**C**	Analysis of radio-ecological status of the site and the environment and the conformity with the legislation in the field.
	Develop and implement a program for operational radiological monitoring of groundwater and drinking water within the scope of the NDF.	E and 3	Monitoring of radioecological status groundwater at the site and NZ of the NDF, in accordance with the legal requirements in the field.

4.2.2.1.3.3 Conclusion:

Implementation of the Project for the NDF site "Radiana" will not lead to significant change in radiation indicators of groundwater outside the typical background levels for the region.

Do not expect significant negative impacts of the project in a non-radiation and radiation aspect into account the proposed engineering barriers that impede the transfer of radionuclides in the environment and existing unsaturated zone between the store and the saturation zone (aquifer). This is confirmed by the applied mathematical models to assess the migration of radioactivity in groundwater used for aquifer near the NDF.

4.3 LANDS AND SOILS

4.3.1 NON-RADIOATION ASPECT IMPACT

4.3.1.1 DURING CONSTRUCTION

The data show that the lands and spoils which will be eventually affected by the implementation of the IP are mainly those which are most common in the area of Radiana site and within 30 km around Kozloduy NPP – anthropic and chernozem (carbonate, typical and leached) as well as alluvial meadow and meadow swampy soils in fewer amounts. Part of them is at different stage of erosion.

I relation to their pollution resistance (the attention is focused on the chernozem) they belong to first and second class because of the high carbonate level and because they are quite rich in humus. The active soil acidity varies in the lightly alkaline spectrum. 7.4–8.4. The soils buffer capacity is high and it successfully neutralize the impact such as aerosol chemical substances pollution, heavy metals and others. Typical for the region is the wind erosion which is extremely severe for the geographical region Zlatiyata. The anthropic soils originate from the same soil types which can be found around Kozloduy NPP. Their anthropogenization is due to the mechanical and technical impact and to a smaller extent to the chemical pollution. The impact on the soils from non-radioactive sources during the different construction stages and the NDF operation is characterized the following way:

- During the construction works on the lands the soils are completely damages, on the whole soil profile because their humus layer is removed first and it is the most important component for the soil fertility. Then the lower soil levels are removed and are stored in depot for future recultivation or for the fillings and relief raking of the site itself. That is why natural soils with their characteristics soil levels do not exist.
- A considerable impact on the soils resulting from the construction is expected only on the construction site itself. Most of the soils will be destructed and some of them will be removed and stored in a humus depot because of the NDF construction and its servicing road. After the end of the construction and the covering of the repository with earth masses the anthropic soils will be restored. The thickness of its humus layer should not be less than 0.3 m from the soils stored at the depot.
- Regardless of the differences of the NDF construction versions – trench and tunnel type considerable construction impact on the soils is expected only on the site itself. Most of the soils will be destructed and some of them will be removed and stored in a humus depot because of the NDF construction and its servicing road. After the end of the construction and the covering of the repository with earth masses the anthropic soils will be restored. The thickness of its humus layer should not be less than 0.3 m from the soils stored at the depot.

4.3.1.1.1 AREAS AND EARTH MASSES BALANCE AT THE TRENCH TYPE OF REPOSITORY

According to the project authors the total areas which should be fenced to serve the needs of the **trench type** repository runs up to 46.4 ha, but during the trench type repository construction process will be needed additional area of 0.40 ha, which will be used for the temporary storage of 68 000 m^3 humus, which will be used at the Radiana site after the completion of the first stage of the repository construction. 90 000 m^3 earth masses will be used for the a loess-cement cushion.

According to the project authors during the first stage of the trench type repository construction together with the attending machinery and the site infrastructure there will be obtained about 68 000 m^3 humus, which can be reused for the site development at the end of the construction. During construction this humus will be stored at a temporary site locate 1 km away from Radiana site (ДОfficial gazette 89 from 22nd October 1996, amended in Official gazette 30 from 22nd March 2002) in compliance with Regulation No 26 for the recultivation of the damaged terrains, the improvement of the low productivity lands, removing and using of the humus layer. The humus removed during the repository construction **phase 2 and 3** amounts to 19 000 m^3 and 24 000 m^3 respectively. It will be used for the improvement of the low productivity lands at the will of the people from the neighborhood.

The designers expect a considerable part of the excavated earth mass during the repository construction first stage (**Phase 1)** to be stored at a depot located at Radiana site because it will be used again for filling up and the building of a protective multi-barrier cover during repository closure. For the placement of the surplus earth masses which are not suitable for the repository closure which amount to 265 000 m^3 there will be an additional site located 1 km away. It is a subject of negotiations with the owner[20].

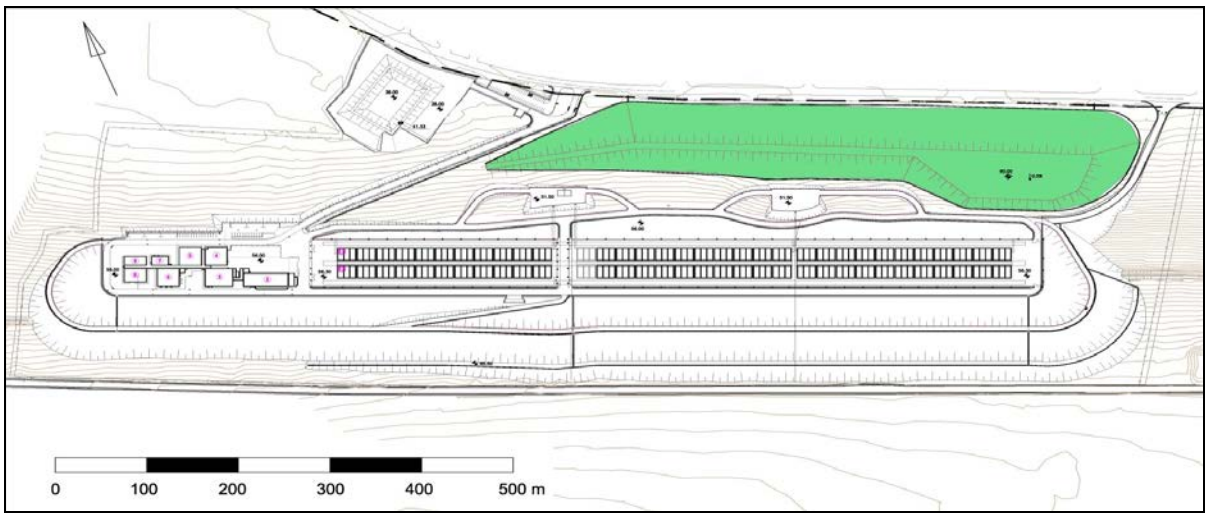

FIGURE 4.3-1 LOCATION OF THE EARTH MASSES DEPOT

The surplus earth masses obtained during the repository construction **phase 2 and** 3 in a long-termed aspect will be used for the recultivation of the damaged terrains in the region according to a scheduled program for the respective periods.

At the site will be built a depot for earth masses amounting to 623 000 m^3. The depot location is given on **Figure 4.3-1**, and the cross section – on **Figure 4.3-2**.

[20] Geoconsult Ltd., Study of a depot site for the storage of surplus earth masses and temporary humus and loess storages, 2014.

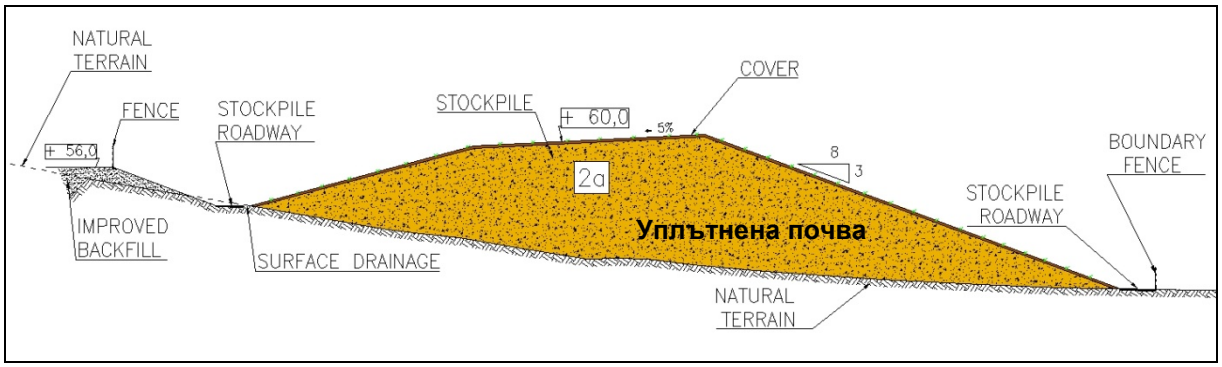

FIGURE 4.3-2 EARTH MASSES DEPOT PROJECT – CROSS SECTION

The depot is placed on a total area of 70 000 m², the maximum elevation is +60 m.. The earth masses are made tight using the standard methods (bulldozer). Humus will be spread on the depot. Grass will be plant in the humus. It will be fertilized and watered.

The construction activity for the trench type NDF construction is done gradually. The type and volume of the earth works is shown in **Table 4.3-1** [21].

TABLE 4.3-1 EARTH WORKS FOR THE NDF CONSTRUCTION AT RADIANA SITE

№	Earth works	Measure	Phase 1	Phase 2	Phase 3	Total
1	Terrain clearing and cutting trees and bushes down	m^2	343 300	52 425	70 400	466 125
2	Excavation and deposit of a soil layer with thickness 0.30 m	m^3	67 824	19 451	24 108	111 383
3	Excavation total for the deposit cells platform	m^3	977 965	772 927	953 668	2 704 560
4	Making embankments	m^3	54 019	6 115	-	60 134
5	Loess-cement cushion	m^3	89 739	71 155	72 874	233 768
6	Crashed stone embankments	m^3				15 108

TABLE 4.3-2 EARTH MASSES BALANCE FOR THE TRENCH TYPE REPOSITORY

№	Earth works	Measure	Phase 1	Phase 2	Phase 3	Total
1	**Excavation**					
1.1	Zone of the platform and the angle of repose	**m^3**	847 911	703 214	810 560	2 361 685
1.2	Additional excavation for the loess-cement cushion from elevation +54.30 m to elevation +50.00 m	**m^3**	77 802	66 016	66 645	210 463
1.3	Main road	**m^3**	348	0	0	348
1.4	Security road	m^3	40 135	---	75 255	115 390
1.5	Emergency road	m^3	4 589	---	---	4 589
1.6	Side road	m^3	2 470	2 777	1 208	6 455

[21] Westinghouse, DBEtec, Enresa, EQI Bulgaria, 2013. Technical project. Part: Geodesy. Quantitave calculation.

№	Earth works	Measure	Phase 1	Phase 2	Phase 3	Total
1.7	Rain water basin	m^3	1 809	---	---	1 809
1.8	Phase 1- Site for a Reservoir for the infiltration control	m^3	2 899	---	---	2 899
1.9	Phases2/3 - Site for a Reservoir for the infiltration control	m^3	0	920	---	920
	Excavation total	m^3	977 965	772 927	953 668	2 704 560
2	**Total site deposit/ usage**					
2.1	Site deposit/usage 5% volume reduction = 591,697m³		622 839	(*)	(*)	(*)
2.2	Reverse embankment of loess-cement from elevation +50.00 to elevation +55.30		89 739	71 155	72 874	233 768
		Total	**712 578**	(*)	(*)	(*)
3	**Above the capacity**					
3.1	Volume transportation outside the site	m^3	265 385	701 772(*)	880 794(*)	(*)

(*) The balance of the surplus earth masses from stage II and III will be specified during the next designing stages. An updated programme for management and usage of the excavated earth masses will be drawn up as well as the arrangement of a depot close to the object having in mind the long-term aspect of the different phases activities.

According to the project developments received for analysis and assessment and the Investor's data at the present stage can be done the following assessments for **phase 1** of the construction of a trench type repository:

- From the platform excavation and the cells are obtained 977 965 m^3 earth masses. Here are included earth masses balance and the excavated masses form the emergency road, the side road, buildings excavations, infrastructure. 89 739 m³ are used for the making of embankments and a loess-cement cushion. There are 834 207 m^3 earth masses left.
- It is suggested that 622 839 m^3 earth masses be deposited at the site depot in order to be used for filling the surfaces above the ones specified for closing and the modules of **phase 1** prepared for this purpose.
- 265 385m^3 will be transported for maximum 300 days to a depot 1 km away from the site. At the moment NDF is taking steps to arrange such a depot.
- The earth masses transported to the depot might be used for the filling of damaged terrains and in other regions, roads, etc.
- The investor suggests to be prepared a program for surplus earth masses transportation for **phase 1** which is expected to be completed in about 300 days.
- After the completion of the filling of the module trenches during the NDF operation and the usage of earth masses for **phase 1** it is expected that the depot will have the capacity to take the additionally generated earth masses form **phase 2** of the NDF construction.
- The surplus earth masses balance from **phase 2 and 3** will be specified during the next designing stages. For every stage will be prepared a program for management and usage of the excavated earth masses as well as the arrangement of a depot close to the object.

4.3.1.1.2 AREAS AND BALANCE OF THE EARTH MASSES FOR A TUNNEL TYPE OF REPOSITORY

The tunnel type is underground parallel tunnel constructions (galleries) – 8 in number with a with large diameter (6.5 m) and length of 1130 m, the access to which is ensured through horizontal

shafts with a small diameter (3.7 m). The distance between two galleries for placement of radioactive waste (axis to axis) is 20 m, and the solid block is 12.6 m. The access to the disposal galleries is done through a transport shaft, which starts at level 59. The layout of the tunnel type of repository is described in **Chapter 2.**

The tunnel type of repository is situated on the Radiana site, selected for the NDF construction, in accordance with Detailed site development plan - Plan for regulation and development. Taking into consideration the implemented approach that the road, which is use for the transportation of radioactive waste from the road, controlled by the Kozloduy NPP, to the disposal facilities should be within the frames of the NDF site, the necessary area is 47.5 ha.

According to the authors of the design, during the construction of the tunnel type together with the additional facilities and the infrastructure of the site are generated about 70 200 m^3 of humus, and about 43 860 m^3 of them are subject to repeated utilization for the recultivation of the site during the closure of the repository. The authors of the document propose a depot for humus soil to be constructed on the site, which should be used for recultivation during the closure of the repository after its 60-year period of construction. The storage of the humus materials is not expedient not only in relation with Regulation № 26/1996 for recultivation of the damaged terrains, improvement of less productive lands, elimination and utilization of the humus layer[22], according to which a humus layer is stored at a depot for a period not longer than 15 years, but also because of the fact that at the current moment it can be used for recultivation purposes at other places. The rest of the humus soil, amounting to 26 340 m^3, can be used in the same way.

The construction activity for the construction of a tunnel type of NDF is proposed to take place in stages. The type and volume of the earth works, which are directly related to the bowels of the earth, are listed in **Table 4.3-3.**

TABLE 4.3-3 BALANCE OF THE EARTH MASSES FOR A TUNNEL TYPE OF REPOSITORY

Stages	Constructions	Length (L)	Diameter (D)	Radius (R)	Section (S)	Number	Volume (V)
		m	m	m	m^2		m^3
I, II and III	Module galleries	1130	7.5	3.75	44.2	8	399 375
I	Module galleries	1130	7.5	3.75	44.2	3	149 766
	Transportation and ventilation servicing and experimental shafts	730	4.5	2.25	15.9	1	11 610
						Total for stage I	**161 376**
						TOTAL	**410 985**

I stage – The volume of the generated during excavation earth masses is created during excavation of:

→ 3 galleries for disposal of RAW, as each of them has a length of 1130 m and a diameter of the tunnel (taking into account the thickness of the lining amounting to 0.45 m) is 7.5 m;

→ and 4 shafts with a total length of 730 m and a diameter of 4.5 m.

[22] Regulation № 26for recultivation of the damaged terrains, improvement of less productive lands, elimination and utilization of the humous layer, SG 89 of October 1996, amended SG 30/22.03.2002

The total volume of the earth masses during the construction of the galleries and shafts for stage I is assumed to be about 161 000 m^3.

Additional earth masses (about 90 000 m^3) are expected to be generated during the implementation of the infrastructure: emergency road, second-rate road, water and sewage infrastructure, reservoir for rain waters, site for a reservoir for infiltration control, buildings, etc., which are constructed during stage I.

Therefore, in the initial output data the excavated earth mass from the gallery and the site is assumed in design to be 650 000 m^3 expanded earth mass (expansion coefficient 1.3). This volume is two times bigger than the existing possibilities to provide areas for storage of earth masses, which are identified in the conducted studies[23]. The surplus earth masses for the first stage of the tunnel type of repository are about 250 000 m^3, which should be transported outside the boundaries of the NDF site to the earth masses depot for a maximal period of 300 days.

4.3.1.1.3 CONCLUSION

The data for the soils in the region – mainly lixiviated chernozem and alluvial soils – show that these soils have a high bonitet number and a deep soil profile, which varies between 0.40 and 0.90 m, which allows to be collected much more humus, which can be utilized as soil cover during the recultivation of the terrain after the completion of the construction, or at other damaged terrains in the region. The humus, collected only from 0.40 m, is much more than the foreseen quantity in the designs for a tunnel and trench type, which allows the soil cover to be no less than 0.30 m (and not 0.10 m, which is not enough for the root system of any grass cover – see the section).

It is expected that during the construction at certain places will be piled different types of waste – industrial waste which are generates should be deposited at the regional depot for industrial waste – Oryahovo. It is proposed that the construction waste is initially deposited at the regional depot for non-hazardous waste Oryahovo, and in the future is checked for an opportunity for deposition at a place, selected by the Kozloduy municipality, where the construction waste will be deposited and further treated. The impact on the component of the environment and the soils in particular caused by the waste factor will be insignificant if the waste is ecologically managed and if there is good organization and control.

Surplus earth masses for the first stage, which will be transported to a depot outside the boundaries of the NDF site for the two technological options, are about 250 000 m^3 for a tunnel type of repository and about 265 000 m^3 for a trench type of repository, and will be transported to the depot for earth masses for a maximal period of 300 days.

During the construction the impacts on the soils, caused by **both technological options for a repository** are **direct, negative long-term** and **irreversible**.

4.3.1.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

During the operation the negative impacts on the lands and soils are significantly fewer compared to the impacts during the construction period. Significantly small area is left from the natural soils – afforested areas and protective zones. The impacts are **temporary** – during trampling caused by the internal transport, leakages of liquids, waste, etc., with low level of impact.

Prior to the beginning of the repository operation and after that the area above and around it should be afforested after an elaborated landscape structural design in accordance with the detailed site development plan of the terrain.

[23] Geoconsult Ltd. Studies for location of a depot for surpluss earth masses and temporary depots for humus and loess, 2014.

4.3.1.3 DURING CLOSURE

During the closure of the NDF and the recultivation of the terrains the impacts on the environment will be similar to the ones during the construction. In contrast to other industrial site, the repository will remain on its location and its safe existence should be controlled – period of institutional control. During closure are dismantled all auxiliary facilities, all servicing buildings are destructed, and the non-hazardous non-radioactive waste are transported. After this activity are created green areas in accordance with preliminary elaborated and approved detailed site development plan and landscape-structural design. In spite of that the region will continue to be unpopulated by people and domestic animals during the period of institutional control. The territorial scope of the impact will be limited – within the boundaries of the NDF, with low level of impact and duration of the impact, which will continue for years after its closure.

It is recommended that the thickness of the upper humus layer, over which will be planted grass vegetation, to be with thickness no less than 0.30 m, because there are no grass species with root system up to 0.10 m. otherwise, more aggressive grasses pierce through the insulations below this layer and the rest species wither.

4.3.1.4 CONCLUSION

The implementation of the investment proposal causes impacts on the **land use**. The impact is related **only to the site**, it affects terrains which mainly state property and a limited area is municipal property (according to the map of the restored ownership of the lands of the Harlets village). The impact is **continuous** because the NDF is continuously situated on the site. Even after the NDF closure (recultivation), the land use of the site will be limited during the whole period of institutional control (300 years).

It is not expected an impact on agricultural lands at the territory of the site due to the practical lack of such lands.

Territorial scope of the impact: it will be **limited** – into the zone of impact of the NDF;

Degree of impact: low;

Duration of the impact: long-term – long years after the decommissioning of the NDF.

Frequency of the impact: continuous.

Cumulative impact – it is not expected.

Reversibility of the impact: To a certain extent it is reversible after implementation of technical and biological recultivation. There is a possibility to create a vegetation belt and landscape shaping with vegetation. Change of the purpose of the land status of the site is necessary. The construction of new infrastructure will damage lands and soils of the land fund.

4.3.2 IMPACT IN RADIATION ASPECT

4.3.2.1 DURING CONSTRUCTION

No impact is expected.

4.3.2.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

Impacts are not expected in relation to the radiation status of the soils in the regions of the Radiana site caused by the implementation of the IP during the operation period of the repository. The package of the conditioned RAW (RCCs) and the other engineering barriers of the NDF guarantee non-distribution of the radioactive substances and protection of the environment against radioactive contamination. It is not expected a change of the radiation indicators of the

soils beyond the background levels, which are typical of the region, caused by the NDF implementation.

4.3.2.3 DURING CLOSURE

No impact is expected.

4.3.2.4 CONCLUSION

It is not expected significant negative impacts of the investment proposal in non-radiation and radiation aspect, in view of the foreseen engineering barriers which prevent the transfer of radionuclides in the environment.

4.4 BOWELS OF THE EARTH AND UNDERGROUND NATURAL RESOURCES

4.4.1 BOWELS OF THE EARTH

The assessment of the potential impact on the bowels of the earth is mainly based on the information about the geological structure and the sources noted in section 4.2.2, terrain inspection of the site and professional assessment and experience, as well as on the standards, norms and requirements set in the legislative documents, which can be applied to the investment proposal.

The analysis of the geological and lithographic construction in section 3.3 and the hydro-geological conditions shows that the Quaternary formations and the Neogene sediments are receptors of the impact caused by the investment proposal. The potential impacts during the different stages of the implementation of the investment proposal can be generated only by activities, which are directly or indirectly related to the receptors.

4.4.1.1 DURING CONSTRUCTION

4.4.1.1.1 NON-RADIATION ASPECT

For a trench type of repository

The approach, stages and the construction activities related to the construction of a trench type of NDF are described in section 4.2.2.1. The type and value of the earthworks, which are directly related to the bowels of the earth, are listed in **Table 4.4-1**[24].

TABLE 4.4-1 EARTH WORKS FOR CONSTRUCTION OF A NDF ON THE RADIANA SITE

№	Earth works	Unit of measurement	Stage 1	Stage 2	Stage 3	Total
1	Cleaning of the terrain and cutting of trees and bushes	m^2	343 300	52 425	70 400	466 125
2	Excavating and deposition of soil layer with thickness of 0.30 m.	m^3	67 824	19 451	24 108	111 383
3	General excavation of a platform of the cells and deposition	m^3	977 965	772 927	953 668	2 704 560
4	Embankments	m^3	54 019	6 115	0	60 134
5	Loess-concrete cushion	m^3	89 739	71 155	72 874	233 768
6	Embankments from broken stone	m^3				15 108

[24] Westinghouse, DBEtec, Enresa, QEQ Bulgaria Ltd, 2013. Techical design. Part: Geodesy. Quantitive calculations

The negative impact on the bowels of the earth, caused by the described construction activities and the physical and geological processes can generally be expressed in the following:

→ Mechanical disturbance of the geological environment at a significant depth up to about 38 m under the terrain and deposition of part of the excavated earth masses on terrains outside the site. This impact is assessed as: negative but unavoidable, direct, primary, continuous, long-term, irreversible, with low level and territorial scope on the site of the investment proposal and partially outside of it (for an earth masses depot, temporary road leading to it, etc);

→ Occurrence of surface erosion. A prerequisite for its occurrence are the temporary surface flows with quite changeable regime, which are created mainly during intense precipitation and the foreseen slopes of the trench for RAW disposal with an inclination of about 20^0, mainly constructed of dust macro-porous loess with delicate structure and seams of loess clays. The potential impact will most probably include formation of shallow grooves and gullies on the surface of the slopes. This impact is negative, direct, primary, temporary, short-term, reversible, with very low level and territorial scope limited to the site of the investment proposal. Expansion of the grooves and gullies into deep formations is excluded because it is foreseen an organized elimination of surface flows through the designed rain drainage system and protection of the slopes surface by soil cover and vegetation.

→ Collapse of the earth foundation. In accordance with article 94 of the „Standards for design of flat foundation“ the earth foundation is divided into two types in accordance with the collapsibility of its own weight: I type – if the collapse does not exceed 5 cm and II type – of the collapse is more than 5 cm. Collapse deformations are not considered if the volume of the macro pores is below 1%.

According to legislative document it is impermissible to construct nuclear facilities on collapsible soils without elimination of the collapsibility.

In the geological and lithological profile of the Radiana site, **layer 1** is of II type according to its collapsibility – dust loess, light blue, macro-porous with delicate structure; it constructs the near-surface part of terrace T_6 with a thickness from 6.0 to 16 m; **layer 1a** is of I types – dust to dust-sand loess, macro-porous, light yellow, with fragile structure, seamed with clay loess at certain areas, with thickness up to 32 m.

Eventual measures to eliminate or reduce the collapsibility properties, in accordance to section I of Chapter 6 of „Standards for design of flat foundation“, are necessary for the design and construction of NDF:

→ the slope part of the terrain – only for the auxiliary buildings and facilities, where layer 1 is partially present at the foundation level;

→ the slanting part of the slope – for repository modules and auxiliary buildings and facilities, which are partially located on layer 1a.

For the foundation of the cells it is provided complete elimination of the collapsible and all weak Quaternary formations which are subject to deformity, as well as construction of a loess-cement cushion. Regarding the fundaments of the auxiliary buildings, it is foreseen improvement of the foundation conditions through congestion and application of a congested layer of gravel with thickness of 1,30 m. In view of these design measures, impact is not expected caused the collapsibility of the loess formations.

→ Sinking and uplifting of the earth foundation. The sinking is caused by congestion of the soils due to external load without significant change of their structure, and the uplifting (upheaval) is a process, which usually occurs in the patten of deep excavations caused by deformation processes in the slope. The results of the deformation analysis for seven stages of the repository implementation are listed in section 3.3.6. Three of these stages are implemented during the construction: excavation of the slope (Stage I), placing of a loess-cement cushion (Stage 2) and construction of the facility (Stage 3).

The results from the conducted calculations show that the following maximum deformations are implemented:

→ during stage 1 – uplifting up to 82 mm in front of the patten of the slope of the trench excavation for RAW disposal;

→ during stage 2 – uplifting up to 67 mm after the placement of the loess-cement cushion;

→ during stage 3 – sinking in the range of 1÷3 mm.

The noted values for sinking and uplifting are permissible in the design. they cause a negative but unavoidable, direct, secondary, continuous, long-term and irreversible impact on the bowels of the earth, with low level and territorial scope limited to the site of the investment proposal. The impact does not cause significant changes of the structure of the geological environment.

→ Eventual development of gravitation processes and, as a result, occurrence of landsliding events on the slopes of the trench for RAW disposal. The design parameters are justified by the respective stability prognoses, the results from which (calculation schemes and safety coefficients) are noted in section 3.3.6. Stability of the scopes. They show that the calculated safety coefficients are higher than the ones required in the normative documents both for main correspondence of the loadings ($FS_{sta} \geq 1{,}50$), and for a correspondence between loadings and the design seismic impacts ($FS_{dyn} \geq 1{,}10$). Therefore, eventual landsliding processes can be triggered only by violation of the design parameters of the slopes and the technology for excavation works. They would cause a negative, indirect, secondary, temporary, short-term, reversible impact with medium level on the bowels of the earth but with significant damages on the constructed buildings and facilities, and a territorial scope limited to the site of the investment proposal. The occurrence of landsliding events is impermissible. Thus, the excavation and embankment activities should be ensured by the design and they should be carried out under strict monitoring of the technology for their implementation and geodesic monitoring for observance and control of eventual deformation processes on the terrain.

→ Infiltration of relatively small volumes of domestic and faeces waters and rain waters, which contain dissolved substances and petroleum products (from accidental leaks of oils, flues and other pollutants from the construction and transport machines), of wastewaters generated by the cleaning of the construction site, the transport and construction machines and facilities, etc. Such eventual contamination, if permissible during the construction period, will most probably be limited to its infiltration in the near-surface area of the Quaternary loess and alluvial formations on the slopes of the excavation for the RAW containers platform and in the Neogene clays of the Brusar formation. This impact is assessed as: negative, indirect, secondary, temporary, short-term, irreversible, with very low level and territorial scope limited to the site of the investment proposal.

