ENVIRONMENT IMPACT ASSESSMENT REPORT ON

INVESTMENT PROPOSAL

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

PART I

ANOTATION OF THE INVESTMENT PROPOSAL FOR CONSTRUCTION, ACTIVITIES AND TECHNOLOGIES OF NDF

Sofia, January 2015

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ABBREVIATIONS	
In Bulgarian	
SPD	State Property Deed
NPP	Nuclear Power Plant
AIS	Automated Information System
AMB	“Archaeological Map of Bulgaria”
AWS	Automatic Weather Stations
NRA	Nuclear Regulatory Agency
SC	Spray cooler
BDWMDR	Basin Directorate for Water Management in the Danube Region
BOD_5	Biological Oxygen Demand
HFS	Housing and Faeces Sewage
GIS	Geographical Information System
MOD	Main Outlet Ditch
LNHIW	Landfill for non-radioactive household and industrial waste
DNHW	Depot for Non-Hazardous Waste
EIAR	Environmental Impact Assessment Report
SERAW	State Enterprise “Radioactive Waste”
EBRD	European Bank for Reconstruction and Development
EURATOM	The European Atomic Energy Community
EMF	Electromagnetic Fields
EA	Ecological Assessment
PE	Production of Electricity
EU	European Union
ASUNE	Act on the Safe Use of Nuclear Energy
WA	Waters Act
PZ	Protected Zones
LCH	Law on Cultural Heritage
EPA	Environmental Protection Act
UPAPZ	Urgent Protective Action Planning Zone (a zone of 30 km defined for the purposes of Emergency Planning),based on the dose rate) and it coincides with the Monitored Area (MA)
PPZ	Precaution Prevention Zone
SPA	State Property Act
FC	Factory Constructions
PT	Protected Territories
LWM	Law on Waste Management
SDA	Spatial Development Act
EEA	Executive Environmental Agency
EAEMDR	Executive Agency "Exploration and Maintenance of the Danube River"

IEZ	Individual Effective Zone
IEL	Individual Emission Limits
IP	Investment Proposal
QAA	Quality of Ambient Air
SZ	Surveillance Zone
IAEA	International Atomic Energy Agency
MDA	Minimal Detected Activity
MH	Ministry of Health
MAF	Ministry of Agriculture and Food
ICPDR	International Commission on Protection of the Danube River
ICRP	International Commission on Radiological protection
ISAR	Interim Safety Assessment Report
MoEW	Ministry of Environment and Water
MCE	Maximal Calculated Earthquake
MRD	Ministry of Regional Development
CM	Council of Ministers
MSK	Medvedev–Sponheuer–Karnik scale
NIAM - BAS	National Institute of Archaeology with Museum at the Bulgarian Academy of Sciences
NEN	National Ecological Network
MZ	Monitored Zone
NIMH	National Institute of Meteorology and Hydrology
NITCH	National Institute of Tangible Cultural Heritage
NICM	Natural Institute on Cultural Monuments
TCV	Tangible Cultural Value
SRP	Standards for Radiation Protection
NSEM	National System for Environmental Monitoring
NDF	National Disposal Facility for Low and Intermediate Level Radioactive Waste
NCRRP	National Centre of Radiobiology and Radiation Protection
NNPGC	New Nuclear Power-Generating Capacity
EIA	Environmental Impact Assessment
MSRP	Main Standards for Radiation Protection
OSG	Outdoor Switchgears
SNF	Spent Nuclear Fuel
PSA	Preliminary Safety Analysis
FP	Fission Products
HAC	Highest Allowable Concentrations
DE	Design Earthquake
GD	Government Decree
CM	Cultural Monument
WWTP	Waste Water Treatment Plant