→ Swamping. The slope character of the Radiana site excludes swamping of the terrain, which is observed northeast from it only the scope of the terrace T_0

→ Liquation of sands. There is no risk of liquation of sands on the Radiana Site. Studies related to the operational security of NPP have proven that after the Vrancea earthquake in 1977, no traces of such processes are observed on the non-flood terrace and respectively on the higher terraces of the Danube River.

For a tunnel type of repository

The approach, stages and construction activity for construction of a tunnel type of NDF are described in **subsection 4.3.1.1.2.** The volume of the earth works, which are directly related to the bowels of the earth, is approximately assessed at 650 000 m^3 and is about two times lower than the volume for the trench type of repository.

The negative impact on the bowels of the earth, caused by the described construction activities and the physical and geological processes can generally be expressed in the following:

→ Mechanical disturbance of the geological environment and deposition of the excavated earth mass. This impact is assessed as: negative but unavoidable, direct, primary, continuous, long-term, irreversible, with low level and territorial scope limited to the site of the investment proposal;

→ Collapsing of the earth foundation – it is not expected. It is impermissible by design. It is eliminated through reinforcement of the massif around the mine construction through cementation and silicatization;

→ Sinking of the earth foundation – it is expected within the frames of the deformations which are allowable for the mine construction. This impact will be negative but unavoidable, direct, primary, continuous, long-term, irreversible, with very low level and territorial scope limited to the site of the investment proposal;

→ Infiltration of relatively small volumes of domestic and faeces waters and rain waters, which contain dissolved substances and petroleum products (from accidental leaks of oils, flues and other pollutants from the construction and transport machines), of wastewaters generated by the cleaning of the construction site, the transport and construction machines and facilities, etc. Such eventual contamination, if permissible during the construction period, will most probably be limited to its infiltration in the near-surface area of the Quaternary loess and alluvial formations on the slopes of the excavation for the RAW containers platform and in the Neogene clays of the Brusar formation. This impact is assessed as: negative, indirect, secondary, temporary, short-term, irreversible, with very low level and territorial scope limited to the site of the investment proposal.

4.4.1.1.2 RADIATION ASPECT:

It is not expected an impact on the bowels of the earth because there are no radioactive sources on the site of the investment proposal.

4.4.1.2 DURING OPERATION AND IN EMERGENCY SITUATIONS

4.4.1.2.1 DURING NORMAL OPERATION

The impact on the bowels of the earth during normal operation, caused by both trench and tunnel type of repository, is practically identical and can be caused by the following:

4.4.1.2.1.1 Non-radiation aspect:

It is expected:

→ sinking of the earth foundation caused by loading due to the containers with RAW in the cells and in the mine constructions. This impact will be negative but unavoidable, direct, secondary, continuous, long-term, irreversible, with very low level of impact limited to the site of the investment proposal. The impact does not cause any significant change of the structure of the geological environment;

→ negative, indirect, secondary, continuous, long-term, irreversible impact with very low level and territorial scope limited to the site of the investment proposal, caused by infiltration of relatively small volumes of domestic and faeces waters and rain waters, which contain dissolved substances.

It is not expected an impact caused by:

→ mechanical damage of the bowels of the earth because excavation and embankment activities are not carried out;

→ collapse of the earth foundation because of the elimination of the collapsibility properties of the loess soils during the construction;

→ manifestation of gravitation processes and events for the trench type of repository, because the stability of the slopes is confirmed both by their implementation with design parameters with sufficient safety and by the results from the geodetic monitoring conducted during the construction period;

→ Surface erosion which may be expressed in the formation of shallow grooves and gullies on the surface of the slopes during the construction of a trench type of repository, due to the implemented afforestation of the slope and the construction of the system for organized collection and elimination of the surface flow.

4.4.1.2.1.2 Non-radiation aspect

During the period of NDF operation the non-distribution of radioactive substances and the protection of the environment, including the bowels of the earth, is guaranteed in the design by the constructed engineering barriers. Thus, during normal operation, *it is not expected a radiation impact on the bowels of the earth*, caused by both a trench and a tunnel type of repository.

4.4.1.2.2 IN EMERGENCY SITUATIONS

Emergency situations can occur as a result of:

→ natural processes and events;

→ external events caused by humans outside the boundaries of the repository;

→ internal events occurring on the site of the repository.

Differentiation of the potentially possible emergency situations within the scope of the investment proposal and an assessment of the potential impact of those of them, which can be related to the bowels of the earth, are listed in **Table 4.4-2**.

TABLE 4.4-2 ASSESSMENT OF THE POTENTIAL IMPACT IN EMERGENCY SITUATIONS

Emergency situations	Type of repository	Assessment of the potential impact on the bowels of the earth	
		Non-radiation aspect	Radiation aspect
Natural processes and events			
Neotectonic processes and events: active fractures have not been proven and endogenic changes are not expected in the bowels of the earth in the vicinity of the Radiana site	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Earthquake: all constructions – slopes, tunnels and construction which impose a risk of radioactive contamination are designed as earthquake-proof for seismic impact levels SL1 or SL2, defined for the site of the Kozloduy NPP	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Surface erosion: it may be expressed in the formation of shallow grooves and gullies on the surface of the slopes in a trench type of repository in cases of low-quality implementation of the foreseen afforestration of the slope and damages in the system for organized collection and elimination of the surface flow	trench	It is expected a negative, direct, temporary, short-term and reversible impact with very low level	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Extreme winds and wind spouts: the designs for the facilities and constructions recognize a foreseen possibility for extreme winds and wind spouts	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
External flood: it is not possible because the site is situated more than 15-20 m above the prognosticated maximal water postures in the Danube River, generated upon destruction of the hydro-electrical system „Zhelezni vrata“ and continuous torrential rains.	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Natural gravitation processes (landslides, tearing-away): not expressed. The natural slope has enough security for both main and specific correspondence of the loads, as the earthquake forces are taken into account	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
External events caused by human activity			
Collapse of the earth surface: in cases of eventual low-quality fixing of the mine construction and enforcement of the surrounding massif	trench	Impact is not expected	Impact is not expected
	tunnel	It is expected a negative, direct, temporary, short-term and reversible impact with medium level	Impact is not expected
Explosion of a cistern, external fire: damage of the earth surface outside the NDF site	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not	Impact is not

Emergency situations	Type of repository	Assessment of the potential impact on the bowels of the earth	
		Non-radiation aspect	Radiation aspect
		expected	expected
Vibrations on the earth surface: they does not affect the stability of the slopes and tunnels, which are secured in the design against seismic impacts, comparable or bigger than the vibration ones	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Internal events			
Accidents during transportation of containers with RAW: slight radioactive consequences	trench	Impact is not expected	It is expected a negative, direct, temporary, short-term, reversible impact with very low level
	tunnel	Impact is not expected	
Leaks from pipes or reservoirs – contamination of the bowels of the earth and ground waters is excluded by the design	trench	Impact is not expected	Impact is not expected
	tunnel		
Damages of the water supply: it does not affect the bowels of the earth	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
External fire: it will be quickly located and extinguished	trench	Impact is not expected	Impact is not expected
	tunnel	Impact is not expected	Impact is not expected
Fall of heavy objects: potential damage of the containers with RAW	trench	Impact is not expected	It is expected a negative, direct, temporary, short-term, reversible impact with very low level
	tunnel	Impact is not expected	
Human error (fall of containers during road accidents, moving and other activities)	trench	Impact is not expected	It is expected a negative, direct, temporary, short-term, reversible impact with very low level
	tunnel	Impact is not expected	

4.4.1.3 DURING CLOSURE

The purpose of the closure is to safely isolate the radioactive waste from the environment and humans through filling of the free space between the packages with RAW and placing of protective screens against the water flow. This should be accompanied by a safety assessment of the Repository during the period of institutional control and implementation of monitoring after the operation is completed.

The life cycle of the NDF closure period is assessed to approximately 15 years, after which follows an institutional control with duration of 300 years.

During the stage of closure will be implemented a dismantling of buildings and facilities, which are not necessary for the following institutional control, and construction of a closure system of the repository.

For a trench type of repository the closure system will include backfill of the space between the cells are around them, construction of a multi-layer engineering barrier, drainage system for atmospheric precipitation, system for monitoring and repeated recultivation and afforestration.

For the tunnel type of repository the closure system will include filling of the space around the containers with loess-cement hydro mixture or with granulated free-flowing material immediately after the storage of the containers in each gallery or in a number of galleries. After the final filling of the underground construction the entrances of the opening groves with surface outlet are sealed.

These activities are similar, but with a lower degree, to the activities described during the construction and operation. Therefore, the impact on the bowels of the earth will be similar.

4.4.1.3.1 NON-RADIATION IMPACT:

It is expected

→ a negative, indirect, secondary, continuous long-term, irreversible impact with a very low level and territorial scope limited to the site of the investment proposal, caused by infiltration of relatively small volumes of domestic and faeces waters and rain waters, which contain dissolved substances.

An impact is not expected to be caused by:

→ mechanical damage of the bowels of the earth because excavation activities are not carried out;

→ collapsing of the earth foundation due to elimination of the collapsibility properties of the loess soils during the construction;

→ manifestation of gravitation processes and event for the trench type of repository because the stability of the slopes is ensured not only by their implementation with design parameters with sufficient safety but also by the results from the geodetic monitoring during the construction and operation period;

→ surface erosion, which may be expressed by the formation of shallow grooves and gullied on the surface of the slopes for a trench type of repository due to the implemented afforestration of the slope and construction of a system for organized collection and elimination of the surface flow.

4.4.1.3.2 RADIATION ASPECT:

It is not expected a change of the radiation indicators of the bowels of the earth beyond the background levels typical of the region, because of non-distribution of radioactive substances and protection of the environment, including of the bowels of the earth, against radioactive contamination, which is ensured by:

→ the package of the conditioned RAW and the other engineering barriers, which preserve their integrity and design characteristics;

→ the construction of the cells for RAW for a tunnel type of repository and the lining of the mine construction for a tunnel type of repository, which are waterproof and are secured against radiation leakage;

→ the constructed drainage and sewerage systems.

In long-term aspect, during the period following the closure of the repository:

→ the multi-layer barrier cover of the trench type of repository practically prevents the infiltration of rain waters due to the very low values of the filtration coefficient (about 10^{-9} m/s) and the infiltration coefficient (about 1.5 l/m^2). This circumstance slows down to a great extend the loss of functionality of the containers with RAW and the leakage of radionuclides into the geological environment under the repository;

→ the high levels of the filtration coefficient (5.8×10^{-6} m/s) and the infiltration coefficient (60÷120 l/m^2) of the natural barrier of the tunnel type of repository, which consists of Aeolic loess formations, are a negative prerequisite for infiltration of rain waters into the mine constructions, respectively for speeding of the process related to the loss of functionality of the containers with RAW with following leakage of radionuclides into the geological environment under the repository.

4.4.2 UNDERGROUND NATURAL RESOURCES

In Section 3.3.4 it is noted that:

→ According to the information in the letter outgoing No 92-00-79/15.05.2014 of the Ministry of Economy and Energy, within the Radiana site there are no fields, which are listed on the National Balance of Reserves and Resources, and no rights for underground natural resources are granted and there are no permits in effect for prospecting and/or exploration of mineral resources. In addition:

→ According to the data of the long-term Kozloduy municipal program there are *quarries for inert materials* at Ogosta River, at the village of Butan and in the river-bed of the Danube River at the town of Kozloduy) At a distance of *about 1.0 km* from the village of Kriva bara there are *quaternary clay deposits* for bricks production;

→ According to the specialized maps under the Subsurface Resources Act /SRA/ approximately 10 fields of underground natural resources in the 30-km zone of Kozloduy NPP are listed on the National Balance of Reserves and Resources (NBRR): oil, gas and condensate (at Butan, Oryahovo, Selanovtsi, Kneja); clays for brick production at Tarnava; limestone in the Hairedin municipality; and the Lom coal field (operation of the field is not anticipated in the foreseeable future);

→ According to the information in letter outgoing № IV-512/14.05.2014 of the Executive Agency *for* Exploration and Maintenance of the Danube River-Ruse (EAEMDR -Ruse) have been issued 32 permits *for* extraction *of* alluvial deposits (sand and rubble) from the Danube River. The following sections of the river are located at the greatest proximity to the Radiana Site: from $^{km}693$ to $^{km}689$ – the town of Kozloduy, $^{km}770 \div ^{km}759$ - the village of Archar, $^{km}676.6 \div ^{km}675.4$ - the village of Leskovets, $^{km}662{,}5 \div ^{km}660$ - the village of Ostrov, etc. Extraction of rubble and sand is also allowed from the Ogosta dam and this is within the authority of the MoEW. There are some small rubble extraction site along the rivers Ogosta and Iskar and their permits have been issued by the Basin Directorate for Water Management in the Danube Region (BDWMDR).

With reference to this information about the underground natural resources:

● **Fields of oil and gas, coal, clay and limestone do not exist** in the depths of the earth at the territory of the Radiana Site. Thus, an impact is not anticipated during all periods of the

implementation of the investment proposal (construction, operation and closure) both in non-radiation and radiation aspect.

● **The construction inert materials (rubble, sand, etc.)** will be part of the construction materials that will be utilized during the main stages of the NDF implementation – the preparation of the site, the construction of underground and surface communication systems and surface construction of buildings and facilities, and the closure of the depository.

4.4.2.1 DURING CONSTRUCTION

The supply of the construction site with the necessary quantities of river gravel and sand will be carried out according to the regulated under the Water Act (WA) ballasts within or outside the area, which are noted in **Chapter 3, Section 3.3.4.** (The Executive Agency for Exploration and Maintenance of the Danube River-Ruse (EAEMDR -Ruse) issues the permits for extraction of alluvial deposits from the Danube River, MOEW – for extraction of inert materials from the dams listed on the Appendix 1 of the WA and the Basin Directorate for Water Management in the Danube Region (BDWMDR) – for extraction of inert materials from the inland rivers).

4.4.2.1.1 NON-RADIATION ASPECT:

An impact is expected on the ballasts' reserves which will be defined in the specific projects related to the construction of the depository. The impact will be negative but it is unavoidable, direct, primary, temporary, short-term, and reversible and its territory scope falls within the boundaries of the particular ballast. The impact is expected to be of a low level because the extraction will only affect the renewable resources of inert materials and will take place under strictly regulated permit regime of the activity and control carried out by the respective state authorities.

4.4.2.1.2 RADIATION ASPECT:

No impact on the ballasts is expected because the usage of radioactively polluted inert materials is impermissible.

4.4.2.2 DURING THE OPERATION AND IN EMERGENCY SITUATIONS

4.4.2.2.1 DURING NORMAL OPERATION

Usage of inert materials is not foreseen during the normal operation of the NDF. Because of this and because of the lack of underground resources in the depths of the earth at the territory of the NDF site, no impact is expected on the fields of underground resources in non-radioactive and radioactive aspect.

4.4.2.2.2 IN EMERGENCY SITUATIONS

No non-radioactive and radioactive impact is expected on the fields of underground resources in cases of emergency situations because the usage of inert materials is not foreseen and there are no underground natural resources in the depths of the earth at the territory of the NDF site.

4.4.2.3 DURING CLOSURE

During the closure of the NDF inert materials will be used for the construction of a multi-layered engineering barrier for a trench type depository and for filling the mine constructions for a tunnel type depository. Thus:

4.4.2.3.1 NON-RADIATION ASPECT

No impact is expected on the underground natural resources because such are not present in the depths of the earth at the territory of the NDF site

An impact is expected on the ballasts' reserves which will be defined in the specific projects related to the closure of the depository. The impact will be negative but it is unavoidable, direct, primary, temporary, short-term, and reversible and its territory scope falls within the boundaries of the particular ballast. The impact is expected to be of a low level because the extraction will only affect the renewable resources of inert materials and will take place under strictly regulated permit regime of the activity and control carried out by the respective state authorities.

4.4.2.3.2 RADIATION ASPECT:

No impact on the ballasts is expected because the usage of radioactively polluted inert materials is impermissible.

4.5 LANDSCAPE

For the protection of the landscape in Bulgaria, apart from the Bulgarian legislation, the European Landscape Convention also plays an important role (ratified on 13.10.2004 / SG issue 94/October 22nd 2004 / in force for the Republic of Bulgaria since March 1st 2005).

The Convention is based on the idea that there is a single landscape, each component of which is important for someone and that both the cultural and natural aspects are relevant to the character and explains its present condition. The main objective of the Convention on the landscape is to preserve the European cultural and natural heritage that defines the appearance of pan-European landscape. To achieve this objective, the Convention brings together the efforts of contracting parties and organizes an effective cooperation for their implementation at a European level, while supporting them to develop a policy for the protection, management and planning of European landscapes at a national and local level. Another objective of the Convention is to demonstrate that natural and cultural components of the landscape can be protected and enhanced without them being declared as monuments.

The two main aspects of the convention are:

- → recognizing the value of all landscape components and their role in providing the quality of human life and the originality of people;
- → the active role of society when accepting and evaluating the landscape.

- **ANALYSIS AND ASSESSMENT OF THE MIGRATION OF THE POLLUTANTS IN THE LANDSCAPES**

The mechanical damage of the geological foundation during the construction is practically irreversible. The mechanical damage of the biocose substrate affects mainly the external structure of the landscapes and the terrain in particular (it is a component of the external structure).

There will also be an unfavourable impact on the vegetation part of which will be affected or destroyed but it is subject to partial artificial restoration (recultivation).

The proposed sites belong to regions that are occupied with agricultural areas, which are in close proximity to populated areas and also to industrial territories known for their environmental pollutants.

The distribution of the pollutants (of the air migrants) depends directly on the specific climate conditions. The main source of pollution will be the transport flow and the construction machines, which can be regarded as a source that emits:

→ constantly but with fluctuating intensity COx, NOx, SO2 and other gases and aerosols containing Pb, Cd, smoky particles caused by the passing-by vehicles and by the amortization of their tyres and the road surface;

→ episodically, emergency volley pollution is separate local regions with very limited chance of occurrence as a result of failure of out-of-order equipment.

The intensity depends on numerous factors which are beyond the scope of the NDF's engineering project. They include: the technical status of the vehicles; type of the fuels used; ways of usage and the movement of the equipment, etc.

The emitted non-volatile aerosols are spread over the surface of the earth and cause accumulating local pollution of the soils and the vegetation.

The migration of pollutants in surface and ground water depends directly on the specific hydrological and meteorological situation, which is determined by the climatic conditions.

Under these conditions the occurrence of increased concentrations of this type of pollutants is impossible in the surface and ground waters.

The radioactivity of the soils in the area of Kozloduy NPP has been subject to detailed and systematic monitoring by the plant since its putting into operation in 1974.

In accordance with Section 3.4 Lands and Soils – Current Situation – "The content of the natural radionuclides ^{238}U, ^{226}Ra, 2^{32}Th is within the natural concentration range for the soils in this region, and the content of the technogenic ^{90}Sr и ^{137}Cs in the surface layer (0-30 cm) is within the normal levels and is not much different from the content of these pollutants in the whole Northern Bulgaria which is due to the Chernobyl's residual pollutions.

The results of the predisposal monitoring of soils from the Radiana site indicate typical levels for the region. 8 control samples are initially analysed (zero readings) and then regularly soils at two control points on the site. The results are: ^{54}Mn: <0.22÷<0.40 Bq/kg, ^{60}Co: <0.40÷<0.70 Bq/kg, ^{134}Cs: <0.45÷<1.09 Bq/kg, ^{137}Cs: 2.98÷ 43.82 Bq/kg, ^{90}Sr: 0.95÷1.55 Bq/kg, ^{238}Pu: < 0.0079÷0.013 Bq/kg, $^{239+240}$Pu: 0.056÷0.17 Bq/kg, ^{241Am}: 0.033÷0.083 Bq/kg, ^{242}Cm: < 0.006÷< 0.0071 Bq/kg and $^{243+244}$Cm: < 0.0061÷< 0.0066 Bq/kg. These activity levels are typical for the soils in the region, with minimal residual technogenic impact from the cross-border transmission as a result of the accident at the Chernobyl nuclear power plant and depositions from the global transfer of the nuclear tests in the last century.

During the investment proposal implementation no radioactive contamination of soils that exceed MRLs is expected, because the operation of the NDF be in accordance with the established policies and regulations for safe management of *radioactive waste management facilities* and with the safety requirements of the nuclear legislation and International Atomic Energy Agency recommendations.

- **ASSESSMENT OF THE LANDSCAPES' POTENTIAL FOR SELF-CLEANING AND SELF-RESTORATION**

Each landscape has its own aesthetic capacity determined by its external structure and ecological capacity that is conditioned by its internal structure. The aesthetic capacity is defined by the boundary at which the visual unity and the aesthetical harmony of the landscape are preserved.

The ecological capacity is determined by the preservation of the self-regulatory mechanisms of the landscape, which ensures the protection of the existing environmental balance.

The self-restoration potential of the landscape in relation to the mechanical damage of the geological foundation (the biocose substrate) is practically non-existent. The mechanical damage of the biocose substrate affects mainly the external structure of the landscapes and the terrain in particular.

The self-cleaning potential in relation to the pollutants emitted by the road (excluding oil products) is sufficiently large, so that the wider distribution of the pollutants in the lithosphere is avoided.

- **PROGNOSIS AND ASSESSMENT OF THE EXPECTED LANDSCAPE DAMAGES TAKING IN TO ACCOUNT THEIR STABILITY AGAINST THE SPECIFIC TYPE OF IMPACT**

The changes in the special and functional structure of the extra-urban zones, which are characterized by industrial and transport and communication type of landscapes, are a result of the development of cities, the new requirements regarding the town and country planning, the land reform and the replacement of the economic reform. After the prognosis and assessment of the expected damages, the landscape planning should be subject to several main groups of criteria:

The ecological criteria are related to the restoration of the damaged environmental unity in the extra-urban zones with increased technogenic loading and transport functions. They are used to determine the parameters of the different landscape components.

The economic criteria are related to the participation of various values in the final balance regarding the conducted events for restoration of the landscape damages.

The aesthetical criteria are related to events regarding the improvement of the area’s appearance and the balanced relation with the surrounding landscape. The visual impact caused by the changed type of the landscape can be mitigated by the selection of a contemporary engineering and architecture type of the object and by the implementation of appropriate gardening of the technologically unoccupied territory within the selected terrain.

The social criteria are related to ensuring the health of the workers at the site and the population in the adjacent territories within the impact zone; preserving the living conditions; preserving the old traditions of land use and protecting of the local landscape – its aesthetic, ecological and emotional value.

The main objective of the IP implementation – construction of the NDF – is to ensure safety and effective protection of the operational personnel, the population and the environment against the potential impact caused by the disposed waste during the operation period and the post-operation phase. The safety measures are carried out during the whole life cycle of the NDF – during the stages of site selection, design, construction, operation, closure and the period of institutional control.

During the implementation of the foreseen investment proposal the landscape will be changed but the main type of the existing landscape will not be changed.

The conditioned foreseen impact of the pollutants on the landscape can be divided into three phases:

4.5.1 DURING THE CONSTRUCTION

The following components of the landscape: *geological foundation*, soils and vegetation will be affected.

The geological foundation will be directly affected as a result of the excavation works during the construction The impact is assessed as direct, negative, primary irreversible, with low or moderate significance, with a limited scope within the construction site of the IP.

The soils are subject to mechanical impact as a result of the earthworks. The humus layer will be stored in a temporary depot within the territory of the selected site.

The changes related to the contamination of the soils will find expression in the following: there will be a local change in the physical and chemical, hydro and physical, and the biological processes that take place in the soil substrate; danger of erosion and aesthetical changes.

The vegetation will be destroyed in the areas that are directly affected by the construction works at the site. *The impact on the soil and vegetation landscape components is assessed as direct, primary, negative, reversible, with low significance, and with a limited scope within the construction site.*

During the construction the *visual perception of the landscape will be changed* in aesthetical and volumetric and special aspect. Certain types of works are foreseen to be conducted – excavation and embankment – which are related to depots for earth masses and a depot for the extracted humus, a machine park for construction equipment, carriages for the workers, etc. The visual landscape complexity is characterized by the specifics of the local landscape (anthropogenic-industrial type of landscape) – manifestation of its dominance through the chimneys and buildings of the Kozloduy NPP. The visual framework of the future NDF will be defined mainly by road and communication networks and by the various view perspectives from neighbouring areas. The elements that affect the aesthetics and vision are related to the construction process, later to the built object. The problem is related to the psycho-physiological assessment of the site, which, in turn, has a particular dynamics depending on the landscape shaping of the site area. *The visual impact can also cause negative feeling for too heavy human intervention in the area.*

The usage of heavy-fright machines and equipment utilized during the construction works will result in *increased levels of noise and harmful emissions*. The single source of pollution and a potential impact can be the *burnt gasses* from the internal-combustion engines of the construction machines - CO, NOX, CH4, SO_2, and hydrocarbons during working hours. *The emissions will have a limited volume and only during working hours*. The period during which the impact will be present will be short and limited – only during the construction, and will depend on the particular climatic conditions. No mitigation measures are necessary.

It is not expected a negative impact and pollution of the ground waters and the soils in the region. Limited amounts of contaminated water generated during the construction may infiltrate in the near-surface layers of the bowels of the earth.

No radiation impacts are expected on the landscape’s components during the construction stage.

No damages are expected in the structure and functioning of the landscapes. There will be a change but will only affect the local structure and will not have an impact on the main type of landscape.

The social and economic functions of the landscape will not be changed during the construction of the investment proposal.

The construction stage is not related to any impacts on landscapes in the neighbouring Romanian territories.

4.5.2 DURING OPERATION AND IN EMERGENCY SITUATIONS

The operation period of the investment proposal and its impact on the landscape are assessed as identical for the four proposed sites:

The operation period of the investment proposal is not related to any negative impact on the landscape components.

It is not expected any contamination of the landscape components with emissions of pollutants.

During the operation of the NDF and after its closure are not expected any significant impacts on the geological foundation, such as contamination with radionuclides because of the presence of the foreseen engineering barriers that prevent the distribution of radionuclides in the environment.

It is foreseen the implementation of control over the radiation characteristics. The non-radioactive emissions will be controlled by a Continuous Emissions Monitoring System.

In cases of emergency situation is possible local contamination of all landscape components. The management of failures and restoration of the damaged landscape will be carried out in accordance with a previously elaborated Emergency Plan.

If all project requirements are observed, it is not expected contamination with liquid RAW because the emissions will fulfil the normative requirements. In danger of failure the Programme for Radiation Protection will be implemented.

The relevant legal requirements should be observed.

The lasting of the impact is limited (during the operation of the NDF).

No impacts are expected on the nature and territory complexes. Transboundary impact is not expected.

No damages of the landscapes' structure and functioning are expected.

4.5.3 DURING CLOSURE

The impact on the landscape will be similar to the impact during the construction.

During the closure no negative impacts are expected on the horizontal and vertical structure of the landscape. The activities related to the closure will be carried out in accordance with a preliminarily elaborated Plan for the closure of the NDF.

Radioactive impacts on the components of the landscape are not expected during the period of closure. No radioactive impacts are expected on the nature and territory complexes in the neighbouring Romanian territories.

The land on which the NDF will be constructed will be permanently occupied by it because after its closure an institutional control will be established and the access to the site will be limited. The land use of the site will be restored after the end of the 300-year period of institutional control.

The activities related to the recultivation of the terrain will have a positive impact on the landscape. They will contribute to the incorporation of the new structure unit to the existing local landscape.

The recultivation of the disturbed terrains is realized through a complex of measures which ensure the fullest possible and effective restoration of the natural potential of the landscape. The recultivation will preserve the aesthetic standard of the neighbouring landscape.

The recultivation is commonly carried out in two stages – technical and biological. The biological recultivation will be consistent with the main function upon future usage of the territory. Depending on the planned usage of the territory of the respective site, it is possible that the anthropogenic landscape is replaced by a new type of landscape.

The local landscape will be changed but the main type of landscape will not be changed.