RAW	Radioactive Waste
WFD2000/60/EU	Water Framework Directive
RHM	Regional Historical Museum
RIEW	Regional Inspectorate of Environment and Water
ReM	Radio Ecological Monitoring
GD	Government Decision
SMM	System for Meteorological Monitoring
WHO	World Health Organization
SDD Units 1-4	Specialised Division “Decommissioning of Units 1-4”
SD RAW Kozloduy	Specialised Division “Radioactive Waste”
SD NDF	Specialised Division NDF
SSCRAW	Storehouse for Storage of Conditioned RAW
STV	Specialized Transport Vehicles
WC	Warm Canal
TLDM	Thermo Luminescent Dose Meters
UACEG	University of Architecture, Civil Engineering and Geodesy
ETC	Educational and Technical Centre
FDP	Fine Dust Particles
DFPEM	Disposal Facility for Polluted Earth Masses
HMS	Hydrological and Meteorological Station
CON	Chemical Oxygen Necessity
SFSF	Spent Fuel Storage Facility
DSFSF	Dry Spent Fuel Storage Facility
HTF	Hydrological and Technical Facilities
WRAWP	Workshop for RAW Processing
CZ	Clean Zone
In English	
EUR	European Utility Requirements
NPP	Nuclear Power Plant
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
CLP	Regulation № 1272/2008 on classification, labelling and packaging of substances and mixtures
IUCN	International Union for Conservation of Nature
REACH	Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals Directive 67/548/EEC
PCBs	Polychlorated biphenyls, polychlorated terphenyls, monomethiltetrachlordipheyl methan, monomethicldichlordiphenyl methyl, monomethicldibromdiphenyl methan and each mixture containing over 0.005 weight %.

TERMS AND DEFINITIONS	
barrier	every physical (engineering or natural) barrier which prevents or hinders the distribution of radioactive substances and protects the RAW from internal and external unfavourable impacts, as well it provides protection against ionizing emissions
geological disposal	disposing of RAW in a stable geological formation at a depth of a few hundred meters or more under the surface in order to guarantee long-term isolation of the radionuclides from the biosphere
closure	completion of all operations on a fixed moment after the disposal of the radioactive waste in a disposal facility. This includes the final engineering or other works, required to set the facility into a safe condition for a prolonged period of time
protected zone	a zone defined for the purposes of physical protection, located at the territory of the site of a nuclear facility or another object for usage or storage of nuclear materials or radioactive substances; the zone is under constant supervision from guards or electronic tools, it is surrounded by a physical barrier with a limited number of access points and the access is allowed only for individuals owning special permits
zone with supervised access	a zone defined for the purposes of physical protection which covers a territory around the protected zone of the nuclear facility; the access to this zone is supervised and can be limited for vehicles
Urgent protective action planning zone (UPAPZ)	a territory around the nuclear facility or the object in whose boundaries the central and local bodies of the executive authority organize the application of immediate protective measures in case of common emergency situation, i.e. prior to or immediately after radioactive substances are emitted in the environment, in order to prevent and limit the risk of severe deterministic effects on the population
site selection	the process for determination of the a suitable place for construction of a particular nuclear facility of an object with sources of ionizing emissions, including the conduction of an appropriate assessment and definition of the design base
category 2	low and intermediate level radioactive waste, in accordance with the Regulation for safe management of radioactive waste, RAW containing radionuclides in concentrations that require measures for safe isolation and storage but do not require special measures for heat removal during storage and disposal. RAW of this category is subdivided into the following way: a) category 2a – low and intermediate level radioactive waste containing mainly short-living radionuclides (with a period of half decay not longer than the one of caesium-

	137) as well as long-living radionuclides with significantly lower levels of activity, limited to the long-living alpha-emitters under 4.10^6 Bq/kg for each packaging and maximal average value of all packaging in the facility of 4.10^5 Bq/kg; such RAW is provided for to be isolated and stored safely for a period of up to a few hundred years; (b) category 2b – low and intermediate level radioactive waste containing long-living radionuclides with activity levels of the long-living alpha emitters exceeding the limits for category 2a;
surface disposal	disposal of RAW in a facility located at the surface or up to a few tens of meters under the surface with the usage of engineer and/or natural barriers
disposal	disposing of radioactive waste in a suitable facility or place without any intentions of its further extraction
storage	storing of radioactive substances into a facility which provides limitation of their impact with the intention of their extraction
radioactive waste management	all activities related to the manipulation, preliminary processing, processing, conditioning, storing and disposal of radioactive waste with the exception of their transportation out of the site