4.6 BIODIVERSITY

4.6.1 FLORA

4.6.1.1 DURING THE CONSTRUCTION

4.6.1.1.1 NON-RADIATION ASPECT

The construction of the NDF is related to the realization of construction and assembly activities on the surface of the Radiana Site whose territory is currently almost fully occupied by forest acacia species. Taking this into consideration, the vegetation on the construction sites will be completely eliminated in stages following an elaborated plan – working schedule. This is related to changes in the appearance of the terrain. The areas where the vegetation will be eliminated are 331.5 dka and they include the sites for the depository's platforms, the zone for the service buildings, the areas for landscape gardening, as well as the adjacent infrastructure – roads, car parks, draining ditches, etc. The total area of the Radiana Site amounts to 464 dka, 132.6 dka of which will not be disturbed, i.e. the vegetation there will preserve its current appearance. At the same time, the areas that are foreseen for landscape gardening amount to 244,5 dka and the vegetation there will be replaced by species that are currently not found in these areas – it is likely that grass zones will be made with ryegrass and flower beds will be planted with various decorative flower species; decorative trees and bushes will also be planted separately or in groups. The on-site terrain studies determined that all vegetation species found on the territories of the Radiana Site that are subject to usage through construction or landscape gardening, as well as the neighbouring terrains and the areas that will be eliminated during the construction are widely distributed and represented in the whole country, and they are not of conservation significance – they are not listed in Appendices №2 and 3 of the Biological Diversity Act, in Appendix I of the Berne Convention, in the Red List of the Bulgarian vascular plants (Petrova & Vladimirov, 2009), in Appendices II and IV of the Council Directive 92/43/EEC, and in the Red Data Book of Bulgaria, volume I – Plants and Fungus (published by the Bulgarian Academy of Sciences and the MOEW, 2011). Practically, the implementation of the IP is not related to loss of valuable of rare plant species ad to disturbance of plant habitats that are characteristic of or valuable for the country because the affected areas are forests with an artificial origin where the main dominant species is the acacia, which is a species introduced in the country. No significant loss is expected of biodiversity and biomass in regard to the flora in the floristic region (Zlatiya) because according to vegetation map of Bulgaria with M 1:600000 (Bondev, I., 1991) the mapped unit "Artificial plantations of acacia (*Robinia pseudoacacia*)".

4.6.1.1.2 RADIATION ASPECT

During the construction of the first platform of the depository and the service buildings, no impacts on the flora in the region are expected in radiation aspect because the facility will not operate as designed, i.e. it will not be used for disposal of *packages* with low and intermediate active RAW. During the construction of the second platform of the depository, the first one will already be constructed and in operation, and during the construction of the third platform, the second one will be already constructed and in operation. Again, no impacts on the flora in the region are expected in radiation aspect because it is not expected radiation contamination due to a number of screening barriers on the platforms with the disposed RAW, which barriers prevent the infiltration of radioactive isotopes and their emissions in the environment. Such impacts will be limited only approximately to the values that are characteristic of the natural radioactive background in the region, i.e. in normal limits. The barriers are described in details and analysed in the section of the EIA Report which contains the characteristics of the IP. It is important to note that the risk of radiation contamination in the region is limited to a minimum in the period of "sealing" of the low and intermediate level radioactive waste in reinforced concrete

containers, which will be closed sources of only gamma-ionizing radiation because the packaging will eliminate the distribution of alpha and beta particles out of it. The containers will constructed in a way that the power of the equivalents dose of gamma radiation from a single RAW packaging is limited to 2 mSv/h on the surface and a maximum of 0.1 mSv/h at a distance of 1 m from the surface. The barriers will also completely screen the distribution of the weak gamma-ionizing radiation emitted by the containers.

4.6.1.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

4.6.1.2.1 NON-RADIATION ASPECT

Significant negative direct, secondary and indirect negative impacts on the flora in the region cannot be expected during the operation because the main impacts will be manifested during the construction period. In this case, at the beginning of the operation period and in case all measures set in the EIA Report in relation to the biological diversity are observed, rather positive impacts can be expected, which are related to the creation of vegetation cover in the areas provided for landscape gardening that amount to 244,5 dka. For this purpose, the afforestation and planting of grass should not be use aggressive and invasive grass and tree species because there is a risk they gradually take the place of the vegetation cover in the adjacent areas that are not affected by the usage of the terrain.

4.6.1.2.2 IN RADIATION ASPECT AND IN EMERGENCY SITUATIONS

During the operation of the NDF, which included the disposal and storage of low and intermediate level RAW in the cells of its platforms, there is not serious risk of additional radiation impacts on the vegetation in the region beyond the existing impacts caused by the constant natural radioactive background that is typical for this part of the country. **This risk is limited to a minimum in the period of “sealing” of the low and intermediate level radioactive waste in reinforced concrete containers (RCCs).** They are closed sources of only gamma-ionizing radiation because the packaging will eliminate the distribution of alpha and beta particles out of it. The containers should be constructed in a way that the power of the equivalent dose of gamma radiation from a single RAW packaging is limited to 2 mSv/h on the surface and a maximum of **0.1 mSv/h at a distance of 1 m from the surface**. In accordance with the law on decrease of the intensity of the equivalent gamma dose with the square of the distance, the estimated equivalent dose after another dozen of meters will practically be zero, i.e. in this case there is no possibility that the nearest to the Radiana Site protected territories under Natura 2000, the natural habitats and the species’ habitats are contaminated in radioactive aspect by the RCCs during their transportation to the NDF.

The following disposal of the packages in the facility’s cells through their closure and covering with multi-layered engineering barrier (including the loess-concrete pillow below them created at a previous stage) will completely neutralize the possibility of radioactive contamination of the waters, soils, air, geological environment and the components of the biodiversity in the region resulting from penetration of gamma radiation in them. Therefore, the quality of the flora habitats in the region cannot be worsened as a result of secondary/indirect impacts of radioactive nature. The systems that service the depository will also be helpful in this respect, especially the network for control and leading away of infiltrated waters, and the deep drainage network which are described in the annotation. It should be taken into consideration that, as a technology, the process of RAW storage in the NDF is not related to any possibility for emitting of gas emissions in the atmospheric air.

Regarding the seismic activity, the Radiana Site is located within the boundaries of the stable part of the Mizia platform which determines a low level of seismic activity in a sub-regional scale. The maximum expected earthquake in the sub-region is M_{max}= 5.0.

The main sources of seismic danger are seismic areas located outside the region of the area. The most important once is the Vrancea zone in Romania, which has generated events with a magnitude of M>7. The local epicentres are with documented earthquakes with magnitudes of M<4 and fall into the category of background seismic activity.

Thus, the depository, its service installations (the system for infiltrated waters, the deep drainage system, the servicing reservoirs, etc.) and the auxiliary buildings as well as the facilities and installations will be designed, constructed, dimensioned and secured in accordance with the seismic division of the Republic of Bulgaria, in conformity with the requirements of Eurocode 8[25] and the standards for design and implementation of constructions which are compulsory for design since January 2014 – defined in accordance with Article 152 of the **Regulation № РД-02-20-2/2012 on design of buildings and facilities in seismic regions (SG, issue 13/2012).**

4.6.1.3 DURING CLOSURE

4.6.1.3.1 NON-RADIATION ASPECT

After the final closure of the NDF, when the multi-layered cover is placed over the disposal cells, the depository will be subjected to technical and biological recultivation in result of which it will be completely covered by soil and vegetation. During the technical recultivation the soil, which has been excavated from the location of the platforms and has been stored at the Radiana Site, will be placed so that the slope approximately restores its initial state. In case all measures set in the EIA Report regarding the biological diversity are observed, this will have a positive impact on the appearance of the flora in the region and part of the species eliminated during the construction of the depository, which are mainly grasses, will again occupy the terrain used for the construction. To avoid potential negative impacts on the existing vegetation cover in the region, the afforestation and planting of grass should not be use aggressive and invasive grass and tree species because there is a risk they gradually take the place of the vegetation cover in the adjacent areas that are not affected by the usage of the terrain.

4.6.1.3.2 IN RADIATION ASPECT AND IN EMERGENCY SITUATIONS

During the implementation of the investment plan no significant negative impacts are expected to occur on the widespread natural vegetation in the region, including agricultural production, as the NDF will be designed and constructed in compliance with the safety requirements laid down by the legislation and with the IAEA recommendations, using the defence in-depth principle and the NDF construction as a multi-barrier engineering facility hampering the radionuclide distribution in the environment, as well as operating the repository according to the principles and rules for safe management of facilities for radioactive waste management. Only a local impact is expected on a limited area associated with the removal of the plant species growing within the construction site and in the immediate vicinity of it. There are no identified species among them which are put under special protection regime under the Biodiversity Act.

No impacts are expected regarding the radiation status of the vegetation and agricultural production in the vicinity of the NDF's Radiana Site caused by the implementation of the IP during the operation period of the depository. The packages of the conditioned RAW (RCCs) and the other engineering barriers of the NDF ensure that the radioactive substances are not distributed and the environment is protected against radioactive contamination. The implementation of the NDF is not expected to change the radiation indexes of the flora in the area beyond the background level characteristic of the region.

[25] Draft of the National appendices of the European standards on design and implementation of constructions (Eurocodes) http://www.mrrb.government.bg/?controller=articles&id=492

No significant negative impacts are expected caused by the investment proposal in non-radiation and radiation aspect considering the foreseen engineering barriers that hamper the distribution of radionuclides in the environment. The expected radiation impact on the flora will be **insignificant**.

4.6.2 FAUNA

4.6.2.1 DURING THE CONSTRUCTION

4.6.2.1.1 NON-RADIATION ASPECT

As a whole, during the construction of the NDF, the service building and the infrastructure it cannot be expected significant negative impacts on the various groups of the fauna that are represented in this part of the Danube plain – invertebrates, fish, amphibians and reptiles, mammals and birds. Considering the nature of the IP, its scale, location and the foreseen construction stages of the depository at intervals of about 20 years, there are no circumstances that presume an occurrence of significant and irreversible changes of the structures of the numerical complexes of the species found in the region, including as a result of cumulative impacts. There are no group fields of rare and endangered animal species of the wildlife fauna on the foreseen site (464 dka) as well as near it. Such species have not been registered during the conducted inspection and had not been listed in literature sources. The territory itself is located in a region, which is relatively preserved but fragmented, and surrounded by anthropologically affected terrains – to the south – class II road Harlets – Kozloduy and agricultural lands beyond the road; to the north – a road providing access to the Kozloduy NPP and the site of the NPP; to the west and east – agricultural lands. This significantly hampers the free and undisturbed access to this region of certain species that move on the ground, and especially of species that are characterized by a higher threshold of anxiety. It is also of great significance that according to the balance sheet for the building-up of the site around **377 dka (approximately 80% of the terrain) are left unoccupied** by way of planted areas and non-disturbed zones, and only **87 dka (approximately 20%) are subject to building-up** through construction of facilities, buildings and infrastructure elements. This is a prerequisite for preservation of the existing functions of the habitats in the non-disturbed areas of the site. The artificially planted areas are also able to continue providing food basis for the animal species found in this part of the country.

During the construction of the NDF's components it is mainly expected a negative impact on the Invertebrates which are found in the areas subjected to construction and development. The invertebrates will be mainly removed with the soil where they are present or large part of them will be driven away (geobionts, geophyles, geoxens), including worms, myriapods, etc., as well as part of the present ground fauna – mainly some species of ants, spiders, hemipterans, etc. It should be taken into consideration that such an impact inevitably accompanies all types of construction works and other activities (especially agricultural ones) in the territories outside populated areas. Also, in this case the characteristics in the descriptive section shows that the IP is at a sufficient distance from all regions with significant distribution and large diversity of rare, endemic and relict invertebrate species in Bulgaria. In this part of the Danube plain it has been established an insignificant number of endemic species and a number of rare species which is among the smallest in the country, while no relict species have been registered. The listed and described five invertebrate species which are of conservation significance and are subject to protection under the Appendices of Directive 92/43EEC and the Biological Diversity Act, are found in water ecosystems or mainly in beech and old oak forests, which are not present in the vicinity of the IP. Thus, the construction of the IP will mainly affect widely-spread species with numerous populations, hence no significant and noticeable changes in their parameters can be expected in this part of the county and in the whole country. In this situation, the death rate of the

Invertebrate fauna should be rather viewed as a loss of food basis for other taxonomies of vertebrates but this will also be unnoticeable, insignificant and, to a certain extent, reversible.

Regarding the Vertebrates, during the construction of the NDF no impacts will occur on the representatives of the ichthyofauna characteristic of this part of the country, because there no fish habitats in the vicinity of the Radiana Site – the nearest water objects are at a distance of 4 km (the Danube River) and over 1 km away (the service canals of the Kozloduy NPP).

As it comes to the amphibians and reptiles, it is expected that only the numerous complexes in this part of the country are partially affected in a low and tolerable level, including the European green toad (*Bufo viridis*), the blindworm (*Anguis fragilis*), the Aesculapian snake (*Elaphe longissima*) and some lizards for which the site provides to a certain extend favourable conditions for living and hiding. If they are found in the region, during the construction works there is a risk of mortality of single specimen (including their generation) as a result of trampling during the utilization of construction machines for clearing and treatment of the areas subjected to building-up and development as well as during manoeuvring of the heavy-fright vehicles utilized for transportation. In any case, as a whole this will not significantly affect the density of the numerical complexes of the mentioned species in this part of the country because despite being listen in Appendix №3 of the Biological Diversity Act, they are found in similar or other habitats in whole country and their number is sufficient to preserve their population structures and functions. This is also confirmed by the fact that the first two species are not endangered in a national or world scale and they are not listed in the category of rare species but the first one is registered in the Red List of the Endangered Species of the IUCN as “slightly affected” (including the Aesculapian snake), while the blindworm is not registered at all. The species are not included in the new issue of the Red Book of Bulgaria, volume 2 – Animals (published by the Bulgarian Academy of Sciences and MOEW, 20011). As it was mentioned in the analytical section, the European green toad is widespread in country at sea level up to 1200 m, mainly in sheltered grass areas, and in some cases its population can even be bigger in country yards in the villages than outside populated areas. It is also found in big cities, including in the areas between apartment blocks (Sofia, Plovdiv and other cities, personal observations), i.e. it is characterized by good levels of synanthropic adaptation. In the vicinity of the IP there are numerous territories similar to the affected one, which are appropriate habitats for the species. Considering this, the risk of mortality will not significantly affect the density of the local population of the European green toad because this species is found in the whole country in its relative biotope, and the number of specimen is sufficient to maintain its population structure and functions. The blindworm is also widely spread in the whole country in a variety of terrains – mainly in non-xerophilous forests and open terrains among them. The Aesculapian snake is found mostly in wet deciduous and mixed forests and nead but it also does not avoid populated areas and can often be found in vineyards, orchards and vegetable gardens, and courtyards where it often becomes a victim of the property’s owner. This is related to one of the greatest dangers for this specimen. As a whole, the risk of mortality for the specimen blindworm (*Anguis fragilis*) and the Aesculapian snake (*Elaphe longissima*) is low during the construction of the NDF and can be limited to a minimum and even almost completely neutralized if certain preventive measures are taken.. The measures should be directed towards an inspection of the terrain by a herpetologist prior to the beginning of the construction. The expert should carry out rescue works regarding the less active specimen and should instruct the workers to discontinue their work when they notice amphibians and reptiles and to wait until the specimen move out of the region or until rescue operations are carried out on-site by an expert called for this purpose. As it comes to the other specimen of amphibians and reptiles which are described in the general characteristics, no significant impacts are expected during the construction. There are no known fields of target and significant taxonomies near the IP.

Regarding the mammals, it cannot be expected significant, direct, negative impacts caused by the construction and resulting in morbidity of species, etc. The main impacts will mainly be related to the chasing away of the present ground mammals from the territories of the surface construction sites. This will happen during the removal of trees which is part of the preparation for construction. Thus, it is not expected to be affected the numerical complexes of the described "target species" characteristic of the region and subjected to protection in the nearest protected areas, and their fields respectively. The territory does not offer suitable conditions and the presence of such species has not been registered. Even though such species have not been observed, there is a minor possibility that the vicinity of the Radiana Site is a habitat of some of the "significant species" – the weasel (*Mustela nivalis*) and the white-breasted hedgehog (*Erinaceus concolor*). The two species are often found near populated areas and even though they are listed in Appendix №3 of the Biodiversity Act, they are not endangered in a national or world scale and they are not listed in the category of rare species, and they are registered in the Red List of the Endangered Species of the IUCN as "slightly affected". The two species are not included in the new issue of the Red Book of Bulgaria, volume 2 – Animals (published by the Bulgarian Academy of Sciences and MOEW, 20011). Even if they are chased away from the territory of the IP, this will not significantly affect the structure of their population because nearby there are suitable habitats where they can settle. In case an offspring of the two species is found at the site, the construction should begin only after the offspring is grown up, so that it starts looking for settlement in other territories or after it is safely moved to suitable territories. Regarding the fauna of rats, as it was mentioned in the descriptive section, there are no suitable shelters for resting and breeding of the so-called "forest rats" at the territory. In practice, the IP site offers mainly conditions for hunting and feeding of some of them, including some "city" species that are likely to use certain buildings and warehouses of the Kozloduy NPP as shelters. As a result of the clearing and the working activities on the site, part of the hunting "city" bats in the region may start temporary visiting other hunting territories during the construction because of the occurred disturbance, especially if the construction works are carried out twenty-four hours a day. Suitable territories are located around the service external canals of the Kozloduy NPP, at the Danube River and other places, so the numbers of the bats in the region are not expected to change as a result of the NDF's construction. At the same time, a retroactive effect my occur – to attract „city" species that hunt in neighbouring territories because of the presence in the vicinity of the site of artificial lighting, which attracts various insects serving as a food basis for the bats. The species from the category "other mammals" including the descriptive section, most of which are hunting species and are widely spread in the whole country, will not be significantly affected by their chasing away from the territory.

Regarding the birds, of the species included in Appendix №2 of the Biological Diversity Act – List 2 in the descriptive part, as it was mentioned there, during the period of nesting only the red-backed shrike has been registered in the areas of the planted territory, in which the terrain of the IP is included (the bird is only found near the periphery of the territory and not in its interior). It is also possible the presence of certain specimen of the Syrian woodpeckers – when looking for food but mainly during the autumn and winter. The red-backed shrike is quite a numerous species in the country and is found from sea level up to great altitudes above sea level. Thus, the species in the whole country and in the vicinity of the IP is not endangered and is not included in the category of rare species, and this is the reason why it is not presented (it is not included by the expert responsible for it) in the new edition of the **Red Book of Bulgaria**. Taking this into consideration, the IP's territory due to its small area compared to the region it falls within, will have an insignificant impact on a limited part of the food and nest basis of the species in the vicinity of the IP. Specimen of the collared flycatcher (both subspecies) and the European pied flycatcher have been registered only during the periods of seasonal migrations and their presence has been longer during the spring migrations. Certain specimen of other species would use the

trees of the planted area only for landing to rest or to spend the night (and they most probably have done this.

The impacts on the fauna, caused by the construction of the object of the investment proposal, will have the following parameters:

Territorial scope: at local level, limited within the scope of the Radiana Site – at an area within the boundaries of the platforms in the controlled zone, the service building and facilities in the protected area, as well as the car parks, the transport links inside the site, pedestrian alleyways, etc. The whole area of the site is approximately 464 dka and only 20% of it is subjected to dense construction as the main impacts during the construction will be concentrated there. The negative impacts will be significantly reduced during the stage by stage construction of the platforms (three stages).

Way of impact – a direct impacts mainly regarding the less active invertebrates within the boundaries of the construction areas, affecting a limited number of representatives of the amphibians and reptiles belonging to the vertebrate fauna in case such are present; a secondary impact when the mammals and birds are chased away and indirect impact on separate specimen of some taxonomies directly found in the adjacent territories.

Degree of impact: weak, without significant change in the number of the fauna complexes in the region and without significant fragmentation of habitats because such is currently existing.

Duration of the impact: temporary, medium to long-term duration of the impact during the construction period.

Frequency of the impact: periodical impact during the construction of the depository itself, at large intervals, i.e. significantly distributed in time because the three platforms of the depository will be constructed at intervals of 20 years, which on one hand will contribute to the significant reduction of generated harmful effects during the construction because the impacts will be divided into portions and each one will be assimilated before the occurrence of the next one, and on the other hand this will contribute to the gradual adaptation of the affected species to the conditions.

Cumulative impacts: it is not expected the occurrence of significant cumulative impacts caused by other similar investment intentions for construction and activities in the region.

Transboundary impacts: no such impacts on the fauna are expected.

Reversibility of the impact: the impact is reversible to a great extend after landscape gardening activities with the boundaries of the site as well as after the technical and biological recultivation after the exhaustion of the capacity for disposal of low and intermediate level radioactive RAW and the closure of the depository.

4.6.2.1.2 RADIATION ASPECT

During the construction of the first platform of the repository, no impacts are expected in a radiation aspect on the fauna in the region because the facility will still not be in operation, i.e. packages of low and intermediate level RAW will not be disposed in it. During the construction of the second platform of the repository, the first one will already be built and will be in operation. Thus, no impacts are expected in a radiation aspect on the fauna in the region because it is not expected a radiation contamination due to the numerous foreseen screening barriers at the platforms with disposed RAW. These barriers will prevent the entrance of radioactive isotopes and their emissions to the environment. Such impacts will be only limited within the values that are characteristic of the natural radiation background in the region, i.e. they will be in normal boundaries. The barriers are described and analysed in details in the section of the EIA Report, which includes a characteristic of the IP. It is important to note that risk of radiation

contamination of the area is limited to a minimum during the stage of „sealing“ of the low and intermediate level active waste in reinforced concrete containers, which will be closed sources of just gamma ionizing emission as the package will eliminate the distribution of alpha and beta particles outside the package. The containers will be constructed in a way that the capacity of an equivalent dose of gamma radiation from one RAW package is limited to 2 mSv/h at the surface and a maximum of 0.1 mSv/h at a distance of 1 m from the surface. The barriers of the repository will also completely screen the distribution of the weak gamma ionizing emission coming from the containers.

4.6.2.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

4.6.2.2.1 NON-RADIATION ASPECT

During the operation, no significant direct, secondary and indirect negative impacts on the fauna in the region can be expected because the main impacts will occur during the construction period. In this case, there is even a possibility that certain representatives of the fungi fauna, which have been chased away from the construction site by the building works, return in proximity of the affected territory, and some birds and bats may settle on or in part of the servicing building and other construction facilities. There is only a limited risk of mortality of certain small and less active vertebrates (amphibians and reptiles) during the transportation of the RCC containers full of RAW carried out by specialized means of transport (SMT) on the road going from the starting point at the Kozloduy NPP to the building for accepting and temporary storage of RAW, and then to the particular platform of the repository. Practically, this risk is insignificant compared to the existing risk caused by the common transport traffic in the vicinity of the NPP, and considering the short route (approximately 3 km) and the fact that the SMT will travel at low speed (ranging from 10 to 20 km/h). The use of the territory for the NDF construction, the continuous human presence during its operation and the fence surrounding the NDF will prevent the possibility big ground animal species to settle there, except some small mammals and reptiles. No significant emergency situations can be expected in non-radiation aspect. The most probably accidents that can be expected are related to leakages of fuels and lubricants, which can be removed quickly. The representatives of the fauna avoid sites of such leakages.

4.6.2.2.2 RADIATION ASPECT

During the NDF operation, which is related to disposal and storage of low and intermediate level RAW in the cells of its platforms, there is no serious risk of excessive radiation contamination in the vicinity of the site, as well as no serious risk of additional radiation impact on the fauna in the region beyond the existing impacts, caused by the continuous natural radiation background characteristic of this part of the country. **This risk is limited to a minimum at the stage of „sealing“the low and intermediate level radioactive waste in the reinforced concrete containers. The type of the radioactive waste, which is subject to disposal, is <u>category 2a</u>** in accordance with the *Regulation on safe management of radioactive waste*.

In practise, the investment proposal is not related to treatment and disposal of spent nuclear fuel resulting from the Kozloduy NPP units or another NPP, as well as of other RAW that are not included in the already mentioned waste category.

The NDF will be used for disposal of treated and conditioned waste in protective reinforced concrete containers (RCCs). **The waste will be closed sources of just gamma ionizing emission because the package will eliminate the distribution of alpha and beta particles to the outside. According to the principle for the reduction of the capacity of the equivalent gamma dose by the square of the distance, the calculated equivalent dose after another dozen of meters will practically be zero, i.e. in this case there is no possibility that the**

nearest to the Radiana Site protected areas under Natura 2000, the natural habitats and the habitats of species are exposed to radiation from the RCCs during their transportation to the NDF.

The following disposal of the packages in the facility's cells through their closing and covering with a multi-layer engineering barrier (including the previously created loess-cement cushion below them) will completely neutralize the possibility for radiation contamination of waters, soils, air, geological environment and components of the biological diversity in the region resulting from infiltration of gamma radiation. Therefore, the quality of the fauna habitats in the region cannot be decreased due to secondary/indirect radiation impacts. The systems that service the repository will also contribute to this, and especially the network for control and leading away of infiltrated water, and the deep drainage network, which are described in the annotation. It should also be taken into consideration that, as a technology, the process of RAW storage in NDF is not associated with a risk of release of gas emissions to the atmospheric air.

4.6.2.3 DURING CLOSURE

4.6.2.3.1 NON-RADIATION ASPECT

After the final closure of the NDF, when the multi barrier cover is placed over the disposal cells, the repository will be subject to technical and biological recultivation, as a result of which it will be completely covered by soil and vegetation. During the technical recultivation of the soil, which has been excavated from the platforms of the site and stored at the Radiana site, will be laid in a way that the slope will approximately restore its initial state. This will also have a positive effect on the fauna in the region because part of the species that have been chased away during the construction and operation of the repository will again start to inhabit the terrain, and spaces will be freed for some new species to inhabit, mainly reptiles, small mammals and birds.

4.6.2.3.2 RADIATION ASPECT

During the construction of the IP at the site it is not expected to be caused significant damages on the fauna in the regions because, on the one hand, the territorial scope of the NDF has a limited area, and on the other hand, there is no serious and significant risk of destroying rare and endangered animal species, which have limited distribution at the territory of the country and in the Danubean fauna region. In practise, the numbers of the fauna complexes in the region between the village of Harlets and the town of Kozloduy will remain almost unchanged or will not change at all.

The impacts on the fauna found in the region, caused by the implementation of the investment proposal, will have a **significantly limited local character** as it comes to their territorial scope – **within the boundaries of the site** and in immediate proximity, **direct** in terms of the way of impact, with **low level**, **temporary** and with **medium duration**, without cumulative effect due to the lack of IP for other large facilities in the region.

During the operation of the investment intention and during the post-operational period no significant impacts are expected in radiation aspect on the animal wildlife, including on the production of domestic animals in the region, because the NDF will be designed and constructed in accordance with the safety requirements set in the normative base and the MAAE recommendations, the principle for deep protection and the construction of the NDF as a multi barrier engineering facility that prevents the distribution of radionuclides in the environment. The operation of the facility will be in accordance with the principles and norms for safe management of facilities used to radioactive waste management.

No significant negative impacts are expected to be caused by the investment proposal in non-radiation and radiation aspect in view of the foreseen engineering barriers that prevent the spread

of radionuclides in the environment. The expected radiation impact on the fauna will be **insignificant**.

4.6.3 PROTECTED TERRITORIES AND PROTECTED AREAS

Having in mind that the NDF site does not fall within the protected areas of the European ecological network Natura 2000 and does not adjoin such areas, the IP implementation cannot have any impacts on the nearest protected areas, related to damage and fragmentation of their territories, and habitat areas subject to conservation in them, as well as any significant impacts on the target species inhabiting the territories and habitats of these areas. No negative indirect impacts in radiation aspect can be expected, as NDF will be designed and constructed in compliance with the safety requirements laid down by the legislation and with the IAEA recommendations, using the *principle* of defence-in-*depth* and the NDF construction as a multi barrier engineering facility hampering radionuclide distribution in the environment as well as operating the repository according to the principles and rules for safe management of facilities for radioactive waste management. The absence of chance for a significant negative impact on the habitats and populations of species subject to conservation in the Zlatiyata - the closest protected area BG0002009 was confirmed by a letter with outgoing No 26-00-1223/20.11.2009 of the MOEW, in which the competent authority has given an opinion under art. 39, par. 3 of the Ordinance on the conditions and procedures for assessing the compatibility of plans, programs, projects and investment proposals with the objects and purposes of the conservation of protected areas. However, because the site is of community significance, a separate assessment of the degree of impact from the IP implementation on the closest protected areas under Natura 2000 will be enclosed in the EIA Report for further completeness and clarity. The assessment will include detailed consideration and evaluation of the potential impacts on habitats and species subject to conservation in these areas.

4.7 WASTE

The expected waste generated during the implementation of the investment proposal includes generation of nonradioactive and radioactive waste.

4.7.1 NON-RADIOACTIVE WASTE

The nonradioactive waste generated by the NDF during the separate periods of implementation of the IP is classified in accordance with Regulation №2 on the waste classification of 23.07.2014, promulgated SG 66/08.08.2014.

The actions and responsibilities concerning the management of nonradioactive waste are regulated in the Waste Management Act (WMA), Promulgated, SG № 53/13.07.2013, in force since 13.07.2013, amended SG 66 of 26.07.2013, in force since 26.07.2013; amended by Decision №11 of 10.07.2014 of the Constitutional Court of the Republic of Bulgaria – issue 61 of 25.07.2014) and its subordinate legislation.

The two types of repository – tunnel and trench – generate nonradioactive waste: household waste; construction waste; industrial non-hazardous and hazardous waste that are expected to have similar quantity and quality characteristics. The differences are in the amounts of the generated unnecessary earth masses during the construction period of the two types of depositories (tunnel and trench) due to the different amounts of the excavated earth masses. However, if the waste is effectively manages, no significant impact is expected on the separate components of the environment.

Due to the specific nature of the investment proposal – construction, operation and closure of a NDF, the quantity of the generated waste cannot be determined in advance, and the quantity of some types of waste cannot be determined even approximately.

4.7.1.1 WASTE GENERATED DURING THE CONSTRUCTION PERIOD

The following types of nonradioactive waste are expected to be generated during the construction: domestic, construction, non-hazardous industrial waste and hazardous industrial waste. The amount of the waste will be relatively bigger during the construction of the IP in the different stages but it depends on the volume of the construction works and the types of the constructed facilities, the amount and type of the construction waste, the condition of the construction and assembly machines as well as on the organization of the construction activity and the training and qualification of the construction workers.

Two technologies have been proposed for implementation of the disposal facility for low and intermediate level RAW category 2a in a surface module engineering depository: trench type and tunnel type. It is foreseen that the construction of the two alternatives associated with the selection of a technology for the implementation of a trench and tunnel type NDF is done in stages.

A preliminary balance has been elaborated of the earth masses per stages, which is described in item 4.3 of this section. The excavated earth masses, including the unnecessary ones, are not expected to be characterized by excessive contamination due to the site there are generated. Part of the excavated earth masses will be used for vertical planning (covering layers of the repository), for roads, for filling of damaged terrains, etc.

According to article 2(2), paragraph 4 of the Waste Management Act, this legal act is not implemented for non-contaminated soil and other materials in their natural state, which are excavated during construction works, when it is ensured that the materials will be used in the construction in their natural state at the same site at which they have been excavated. In this particular case, the amounts of the humus and other earth masses to be used at the site can be determined only approximately, and respectively it is difficult to determine the amount of the excessive earth masses that will be generated during the two technologies for the implementation of the disposal facility for low and intermediate level active RAW category 2a in a surface module engineering repository – **trench type** and **tunnel type**.

According to a preliminary assessment, the amounts of the generated waste are different mainly in terms of the formed amounts of unnecessary earth masses and the separated humus, but the design of the tunnel type repository is at an earlier stage and the comparison of the individual phases is not completely correct.

As it is foreseen in both technological disposal options, unnecessary earth masses excavated during the first stage will be transported to a depot outside the NDF site. It is assumed that their amount is approximately 250 000 m^3 for a tunnel type repository and approximately 265 000 m^3 for a trench type repository. The earth masses will be transported to the depot for a maximum of 300 days.

The balance of the unnecessary earth masses during the second and third stage will be specified in the following design phases. A programme for management and usage of the excavated earth masses will be elaborated for each separate stage, and a depot will be organized in proximity of the site.

The rest of the generated waste is identical for the two types of repositories. All generated waste is defined and classified in accordance with Regulation №2 for waste classification of 23.07.2014, promulgated SG 66/08.08.2014.

4.7.1.1.1 CONSTRUCTION WASTE

The waste generated during the construction and excavation works for the construction of buildings and facilities are of a Group with code 17 05 – Soil (including soil excavated from contaminated site, stones and excavated earth masses), with code 17 05 04 – soil and stone different from the waste with code 17 05 03* (not containing hazardous substances) – will be generated during the construction of concrete pavement, the formation of the fundaments of the production and administrative building and the underground facilities of the repository. It is foreseen that part of the excavated earth masses are used for vertical planning. Explosives will not be used during the excavation works.

During the construction works will also be generated waste of a Group with code 17 01 and a Group with code 17 03.

- **Group 17 01 -** Concrete, bricks, floor-tiles, tiles, faience and ceramic products with the following codes:
  - → code 17 01 01 - concrete with a presumed volume of about 5 m^3.
  - → Tiles, floor-tiles, faience and ceramic products with code 17 01 03 – Mixed construction waste with a volume of about 2 m^3;
  - → Mixtures of various types of construction waste – mixtures of concrete, bricks, tiles, floor tiles, faience and ceramic products with code 17 01 07 – different from 17 01 06* - about 200 m^3 for the whole construction period.
- **Group 17 03 -** Asphalt mixtures, coal tar and products that contain tar:
  - → Asphalt mixtures with code 17 03 03 that contain other substances other than the ones mentioned in 17 03 01* - during the elimination of pavement with low quality.

- It is proposed that the construction waste that is not used is disposed at a regional depot for non-hazardous waste in Oryahovo. At moment, the municipality of Kozloduy does not have a depot for construction waste. The municipality has demonstrated preparedness to propose a terrain, which is suitable for construction of a site for treatment and neutralization of construction waste (a letter included in the Appendices).

4.7.1.1.2 NON-HAZARDOUS (INDUSTRIAL) WASTE

- **Group 17 04** - metals (including their alloys) with code 17 04 05, iron and steel of about 0.5 t/y for the whole construction period.
- **Group 12 01** - Waste from moulding, physical and mechanical surface treatment of metals and plastics:
  - → **Shavings, chips and clippings from ferrous metals** – steel chips generated during cold treatment of details – up to 0.05 t/y for the whole construction period – Code 12 01 01.
  - → **Shavings, chips and clippings from non-ferrous metals.** They will be generated during assembly works of facilities and communications – cable cutting, etc. up to 0.02 t/y – Code 12 01 03 during the construction period.
- **Group 15 01** - Packages (including domestic ones that are separately collected) -
  - → **Paper and cardboard packages**. The generated waste will include boxes and packages from construction materials and equipment. Code 15 01 01 – about 2 m^3 during the whole construction period, will be stored at the temporary set locations at the site in a container and are handed over to a company licensed for recycling after signing a contract.

→ **Plastic packages**. The generated waste will include boxes and packages from construction materials. Code 15 01 02 – about 2 m^3 during the whole construction period, will be stored at the temporary set locations at the site in a container and are handed over to a company licensed for recycling after signing a contract.

→ **Packages from wooden materials.** The generated waste will include packaging wood for equipment and so on. Code 15 01 03 – about 3 m^3 are handed over to a licensed company after signing a contract.

→ **Metal packages.** Metal packages from equipment – 0.1 t. They will be handed over to a company licensed for recycling after signing a contract and under the Waste Management Act. Code 15 01 04.

→ **Mixed packages** code 15 01 06 - generated by materials and equipment, with an expected amount of about 5.0 m^3, are handed over to a company licensed for recycling after signing a contract.

- **Group 16 01** - Old tires – tires that are in disuse – worn-out tires that are not fit for further usage. Generated by transport and construction machines in an amount of about 50 items during the construction period. Code 16 01 03.
- **Group 17 06** - Other insulation materials – heat insulation materials, glass and mineral wool, which does not contain asbestos, about 0.3 t/y generated during the construction period, code 17 06 04 – insulation materials other than the ones mentioned in 17 06 01 and 17 06 03.
- **Group 08 01** - Waste resulting from production, formulation, supply, usage and elimination of paints and varnishes with code 08 01 12 – waste paints and varnishes other than the ones mentioned in 08 01 11.

4.7.1.1.3 HAZARDOUS WASTE

→ **Non-chlorinated hydraulic mineral oils** (from hydraulic systems of the equipment, etc.) 13 01 10*. They will be collected at the place they are generated by the companies that handle the equipment in their own containers specially provided for this purpose and will be transported and handed over to a company licensed to neutralize such waste and having all necessary permits under the Waste Management Act – 0.05 t.

→ **Non-chlorinated motor mineral lubricants and mineral oils for gearing** (from the lubricating systems of the technological equipment) code 13 02 05* - generated by the construction machines with an expected amount of up to 100 l, which will be handed over to a company licensed to neutralize them.

→ **Other motor and lubricating oils, and oils for gearing** – spent machine and lubricating oils from the transport activities – 13 02 08*.

→ **Sludge from oil catcher shafts** – code 13 05 03* - they are generated during the cleaning of petroleum containing waste waters in mud and oil catchers. When the facilities are cleaned, the sludge is handed over to external companies licensed to neutralize them.

→ **Lead accumulator batteries** – Origin of the waste – old and unfit to use accumulators from transport and construction machines – about 0.05t during the construction period – Code 16 06 01*. They will be handed over to a licensed company for further treatment.

- **Packages that contain residues of hazardous substances** or are contaminated with hazardous substances (metal packages and packages from polymers contaminated with paints, varnishes, disinfectants, oils, etc.). Code 15 01 10*, amounts up to about 0.05-0.1 m^3 for each stage – a total of 0,2 m^3 during the whole construction period.

→ **Asphalt mixtures**, containing coal tar, code 17 03 01* - They will be handed over on the basis of a written contract to an authorized company for further treatment under the Waste Management

4.7.1.1.4 HOUSEHOLD WASTE, INCLUDING SEPARATELY COLLECTED FRACTIONS

Household waste (domestic waste and similar waste generated by commercial, industrial and administrative activities), including separately collected fractions – **group 20**.

- **Group 20 01** - Separately collected fractions (excluding 15 01)
  - → **Luminescent pipes and other waste containing mercury** – Generated by the replacement of unfit lamps up to 10 items per year. Code 20 01 21*
- **Group 20 03** - Mixed household waste – generated by domestic activities conducted by the personnel -
  - → **Household waste** - code 20 03 01 (mixed household waste) generated by the construction workers during the whole construction period and will be about 37.5 m^3/a. It will be stored in containers at the temporary set locations at the site. It will be deposited at a depot for non-hazardous household and industrial waste, the RDNHW – Oryahovo.
  - → **Biodegradable waste** - 20 02 01- It is generated when the terrain for the construction of the modules is cleaned from plant waste, tree branches, etc. The amounts of the waste for both alternatives are expected to be analogous.
  - → **Soil and stones** - 20 02 02- They are generated during the excavation works.

Table 4.7-1 shows a list of the expected waste which will be generated during the NDF construction with its code and name in accordance with Regulation № 2 on waste classification of 23.07.2014, promulgated SG 66/08.08.2014.

TABLE 4.7-1 WASTE GENERATED DURING THE CONSTRUCTION

№	Code of the waste	Name of the waste
Construction waste		
1	17 01 01	concrete
2	17 01 03	Mixed construction waste – roof tiles, floor tiles and ceramic products
3	17 01 07	Mixtures of various types of construction waste – other than 17 01 06*.
4	17 03 02	asphalt mixtures, which contain substance, different from the ones mentioned in 17 03 01
5	17 04 05	iron and steel
6	17 05 04	Soil and stones, different from the ones mentioned in 17 05 03
7	17 05 06	Excavated earth masses, other than 17 01 05*.
Hazardous waste		
8	13 01 10*	Non-chlorinated hydraulic mineral oils (from hydraulic systems of the equipment, etc.)
9	13.02.08*.	Other motor and lubricating oils, and oils for gearing – spent machine and lubricating oils
10	13 02 05*	Non-chlorinated motor mineral lubricants and mineral oils for gearing
11	13 05 03*	Sludge from oil catcher shafts
12	15 01 10*	Packages that contain residues of hazardous substances or are contaminated with hazardous substances
13	16 06 01*	lead accumulator batteries
14	17 03 01*	Asphalt mixtures, containing coal tar
15	20 01 21*	Luminescent pipes and other waste containing mercury

Industrial waste /non-hazardous waste/		
16	08 01 12	waste paints and varnishes, other than the ones mentioned in 08 01 11
17	12 01 01	Shavings, chips and clippings from ferrous metals
18	12 01 03	Shavings, chips and clippings from non-ferrous metals
19	15 01 01	Paper and cardboard packages
20	15 01 02	Plastic packages
21	15 01 03	Packages from wooden materials
22	15 01 04	Metal packages
23	15 01 06	Mixed packages
24	16 01 03	Tires that are in disuse
Household waste		
25	20 03 01	mixed household waste
26	20 02 01	Biodegradable waste

In accordance with the Waste Management Act (WMA), before the beginning of the IP construction, all necessary documents should be provides, which are related to the waste management activities.

4.7.1.2 WASTE GENERATED DURING THE OPERATION PERIOD

Various types of waste will be generated during the operation period, depending on the activities that are carried our during the stage-by-stage construction of the NDF modules, their operation and closure: household waste, non-hazardous industrial waste, hazardous waste and construction waste.

The waste management will be conducted under strict control and management to ensure prevention of negative impacts on the environment.

4.7.1.2.1 HOUSEHOLD WASTE, INCLUDING SEPARATELY COLLECTED FRACTIONS

Household waste (domestic waste and similar waste generated by commercial, industrial and administrative activities), including separately collected fractions – **group 20**.

- **Group 20 01** - Separately collected fractions (excluding 15 01)
  - → **Fluorescent pipes and other waste containing mercury** – Generated by the replacement of unfit lamps up to 10 items per year. Code - 20 01 21*
  - → Code 20 01 36 – electrical and electronical equipment fell in disuses, other than the one mentioned in 20 01 21 and 20 01 23 and 20 01 35
  - → Code 20 01 01 – paper and cardboard;
  - → Code 20 01 02 – glass;
  - → Code 20 02 01- Biodegradable waste generated during cleaning of green areas.
  - → Code 20 02 02 - Excavated earth masses, other than the ones mentioned in 17 05 05 – 17 05 06 (soil and stones, generated during repairs of alleyways, sites, etc.)
- **Group 20 03 -** Mixed household waste – generated by domestic activities conducted by the personnel – up to 4 t/y – code 20 03 01.

The foreseen amount of solid household waste according to the number of the servicing personnel of 64 people is approximately 32 m^3/a. It will be collected in metal containers and will be transported to a licensed company for further treatment (it is currently disposed at a depot).

4.7.1.2.2 CONSTRUCTION WASTE

During the operation of the constructed modules the following types of waste will be generated by repair works:

- **Group 17 01** - Concrete, bricks, floor-tiles, tiles, faience and ceramic products with the following codes:
  - → **Concrete** - code 17 01 01 up to 1.0 m^3/y;
  - → **Mixed construction waste** – tiles, floor tiles and ceramic products - code 17 01 03 – up to 0.1 $m^{3.}$
  - → Mixtures of various types of construction waste with code 17 01 07 – other than 17 01 06*.– up to 0.1 m^3
- **Group 17 03** – with code17 03 02 - asphalt mixtures that contain other substances, different from the ones mentioned in 17 03 01 * - (not containing coal tar) resulting from repairs of asphalt pavements up to 0.1 m^3/y;
- **Group 17 04** - metals (including their alloys) with code 17 04 05, iron and steel of about 0.05 t/y during construction works.
- **Group 12 01 –** waste from repair works during maintenance of machines and facilities:
  - → **Shavings, chips and clippings from ferrous metals** – steel chips generated during cold treatment of details with code 12 01 01 – will be generated during maintenance, routine maintenance, repairs (planned or emergency) up to 0.01 t/y.
  - → **Shavings, chips and clippings from non-ferrous metals** with code 21 01 03 - they will be generated during assembly works of facilities and communications – cable cutting, etc. up to 0.005 t/y.
- **Group 15 01 - Paper and cardboard packages -** they will be generated by boxes and packages of construction materials and equipment during repair works:
  - → **Paper and cardboard packages** with code 15 01 01 – about 0.05 t/y. They will are handed over to a specialized company for utilization;
  - → **Plastic packages.** They will be generated by boxes and packages from construction materials. Code 15 01 02 – about 0.03 t/y.
  - → **Packages from wooden materials.** They will be generated by packaging wood for equipment and so on. Code 15 01 03 – about 0.1 t.
  - → **Metal packages** code 15 01 04 **from equipment -** 0.02 t**.** They will be handed over to a company licensed for recycling after signing a contract and under the Waste Management Act.
  - → **Mixed packages –** code15 01 06 -
  - → **Waste** with code 15 01 06 absorbents, filtrating materials, cleaning towels, protective clothing, other than the ones mentioned in 15 02 02.
- ***Group 16*** - waste that is not mentioned in the list.

The tires, which are in disuse and are left from the motor transport and the construction machines after repair works and routine maintenance, are classified as non-hazardous waste with code 16 01 03. Routine repairs and preventive maintenance can generate electrical and electronical equipment in disuse with code 16 02 14 – equipment in disuse, other than the one mentioned in

codes 16 02 09 and 16 02 13, and with code 16 02 16 – components, which are removed from equipment in disuse, other than the ones mentioned in code 16 02 15.

4.7.1.2.3 HAZARDOUS WASTE

- ***Group 13*** - Waste from oils and liquid fuels (with the exception of food oils which are consumable and of oils from the groups 05, 12, 19).
- **Group 13 01** - Waste hydraulic oils – code 13 01 10* non-chlorinated hydraulic mineral oils (from hydraulic systems of the equipment, etc.) They will be collected at the place they are generated by the companies that handle the equipment in their own containers specially provided for this purpose and will be handed over to a company licensed to neutralize such waste – about 0.05 t/y.
- **Group 13 02** - Spent motor oils, lubricants and gearing oils

  → Code 13 02 05* non-chlorinated mineral motor oils, lubricants and gearing oils (from the lubricating systems of the technological equipment) - 0,05t/y.
- **Group 13 03** - spent insulation and heat transfer oils on mineral basis - 13 03 07* non-chlorinated insulation and heat transfer oils on mineral basis about 0.05 t/y

The spent machine and lubricating oils are mainly related to maintenance of pumps, compressors, motor transport and construction machines.

- ***Group 15*** - Waste from packages; absorbents, filtrating materials, cleaning towels and protective clothing which are not mentioned in the list.
- **Group 15 01** Packages (including household waste packages which are separately collected) with code 15 01 10*, Packages that contain residues of hazardous substances or are contaminated with hazardous substances (metal packages and packages from polymers contaminated with paints, varnishes, disinfectants, oils, etc.). They will be handed over to a company licensed to neutralize such waste under the Waste Management Act.
- **Group 15 02** - Absorbents, filtrating materials, cleaning towels and protective clothing. Absorbents and filtrating materials (oil filters) will be generated during the operation of the ventilation systems, the constructions and assembly equipment, and will be classified as hazardous waste 15 02 02* absorbents, filtrating materials (including oil filters which are not mentioned anywhere else), cleaning towels and protective clothing contaminated with hazardous substances.
- ***Group 16*** - waste that is not mentioned anywhere else in the list.
- **Group 16 06** - Batteries and accumulators. Unfit batteries and accumulators, which are typically classified as hazardous waste with code 16 06 01* lead accumulator batteries, will be generated from replacement of components of the equipment's operative and spare power, emergency lightening and maintenance of transport machines. They will be handed over on the basis of a written contract to an authorized company for neutralization under the Waste Management Act, and the company should have the necessary permit under the Act to receive the waste at the place it is generated.

4.7.1.3 WASTE GENERATED DURING THE CLOSURE OF THE NDF

Limited amounts of waste will be generated during the NDF closure:

→ *household waste* generated by the 40 workers at the site – up to 18 m^3/y;

→ *construction waste* –part of the buildings will be used after the NDF closure for the purposes of the institutional control. Certain amounts of waste will be generated during

the final sealing of the modules and the establishment of institutional control over the systems. Currently, the amount of this waste is estimated at approximately 150 m^3.

The amounts of generated waste cannot be estimated at this stage and their treatment will be carried out in accordance with a specific Programme for construction waste. After the waste is checked for radiation and it is proven it is not contaminated, the waste will be disposed at a depot for non-radioactive household and industrial waste or at a construction waste site.

4.7.1.4 WASTE GENERATED DURING THE INSTITUTIONAL CONTROL AFTER THE NDF CLOSURE

Limited amounts of waste will be generated during the period of ***institutional control*** after the NDF closure: household waste generated by approximately 15 people working at the site amounting to up to 6 $m^{3.}$/y.

4.7.1.5 COLLECTION, STORAGE, TRANSPORTATION AND TREATMENT OF WASTE. TRANSPORT SCHEME FOR TRANSPORTATION OF HAZARDOUS AND INERT WASTE. NECESSITY OF TEMPORARY STORAGE.

4.7.1.5.1 WASTE MANAGEMENT DURING THE CONSTRUCTION PERIOD

→ **Construction waste** Concrete waste (17 01 01) and bricks (17 01 02) will be generated as a result of the construction waste at the site provided for the IP implementation. It will be specified the possibility the investor to assign the management of all waste, generated during the site preparation for construction and during the whole construction period, to a construction company (this practise is commonly applied for similar sites. Construction waste will be disposed at a regional depot for non-hazardous waste in Oryahovo. All unnecessary earth masses, which are generated during the excavation works and used at the NDF site, can then be utilized at other places in the region to fill in damaged terrains, to create embankments or will be transported to a depot. No explosive works will be applied during the excavation processes.

→ All types of metal waste generated by the construction works (17 04 05, 12 01 01, 12 01 03, 15 01 04) will be handed over for recycling to a company, which has a permit under article 65 or a complex permit under article 35, paragraph 1 of the Waste Management Act and a signed written contract under article 39, paragraph 1 of the same Act.

→ The waste packages (15 01 01, 15 01 02, 15 01 03) will be generated during assembly of facilities and installations. A space for storage of the packages from the equipment and facilities should be provided at the territory of each site. The packages should be sorted into types (wooden, plastic, metal, paper and cardboard) and they should be handed over for recycling.

The expected amount of household waste will be approximately 37.5 t/y – it foreseen that the waste is collected in containers and is periodically transported to the depot for household waste. The waste will be disposed at the regional depot for non-hazardous waste, which is managed by a regional association for waste management. The waste will be periodically transported by a company for waste collection and transport after a signed written contract between the company and the subcontractor responsible for the construction works.

→ Hazardous waste classified in Group 13 is likely to be generated from the maintenance of the construction machines in case they are not subjected to regular technical servicing at a particular run or number of working hours. In such cases, at most construction sites the following practice is applied: when motor oils are replaced, they are collected at the site by the companies responsible for the maintenance of the machines in their own

containers, and are then transported and handed over to a company, which is authorized to neutralize such waste and has the necessary permits under the Waste Management Act. Specific site are created for the collection of hazardous waste and these sites should meet the respective fire prevention and normative requirements.

→ It is likely that flat accumulators (16 06 01*) from the utilized vehicles and machines are generated during the construction works. It is foreseen that the old accumulators are given to the individuals in accordance with the Regulation on batteries and accumulators and unfit to use batteries and accumulators, adopted by Government decree № 351 of 27.12.2012, promulgated SG 2/08.01.2013, effective as of 08.01.2013, amended SG 6/22.01.2013, amended and supplemented SG 51/11.06.2016, effective as of 11.06.2013.

→ Packages from paints and varnishes, which contain hazardous substances, should be collected and temporary stored in accordance with the normative requirements in a BB cube or another type of facility, which is closed tightly, with clearly marked signs about the type and the risk of the waste. The packages should be handed over to a company licensed to treat such waste and having all necessary permits under the Waste Management Act.

→ The management of waste generated during the construction will be carried out in accordance with the normative requirements through establishment of particular sites and specific areas for handling and temporary storage of the respective types of waste. The waste intended for final neutralization will be handed over to companies on the basis of written contracts. These companies should have a permit under article 35, paragraph 1, item 1 of the Waste Management Act (Promulgated SG, 53/13.07.2012) or a complex permit pursuant to the procedures set in the Environmental Protection Act.

→ The unfit fluorescent pipes are handed over to a company for following treatment in accordance with the normative requirements.

4.7.1.5.2 WASTE MANAGEMENT DURING THE PERIOD OF OPERATION

It is provided that the **waste, generated during the period of operation,** is temporary stored at the site of the installation in accordance with the existing legislation, where t SE RAW has experience.

- **Construction waste** - it will be generated during repair works and will be disposed at a depot for construction waste.

  → **All types of metal waste** and scrap (17 04 05, 12 01 01, 12 01 03, 15 01 04) will be temporary stored at the site and handed over for recycling to a company, which has a permit under article 67 or a complex permit under article 35, paragraph 1 of the Waste Management Act and a signed written contract under article 39, paragraph 1 of the same Act.

  → **The waste packages** (15 01 01, 15 01 02, 15 01 03) - A space for their temporary storage should be provided at the territory of the site and the packages should be sorted into types (wooden, plastic, metal, paper and cardboard) and they should be handed over for recycling.

- The expected amount of **household waste** will be approximately 32 t/y and it foreseen that the waste is collected in containers and is periodically transported to the depot for household waste. The waste will be periodically transported by a company for waste collection and transport after a signed written contract.

- **Hazardous waste** classified in Group 13 is likely to be generated from the maintenance of the construction machines and it will be temporary stored at the site in accordance with the

normative requirements. It will be regularly handed over to a company, which is authorized to neutralize such waste and has the necessary permits under the Waste Management Act. The sites for hazardous waste should meet the respective fire prevention and normative requirements.

→ **Lead accumulator batteries** (16 06 01*) from the utilized vehicles and machines are given to the individuals in accordance with the Regulation on batteries and accumulators and unfit to use batteries and accumulators, adopted by Government decree № 351 of 27.12.2012, promulgated SG 2/08.01.2013, effective as of 08.01.2013, amended SG 6/22.01.2013, amended and supplemented SG 51/11.06.2016, effective as of 11.06.2013.

→ **Packages from paints, varnishes, etc. which contain hazardous substances**, should be collected and temporary stored in accordance with the normative requirements in a BB cube or another type of facility, which is closed tightly, with clearly marked signs about the type and the risk of the waste. The packages should be handed over to a company licensed to treat such waste and having all necessary permits under the Waste Management Act.

→ **The unfit fluorescent pipes** are temporary stored in a premise at the territory of the site in strong, tightly closed cardboard boxes. They are periodically handed over to a company for further treatment.

The transportation of the waste will be carried out under strict observation and the normative requirements for treatment and transportation of industrial and hazardous waste.

The waste will not be utilized, treated, recycled and neutralized at the territory of the site.

Control and measurements – The amounts of the generated waste will be controlled.

Document and reporting of waste management activities: In accordance with the existing normative requirements related to the waste management activities: - waste report books; annual reports, which include waste data cards per types of waste.

Prior to the beginning of the IP construction, the site will be prepared for construction and equipment of the modules, which are included in the construction of NDF stage I.

During the operation, all requirements related to the documentation and reporting of the waste management activities will be observed. The Investor has experience in this aspect.

During operation and a long-term aspect after the closure, the generated waste will be separately managed by the NDF management.

In case of strict control, effective waste management and strict observation of the proposed measures, no significant negative impacts are expected on the environments, the personnel at the sites related to the IP operation and the population in the region.

4.7.1.6 ENVIRONMENTAL IMPACT ASSESSMENT

4.7.1.6.1 DURING CONSTRUCTION

During the construction of the sites, related to the IP implementation, are expected temporary impacts on the environment, which will be limited to the boundaries of the investment proposal site and only to the construction period. The impact will be negative, with low level of impact, direct on the site because the waste will be generated at the site of the construction works.

In terms of frequency, the impact is expected to be temporary (during the construction of the IP sites), and in terms of reversibility – reversible because the generated waste will be temporary stored at the site and will be transported for further treatment.

4.7.1.6.2 DURING OPERATION

The impact is assessed as direct, primary, negative with low level of impacts, reversible, local and relatively limited in scope, within the boundaries of the investment proposal production site.

4.7.1.6.3 DURING CLOSURE

In terms of frequency, the impact is expected to be temporary, negative, with low level of impact, local and short-term, limited only during the closure of the IP sites, reversible because the generated waste will be temporary stored at the site and will be transported for further treatment.

4.7.1.6.4 IN EMERGENCY SITUATIONS

Emergency situations during the IP construction and operation may occur in cases of eventual failures: leakages, fires, and as a result of natural disasters (such as earthquakes, floods), etc. Emergency situation may occur during the operation. In such cases the expected impacts are direct, temporary, short-term and reversible negative with low level of significance.

4.7.1.6.5 CONCLUSION

It should be ensured strict control and efficient waste management during the different stages of the NDF implementation, where the SE RAW is experienced, related to:

- temporary storage of part of the waste at selected areas, which fulfil all legislative requirements;
- timely handing over to a specialized company of the waste types which require further treatment;
- timely transportation of the construction and household waste to the regional depot for non-hazardous waste Oryahovo;
- in the future, specifying a possibility for implementation of a construction waste depot at the territory of the Kozloduy Municipality.

In case of strict control and efficient management of non-radioactive waste generated during the construction, operation (normal operation and emergency situations) and closure of the NDF are not expected significant negative impacts on the environment.

Cumulative effect is not expected.

Transboundary impact is not expected.

4.7.2 RADIOACTIVE WASTE

4.7.2.1 DURING CONSTRUCTION

Radioactive waste is not generated during the construction period.

4.7.2.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

4.7.2.2.1 SECONDARY WASTE (RAW)

During the operation can be generated liquid and solid secondary waste as a result of operative situations (normal and accidental occurrence) and they should be safely managed. The levels of the activity they contain will determine the management strategy.