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INTRODUCTION

The Environmental Impact Assessment Report (EIAR) on the Investment proposal/IP **for Construction of National disposal facility for Low and Intermediate Level Radioactive Waste (NDF)** at the “Radiana” site in the area the village of Harlets, Kozloduy Municipality, District of Vratsa, UCATTU 775548 is elaborated in accordance with Article 95, paragraph 2 of the Environmental Protection Act/EPA (Official Journal, No 91/2002, last amended in OJ, No 22/11.03.2014) and Article 9, paragraphs 1 and 4, Article 10, paragraphs 1 and 3 of the Regulation on the Terms and Procedure for Environmental Impact Assessments (OJ, No 25/2003 last amended in OJ, No 94/30.11.2012).

The EIA procedure is regulated by *the Environmental Protection Act* and *the Regulation on the Terms and Procedure for Environmental Impact Assessment*. The provisions of Bulgarian legislation are harmonized with those of the EU law - EU Directive 85/337/EEC on the assessment of environmental impact, as amended by Directive 97/11/EC, as amended by Directive 2003/35/EC on the participation of the public in drawing up certain plans and programmes relating to the environment. The national legislation also regulates the EIA procedure in the transboundary context in accordance with *the Convention on EIA in Transboundary Context*, ratified by Bulgaria in 1995. The EIA procedure of the NDF also complies to the requirements of the EBRD on the environment.

The regulatory and statutory requirements allow to the affected public to express its opinion on the results of the EIA made (and indirectly to the plan, the project or the facility in exploitation). This gives actually the possibility of having an impact on decision making - in terms of the existing alternatives, propositions of new alternatives, in certain cases it can even concern non-permission for project implementation or partial suspension of facilities in exploitation, currently in force.

In accordance with the requirements of the Bulgarian Environmental Protection Act (EPA) the Investment proposal of SE "RAW" for Construction of NDF is subject to a mandatory EIA as it falls in sect. 3 of Appendix No 1 to art. 92 in compliance with the requirements of *the Convention on EIA in Transboundary Context* (the Espoo Convention).

The construction of NDF has been assigned to the SE "RAW" by the Council of Ministers Decision No 683 of 25 July 2005.

By Decision No 21-9/10.11.2011 the Ministry of Environment and Water (MoEW) on Environmental Impact Assessment (EIA) approved the implementation of the Investment proposal for Construction of National disposal facility for Low and Intermediate Level Radioactive Waste (NDF).

According to letter No Ж -320 / 19.12.2013 from the MoEW SE "RAW" has been informed about the cancellation of the above Decision following Decision No 15645/26.11.2013 of the Supreme Administrative Court sitting with five Judges, delivered in administrative Case No 12075/2013 for maintained Decision No 11040/22.07.2013 of the Supreme Administrative Court sitting with three Judges, delivered in administrative case No 14 1090/2011.

In relation to the reasoning of the Supreme Administrative Court Decision and in accordance with the public interest, the MoEW recommends that an update of the Terms of Reference setting out the scope and content of the EIA should be carried out and consultations held with the municipality of Kozloduy and Harlets as well as the designated and notified institutions and departments - MoEW , Regional Inspectorate of Environment and Water (RIEW) Vratsa, RIEW Montana, Basin Directorate for Water management of the Danube Region (BDWMDR) and with following institutions and departments, municipalities, and others :

→ Ministry of Economy and Energy, Ministry of Agriculture and Food, Ministry of Interior, Ministry of Defense, NRA, “Kozloduy NPP – New Build” EAD, “Kozloduy NPP” EAD, Water supply and Sewerage utilities in the area of the Investment Proposal, other authorities and juridical entities, NGOs and others that might be affected by the implementation of the IP.