The main sources of liquid and solid RAW during normal operation are:

→ **Solid waste** (cotton, etc.) generated by samples for analysis of surface contamination of the packages with radioactive treated waste; personal protective equipment used in the NDF controlled area;

→ **Liquid waste** generated by laboratory radiochemical analyses and water collected from the drainage system of the common servicing building, from the drainages of the facilities situated in the controlled zone of the building and from the building for receiving and temporary storage of RAW packages.

The generation of solid waste resulting from checks with smears is determined through indication of the following procedure parameters:

→ The smear check is usually carried out on 300 cm^2 surface of the RAW package;

→ The removed contamination is about 4 Bq/cm^2 (it corresponds to the level for discharge of control of the gamma-beta nuclides, presuming that 100% of the contamination is removed);

→ It is agreed that the weight of the smear material is 20 g;

→ The number of smear checks is assumed to be 4 smears for a RAW package and 200 packages per year.

Therefore, the total gamma-beta activity is 1200 Bq and the specific activity of the solid waste is 60 Bq/g, which exceeds the level for control discharge of 1 Bq/g and therefore it is classified as radioactive waste.

The total weight of the solid waste is 16 kg, which will not be significant and is below the volume of one 220-litre barrel.

The main sources of radioactive waste in cases of deviation from normal operation include:

→ Liquids collected from wet disinfection processes;

→ Liquids collected from the infiltration waters network.

The generated **liquid secondary** waste will be with quite a limited amount. The following monthly amounts are conservatively assumed in the investment proposal:

→ It is assumed that the sample preparation and material cleaning will generate 10 l per day or 200 l per month.

→ Floor cleaning in the controlled area, conservative:

- Premises in the buildings: 40 l/month;
- Vehicles (the area for loading/unloading of trucks in the building for receiving and temporary storage of RAW packages.

To limit the amount of liquid waste, it is foreseen a premise for external cleaning of non-radioactive contamination of trucks when they arrive at the facility and before they enter the zone. This premise can be used in bad weather. Thus, approximately 50 l per month are expected in the area for loading/unloading of trucks.

→ Deactivation showers: Even though the contamination of operators is hardly probably, it is foreseen by way of exception waste water from two washings per months. Waste waters, which are generated at other deactivation sites (such as wash bins for hands washing that are situation near the hands and feet monitors) are considered insignificant and are included in this calculated debit: 0.2 l/s x 5 min x 60s/min x 2 time/month = 120 l per month

→ Cleaning of contaminated trucks. Radioactive contamination of trucks is hardly probable. The single probability for contamination is during the unloading of the packages. Cleaning with water is not foreseen.

The expected liquid effluents (after contamination with potential RAW) are 410 l/month.

The effluents are collected into storage tanks, which are placed in underground premise, next to the common servicing fence.

Collected liquids from the infiltration waters network are not expected, and only a small amount of them can be contaminated, if they are present. The infiltration water is collected in a special tank created for this purpose.

4.7.2.2.2 INDIVIDUAL PROTECTIVE MEANS AND TOOLS

During the NDF operation there will be a relatively small amount of individual protective means, such as protective clothing, shoes or gloves (not more than 40 sets per year or up to about 0.05 m^3/year) as well as other dry waste (towels, paper).

The means for individual protection and other waste (towels, paper), which are used during the operation, may be considered as non-contaminated material after a radiological check even if contamination is found. This flow of materials is considered as a dry waste for compacting process.

4.7.2.2.3 MANAGEMENT OF LIQUIDS

The NDF will not have a system for treatment of radioactive liquids.

The strategy for management of liquid waste is the following:

→ Waters, collected from the controlled zone, will be radiologically checked through sample taking and their analysis, so that the water is directed towards the drainage waters reservoirs. If the lack of radioactive contamination is proven, then the water is directed towards the drainage system for conditionally non-contaminated waters in accordance with the legislative requirements.

→ In case radioactive contamination is found exceeding the defined limit values for permissible radioactivity, the controlled volume will be moved to suitable containers and will be transported to the facilities of the Workshop for RAW treatment where the waste will be further treated.

4.7.2.2.4 MANAGEMENT OF SOLID WASTE

It is not foreseen that the NDF is equipment with a facility for treatment of solid radioactive waste. Therefore, all materials classified as radioactive waste (unless they are below the discharge limits) will be transported to an external facility of the Workshop for RAW treatment for waste management.

The solid waste management system consists of functions, required for the collection, handling, treatment and storage of waste.

Solid radioactive waste generated by the operation and classified as radioactive waste are collected into barrels at a specific point in the common servicing building (premise E-1-27). This premise does not require special measures for radiation protection (ventilation, radiation control) because the waste is characterized as low level of contamination, but in spite of that the barrel should be with its lid closed.

The instruments used during the operation activities can be considered non-contaminated after a radiological check or may be deactivated in case of an established radiation contamination.

The activities related to the handling of secondary RAW include moving the barrels closed with a lid from the point of collection to the storage area, and moving them from the storage area to the truck, which will transport them to an external facility for further treatment and conditioning process.

The handling of radioactive waste, collected into barrels, is carried out with a wheelbarrow, which can be manoeuvred inside the buildings.

The final moving of the barrels to the truck for transportation is carried out with a power truck equipped with a fork.

4.7.2.3 DURING CLOSURE

Generation of secondary RAW is not expected during the closure of the NDF.

4.8 HAZARDOUS SUBSTANCES

4.8.1 DURING THE CONSTRUCTION

The law of protection from the harmful impact of the chemical substances and mixtures (LPHICSM, promulgated SG 10/04.02.2000, effective as of 05.02.2002, last amended SG 1/03.01.2014) and its subordinate legislation are the basis of hazardous substances management. In accordance with this law, as hazardous are classified chemical substances and mixtures, which possess some of the dangerous properties listed in **Table 4.8-1**.

TABLE 4.8-1 DANGEROUS PROPERTIES OF THE HAZARDOUS CHEMICAL SUBSTANCES AND MIXTURES

Properties and signs of chemical substances and mixtures	
1. Explosive (E)	8. Harmful (Xn)
2. Oxidants (O)	9. Corrosive (C)
3. Exclusively flammable (F^+)	10. Irritating (Xi)
4. Easily flammable (F)	11. Sensitizing * (Xi)
5. Flammable (F)	12. Carcinogenic * (T, Xn)
6. Strongly toxic (T^+)	13. Toxic for reproduction * (T, Xn)
7. Toxic (T)	14. Mutagenic * (T, Xn)
	15. Dangerous for environment (N)

Note: The substances and preparations, which causes damages ager longer periods of impact have long-term effects on the human body (*).

In recent years decrees, regulations and other regulations and lists of applications for classification and coding of hazardous substances in accordance with different international conventions are promulgated: working with hazardous substances; storage; transportation; import, export and transboundary movement of hazardous substances (chemical substances and mixtures).

During the construction of the IP the following will be used:

- → diesel fuels, gasoline, hydraulic oils etc. – used for the construction machines and transportation vehicles;
- → Paints and varnishes – for industrial design;
- → Disinfectants for household waste;

→ Asphalt mixtures, etc.

During the construction of the IP site it is foreseen that the utilization of hazardous substances is carried out under strict control and hazardous substances management. The substances, which will be used during the IP construction, are classified in accordance with the risk categories regarding the health risk to the personnel working in the various areas and to the environment.

Activities provided for the construction of the investment proposal are related to the use of hazardous substances from the group of petroleum products – diesel and mineral oils, as well as hazardous paints and varnishes in the implementation of some of the finishing work as follows:

→ Use of fuels for the construction service machines related to the implementation of the respective construction works on the sites: preparation of the sites; implementation of the internal infrastructure related to communications, electricity, water supply, roads, etc.; additional activities.

→ Use of fuels for the vehicles servicing the construction used for delivery and transportation of materials , equipment and facilities.

→ The provided for transport and construction machines and vehicles are also related to usage of lubricants (motor oils) which possess certain toxic characteristics even in limited amounts and these characteristics make them dangerous to humans and the environment.

→ The fine finishing works are associated with the use of paints and varnishes containing organic solvents or other hazardous substances;

→ Chlorinated lime – it is used to disinfect the collected household waste generated by workers.

Table 4.8-2 lists the chemicals expected to be used during construction of the sites of the IP with their CAS No. and EC No. Their classification classes, categories and hazard statements are under Regulation (EC) No. 1271/2008 on classification, labelling and packaging of substances and mixtures (CLP).

TABLE 4.8-2 HAZARDOUS CHEMICAL SUBSTANCE USED DURING THE CONSTRUCTION OF THE IP

Name	Place of use	EINECS№	CAS №	Classification 67/548/EEC Hazard sign R risk phrase S warning phrase	Classification (EC) №1272/2008 CLP H phrases -- hazard statement P- safety recommendations
Diesel fuel	Construction machines and transport vehicles	269-822-7	68334-30-5	Xn,F,N, Xi R40, R20- R 65 R38 R51- R 53	H226, H304, H315, H332, H351, 373 H341 ,
Motor oils	Construction machines and transport vehicles	309-874-0	101316-69-2	Xn,N,Xi sources of PAH R21/22, R36- R 36/38; R38 R50- R 52 S 25; S 26 ; S 37	H350
Mineral petroleum oils	Construction machines and transport vehicles, machines			Xi ,Xn, N R21/22, R36- R 36/38; R38 R50- R 52 S 25; S 26 ; S 37	H302/312, H314, H315,H19, H400,

Name	Place of use	EINECS№	CAS №	Classification 67/548/EEC Hazard sign R risk phrase S warning phrase	Classification (EC) №1272/2008 CLP H phrases -- hazard statement P- safety recommendations
Chlorinated lime (O,C,N)	Disinfection of mixed household waste	231-908-7	7778-54-3	O,C,N	H314
Oxidized asphalt, ID № 649-034-003	Laying asphalt on sites, etc.	265-196-4	64742-93-4	Xn, Xi R20, R45 R 46 S 20/21; S 36/37	H332; H340; H350 P- 102; P- 262; P- 270;P- 280
Gasoline	Transport vehicles	-	-	Xn, Xi, F,N R12; R 38; R46;, R62-63; R 65; R 67, R51-53;	H224;,H304; H315;, H336;H361;,H411 P- 201; P- 210; P- 301
Transformer oil mixed with inhibitor additive	Used to fill up transformators and traction substations	265-156-6/ 64742-53-6	128-37-0/ 204-881-4	N R50-53;	H304;,H400; H410
Paints and varnishes (Xn, Xi, F)	Shaping of internal and external decorative elements, etc.	203-539-1, 203-905-0, 201-083-	107-98-2, 111-76-2 78-10-4	Xn, Xi, F R10; R 66-67; R20/21R60 S 23; S 36/37/39 S 36	H226 H302,H312, H332
Paints and varnishes	Shaping of internal and external decorative elements, etc.	234-324-0 etc.	11099-06-2 etc.	Xn, Xi, F R10; R 66-67; R20/21;, R60 S 23; S 36/37/39 S 36-	H226;,H336; H332;
Paints and varnishes	Shaping of internal and external decorative elements, etc.	204-658-1, 203-603-9, 215-535-7, 203-933-3 etc.	123-86-4, 108-65-6, 1330-20-7, 112-07-2 etc.	Xn, Xi, F R10; R 66-67; R20/21; R60- S23;S 6/37/39; S 36	H226, H332
Greases – mixture of calcium special soap, mineral oil 50-75% and an additive 0,25-2,5%	Construction machines and transport vehicles, machines	265-157-1 270-128-1	64742-54-7 68411-46-1	F ,Xn R52/53; R 65; R66,	H412
Slaked lime – Calcium hydroxide	Construction works and Disinfection of mixed household waste	207-838-8	497-15-8	Xi, R36, R37, R38, R41, R43,	H315 H318 H335
Portland cement	During construction works	266-043-4	65 997-15-1	Xi, R36, R37, R38, R41, R43,	H315 H318 H335
Portland cement modified additives and mineral filler calcium hydroxide	During construction works	1305-62-0	215-137-3	Xi, R36, R37, R38, R41, R43, R66 S 2; S 22;S 26; S 26;	H315 H318 H335,

According to data from standardization documents, scientific literates and data from experience the chemical substances and mixtures listed in **Table 4.8-2** posses the following toxic characteristics:

- *Automobile fuels:* Contain polycyclic aromatic hydrocarbons (PAH). Affect the central nervous system, respiratory tract, circulatory system, the condition of the liver and other internal organs, lipid metabolism and skin – oil acne. Have narcotic effect on people. Deterioration of hypertensive conditions and shortness of breath. Increased irritation in individuals and are often accompanied by anaemia and other negative phenomena. The safe way to store is in metal containers in the ground or indoors. The transportation vehicles will be refilled at service stations outside the site of the investment proposal.
- *Lubricating oils*: Damage the nervous system, the functional state of the liver, lipid metabolism, cause lipoid pneumonia in an aerosol exposure, oil acne, eczema, dermatitis and melanosis (which are likely to develop into malignant phenomena) folliculitis, hyper pigmentation, solar dermatitis. Have long-term effects – mutagenic, carcinogenic and are toxic for reproduction. These relate mainly to spent petroleum oils. Particularly hazardous are those oils and greases which are produced in the dry distillation of solid fuels. Less hazardous are oils produced synthetically and they possess much better performance properties. The procedure for the storage and use of the oils is the same as for fuels, and their quantities are significantly lower due to their low specific consumption.
- *Paints and varnishes*: Cause acute and chronic diseases due to irritation or allergic reactions. Damage the nervous and respiratory systems, liver, the endocrine balance and skin. Will be delivered to the site prior to their use in the respective isolated from the environment containers and their use will be in accordance with the information on labels and instructions for use.
- *Asphalt:* Hazard Class at transportation 9. When laying asphalt it is necessary to follow the instructions for labour safety, hygiene and fire safety (LSHFS). REACH Registration No. 01-2119498270-36- 0013 UN List – UN3257.

Accident spills of fuels and lubricants and other contamination of soil and surfaces should be immediately decontaminated with chemicals, dredged and removed from the site as a hazardous waste in accordance with regulatory requirements. It is not expected a negative impact on the environmental media – air, water, soil, flora, fauna and cause health risks for the population living in the area.

The investment proposal does not provide for activities such as storage and handling hazardous substances in quantities requiring a permit under Article 104 of the Environmental Protection Act (EPA).

During the construction period, at the site will temporary be stored auxiliary materials classified as hazardous substances, and the containers and sites for temporary storage will meet all legislative requirements for safe storage of hazardous chemical substances and mixtures.

Prior to the beginning of the construction will be elaborated organization and management measures for safe storage of the utilized hazardous substance and mixtures (including paints, fuels and lubricating oils) in accordance with the Regulation on the terms and procedures for storage of hazardous chemical substances and mixtures (adopted with Government Decree 152/30.05.2011, promulgated SG 43/07.06.2011) and with the set requirements provided in the attached data sheets for safe usage and safe storage of chemical substances and mixtures.

A special storage house will be created in the NDF laboratory where chemical substances and mixtures will be stored. It should meet all regulatory requirements.

An *Assessment of the safe storage of chemical substances and mixtures* will be carried out to ensure safe usage and safe storage of hazardous chemicals and its results will be documented. (Instructions for conduction and documentation of an assessment of safety storage, Order № РД-288/03.04.2012 of the Minister of Environment and Waters). The purpose of the assessment is the elaboration of technical, organization and management measures for safe storage and usage of hazardous chemical substances and mixtures (including paints, fuels, lubricating oils, etc.) in accordance with the Regulation on the terms and procedures for storage of hazardous chemical substances and mixtures, and with the requirements set in the attached safety sheets.

4.8.2 DURING OPERATION

During the IP operation and the implementation of the main technological processes, and the transport of materials and waste will be used hazardous chemical substances and mixtures.

The main activity of the NDF is not related to the usage of hazardous chemical substances and mixtures. Hazardous chemical substances and mixtures (**Table 4.8-3**) will be used for the operation of machines and facilities as well as for the maintenance of transport machines used to transport the personnel and, periodically, for transport of waste, auxiliary materials, etc. Small amounts will be used in the laboratory for laboratory analyses.

TABLE 4.8-3 HAZARDOUS CHEMICAL SUBSTANCES AND MIXTURES IN THE TECHNOLOGICAL PROCESS

Name	Place of use	EINECS№	CAS №	Classification 67/548/EEC Hazard sign R risk phrase S warning phrase	Classification (EC) №1272/2008 CLP H phrases -- hazard statement P- safety recommendations
Diesel fuel	Construction machines (during repair works) and transport vehicles	269-822-7	8334-30-5	Xn,F,N, Xi R40, R20- R 65 R38 R51- R 53	H226, H304, H315, H332, H351, 373 H341 ,
Motor oils	Construction machines (during repair works) and transport vehicles	309-874-0	101316-69-2	Xn,N,Xi sources of PAH R21/22, R36-R 36/38; R38 R50- R 52 S 25; S 26 ; S 37	H350
Mineral petroleum oils	Construction machines (during repair works) and transport vehicles	-	-	Xi ,Xn, N R21/22, R36-R 36/38; R38 R50- R 52 S 25; S 26 ; S 37	H302/312, H314, H315,H19, H400,
Oxidized asphalt, ID № 649-034-003	Laying asphalt on sites, etc. (during repair works)	265-196-4	64742-93-4	Xn, Xi R20, R45 R 46 S 20/21; S 36/37	H332;,H340;, H350 P- 102; P-262; P- 270;P- 280
Gasoline	Transport vehicles	-	-	Xn, Xi, F,N	H224;,H304;

Name	Place of use	EINECS№	CAS №	Classification 67/548/EEC Hazard sign R risk phrase S warning phrase	Classification (EC) №1272/2008 CLP H phrases -- hazard statement P- safety recommendations
				R12; R 38; R46;, R62-63; R 65; • R 67, R51-53;	H315;, H336;H361;, H411 P- 201; P- 210; P- 301
Paints and varnishes (Xn, Xi, F)	Shaping of internal and external decorative elements, etc.	203-539-1, 203-905-0, 201-083-	107-98-2, 111-76-2 78-10-4	Xn, Xi, F R10; R 66-67; R20/21;, R60- S 23; S 36/37/39 S 36	H226 H302,; H312, H332 •
Paints and varnishes	Shaping of internal and external decorative elements, etc.	234-324-0 etc.	11099-06-2 etc.	Xn, Xi, F R10; R 66-67; R20/R60 S 23; S 36/37/39 36-	H226;,H336; H332;,;
Paints and varnishes	Shaping of internal and external decorative elements, etc.	204-658-1, 203-603-9, 215-535-7, 203-933-3 etc.	23-86-4, 108-65-6, 1330-20-7, 112-07-2 etc.	Xn, Xi, F R10; R 66-67; R20/21;, R60- S 23; S 36/37/39 S 36	H226, H332
Greases – mixture of calcium special soap, mineral oil 50-75% and an additive 0,25-2,5%	Construction machines and transport vehicles, machines	265-157-1 270-128-1	64742-54-7 68411-46-1	F ,Xn R52/53; R 65; R66,	H412
Slaked lime – Calcium hydroxide	Construction works (during repair works) and disinfection of household waste	207-838-8	497-15-8	Xi, R36, R37, R38, R41, R43,	H315 H318 H335

4.8.3 POTENTIAL IMPACT OF HAZARDOUS SUBSTANCES ON HUMANS AND THE ENVIRONMENT

4.8.3.1 IMPACT ON HUMANS AND THE ENVIRONMENT DURING THE CONSTRUCTION

Use of hazardous substances during the construction phase of the investment proposal is controlled. During construction mainly fuels for the transportation vehicles and construction machines will be used, much smaller quantities of oils and greases, also paints and varnishes. Oil changes and refuelling of transport equipment will be carried out well beyond the construction site in the existing motor service stations and diesel fuel for the abnormal contraction and assembly machines will be supplied by a mobile cistern. Negative impact at the work place and the environment is not expected in case the instructions for labour safety, hygiene and fire safety (LSHFS) are strictly observed and followed.

Construction activities related to the construction of the sites of the IP will have an additional, short term impact of some hazardous substances. This is due to the fact that the heavy excavation and construction machinery are using mainly diesel fuel, petroleum oils and greases, construction dust, cement, generating construction waste containing materials for waterproofing and hydrocarbon resins, waterproofing materials, polymer adhesives, paints and varnishes, special flooring. **Table 4.8-4** lists hazardous substances and products that may pose a risk mainly **for workers' health during construction works**.

TABLE 4.8-4 HAZARDOUS SUBSTANCES AND PRODUCTS WHICH MAY POSE A RISK MAINLY FOR WORKERS' HEALTH DURING CONSTRUCTION WORKS

Chemicals or preparations CAS №	Hazard sign	Adverse health effects	Risk exposure
Spent motor oils: PCB's 1336-36-3	Xn Harmful N-Harmful for the environment	Harmful. Cumulative effect danger. Affect the nervous, cardio-vascular, system, liver, kidneys. Mutagens. Hazardous for the environment – in particular aquatic organisms.	Chronic diseases in non-compliance with safety-labour requirements
Diesel fuel 94114-59-7	Xn Harmful	Cumulative effect danger. Allergens. Damages the nervous system, skin, haematopoiesis, liver, kidneys. Mutagen. Hazardous for environment – in particular for aquatic organisms	
Cement	Irritant Allergen	Irritant for the skin, eyes and the respiratory tract Allergen. Contains pollutants (Cr- VI, Cd, Co, Ni) and is controlled by CM Decree No.156/2004). Inflammatory and allergic impairments of skin and mucous membranes.	
Paints, varnishes, adhesives Polymers	Xi Irritants Xn Harmful	Damage the nervous system, liver, endocrine system, respiratory organs, skin and mucous membranes. Cause allergic diseases.	

The substances listed in the above Table may cause chronic diseases in case of non-compliance with the safety labour requirements and in non-use of personal protection equipment when this is mandatory and recommended on the label, in accordance with the Regulation on classification, labelling and packaging of hazardous chemicals.

The supply of hazardous substances should be accompanied by a certificate and detailed instructions for storage and handling – Information Safety Sheet.

Under strict compliance with the instructions for safety, hygienic labour and fire safety related to handling of hazardous substances (mandatory use of personal protective equipment and other measures) risk to health of workers, local population and the environment is not expected.

Potential impact of the hazardous substance on the environment: direct, short-term, temporary, with an insignificant level of impact. In case the instructions for handling of hazardous substances are observed and limited accidental spills are timely eliminated, the possibility of impact occurrence is limited to a minimum.

→ health risk for the workers handling hazardous substances is not expected subject to compliance with the labour safety, hygiene and fire safety (LSHFS) instructions, and labour discipline;

→ health risk for the population in the region of the site is not expected due to the use of relatively limited quantities, the remoteness of the sites and planned measures for their use and consumption;

→ for materials classified as hazardous substances measures for storage and control are provided for in compliance with all legislative requirements. Spills and leaks are almost totally excluded if strict control is implemented, which may have a negative impact on the environmental components – air, water, soil, flora, fauna and that may cause health risks for the population living in the area are almost excluded.

The listed expected hazardous are significant in relation to the health of the workers engaged in the construction and operation of the facility. Companies, which are licensed to carry out specific construction activities, will be hired for the construction. To limit the risk, it is significant to have experienced organizations, to use properly maintained construction machines and heavy-duty trucks, to use quality fuels for these machines and to change lubricating oils beyond the site, the efficient instructions, the usage of personal protective equipment and appropriate clean working clothing as well as providing necessary conditions for personal hygiene.

4.8.3.2 DURING OPERATION ON HUMANS AND THE ENVIRONMENT

During the IP operation and the implementation of the main technological processes, and the transport of auxiliary materials and waste will be used hazardous chemical substances and mixtures. The main activity of the NDF is related to the usage of limited amounts of substances classified as „hazardous substances“.

Potential impact of the hazardous substances on the environment: In case all instructions for handling of hazardous waste are observed and eventual small emergency spills are timely removed, the possibility of impact occurrence is limited to a minimum.

4.8.4 IN EMERGENCY SITUATIONS

Emergency situations during the IP construction and operation may occur in cases of eventual failures: leakages, fires, and as a result of natural disasters (such as earthquakes), etc. In such cases the expected impacts are direct, temporary, short-term negative with low level of significance.

The impacts are analogous for both technological options – trench and tunnel type, and in case all requirements for handling are observed, the impacts can be minimized.

To prevent health risk to the personnel working at the site, protection of the workers' health and prevention of negative impact on the environment caused by chemical substances and mixtures, it is necessary to observe all requirements, related to their safe storage and usage.

4.9 HARMFUL PHYSICAL FACTORS

4.9.1 NOISE

The implementation of the Investment proposal (IP) for construction of NDF is related to three periods of noise emissions to the environment – during its construction, operation and closure.

The limit values for noise levels at various territories and special development zones are set in Regulation № 6 on indicators for environmental noise (MH, MOEW, 2006) and are for:

→ residential areas: daytime – 55 dBA, evening – 50 dBA, night – 45 dBA;

→ industrial areas: 70 dBA for daytime, evening and night.

The territories, which are the closest to the site and have a fixed noise regime, are the town of Kozloduy (3.3 km southeast of the regulatory line), the village of Harlets (4.3 km northwest of the construction boundaries) and the Kozloduy NPP industrial site.

4.9.1.1 DURING CONSTRUCTION

Noise source to the environment will be the construction and assembly machines, used for the implementation of various activities, related to the construction of the foreseen facilities at the main (technological) site and the auxiliary sites (border-crossing point, administrative and laboratory buildings, auxiliary units 1 and 2, pump station, operative warehouse, ventilation system building, compressor premise, transformer station, etc.). It is also foreseen construction of technological roads. The noise levels of the traditionally used machines are: excavator - 80÷91 dBA, bulldozer - 97÷105 dBA, crane - 92÷98 dBA, cement truck and cargo trucks - 80÷92 dBA, front loader - 80÷95 dBA.

In the trench type facility, the main excavating machine used for the excavation of the trench is an excavator with a noise level mentioned above. It is a noise source to the environment during the initial stage of the construction at the surface until reaching a depth of about 2÷2.5 m. As the excavation (trench) becomes deeper, the machine will not be a noise source to the environment because of the strong screening effect of the slope. The noise will be a factor of the work environment. The noise load is slighter if modern machines are utilized.

Noise sources during ground construction activities will be concentrated on the construction site, with the exception of the servicing cargo transport used for transportation of mine rock masses to the spoil and supply of the necessary materials and technological elements. The equivalent noise level can reach 90 dBA near the currently working machines at the construction site during certain periods of time.

Impact of the noise emitted to the environment during the construction works is unavoidable, negative, temporary (only in daytime) and covers the territory of the construction site and, partially, the terrains around it. There are no requirements about the terrains around the site related to the noise regime but the construction activities will temporary chance the currently existing noise background. It is not expected an impact on the territories of the populated areas in the region due to their remoteness from the site.

The noise impact during the construction works promises to become a significant factor mainly for the work environment (the servicing personnel). Personal protective equipment should be provided for the personnel.

The surplus excavated earth mass should be transported with cargo trucks 77/(73) transport trips per day for stage I of trench/(tunnel) type of repository. The equivalent noise level for this type of transport is about 60 dBA. The transport does not pass through populated areas. At this stage there is no information about the number of trips carried out by cargo trucks to transport construction waste and supply the necessary materials and components of the facilities. The transport, which services the construction, will travel on the road network in the region. The expected noise characteristic of the transport flow on the main road II-11for the year 2015 is 70 dBA (at 7.5 m from the axis of movement). During the construction of the NDF the servicing cargo transport will increase the level of the noise emitted by the transport flows on the road network on the region. The expected increase for road II-11 is up to 1dBA (cumulative effect).

TABLE 4.9-1 NOISE IMPACT DURING THE NDF CONSTRUCTION ACTIVITIES

Way of impact	**direct, negative**
Territorial scope	localized (mainly on the construction site)
Impact frequency	temporary, periodically (only during daytime)
Level of impact	moderate for the working site and compatible for its surroundings
Cumulative effect	it is expected in relation to the transport servicing the construction
Transboundary impact	it is not expected

4.9.1.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

During the operation of the repository, noise sources to the environment will be the facilities, servicing the activities of delivering, correspondence check and storage of fuel (special wheel transport vehicle (STV), trucks, and cement trucks) with noise levels up to 85 dBA. Sources of noise will also be all auxiliary facilities and systems, which ensure normal operation of the repository (ventilation systems, compressors, crane, mechanical workshop, etc.) with various levels of emitted noise ranging from 85 dBA to 105 dBA. The facilities are situated into buildings with monolithic reinforced concrete construction. The internal enclosing walls are made of aerated concrete blocks with sound insulation index not lower than 45 dBA. The working warehouse situated above the gallery for waste storage is designed with a metal bearing construction and enclosing facades of sandwich panels with sound insulation index about 25 dBA. The expected level of noise that passes through the premises of the buildings into the surrounding space at the site is about 60 dBA, which does not exceed the limit values for noise for industrial and storage areas.

The activities related the operation of the repository are not a source of noise impact on the populated areas in the region because of significant distance between them and the site.

The impact of noise emitted to the environment during the operation of the repository is continuous, covers the territory of the site, without exceeding the hygienic norms set in the country.

The transport vehicles which service the NDF operation (STV, trucks, concrete trucks) will travel at low speed on the technological roads towards the road leading to the NPP.

TABLE 4.9-2 NOISE IMPACT DURING THE NDF OPERATION

Way of impact	**direct, negative**
Territorial scope	localized (on the site)
Impact frequency	continuous (during the whole operation of the repository)
Level of impact	compatible (the impact is within the limits of the set norms)
Cumulative effect	it is not expected
Transboundary impact	it is not expected

In cases of emergency situations it can be expected an increase noise level at the repository site and the road leading to it, which is related to accumulation of specialized motor vehicles, people, etc.

TABLE 4.9-3 NOISE IMPACT DURING EMERGENCY SITUATIONS

Way of impact	**direct, negative**
Territorial scope	localized (in the vicinity of the repository)
Impact frequency	accidental, temporary
Level of impact	ranging from moderate to severe at certain moments
Cumulative effect	it is expected in relation to the transport vehicles
Transboundary impact	it is not expected

4.9.1.3 DURING CLOSURE

Noise sources are the machines and facilities used for different activities related to the closure of the repository (backfill of the chambers with loess-cement solution, construction of a covering slate and multi-barrier protective cover, dismounting and destruction of buildings and facilities, including recultivation of the terrains).

The main used machines and facilities include: stower complex, excavator, bulldozer, concrete truck, dumper trucks with noise levels ranging from 80 to 105 dBA. The equivalent noise level can reach 90 dBA at the site of the repository, near the working machines.

The number of trips carried out by the servicing transport vehicles (dumper trucks) is low – 10 trips per day and they will not be a significant noise factor both on the repository site and on the transportation route.

The impact of this activity is the same as the one during the construction period.

TABLE 4.9-4 NOISE IMPACT DURING THE NDF CLOSURE

Way of impact	**direct, negative**
Territorial scope	localized (on the repository site)
Impact frequency	temporary, periodically (only in daytime)
Level of impact	moderate for the working site and compatible for its surroundings
Cumulative effect	it is expected in relation to the servicing cargo transport
Transboundary impact	it is not expected

To limit the noise impact on populated areas, to reduce the noise emissions to the environment and to protect the health of the personnel (ensuring safe and healthy labour conditions) and the population in the region, it is necessary effective control and management of all activities, related to the various periods of the IP implementation through observation of all requirements of the existing legislation and implementation of all proposed measures for minimization of the negative impact.

→ When the construction company elaborates a Plan for organization of the construction works, the proposed transportation scheme should limit the passing of heavy-fright machines through populated settlements. If this is unavoidable, quick and unimpeded passing through the populated settlement should be assured with steady speed (without stopping and reduction of the allowed speed). The reduction of the noise load in populated settlements requires the elaboration of the respective documents in accordance with the normative base.

→ Usage of modern construction machines and equipment characterized by good acoustic indicators. The machines should be in order and should fulfil all contemporary technical requirements, specifications and regulations that are compulsory for the EU.

→ Observation of the national legislative documents related to the protection of the personnel working in electromagnetic fields – Law for Safe Labour Conditions, Regulation №7, SG 88/1999, Regulation №3, SG 14/2008 on the terms and procedures for implementation of activities of occupational medicine services.

→ The usage of personnel noise protective equipment is necessary during the construction to ensure personal safety and protection against noise load of the workers.

4.9.1.4 CONCLUSION

Due to the remoteness of the repository site from the locations with fixed noise requirements (populated settlements), the activities related to its construction, operation and closure will not be a noise source for them.

During the construction of the repository, the servicing transport will deteriorate the acoustic medium of the surrounding terrains upon travelling through populated settlements, depending on the route for travel on the road network in the region. The impact will only occur during daytime and for a limited period of time – until the completion of the construction works.

The servicing transport does not pass through the territories of the near populated settlements during the NDF operation and closure.

Excessive noise levels are not expected along the boundaries of the site where the RAW repository is located.

4.9.2 VIBRATIONS

4.9.2.1 DURING CONSTRUCTION

The construction machines used for construction of the site are not a source of vibrations to the environment. Vibrations are a factor of the work environment when certain types of machines are used. Vibrations are characteristic of large-scale machine details at high rotation speeds. For the machinery and equipment, limiting the distribution of vibrations outside the source is achieved by compliance with special technical requirements to the installation: anti-vibration treatment of their foundations by means of rubber pads, insulation joints of vibration damping materials, removal of the rigid connection between the vibrating sites and the structural elements of the premises, etc.

4.9.2.2 DURING OPERATION AND IN EMERGENCY SITUATIONS

The project does not provide for the future technological equipment to be a source of vibrations to the environment. The transport vehicles, servicing the activities of the new nuclear unit, are not expected to become source of vibrations in the environment. They shall travel along the class II national road network, designed to comply with the respective road traffic category, which provides for attenuation of the vibrations from heavy vehicles within a short distances from the road.

4.9.2.3 DURING CLOSURE

The machines are similar to the ones used during the construction stage, and they are not a source of vibrations to the environment. The assessment is similar to the one for the construction stage.

4.9.3 RADIATION

4.9.3.1 DURING CONSTRUCTION

During the construction, it is not expected an impact caused by radiation factors, related to the investment proposal, due to the lack of significant, continuous and unregistered radioactive sources during this period. The usage of flaw-detecting apparatuses to observe the safety measures should not be a factor for radiation contamination of the work environment during the NDF construction.

4.9.3.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

The main source of ionizing radiation (IR) are mainly the RAW containers which might be a radioactive risk during their transportation to the NDF, their arrangement in cells until the moment when every cell is filled and sealed with a reinforced concrete cover slab and until the cells are covered with protective multilayer cover.

The containers are made of reinforced concrete and have cubic shape with length 195x195x195 cm and wall thickness no less than 10 cm. The bottom of the container is no less than 14 cm and the cover – no less than 8 cm – **Figure 4.9-1**. The maximum mass of every container filled with conditioned RAW does not exceed 20 t. Every container is marked and the dose rate is written on its surface. All the containers characteristics are stored in an electronic database and a hard copy. All the containers sent to the repository are checked and certified meeting the following approved radioactive criteria:

⇒ The rate of the equivalent gamma rays dose from a package treated with RAW is limited to:
  → 2 mSv/h on the container surface;
  → 0.1 mSv/h at 1-meter distance from the container surface.

⇒ The non-fixed surface contamination average for 300 cm² of a package should not be less than:
  → 4 Bq/cm^2 for β and γ emitters
  → 0.4 Bq/cm^2 for all kinds α emitters.

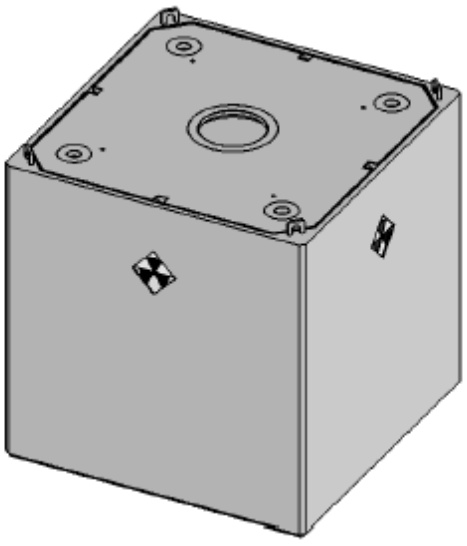

FIGURE 4.9-1 TYPE OF THE PACKAGE/CONTAINER WITH CONDITIONED RAW

The nuclide vector of all the radionuclides in a container filled with RAW is a covered source. This is precondition for detectable alpha and beta radiation outside the container. The power of the ionizing radiation is proportional with the concentration of radioactive isotopes. The following limits of the activity have been specified[26] :

- ⇒ **From a package** – the maximum specific activity of the long-lived radionuclides is ≤ 4.0E+06 Bq/kg according to the definition for category 2a,
- ⇒ **From the disposal cells** – the maximum average value of the long-lived radionuclides should not be higher than 4.0E+05 Bq/kg.

Because of the composition of the radionuclide vector there is no measured neutron radiation from the package because the cement matrix itself and the container shielding eliminate the alpha and beta radiations. In the Interim Report on Safety Analysis of the NDF is reported and calculated the dose rate resulting from the penetrating gamma radiation from the container. The main sources in the cement matrix composition are ^{60}Co, ^{134}Cs and ^{137}Cs.

On **Figure 4.9-2** is shown the annual dose rate as a result of the ionizing radiation from a cell with disposed RAW containers with wall thickness 50 cm as a distance function. The blue line is the personnel dose (1700 hours per year) and the pink one shows the population dose (8800 hours per year).

The location of the NDF outer fence is about 140 m at the closest point of the disposal area – the cells with reinforced concrete containers. Depending on the levels of the dose rate shown on **Figure 4.9-2** at a distance of 140 m the annual dose for the population is 0.017 mSv, which is more than 5 times **lower** than the maximum effective dose for a critical group of the population which is 0.1 mSv per year.

Therefore, for the population of the nearest town or village on the territory of the Republic of Bulgaria (distance of 2500 m) the radiological impact is assessed as practically non-existing.

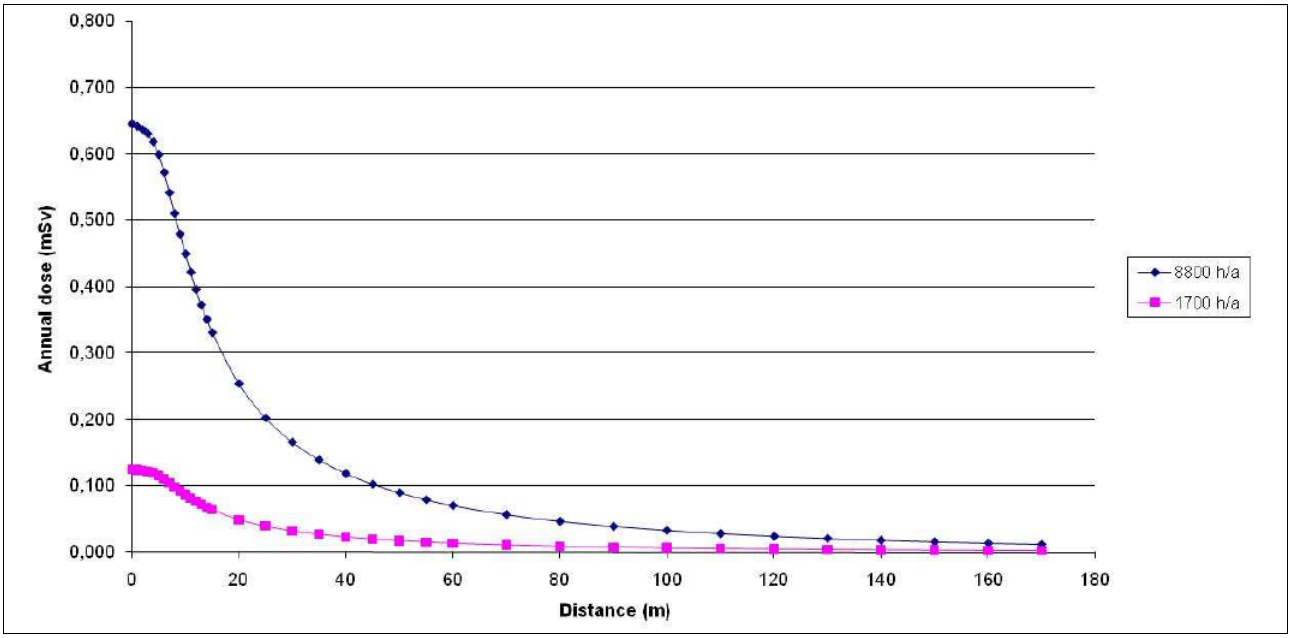

FIGURE 4.9-2 THE DECREASE OF THE ANNUAL INDIVIDUAL DOSE AT DIFFERENT DISTANCES FROM A CELL FILLED WITH CONTAINERS.

[26] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

The radionuclides, used for calibration, are an additional source of radiation. The calibration equipment consists of a screened gamma calibrating source, which has a collimated radiation ray with different intensities of the radiation field. The covered sources are placed into cylindrical lead screened containers, which are in turn placed into a roll selector (revolver type) with a mobile wedge pin for the opening that allows selecting the necessary source.

The radioactive sources of great significance include ^{60}Co, ^{137}Cs and ^{241}Am. In the case of ^{137}Cs, there are 4 radiation sources with **10**Ci, **1**Ci, **0.1**Ci and **0.01**Ci activity. The activities of the ^{60}Co and ^{241}Am sources are **1**Ci. (**1**Ci.= $3.7.10^{10}$ Bq).

The positioning system consists of a bolster with adjustable height, which moves on rails via a system that has a batten and a pinion, and is set in motion by an engine. The whole surface of the stand is made of aluminium or other light elements. A command post controls the horizontal movement. The positioning table has an effective length of 3 metres and its precision when defining a distance is ±2 mm. A video surveillance system allows the distance between a source and a detector to be supervised from the command post. This source of ionizing radiation is supervised and limited, and there is no risk about the NDF personnel if the calibration procedure is observed.

The ionizing radiation in the NDF is controlled by a system with stationary equipment which measures the dose rate. This dose rate stationary equipment notify the operation and maintenance personnel about unusual increase or high levels of radiation in the zones where significant amounts of radioactive materials are treated or stored and where it is foreseen temporary or continuous presence of personnel.

The stationary equipment, which measures the dose rate, provide visual and acoustic signal in the zone where the detector is located and send signal to the operation stations for radiation monitoring. Similarly, the values measured by each detector, are also visualized on the operation stations as per their place, and are recorded.

The location of each piece of dose rate stationary equipment should be selected so that the signal and the alarm are visible when entering the zone.

4.9.3.3 DURING CLOSURE

The NDF closure is foreseen to take place after the cells are filled with containers following the defined scheme (60 years of operation). The construction of a multi-layer protective cover is planned during the period of closure, as well as decommissioning of the buildings which are not necessary for the following institutional control.

During the institutional control surveillance of the site will be ensured. Other activities are not foreseen unless this is necessary, and in this case minimal technical maintenance or repairs will be used. After the completion of this period the storage activity is reduced to permit to use the site without any radiological limitations.

Impact of the ionizing radiation generated by the disposed containers with RAW beyond the allowed radiological criteria (0.1 mSv/a) is not expected. The dose rate at the surface of the terrain will be within the boundaries of the natural gamma background fluctuations in the region.

After the closure of the NDF are not expected external radiation from the RAW disposed in the cell, which exceeds the background radiation. The dose rate from external radiation on the site is expected to vary within the boundaries of the natural background fluctuations.

4.10 IMMOVABLE CULTURAL HERITAGE

4.10.1 DURING CONSTRUCTION

According to the conclusion provided in the Report elaborated by the experts from the Laboratory on archeometry and experiment archaeology at the New Bulgarian University, the group of mounds in the vicinity of the Kozloduy NPP can be considered an archaeological complex of regional significance. The studies show that the moulds in the west groups (moulds №2, 3 and 4) are unlikely to be affected or destroyed as a result of the IP implementation. The data from the geomagnetic measuring contain indications about the presence of archaeological structures, which are partially affected by agricultural machines in the region beyond the boundaries of the Radiana site. This calls for their urgent studying with archaeological methods.

It should not be excluded the possibility that during the construction works are found non-registered archaeological finds, objects or parts of objects in the boundaries of the Radiana site, so it is necessary to observe article 161, paragraph 2 of the Cultural Heritage Act (CHA), namely, in case archaeological objects are found, articles 148 and 160 of the CHA are observed. The activity should immediately be discontinued and actions are initiated in accordance with articles 72 and 73. The mayor and the manager of the regional inspectorate for protection of cultural heritage by the location of the cultural value should be informed about its finding. In such case it is necessary to observe article 147, paragraph 5, section 2 and to carry out rescue archaeological on-site studies.

During the period of construction works the following measures for protection of the cultural monuments should be applied, if necessary:

- To be observed the requirements of article 83, paragraph 1 and 2; article 93, paragraph 1; article 94 and article 97 of the Cultural Heritage Act for protection, identification and storage of cultural values as well as article 158, paragraph 1 for handing in movable archaeological values to the RHM-Vratsa.

- In accordance with article 160, paragraph 1 and 2 of the Cultural Heritage Act, when during construction and developing works are found structures and findings that appear to be cultural values, the activity is immediately stopped and article 148, and articles 72 and 73 are applied.

If the measures, which are set in the Cultural Heritage Act and are described above, are observed, will be prevented potential negative impacts both on already registered and non-registered objects of the cultural heritage.

4.10.2 DURING NORMAL OPERATION AND DURING CLOSURE

During the NDF operation and closure are not expected impacts in non-radiation and radiation aspect on immovable and movable cultural values, under the condition that prior to the beginning of the construction activities and during their implementation all measures provided in this EIA Report and in the Cultural Heritage Act are observed.

4.11 PROGNOSIS AND ASSESSMENT OF THE PRESUMED IMPACTS ON THE HEALTH OF HUMANS, WHO ARE EXPECTED TO BE AFFECTED BY THE IMPLEMENTATION OF THE INVESTMENT PROPOSAL

4.11.1 NON-RADIATION RISK TO THE POPULATION

4.11.1.1 DURING CONSTRUCTION

The NDF construction will include the following activities: excavation and earth-filling works, supply of materials to the site and construction of a loess-cement fundament, construction of the main building and auxiliary sites, as well as construction of suitable infrastructure. It will be indicated air pollution with irritating and harmful gasses, common soil and construction dust and fine dust particles with dimensions ranging from 2.5 μm to 10 μm. Due to the processes of self-cleaning of the atmosphere and deposition of the larger dust particles, the concentration of air pollutants is reduces at a certain distance away from the source and it reaches the highest values at a distance below 10 m. Soot within these boundaries is also in lower concentrations below the limit. The activities related to heavy-duty vehicles traffic, operation of heavy construction machines, utilization of large amounts of construction materials, cause generation of additional noise and vibration levels, which will be a labour and hygiene problem and will not have a negative impact on the population.

Conclusion: Due to the big distance between the construction site and the populated settlements, it is not expected a non-radiation impact on the population of the near settlements located in the vicinity of the Radiana site, on which the investment proposal will be implemented.

4.11.1.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

Both during the construction and during normal operation, due to the big distance between the construction site and the populated settlements, it is not expected a non-radiation impact on the population of the near settlements located in the vicinity of the Radiana site, on which the investment proposal will be implemented.

4.11.1.3 DURING CLOSURE

The closure of the NDF includes the following activities: filling of the chambers with loess-cement solution, construction of a cover slab and multi-barrier protective cover, dismantling and destroying of buildings and facilities, and recultivation of the affected terrains. The population will not be affected, just like during the construction.

Conclusion: Due to the big distance between the NDF site and the populated settlement, it is not expected a non-radiation impact on the population during the closure period.

4.11.2 NON-RADIATION RISK FOR THE CONSTRUCTION WORKERS AND THE PERSONNEL OF THE NDF

4.11.2.1 DURING CONSTRUCTION

As it was mentioned in section 4.11.1, the construction will include the following activities: excavation and earth-filling works, supply of materials to the site and construction of a loess-cement and reinforced concrete fundaments, contraction of the disposal facility, construction of the main building and facilities for physical protection of the NDF, as well as construction of suitable infrastructure.

The following materials will be necessary for the construction: concrete, sand, gravel, cement, lime, reinforcement of aerated concrete blocks, fibre boards and other construction materials, such as material for roofing, shuttering for the reinforced concrete constructions, pipes, cranes,

electric cables, etc. The raw materials that will be necessary during the construction include: electricity, water, etc.

It is foreseen that during the construction of the NDF First stage about 40 qualified individuals will participate who will work in a single shift. The impact of the adverse factors of the work environment on them will be direct, temporary and reversible in case all safety and health labour requirements are observed. The construction works are related to a direct, cumulative and combined negative impact caused by chemical, physical and ergonomic factors on human health, risk of traumas and accidents.

The main risk factors for workers involved in the construction activities for the implementation of the investment proposal are related to dust, hazardous substances and materials (**Table 4.11-1**).

TABLE 4.11-1 HAZARDOUS SUBSTANCES, PREPARATIONS AND MATERIALS WITH UNFAVOURABLE HEALTH IMPACTS DURING THE CONSTRUCTION WORKS FOR THE NDF IMPLEMENTATION (ACCORDING TO THE INFORMATION SAFETY LISTS)

Chemical substance, preparation CAS №	Risk sign	Adverse health impacts	Risk exposure
Carbon monoxide 630-08-0	F+ Highly flammable, T Toxic	Highly flammable, toxic upon breathing – causes hypoxia and hypoxemia. Results into a carboxyhemoglobin. Damages the nervous, cardio-vascular systems and haemotopoiesis. Toxic for reproduction.	Risk exposure to exhaust gas emissions
Carbon dioxide 24-38-9		Asphyctant - displaces oxygen from air. Damages the nervous system	Risk exposure to exhaust gas emissions
Nitrogen oxides 10102-44-0	T+ Toxic Xn Harmful	Irritating, causes non-specific inflammatory diseases of the respiratory system. In high concentrations lead to edema of the lung, alveolitis. Toxic – affects mainly the nervous system and haemotopoiesis (form methemogolobin)	Risk exposure to exhaust gas emissions Occur due to explosions, oxyacetylene and electric welding
Sulphur dioxide 7446-09-5	T Toxic, C Corrosive	A gas with local irritative and toxic effect, damages the respiratory organs (causes chronic bronchitis, asthma, etc). Excessive SO_2 concentrations cause changes in blood composition, damage metabolism, increase the susceptibility of the body to infections. In high concentrations, results in chemical burns.	Emission sources include liquid and solid fuels, and motor vehicles Risk exposure to exhaust gas emissions
Diesel fuel 8006-61-9 - mixture of light hydrocarbons, it is composed of paraffin, cycloparaffin aromatic hydrocarbons – colourless, with specific smell, evaporating under normal conditions	Xn Harmful N Hazardous for the environment	Vapour at concentrations of 40 mg/m3 are life-threatening if inhaled for 5-10 min. Danger of cumulative effect. Allergen – damages the nervous system, haemotopoiesis, liver, kidneys, and skin. Mutagen. Hazardous for the environment. Lower exposure concentrations of one or more hours cause irritation of the mucous membranes of the upper respiratory tract, conjunctiva of the eyes, headache, dizziness, stomach pain. Danger of cumulative effect.	Chronic effects in non-compliance with safety regulations
Cement	Xi Irritant Allergen	Irritant for the skin, eyes and the respiratory tract. Allergen. Contains pollutants (Cr- VI, Cd, Co, Ni). Controlled by CM Decree No.156/2004** (content of hexavalent chrome 0.0002%). Inflammatory and allergic impairments of skin and mucous membranes.	Chronic effects in non-compliance with safety regulations

Chemical substance, preparation CAS №	Risk sign	Adverse health impacts	Risk exposure
Asphalt 84989-11-7	T Toxic	Chronic damage of haemotopoiesis, respiratory system liver and skin, endocrine glands and immune system. Classified as human cancerogen of category 2, allergen and photo allergen.	Chronic effects in non-compliance with safety regulations
Polyurethane and epoxide coatings for surfaces and adhesives	Xi Irritant Allergens	Cause acute and chronic diseases due to irritation or allergic reactions of the respiratory system (bronchial asthma) and skin.	Usage without prior information obtained from the labels and instructions for work
Dust – soil, construction materials, transport vehicles Fine dust particles (FDP) – only the fraction FDP 2.5 because the higher fraction FDP 2.5÷10 has an insignificant amount in the soot of exhaust gasses,		Fine dust particles damage lung function either temporarily (reversibly} or permanently(irreversibly). They help in the development of chronic bronchitis and are a prerequisite for the development of acute bacterial or viral respiratory infections, particularly in susceptible individuals. Cause chronic inflammation of the upper respiratory tract, chronic bronchitis, eye inflammations and worsen the state of the cardio-vascular system.	During adverse weather conditions (dry and windless weather), the dust is the main potential health hazard to workers Dust is generated by excavation works, cargo trucks, heavy construction machines, and the usage of large amounts of construction materials.

* - Law on protection against the harmful impact of chemical substances, preparations and products, Law amendment of the Law on protection against the harmful impact of chemical substances, preparations and products, Council of Ministers Decree № 316 and Regulation on the terms and procedures for classification, packaging and labelling of existing and new chemical substances, preparations and products, and Council of Ministers Decree № 174 for amendment of Council of Ministers Decree № 316 [54].

** - Council of Ministers Decree № 156 for amendment of the Regulation of hazardous chemical substances, preparation and products subject to prohibition or limitations upon trade and usage, approved by Council of Ministers Decree № 130

The unfavourable impacts, related to hazardous chemical substances caused by the construction machines and cargo vehicles, can be controlled only if diesel fuels are used, which meet the requirements of Regulation №17 on standards for fuel content of lead, sulphur and other substance that are hazardous for the environment.

The other harmful impacts, related to the construction works – unfavourable physical factors of the work environment, physical and psycho-sensory load of the personnel directly involved into the construction, prerequisites for failures and labour incidents, which may occur during the NDF construction – are summarized in **Table 4.11-2**.

TABLE 4.11-2 UNFAVOURABLE HEALTH IMPACTS, RELATED TO PHYSICAL FACTORS OF THE WORK ENVIRONMENT, PHYSIOLOGICAL LOAD AND INCIDENTS DURING THE CONSTRUCTION WORKS FOR THE NDF IMPLEMENTATION

Harmful factors	Adverse health impacts	Risk exposure
Physical factors of the work environment		
Noise caused by construction machines, cargo trucks, construction activities*	• Extra-auricular effects affecting the central nervous system – irritation, mental instability, memory disturbances, reduced working capacity and nervous exhaustion; impact on the vegetative nervous systems – enhanced vascular tone, heart rate disturbances, arterial blood pressure fluctuations; impacts on the digestive system – reduced quantity and acidity of stomach secretion, deferred passage and disturbed absorption of food ingredients; impact on the respiratory system – changes in the	Traffic of cargo vehicles, operation of heavy construction machines, usage of large amounts of construction materials Working with obsolete, poorly maintained machines, low quality routes, usage cabins, without antiphons

Harmful factors	Adverse health impacts	Risk exposure
	frequency of respiratory movements and increase of the respiratory output; impact on the endocrine system – increased secretion of catecholamines, adrenocorticotropic hormone and thyroid-stimulating hormone; • Specific auditory changes – they are usually the last to occur after the other functional and pathological changes in the body are already present.	
Overall vibrations in excessive levels, generated by heavy-duty machines	They affect mainly the analysing functions – vestibular apparatus (from increased excitability to expressed vestibulopathy). Due to resonant events, in the eyeball are registered reduced visual sharpness, changes in the periphery vision which are mostly expressed in cases of vibrations of 35 Hz, reduced threshold of perception. Reduction of the auditory sensitivity for low frequencies is characteristic of the overall vibration impact.	Vertical vibrations have the greatest intensity and their highest values are in the range 1-4 Hz. They are more pronounced with older machines. Drivers of heavy trucks, excavators, bulldozers will be exposed to overall vibrations.
Local vibrations **In cases of arm pressure, vibration conductivity is increased for all frequencies, and its maximum is for 30-60 Hz (the range of the resonant frequency of the arms)**	Characteristic of the local vibration impact are vascular damages in the capillary and pre-capillary vascular network, periphery sensory (vibration sense) as well as pain, temperature and tactile sensitivity. Osteo-articular changes are expressed by pains, mainly in the arms and shoulder girdle, reduced tendon and increased tonic reflexes, reduced muscle strength and endurance.	The impact of local vibrations will affect drivers of servicing machines. Non-conformity with labour and rest regime Working in overcooling microclimate conditions
Microclimate beyond the comfort zone**	Cooling, freezing or overheating. Damages the cardio-vascular system the locomotor apparatus, infectious diseases	Working in the open or in the cabins of transport vehicles. Lack of places to rest. Inappropriate work clothes, gloves and shoes
Physiological and ergonomic factors of the work environment		
Weightlifting	Damages to the joints, bones and cardiovascular problems	Non-observance of the requirements of Regulation № 16/1999 г. ****
Physical fatigue and tension	damage to the joints, bones, neurological and cardiovascular problems	Non-observance of the requirements of Regulation № 15/1999 г. ***
Psycho-sensory tension	Neuroses, neurasthenia, cardiovascular problems, stress	
Forcible labour posture	Damages the joints and bones	Specific construction activities
Emergencies and incidents		
Occupational accidents Injuries	Falling down into excavations, from heights, burying, injuries from heavy machines and facilities	Specific construction activities
Fires and explosions	Burns, injuries, suffocation. Electroshock.	Lack of electricity safety Inappropriate storage of petroleum products and fuels
Road accidents	Injuries, burns, damages from petroleum fuels, burying beneath inert materials	Transportation of large amounts of construction materials

* BDS 14478-82 Noise. Permissible levels at workplaces. General requirements for conduction of measurements.

** BDS 14776-87 Industrial microclimate

*** Regulation № 15 on the terms, procedures and requirements for elaboration and implementation of physiological regimes of labour and rest during work

**** Regulation № 16 on physiological standards and rules for hand manipulation of weights

Characteristic of the exposure: During the implementation of the project, the construction works will be subject to a wide range of non-radiation activities which are harmful for their health. However, the conditions of these impacts are not unambiguous and the same for all workers. They depend on the specific job, occupational task and duration of work. Therefore, the exposure should be assessed not in accordance with the duration of the work shift, but in accordance with the time necessary to complete each industrial task. Thus, the impacts can be defined as direct, short-term, temporary and localized within the boundaries of the site on which the investment proposal is implemented.

Assessment of the possibilities for combined, complex, cumulative and distant impact of the established risk factors.

→ Combined is the action of gaseous pollutants with local irritating effect and dust aerosols with organic solvents and hydrocarbons. These chemical noxae have cumulative effect on the nervous system.

→ Coordinated is the action of gases with mainly local irritating impact and the dust aerosols and cooling microclimate (during work in the cold and the transitional period of the year); of noise and vibrations; bituminic materials with ultraviolet radiation.

→ Distant is the impact of substances with high oncogenic probability – 3.4 benzopyrene. The bitumen released during insulation works has lower oncogenic probability.

Conclusion: The probably impacts during the construction will have a limited scope only at the territory of the main construction site. They will mainly affect the construction workers. The health risk is permissible and supervised.

4.11.2.1.1 MEASURES FOR HEALTH PROTECTION AND RISK MANAGEMENT

All contraction and repair works will be in compliance with REGULATION № 2 of 22.03.2004 on minimal requirements for healthy and safe labour conditions during construction and assembly works – Appendices № 1-5 of article 2, paragraph 2, and REGULATION № 4 of 27.12.2006 on limitation of harmful noise through noise insulation of the buildings during their designs and on the rules and standards for implementation of constructions regarding the noise emitted during construction.

→ Reduction of dust emissions through irrigation of the areas where dust is raised (in dry weather and wind). Usage of concrete and solutions that are centrally prepared at a concrete plant, and their application with machines.

→ Accidental leaks and spillage of oils, petroleum products, etc. should be avoided. In case of spillage immediate measures should be taken for its localization and following treatment.

→ After the completion of the construction and assembly works, the areas of temporary open-air warehouses for construction materials should be cleaned. This will discontinue the dust emissions to the atmospheric air in dry and windy weather.

→ All construction machines should be maintained in working order and optimal capacity to, on one hand, reduce the amount of exhaust gases and, on the other hand, to reduce noise and vibrations.

→ The regime of labour and rest under vibration impact should be organized so that the total exposure for one shift (for contact with vibrations) should not exceed 90-120 min. Construction and assembly works should not be allowed during night.

→ For professional activities it is compulsory to use appropriate for the season working clothes, personal protective equipment in case harmful factors of the work environment are present (anti-dust masks, noise mufflers, anti-vibration gloves) and to ensure rational regime of labour and rest.

→ Observation of all instructions about labour safety and health, and fire safety for the different types of jobs. Obligatory instruction of the personnel by experts on health and safety labour.

→ Observation of all requirements for health prevention regarding the physiological labour and break regimes and the physiological norms for handling weights, set in the Regulations of the Ministry of Health.

→ A first aid kit to be maintained in working order to give first aid.

4.11.2.2 DURING OPERATION

The main risk factors in non-radiation aspect for the workers during the NDF operation are the hazardous substances in the work environment (**Table 4.11-3**) and the unfavourable factors of the work environment (**Table 4.11-4**).

TABLE 4.11-3 HAZARDOUS SUBSTANCES AND MIXTURES WITH UNFAVOURABLE HEALTH IMPACTS DURING THE CONSTRUCTION WORKS AND OPERATION OF THE NDF

Chemical substance, preparation CAS №	Risk sign	Adverse health impacts	Risk exposure
Ozone 10028-15-6	Xn Harmful	Damaged vision, neuroses, irritation of eyes and respiratory tract, headache, cough, dyspnoea, chronic bronchitis, cardiovascular problems	Welding in closed premises, without aspiration
Iron monoxides Iron dust and vapour	Xi Irritants	Upon welding in closed premises, they cause irritation of the respiratory tract and eyes, cough, dyspnoea, and sometimes high temperature.	Welding in closed premises, without aspiration
Hydrogen cyanide, cyanides 74-90-8	T Toxic	Headache, weakness, dizziness, cardiovascular problems, anaemia, endocrine and immune problems	Welding in closed premises, without aspiration
Helium		An inert gas, which may cause suffocation due to the lack of oxygen in the air	Leaking into the air of the work environment
Carbon monoxide 630-08-0	F^+ Highly flammable, T Toxic	Highly flammable, toxic upon breathing – cause hypoxia and hypoxemia. Results into a carboxyhemoglobin. Damages the nervous, cardio-vascular systems and haemotopoiesis. Toxic for reproduction.	Risk exposure to exhaust gas emissions – anaemia, headache, malaise.
Carbon dioxide 24-38-9		Asphyctant - displaces oxygen from air. Damages the nervous system	Risk exposures to exhaust gas emissions – leads to headaches.
Nitrogen oxides 10102-44-0	T^+ Toxic Xn Harmful	Toxic - Damage lung alveoli causing lipid peroxidation. In high concentrations lead to edema of the lung, alveolitis. Irritate respiratory tract , eyes and skin, chronic bronchitis, bronchopneumonia.	Risk exposures to exhaust gas emissions – leads to chronic bronchitis, bronchopneumonia.
Lubricating oils Diesel fuel 8006-61-9	Xn Harmful N Dangerous for the environment	Danger of cumulative effects. Allergens. Damage the nervous system, skin, haemotopoiesis, liver, kidneys. Mutagens.	Chronic impacts in non-conformity with the requirements for safe labour.

Other possible harmful impacts – physical and psycho-sensory loading of the workers, who are directly involved into the specific activities in the NDF and the control for prevention of failures and occupational incidents are shown in **Table 4.11-4**.

TABLE 4.11-4 UNFAVOURABLE HEALTH IMPACTS RELATED TO PHYSICAL FACTORS OF THE WORK ENVIRONMENT, PHYSIOLOGICAL LOADING AND INCIDENTS DURING THE NDF OPERATION

Risk factors	Adverse health impacts	Risk exposure
Physical factors of the work environment		
Microclimate beyond the comfort zone – high temperatures	High temperatures during activities, weldings, etc. Damage the cardiovascular system.	Gaps in the control of temperature in the work environment
Light*	Risk of incidents in cases of insufficient and inappropriate light in the work zones	Non-conformity with the light requirements**
Gases under pressure	Risk of incidents, traumas and injuries (air or helium under pressure)	Non-conformity with the safety requirements
Non-ionizing radiation during the NDF closure	Eye damage. Early development of cataract.	Inappropriate personal protective equipment for the eyes
Physiological and ergonomic factors of the work environment		
Weightlifting (the lids of the cassettes, heavy equipment)	Damage of joints, bones, cardiovascular problems	Non-conformity with the requirements of Regulation № 16/1999
Physical fatigue and tension – large sizes of the packaging kits	Damage of joints, bones, cardiovascular problems	Non-conformity with the requirements of Regulation № 15/1999
Psycho-sensory tension	Stress and exhaustion, neuroses, cardiovascular problems	
Forcible work posture	During NDF closure, air elimination, drying. Damage of joints and bones	Specific activities
Failures and accidents		
Occupational incidents	Falling down into excavations, from heights	Specific activities
Injuries	Injuries from heavy machines and facilities	Specific activities
Falling down into containers	Injuries	Specific activities
Failures during transportation	Injuries, burns, damages from petroleum fuels, heaping inert materials	Transportation of large amounts of construction materials

* BDS1786-84 Light. Natural and artificial [3.79], ** Regulation on artificial light in buildings № 0-49 [3.33]

The listed unfavourable impacts are temporary, direct and are related mainly to the individuals, who are directly involved into the construction and assembly activities at the NDF site.

4.11.2.2.1 MEASURES FOR HEALTH PROTECTION AND RISK MANAGEMENT

→ Observation of all instructions about labour safety and health, and fire safety for the different types of jobs.

→ Observation of all requirements for health prevention regarding the physiological labour and break regimes and the physiological norms for handling weights, set in the Regulations of the Ministry of Health.

→ Strict usage of the provided personal and collective protection means.

→ Obligatory instruction of the personnel by experts on health and safety labour.

→ Medical check-ups should be carried out at least once per year depending on the conducted activities.

→ A first aid kit to be maintained in working order to give first aid.

Conclusion: The non-radiation impact during the operation of the NDF on the personnel health is negative, direct, combined and cumulative. It is associated with risk of impact of unfavourable physical, chemical, psycho-sensory, physiological and ergonomic factors of the work environment, possible accidents and incidents. The health risk is permissible and controllable.

4.11.2.3 DURING CLOSURE

The foreseen operation of the NDF will continue at least 60 years. The organization of the works for backfilling the disposal modules and the site closure will begin after the year 2058. This will happen under optimal safety of the activities and the personnel on the basis of suitable safety in accordance with the actual state of the NDF and the scientific achievements in this field of the particular investment proposal.

Conclusion: It is expected that the non-radiation impact on the personnel health during the NDF decommissioning will be the same as the impact during its construction but with lower level due to the natural of the activity.

4.11.3 RADIATION RISK FOR THE POPULATION

In practice, the disposal technology (tunnel or trench type) does not have a different radiological impact on the personnel and population.

4.11.3.1 DURING CONSTRUCTION

During the construction it is not expected a radiation risk for the population because of the lack of ionizing radiation sources.

4.11.3.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

The main safety criteria are the actual and long-term protection of the population and environment, and they are guided towards implementation of the radiological limitations listed below and set in the design permit, as well as in the Regulation on basic norms of radiation protection, Regulation of safe management of RAW and the AIEA standard about the requirements for the safety disposal of radioactive waste, provided in SSR-5-2011. The impact limitations are expressed in the annual dose boundaries:

→ The limit of the individual annual effective dosage for the respective critical group of individuals from the population during normal NDF operation should not exceed 0.1 mSv;

→ The limit of the individual annual effective dosage for the respective critical group of individuals from the population after the NDF closure should not exceed 0,1 mSv.

In addition to the limits for radiation emissions, set in this Regulation, in the world’s practise there also exists a requirement to ensure that all radiation emissions will be well-grounded and maintained to ALARA levels below the dose limit values, defined in the Regulation, as the social and economic conditions are taken into account.

In conformity with the Regulation on basic norms of radiation protection (2012) and the implementation of the ALARA principle, it is recommended to introduce control limits for

professional radiation exposure of the personnel. In the case the assessed annual dosage for radiation exposure to any individual from the population, caused by the facility for RAW management, is below 0,01 mSv, it is accepted that the best possible means for RAW management are used and it is met the requirement of article 8, section 2 of the Regulation for safe management of radioactive waste regarding the population.

It is foreseen that a fence is constructed – a physical boundary, which does not allow free access of strangers to the NDF site. The closest distance from the disposal zone to this boundary, i.e. to a person situated right to the fence, is approximately 140 metres.

Radiation protection of the population and environment is achieved by implementations of measures, related to the design of the repository. Some of these measures include:

→ Defining a zone with strict regime (Controlled zone), which is the zone where presence of the population is not allowed and it is subject to special measures for protection and surveillance.

→ The pipelines, valves and reservoirs of the System for liquid radioactive waste are made of stainless steel. The connection of the pipelines and fixtures to the equipment is done with welding, unless for the purpose of technical maintenance and the pipeline systems are designed in a way to prevent accumulation of deposits.

→ Liquid radioactive waste are not released into the environment. Liquids are collected into reservoirs and are later treated in another facility outside the NDF. The storage reservoirs and the pumps are situated into an insulated premise which ensures retention of liquids in case of breakage or leak from a reservoir or a pipeline.

→ The pipelines of the network consisting of drainage and inspection galleries are situation into accessible galleries. These pipelines are designed (slope and size) in a way that there is gravitation flow towards the last control reservoir. In the network below each storage cell there is a control reservoir for surveillance and detection of storage cells affected by anomalies.

→ The network of drainage and inspection galleries is independent from the Network for collection of rain waters to prevent releases without preceding control of the radioactive substances they contain.

→ All radioactive liquids, which eventual enter the Network of drainage and inspection galleries is not released into the environment.

The requirements for screening are taken into consideration, as well as acceptation of conservation coefficient **5** in the calculations, so that all secondary limits for external radiation of the population are observed.

The radiation on the population is analysed in the Interim report on safety analysis[27], mainly because of the presence of external radiation, because gaseous and liquid emissions from the NDF are not expected during normal operation. Emergency situation are described and discussed in another section of this report.

As it is known that this is the single direct route, the project for NDF implementation includes a number of protections against such radiation. These protections are described in the presentation of the NDF technical characteristics. It is analysed the potential radiation per a member of the population resulting from:

[27] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

→ Direct direction from the NDF disposal cells

→ Radiation from the container-package with RAW, placed in the trailer during transportation to the NDF site

→ Diffused radiation from the disposal zone

Due to the specifics of the NDF as a nuclear facility for near surface storage of low and intermediate level RAW, a large number of all possible routes for impact that are shown on the figure below are actually non-existent.

If one analyses the impact scheme, provided in the safety standard of the AIEA, RS-G-1.8, all routes of impact during normal operation of the NDF are eliminated, except the directly existent external radiation.

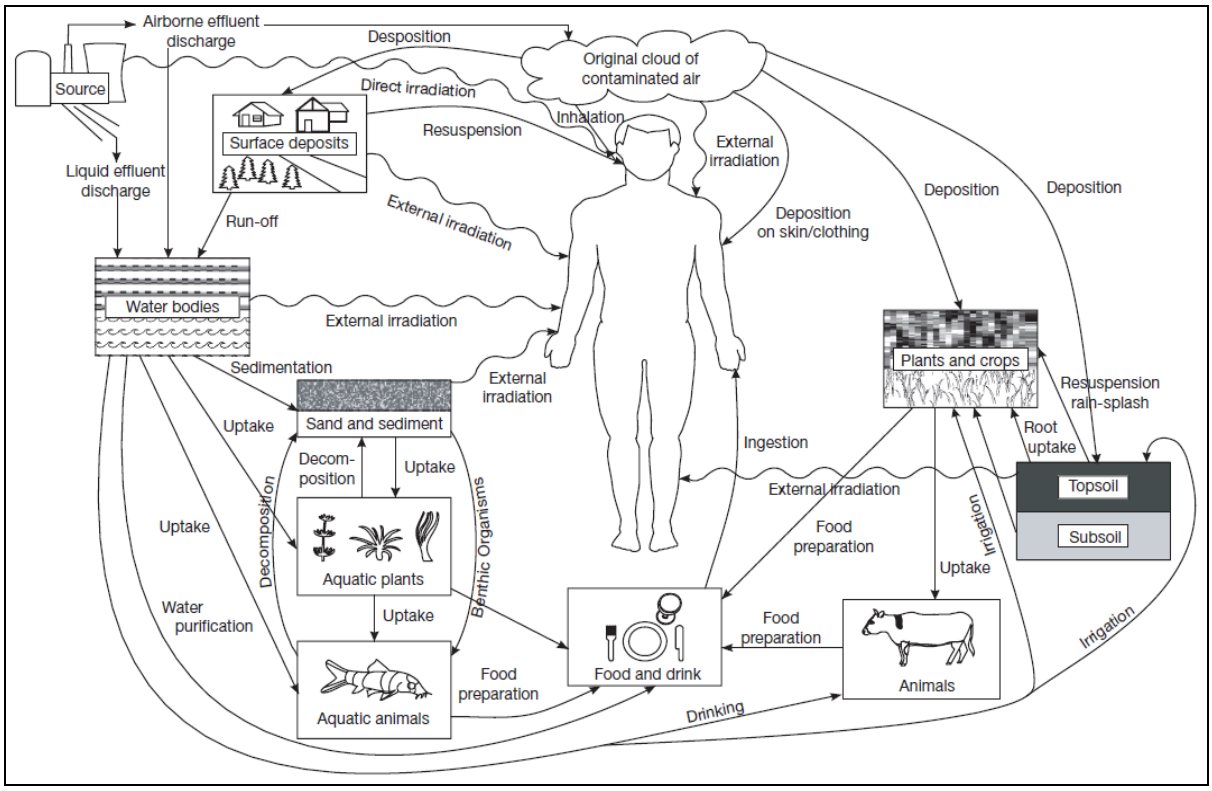

FIGURE 4.11-1 ROUTES FOR RADIATION OF A MEMBER OF THE CRITICAL POPULATION GROUP (EXTERNAL IRRADIATION AND INNER RADIATION THROUGH INGESTION AND BREATHING)

4.11.3.2.1 DIRECT RADIATION FROM THE DISPOSAL CELLS

In the Interim Report on Safety Analysis[28] is assessed the annual dose from the disposal zone consisting of cells with wall thickness of 50 cm and distance between the cells of 143 metres (conservatively, this is the closest distance to the fence) at about 17 μSv/a.

4.11.3.2.2 RADIATION FROM A CONTAINER – PACKAGE WITH RAW

To assess the contribution of the packages with RAW in the trucks, the following assumptions exist:

[28] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

→ transportation of 800 packages per year and

→ 15 minutes duration of each transportation.

→ The dose rate of a single package with RAW at a distance of 143 m is approximately 5E-3 μSv/h. Thus, the contribution of the packages with RAW in the trucks towards the annual radiation of the population is 1 μSv/a, (800x0.25x0.005).

TABLE 4.11-5 DOSE RATE AT DIFFERENT DISTANCES FROM PACKAGE/CONTAINER (TABLE 8.6-1, IRSA)

Distance (m)	Dose rate [μSv/h]		Effective dose at a single package 8800 hours [mSv/a]	Effective dose at 8800 h/a from the whole disposal area [mSv/a]
	From one package	From the whole area with cells		
0	192.700	0.073	1695.760	0.644
1	100.000	0.073	880.000	0.641
2	41.490	0.072	365.112	0.636
3	21.410	0.072	188.408	0.630
4	12.830	0.070	112.904	0.618
5	8.484	0.068	74.659	0.598
6	6.000	0.065	52.800	0.571
7	4.454	0.061	39.195	0.541
8	3.430	0.058	30.184	0.510
9	2.719	0.054	23.927	0.479
10	2.205	0.051	19.404	0.449
15	0.971	0.038	8.548	0.330
20	0.533	0.029	4.687	0.253
25	0.336	0.023	2.952	0.202
30	0.227	0.019	2.000	0.165
355	0.163	0.016	1.433	0.138
40	0.121	0.013	1.068	0.118
50	0.074	0.010	0.648	0.089
60	0.048	0.008	0.426	0.070
70	0.034	0.006	0.296	0.056
80	0.024	0.005	0.214	0.046
90	0.018	0.004	0.160	0.038
100	0.014	0.004	0.122	0.032
110	0.011	0.003	0.095	0.027
120	0.009	0.003	0.076	0.023
130	0.007	0.002	0.061	0.020
140	0.006	**0.002**	**0.049**	**0.017**
150	0.005	0.002	0.041	0.015
160	0.004	0.001	0.034	0.013
170	0.003	0.001	0.028	0.011

Below is presented the graphics of the dependence of the annual dose on the increase of distance from one container and for a different number of work hours, i.e. the presence of a particular distance.

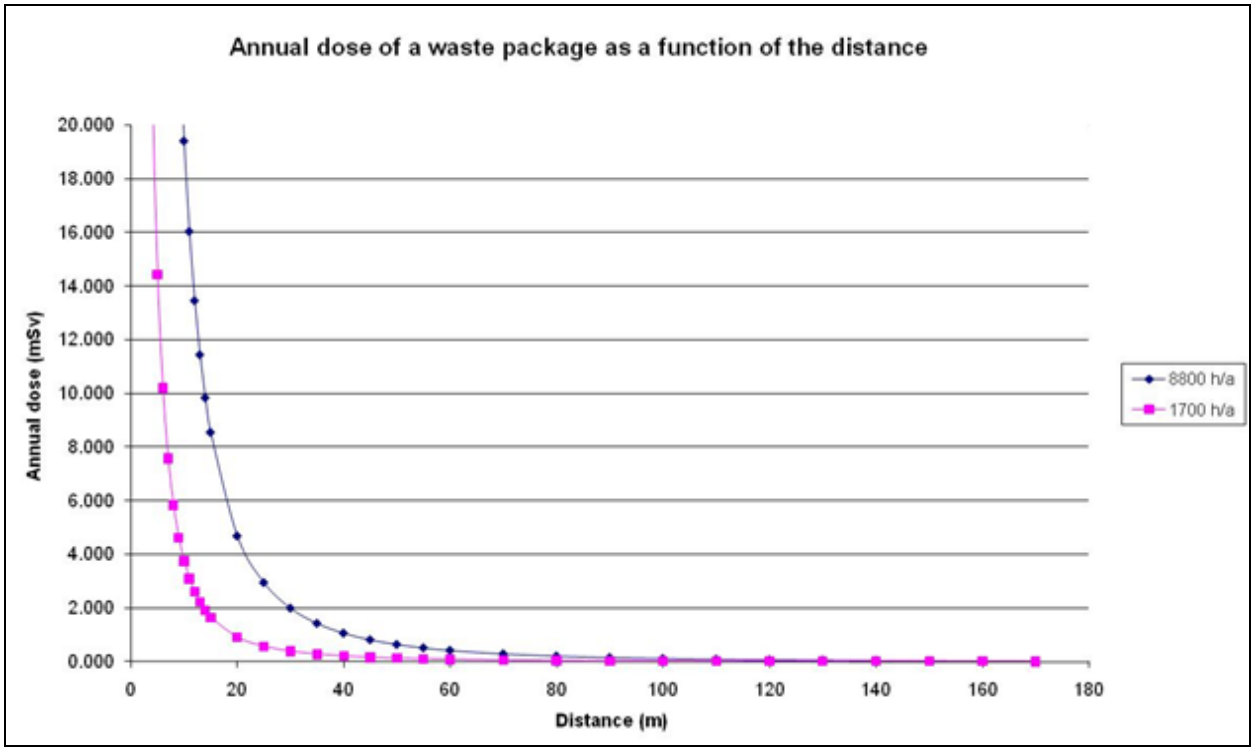

FIGURE 4.11-2 ANNUAL DOSE MSV/A FROM ONE PACKAGE WITH RAW DEPENDING ON DISTANCES UP TO 180 M FOR VARIOUS NUMBER OF HOURS – 1700 IN PINK COLOUR AND 8800 IN BLUE COLOUR[29]

4.11.3.2.3 DIFFUSED RADIATION FROM THE STORAGE CELL (SKYSHINE)

In addition to the radiation coming directly from the source, the emission of secondary radiation from substances, which interrelate to the primary radiation, can also contribute to the dose rate in the NDF environment. This phenomenon is usually called skyshine (diffused radiation caused by the primary sources of gamma radiation, which is generated through air dispersion. This may be attributed to the possible transfer of secondary radiation, coming from the roofing of the nuclear facility to the dose rate at the work places, even if the direct radiation is prevented through screening. As it comes to the primary gamma radiation, the secondary radiation is generated mainly by three physical events: photoelectric effect, Compton scattering and pair production.

Typically, the contribution of skyshine to the dose rate is mainly generated by neutron or gamma radiation above 1 MeV. Photons with lower energy do not produce pairs of proton-electron and the dominating diffusion mechanisms of low energy photons is the photoelectrical effect, which only causes low energy β and *x*-radiation. In regard to the NDF, Skyshine can be significant for dose rates for the population, due to the share of gamma rays diffused in the air.

Regarding the nuclide inventory of the packages with RAW in the NDF, the neutron radiation does not have practical significance. However, one significant share can be generated by the inventory of ^{60}Co in the packages with RAW. Regardless of that, the contribution to the skyshine of the RAW packages in the disposal cells, covered with concrete slabs, is insignificant. Similarly, in the case of RAW packages in an open disposal cell, the contribution to the skyshine can also be considered insignificant due to the distance to the fence (143 m).

[29] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

Taking the two shares into consideration (direct radiation from the storage site and from packages with RAW in the trucks), the total annual dose is formed at 18 μSv (≈0.02 mSv) from direct radiation and is a way below the secondary limit (100 μSv/a).

The radiation risk for a member of the population at this highest dose quota is: 1.10^{-4} x $0.05=5.10^{-6}$. If we make a comparison with the set individual life risk of 5.10^{-5}, which is applied to define the dose annual limit, then this risk is smaller by one order.

Therefore, the protection foreseen in the NDF design is enough to ensure the observation of this dose limit.

4.11.3.3 DURING CLOSURE

During the period of closure, which will continue 15 years, a multi layer protective cover is construction after the free space between the cells is filled. The single radiological risk during this stage is the direct radiation from the closed cells.

As soon as the two barriers – the package with RAW and the cells – are present and complete insulation is achieved through the construction of a multi layer insulation barrier, the total risk caused by the facility is controlled by the existing two reinforced concrete barriers. The construction of the cover does not affect the integrity of these two reinforced concrete barriers and the single radiological risk left is the potential exposure to direct low level radiation.

The access to the closed facility is under control and the radiation impact on the population is conservatively assesses as for a person who is continuously located immediately next to the fence. The Table above shows that such an impact is practically immeasurable and is within the frames of the fluctuations of the natural background in the region.

The dose rate beyond the fence perimeter (>140 metres) is expected to be <0.01 μSv/h above the rate of the natural gamma background in order to be observed the dose limit of 100 μSv/a for a member of the population.

The dose limit is conservatively assessed for continuous presence (8800 hours) of the individual near the fence.

It can be concluded that during normal operation and after the closure of the NDF, the radiation impact on the population will not exceed the set dose quota of 0.1 mSv/a.

4.11.4 WORK ENVIRONMENT AND RADIATION RISK FOR CONSTRUCTION WORKERS AND PERSONNEL DURING THE NDF OPERATION

Practically, the disposal technology (tunnel or trench type) does not have a different radiological impact on the personnel and population.

4.11.4.1 DURING CONSTRUCTION

During the construction of the main NDF infrastructure, there is no ionizing radiation at the site and, respectively, there is no radiation risk for the construction workers and the NDF personnel.

4.11.4.2 DURING NORMAL OPERATION AND IN EMERGENCY SITUATIONS

During the operation of the NDF is expected ionizing radiation with different intensity at the site classified areas. The impact of this ionizing radiation is subject to regulation and implementation of measures to limit its radioactive impact on the personnel.

The harmful effect of the ionizing radiation on humans results in two types effects – determined and stochastic (probable). The first group is directly connected to the radiation dose. These are threshold effects, i.e. they appear if one is exposed to a certain dose. The dose threshold is different for the different effects. It slightly varies depending on the individual radiation

sensitivity. They are a result of the death of a certain number of cells from a certain organ or tissue which cause their dysfunction. The degree of the dysfunction is getting higher with the dose increasing. These effects are somatic, they affect only the body cells and appear only in the person exposed to radiation. Depending on the radiation sensitivity of the organs, the received dose and mainly its rate, they can be early (starting minutes, days and weeks after the radiation) or late (years after the radiation).

The stochastic effects appear later. Depending on the type of the affected cells they are somatic – the people exposed to radiation suffer from malignant diseases or genetic - mutations in the posterity. They do not depend directly on the dose. Their frequency is growing with the increasing of the received dose but it is considered that they do not have a threshold appearance. Their effect depends on the affected part of the genome of the respective cell.

The ionizing radiations as a factor harmful to the working environment have some characteristics typical only for them. The ionizing radiation biological impact is connected to the possibility of appearing of effects harmful to the health directly on the individual exposed to the radiation and on his/her posterity too. An important characteristic of the ionizing radiation impact is that it’s difficult to be distinguished in a working environment directly by the individual because people don’t have organs of senses for it. The impact of the ionizing radiation is cumulative and the damages on human organism are irreversible. These characteristics of the ionizing radiation upon the organism define the concepts “radiological risk” and “damage”. They underline the principles of the radiation protection which main purpose is to minimize the radiological risk at reasonable level which is lower than 10^{-4} per year. The World Health Organization (WHO) considers professions with such a risk level safe. In order to reduce the radiological risk to reasonable level, it’s necessary to standardize strictly the radiation factor of the working environment by defining the dose limits and taking mandatory measures for protection of the individual. This is done through legislative regulating documents and the creation of a proper work organization.

For normal operation with sources of ionizing radiation, the above mentioned limit of the annual effective dose is fixed by the International Commission on Radiological Protection at life risk 10^{-3}. The averaging quantity of the coefficient for the fixed dose limits for the staff and population is 0.05 Sv^{-1} (as an example where the individual dose limits equals to $1.10^{-3}/5.10^{-2}= 2.10^{-2}$ Sv/a , which is 20 mSv/a). For example, if the worker is exposed to 6 mSv/a, then the biological risk for him/her is 6.10^{-3} x 5.10^{-2} = 3.10^{-4} .

The regulatory documents ensuring radiological protection of the personnel are the following:

→ Regulation on basic norms of radiation protection, 5th October 2010

→ Regulation on Radiation Protection during Activities with Sources of Ionizing Radiation, 08.10.2012

→ Regulation for safe management of radioactive waste, 30.08.2013

→ Design permit for a nuclear facility with registration No: HX-3593, 4th May, 2012

For the purpose of the radiological protection the NDF personnel working with sources of ionizing radiation is divided into two groups: category A and category B. These categories are regulated in Regulation on basic norms of radiation protection, 2012 are:

→ Category A – personnel that might receive an annual effective dose over 6 mSv or annual equivalent doses higher than 15 mSv for the eye lens or higher than 150 mSv for the skin and limbs;

→ Category B – personnel that does not fall into category A.

The defined annual limits for the personnel from category A are the following:

→ The limit of the effective dose for professional radiation is 20 mSv for every single year.

→ By using the limits from paragraph 1, the limits of the annual equivalent doses for the staff are:

→ 20 mSv for the eye lens;

→ 500 mSv for the skin (this limit is for the average dose received from every surface of 1 cm^2 regardless of the area of the radiated surface);

→ 500 mSv for the palms, armrests, feet and ankles.

The NDF investment proposal includes radiation control and radiation protection program and guarantees that the radiation of the workers is in accordance with the ALARA principles and is limited in accordance with the Regulation on basic norms of radiation protection, 2012.

In the Interim Report on Safety Analysis [30] of the Investment proposal has been done a conservative analysis of the individual dose rate of the staff when accepting, arranging and placing the containers – packages in the repository. The purpose of the estimation of a worker's dose is to analyze at which operations is formed the bigger part of the annual dose exposure. The repetition and duration of every activity (inspection, transport manipulation, disposal in the repository) is an important factor for the accumulation of an individual dose.

The operation doses are estimated by considering the outer radiation from all the radiation sources and the duration of each activity. For each activity the operation dose is estimated by the formula:

$$D_{\bar{i}}\,(\mu Sv) = \sum DR_{\bar{i}} \times T_{\bar{i}}$$ where

DR_i is the dose rate of the worker's activity [μSv/h] and T_i – the time needed for the activity completion, [h].

The professional doses are set by using the calculations of the software Grovesoftware MicroShield, Version 9.04, 1995-2012. These calculations are based on the assumption that every single package has a nuclide composition which provides the maximum permitted dose rate at a distance of 1 meter. There is an assumption for a homogeneous distribution of the nuclides in the cement matrix. As a result of it this conservative assumption the calculated nuclide composition is about three times higher than the total package activity provided for disposal in the NDF. In addition to this conservatism the corrections for the nuclide half-life haven't been taken into consideration. This is important to note because the short-lived 60 Co contributes for the dose rate outside the concrete protection.

Generally, the duration of the different activities is roughly estimated based on the operational experience in a similar facility and the reasonable assumption for the type of activity and the ALARA measures.

The dose exposure of the staff for the different activities has been estimated. Here are the activities:

→ Acceptance and confirmation (inspection, monitoring) of a RAW container;

→ Transportation of the container from the acceptance room to the disposal area;

[30] Interim Report on Safety Analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

→ Maintenance activities :

→ The crane located in the Waste reception and buffer storage building

→ The crane located in the disposal cells area

→ The disposal area

→ Closure and sealing of the cells.

Below are shown the tables with the dose rate for the different distances and the dose for the different activities, duration and the exposure for this activity.

TABLE 4.11-6 DOSE RATE AT DIFFERENT DISTANCES FROM A PACKAGE/CONTAINER AND THE WHOLE AREA (INTERIM REPORT ON SAFETY ANALYSIS, ROW 2)

Distance (m)	Dose rate [µSv/h]		Effective dose at a single package	Effective dose at a single package	Effective dose at 8800 h/a form the whole disposal area at a cell wall thickness 50 cm
	From one package	From the whole area with cells	8800 hours [mSv/a]	1700 h [mSv/a]	[mSv/a]
0	192.700	0.073	1695.760	327.590	0.644
1	100.000	0.073	880.000	170.000	0.641
2	41.490	0.072	365.112	70.533	0.636
3	21.410	0.072	188.408	36.397	0.630
4	12.830	0.070	112.904	21.811	0.618
5	8.484	0.068	74.659	14.423	0.598
6	6.000	0.065	52.800	10.120	0.571
7	4.454	0.061	39.195	7.572	0.541
8	3.430	0.058	30.184	5.831	0.510
9	2.719	0.054	23.927	4.622	0.479
10	2.205	0.051	19.404	3.749	0.449
15	0.971	0.038	8.548	1.651	0.330
20	0.533	0.029	4.687	0.905	0.253
25	0.336	0.023	2.952	0.570	0.202
30	0.227	0.019	2.000	0.386	0.165
35	0.163	0.016	1.433	0.277	0.138
40	0.121	0.013	1.068	0.206	0.118
50	0.074	0.010	0.648	0.125	0.089
60	0.048	0.008	0.426	0.082	0.070
70	0.034	0.006	0.296	0.057	0.056
80	0.024	0.005	0.214	0.041	0.046
90	0.018	0.004	0.160	0.031	0.038
100	0.014	0.004	0.122	0.024	0.032
110	0.011	0.003	0.095	0.018	0.027
120	0.009	0.003	0.076	0.015	0.023
130	0.007	0.002	0.061	0.012	0.020
140	0.006	0.002	0.049	0.010	0.017
150	0.005	0.002	0.041	0.008	0.015
160	0.004	0.001	0.034	0.006	0.013

Distance (m)	Dose rate [µSv/h]		Effective dose at a single package	Effective dose at a single package	Effective dose at 8800 h/a form the whole disposal area at a cell wall thickness 50 cm
	From one package	From the whole area with cells	8800 hours [mSv/a]	1700 h [mSv/a]	[mSv/a]
170	0.003	0.001	0.028	0.005	0.011

On the basis of these values can be done easy but conservative calculations for the maximum individual dose for a worker category A and B (fifth column) if they are permanently around the container at a certain distance which would be unusual and against the working procedures and rules.

In the tables below are given the estimated individual effective doses and the collective doses for separate typical activities done by the NDF personnel.

TABLE 4.11-7 RADIATION EXPOSURE OF A WORKER ACCEPTING A CONTAINER AT A REGULAR BASE – 800 TIMES YEARLY (INTERIM REPORT ON SAFETY ANALYSIS, ROW 2)

Type of activity	Duration [min]	Number of workers	Location	Source	Dose rate [µSv/h}	Individual dose [mSv/a]	Collective dose [man.mSv/a]
Check of the access permit to the controlled zone	15	2	Control zone of P3	Container buffer zone	0.024	0.005	0.010
Preparation for the trail discharge	3	1	Acceptance buffer zone	Container trail	100	4.000	4
Transport of the container to the base	15	1	Control panel	0	0	0	0
Measuring of the container: smear and P-gamma	3	1	Inspection room	Base container	182.5	7.300	7.300
Visual inspection	10	1	In the acceptance room	Base container	0.027	0.004	0.004
Going out of the trailer	2	1	In the cabin	Base container	0.07	0.002	0.002
Transport of the container from the base to the buffer zone	20	0	Control panel in building H	0	0	0	0
TOTAL	90						11. 315

TABLE 4.11-8 RADIATION EXPOSURE OF A WORKER WHILE THE CONTAINER IS TRANSPORTED TO THE DISPOSAL ZONE (INTERIM REPORT ON SAFETY ANALYSIS, ROW 2)

Type of activity	Duration [min]	Number of workers	Location	Source	Dose rate [μSv/h}	Individual dose [mSv/a]	Collective dose [man.mSv/a]
Trailer parking at a definite location	5	1	Buffer zone route	Container buffer zone	0.068	0.005	0.005
Container loading onto the trailer	15	0	Control panel	Container trailer	0	0	0
Transport preparation of the container to the base	2	1	Buffer zone route	Container trailer and buffer zone packages	100	2.667	2.667
Container transportation to the disposal zone	15	1	Near the cells	Container trailer Cells	20	4	1
Preparation for the trail discharge	3	1	Near the cells	Base container, cells	100	4	1
Placing the container in a cell	5	1	Near the cells	Air container, cells	50	3.333	3.333
Return of the trail to the buffer zone	5	1	Near the cells	Disposal cells	0.068	0.005	0.001
TOTAL	50						14.009

For the maintenance and repair of the mobile roof, crane and disposal zone which are done once a month and take about an hour is estimated conservatively a collective annual dose of 0.240 man.mSv, which is considerably lower than that shown for the routine activities in the above mentioned table.

TABLE 4.11-9 DOSE EXPOSURE WHILE SEALING A CELL WITH REGULARITY ONE PER YEAR (INTERIM REPORT ON SAFETY ANALYSIS, ROW 2)

Type of activity	Duration [days]	Number of workers	Location	Source	Dose rate [μSv/h}	Individual dose [mSv/a]	Collective dose [man.mSv/a]
Preparation and scaffolding	7	4	Near the cells	Cells	0.068	0.003	0.013
Filling the empty spaces with gravel	2	4	Above the concrete slab	Cell	2.333	0.033	0.131
Polyethylene placing	8	4	Above the concrete	Cell	2.333	0.131	0.523
Topographic levelling	4	2	Above the concrete slab	Cell	2.333	0.065	0.131
Horizontally levelling /concrete levelling/	1	9	Above the concrete slab	Cell	2.333	0.016	0,147
Abrasive processing of	11	4	Above the concrete	Cell	2.333	0.180	0.719

Type of activity	Duration [days]	Number of workers	Location	Source	Dose rate [μSv/h}	Individual dose [mSv/a]	Collective dose [man.mSv/a]
studs			slab				
Abrasive processing	3	2	Above the concrete slab	Cell	2.333	0.049	0.098
Steel construction activities	42	4	Above the concrete slab	Cell	2.333	0.698	2.744
Placing casing and its removing	22	6	Above the concrete slab	Cell	0.068	0.010	0.063
Concrete structural pointing	1	21	Above the concrete slab	Cell	0.068	0	0.010
Placing a temporary fence	14	2	Near the cells	Cells	0.07	0.007	0.010
Movable roof replacement	1	4	Near the cells	Cells	0.068	0	0.002
TOTAL	116						4.592

The duration of the activity is based on the operational experience from referential facilities and reasonable assumptions connected to the type of activity and also if any measures have been taken in order to reduce to collective dose in accordance with the ALARA principle.

The maximum collective dose is estimated to about 30.7 man.mSv. Because of the conservative approach of the above mentioned calculations the dose rate is expected to be considerably lower. The individual effective dose of a worker is expected to be less than 6 mSv/a.

4.11.4.2.1 RADIATION PROTECTION OF THE PERSONNEL

The site is divided into three zones:

→ Administrative zone;

→ Operative/exploitation zone;

→ Disposal zone.

In the control zone of the NDF the radiological conditions can result in external radiation beyond 6 mSv/a (**category A personnel**) – **Figure 4.11-3.**

In the surveillance zone the dose loading is within the boundaries between 1 and 6 mSv/a (**category B personnel**) – **Figure 4.11-3.**

4.11.4.2.2 SURVEILLANCE AREA

In order to ensure optimal radiation protection of the personnel (also, indirectly of the population) the following measures are implemented:

→ Safe remote control of the containers' transportation (the RAW packages) in the reception zone, the buffer zone and the disposal in the cells;

→ Installation of the protective mobile roof over the operative cells;

→ Covering of the cell during closure;

→ Classification of the premises and protection planning;

→ System for radiation monitoring and setting of an appropriate alarm thresholds;

→ Lack of gaseous and liquid emissions;

→ The protection during the design and operation of the NDF should provide correspondence to the dose boundaries or the dose limits for workers (and population):

- 0.1 mSv/a for the population;
- 6 mSv/a for a worker during the whole operation (dose limit);

The radiation from the RAW containers without protection is limited for a short period of time during the preparation and sample taking for beta contamination control. The transport operations with the crane will be carried put remotely, so that a significant dose loading of the personnel is eliminated.

All premises where activities with radiation risk are carried out are well-lit to make the process fast and easier. Additional portable lightning is provided, if necessary.

The disposal cells and the buffer zone are equipped with concrete protection, which is 50 cm thick, and there are additional 10 cm from the package's walls. This guarantees that each worker who is outside the building for buffer storage is exposed to a maximum of $7x10^{-5}$ mSv/h beyond the background. This value is of the order of the natural background.

The disposal cells are also protected by a concrete slab with thickness of 25 cm which is cast preliminarily, before the cells are closed. Television cameras are installed in the areas where visual observation is required.

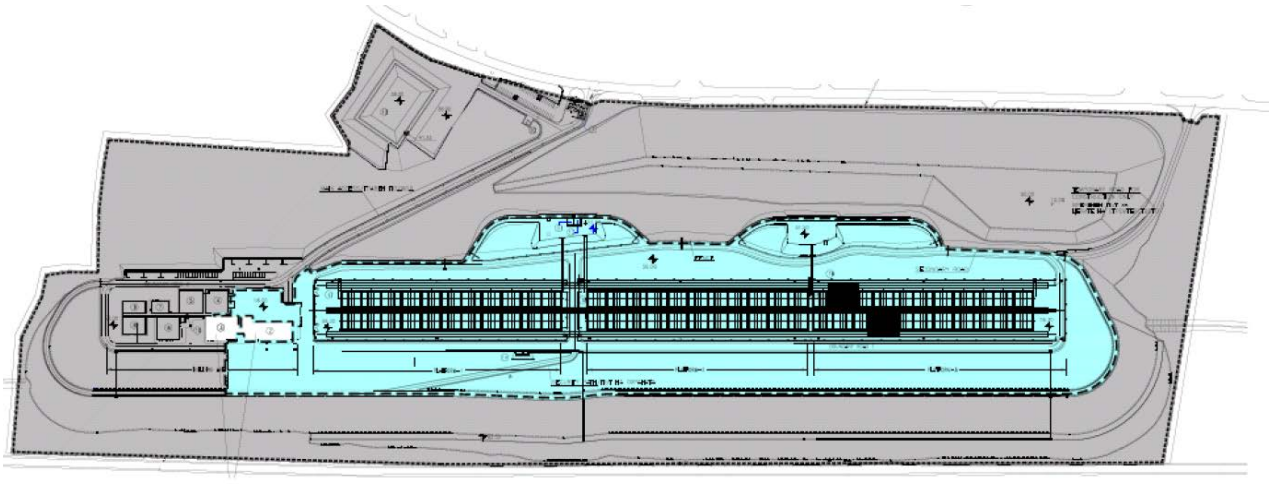

FIGURE 4.11-3 SUPERVISED AREA (GREY) AND CONTROLLED AREA (BLUE AND WHITE) OF THE NDF

The investment proposal of the NDF, which includes technological and laboratory radiation control and a programme for radiation protection, guarantees that the radiation on the workers will be in accordance with ALARA principle and will be limited within the limits set in the Regulation on basic norms of radiation protection, 2012.

Due to the nature of the conducted activity and the possibility for the implementation of the ALARA principle, the expected actual dose impacts will be below the limits set in the Regulation on basic norms of radiation protection, 2012.

In accordance with the Investment proposal, the radiation protection of the personnel working in the NDF will be ensured through:

→ Suitable screening (protection), which will prevent the increase of the permissible limits for the exposure;

→ Continuous radiological monitoring with alarm devices;

→ Minimization of the time for work, repair and maintenance in radioactive environment;

→ Zone division of the NDF premises;

→ Controlled access to the premises within the NDF controlled zone (CZ);

→ Dosimetry control of the personnel;

→ Prescription of personal protection means during risk assessment of the conducted activity and the necessity of their utilization.

In order to minimize the dose from external radiation, the management of the cranes used to position the containers, close the cells and place the covering panels of the mobile roofing is done remotely from a panel situated in the control room and an internal TV surveillance system .

4.11.4.3 DURING CLOSURE

During the NDF closure, after the cells are filled with a certain number of containers with RAW, all dose loading activities are discontinued. This is associated with reduction of the NDF personnel. The dismantling requires a permit from the Nuclear Regulatory Agency. The minimal number of workers, foreseen in the design and involved into the control of the NDF state, should be classified as category B, in case their permanent job is within the perimeter of the fence surrounding the NDF site.

It can be concluded that during the NDF operation and closure, the annual limit for an individual effective dose, set in the Regulation on basic norms of radiation protection, 2012, will not be exceeded for the NDF personnel.

4.12 MATRICES FOR ASSESSMENT OF THE POTENTIAL IMPACTS ON HUMANS AND THE ENVIRONMENT

When the impact is assessed, a general approach will be applied which takes into account both the requirements of the Bulgarian legislation and the international practice for assessment of the environmental impacts and the risk to human health by using:

1. **Probability of impact occurrence** – expected, not expected;
2. **Territory range** of the impact within the boundaries of the: construction site of the IP, Kozloduy NPP Site, the 30 km urgent protective action planning zone (UPAPZ)
3. **Type of impact** – positive/negative and direct/indirect, primary and secondary
4. **Degree (significance) of the impact** in 5 stages: 1 – very low, 2- low, 3 – medium, 4 – high, 5 – very high;
5. **Nature of the impact:**
6. **Frequency** – permanent, temporary;
7. **Duration** – short-term, long-term;

8. **Cumulative** – simultaneous impacts that affect the same environmental component/factor;
9. **Impact convertibility** – reversible, irreversible.

To assess the significance of the impact, a 5-stage scale is applied: **1** – very low, **2** – low, **3** – medium, **4** – high, **5** – very high;

Table 4.12-1 and **Table 4.12-2** shows an assessment of the potential impacts of the IP on all components and factors of the environment, respectively in non-radiation and radiation aspect.

TABLE 4.12-1 MATRICES FOR ASSESSMENT OF THE POTENTIAL IMPACTS OF THE INVESTMENT PROPOSAL IMPLEMENTATION IN NON-RADIATION ASPECT

Component/ Factor	Stage	Probability of impact occurence[1]	Territory range of the impact[2]	Type of the impact			Degree of impact[3]	Nature of the impact			Convertibility[7]
				Positive/ Negative	Direct/ Indirect	Primary/ Secondary		Frequency[4]	Duration[5]	Cumulative effect[6]	
1.1. Atmospheric air	Construction	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	Yes	Reversible
	Operation	Not expected									
	Closure	Not expected									
1.2. Surface waters	Construction	Expected	IP Site	Negative	Indirect	Secondary	Very low	Temporary	Short-term	No	Reversible
	Operation	Expected	IP Site	Negative	Direct	Secondary	Very low	Continuous	Long-term	No	Irreversible
	Closure	Expected	IP Site	Negative	Direct	Secondary	Very low	Continuous	Long-term	No	Reversible
1.3. Ground waters	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.4. Bowels of the earth	Construction	Expected	IP Site	Negative	Direct	Primary	Low to medium	Continuous	Long-term	No	Irreversible
	Operation	Expected	IP Site	Negative	Direct	Primary	Very low	Continuous	Long-term	No	Irreversible
	Closure	Not expected									
1.5. Lands and soils	Construction	Expected	IP Site	Negative	Direct	Primary	Medium	Continuous	Long-term	No	Irreversible
	Operation	Expected	IP Site	Negative	Direct	Primary	Very low	Continuous	Long-term	No	Irreversible
	Closure	Expected	IP Site	Positive	Direct	Primary	Low	Continuous	Long-term	No	Irreversible
1.6. Landscape	Construction	Expected	IP Site	Negative	Indirect	Secondary	Low	Temporary	Short-term	No	Reversible
	Operation	Not expected									
	Closure	Expected	IP Site	Positive	Indirect	Secondary	Low	Temporary	Short-term	No	Irreversible
1.7. Waste	Construction	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	No	Reversible
	Operation	Expected	IP Site	Negative	Direct	Primary	Very low	Temporary	Long-term	No	Reversible
	Closure	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	No	Reversible
1.8. Flora	Construction	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	No	Reversible
	Operation	Not expected									
	Closure	Expected	IP Site	Positive	Direct	Primary	Low	Temporary	Short-term	No	Reversible
1.9. Fauna	Construction	Expected	Local	Negative	Direct/ Indirect	Mainly Secondary	Low	Temporary	Short-term	No	Slightly reversible
	Operation	Expected	Local	Negative	Indirect	Secondary	Very low	Continuous	Long-term	No	Partially reversible
	Closure	Expected	Local	Positive	Direct и Indirect	Primary/ Secondary	Low	Continuous	Long-term	No	Irreversible
1.10. Hazardous substances	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.11. Noise	Construction	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	No	Reversible
	Operation	Not expected									
	Closure	Expected	IP Site	Negative	Direct	Primary	Low	Temporary	Short-term	No	Reversible
1.12. Vibrations and non-ionizing radiation	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.13. Health and hygiene aspects - Personnel	Construction	Expected	IP Site	Negative	Direct	Primary	Very low	Temporary	Short-term	No	Reversible
	Operation	Expected	IP Site	Negative	Direct	Primary	Very low	Temporary	Short-term	No	Reversible
	Closure	Not expected									
1.14 Health and hygiene aspects - Population	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									

[1] expected, not expected;

[2] selected site, NDF site, servitude zone, local, transboundary;

[3] **1** – very low, **2** – low, **3** – medium, **4** – high, **5** – very high;

[4] continuous, temporary;

[5] short-term, medium or long-term;

[6] no/yes;

[7] reversible, irreversible.

Italics - Matrix elements with positive impacts.

Underlined - Matrix elements, which are not expected to have an impact or elements, which are expected to have an insignificant negative impact.

Bold - Matrix elements, which are expected to have a significant negative impact.

TABLE 4.12-2 MATRICES FOR ASSESSMENT OF THE POTENTIAL IMPACTS OF THE INVESTMENT PROPOSAL IMPLEMENTATION IN RADIATION ASPECT

Component/ Factor	Stage	Probability of impact occurence[1]	Territory range of the impact[2]	Type of impact			Degree of impact[3]	Nature of the impact			Convertibility[7]
				Positive/ Negative	Direct/ Indirect	Primary/ Secondary		Frequency[4]	Duration[5]	Cumulative Effect[6]	
1.1. Atmospheric air	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.2. Surface waters	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.3. Ground waters	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.4. Soils, radioactive	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.8 RAW	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									
1.9 Radiation risk - Personnel	Construction	Not expected									
	Operation	Expected	NDF Site	Negative	Direct	Primary	Very low	Continuous	Short-term	Yes	Reversible
	Closure	Not expected									
1.9 Radiation risk – Population	Construction	Not expected									
	Operation	Not expected									
	Closure	Not expected									

[1] expected, not expected;

[2] selected site, NDF site, servitude zone, local, transboundary;

[3] **1** – very low, **2** – low, **3** – medium, **4** – high, **5** – very high;

[4] continuous, temporary;

[5] short-term, medium or long-term;

[6] no/yes;

[7] reversible, irreversible.

Italics - Matrix elements with positive impacts.

Underlined - Matrix elements, which are not expected to have an impact or elements, which are expected to have an insignificant negative impact.

Bold - Matrix elements, which are expected to have a significant negative impact.

4.13 RATIONALE FOR THE SELECTED ALTERNATIVE – TUNNEL OR TRENCH TYPE REGARDING THE IMPACT ASSESSMENT ON ALL COMPONENTS AND FACTORS OF THE ENVIRONMENT AND OF THE TANGIBLE AND CULTURAL HERITAGE, AND PRESUMABLE POTENTIAL IMPACTS ON THE POPULATION IN THE REGION AND THE WORKERS AT THE IP SITE

4.13.1 REGARDING THE IMPACT ON ATMOSPHERIC AIR

Regarding the component „atmospheric air“ in non-radiation aspect, the two alternatives of the disposal technology of category 2a RAW have an impact with equal significance – very low. Both types of repository do not have a potential danger of anthropogenic air contamination with non-radioactive pollutants in the vicinity of the IP. Both the impacts of emissions and the concentrations of pollutants are way below the limits for the quality of atmospheric air (QAI).

4.13.2 REGARDING THE IMPACT ON GROUND WATERS

A comparison between the impacts on the ground waters in non-radiation and radiation impact caused by the alternative technologies shows that these impacts are generally similar, and the trench type of technology is preferred for the NDF construction because of the following circumstances:

→ **the trench type of repository** does not pose a risk for change of the existing natural quantity and chemical status of ground waters. Also, there is a greater technological possibility for implementation of barriers, which will prevent an impact on ground waters, as well as surveillance systems and preventive correction activities (including removal of compromised containers from a particular cell), which ensure control over potential impacts on ground waters;

→ **the tunnel type of repository** has the following features:

- there are limited or completely lacking technical opportunities for continuance surveillance, control and preventive correction activities; there is no inspection drainage gallery to allow immediate control of the infiltrate from each repository cells, as well as there is no possibility for maintenance of the whole drainage system;
- there is no cement-loess cushion, which is very important to reduce the distribution of radionuclides;
- there is a danger from water breakthroughs and occurrence of suffusion event in case of low-quality implementation of the foreseen overtaking tamponage of water zone in the Brusar formation, which are to be crossed by mine constructions. This raises apprehensions for irreversible compromise of areas of the mine constructions and accidents with workers.

4.13.3 REGARDING THE IMPACT ON THE BOWELS OF THE EARTH

The damage level of the bowels of the earth is lower for the tunnel type of repository because the volume of the excavated masses is about three times smaller than the one for the trench type of repository. A significant disadvantage of the tunnel type repository is the complicated and expensive technology for implementation of mine construction in weak soils (loess, clays, sands) and it is possible collapse of the earth surface due to low-quality fixing of the mine construction and enforcement of the surrounding massif. This circumstances also raises apprehensions about compromise of areas of the mine constructions and accidents with workers. Therefore, the trench type of facility is preferred.

4.13.4 REGARDING THE IMPACT ON SURFACE WATERS

It is not expected a violation of the individual emission limits during discharge of waste water for both types of repository – tunnel and trench.

4.13.5 REGARDING THE IMPACT ON LANDS AND SOILS

The volume of the excavated masses for the tunnel type of repository is about three times smaller than the one for the trench type of repository. However, in case of quality management and implementation of the Programme for their utilization for backfilling of damaged terrains in the region (Kozloduy NPP, Kozloduy Municipality) this difference can be significantly reduced. Regarding the impact on adjacent lands and soils – impact is not expected on adjacent lands and soils.

Both alternative technologies for disposal or category 2a RAW have an impact on the biodiversity with a low significance level.

4.13.6 REGARDING THE IMPACT ON BIODIVERSITY

The two alternative technologies for repository of RAW Category 2a have very low significance of the impact on biodiversity.

4.13.7 REGARDING THE IMPACT ON LANDSCAPE

Both types of repository do not have a potential risk to the landscape.

4.13.8 REGARDING THE IMPACT ON CULTURAL HERITAGE

Negative impact is not expected for the two options.

4.13.9 REGARDING THE IMPACT OF WASTE

Negative impact is not expected for both option. The quantity and quality characteristics of the generated waste are similar for the tunnel and trench type, with the exception of the generated surplus earth masses during the construction period. (According to preliminary calculations, the surplus masses generated during stage I of the trench type repository, which should be transported outside the NDF site a 265 000 m^3, while during stage I of the tunnel type repository will be generated 250 000 m^3. In case of quality management and implementation of the Programme for their utilization for backfilling of damaged terrains in the region (Kozloduy NPP, Kozloduy Municipality) this difference can be significantly reduced, including in the following stages of the IP implementation.

4.13.10 REGARDING THE IMPACT OF HAZARDOUS SUBSTANCES

Negative impact is not expected for the two options.

4.13.11 REGARDING THE IMPACT OF HARMFUL RADIATION

Negative impact is not expected for the two options.

4.13.12 REGARDING THE IMPACT OF IP ON THE PERSONNEL WORKING AT THE SITE

During the periods of construction, operation and closure of the NDF, if all technological instructions and the instructions for safety, labour hygiene and fire safety, negative impact and health risk for the personnel is not expected.

During the period of operation is possible occurrence of low level impact on the personnel, which is short-term, direct and reversible negative.

4.13.13 REGARDING THE IMPACT OF IP ON THE POPULATION IN THE REGION

During the periods of construction, operation and closure of the NDF, if all technological instructions and the instructions for safety, labour hygiene and fire safety, negative impact for the population is not expected.

It is possible that the activities, related to the implementation of the IP, generate health risk for the population in the area.