→ Municipalities: Kozloduy, Mizia, Oryahovo, Valchedram, Hayredin and municipalities within the 30 km radius zone around the chosen in the IP “Radiana” site.

An updated Terms of Reference for scope and content of EIA Report has been produced and it is subject to a new procedure in accordance with the requirements set by the MoEW.

The scope of the updated Terms of Reference is fully consistent with the requirements of Article 10 of the Regulation on the Terms and Procedure for Environmental Impact Assessment, the updated Terms of Reference is consistent with the requirements of the MoEW as stated in letter No Ж-320/19.12.2013 following Decision No 15645/26.11.2013 of the Supreme Administrative Court sitting with five Judges, delivered in administrative Case No 12075. The updated Terms of Reference is elaborated in compliance with the requirements of the laws, regulations, rules and standards of the Republic of Bulgaria and the main EU Directives on environmental protection related to the project, the Bulgarian Environmental Protection Act (EPA), the Regulation on the Terms and Procedure for Environmental Impact Assessments, Directive 2011/92/EU, the Convention on Environmental Impact Assessment in Transboundary Context (the Espoo Convention).

The updated Terms of Reference setting out the scope and content of the EIA takes into account all the feedback (comments and suggestions) from consultations conducted with special departments, organisations and community representatives as referred to in Article 95, paragraph 3 of the Environmental Protection Act as well as the opinion of Minister of Environment and Water as stated in outgoing letter No 26-00-1943/15.08.2014.

This EIA Report takes into account the interim results and conclusions achieved during the ongoing projects for justification of the NDF construction.

Additionally, all reasoning for omissions mentioned in the Supreme Administrative Court decision is taken into account.

Following both its main and specific objectives, these Terms of Reference are to identify environmental components and factors on the expected potential impact resulting from the implementation of the IP, possible cumulative effects, risk of accidents and possible transboundary impact which shall be thoroughly reviewed and assessed in the EIA report. Considering equally both technical and layout solutions for the NDF implementation, the main purpose of the assessment shall be to justify and motivate the most appropriate alternative solution by proposing measures meant to decrease, prevent or eliminate as much as possible the identified impacts on the environment and human health.

The main objectives of this environmental impact assessment of the Investment proposal /IP/ of State Enterprise "Radioactive Waste" for the implementation of National disposal facility for Low and Intermediate Level Radioactive Waste are:

→ to determine at an early stage the impact on all components of the environment and the factors affecting it and mostly on the health of the population in the region and the servicing personnel during construction, operation and closure of the facility.

→ to propose measures for minimizing the negative impacts on the environment caused by the IP.

As the NDF should be constructed, exploited and closed in a way that ensures long-term isolation of radioactive waste from humans and environment, this EIA Report assesses its closure and its potential impact during the post-operational period. According to the Bulgarian nuclear legislation, it is also subjected to licensing regime and a separate EIA procedure is required prior to the closure of the facility.

During the elaboration of EIA Report are observed the requirements stated in the laws, regulations, statutes, norms and standards of the Republic of Bulgaria and the main Directives of the EU related to the environment and the project.

The EIA procedure is regulated at national level by Chapter 6 of the Environmental Protection Act (EPA) and the Regulation on the Terms and Procedure for Environmental Impact Assessment (OJ, No 25/18.03.2003 last amended in OJ, No 94/30.11.2012).

The above documents have been transposed of EU Directive 85/337/EEC on the assessment of environmental impact, as amended by Directive 97/11/EC, as amended by Directive 2003/35/EC)

This EIA report is intended to outline the major ecological parameters of the Investment Proposal and to clarify its environmental impact during construction, exploitation and closure of the facility.

The environmental impact assessment is elaborated in compliance with the Regulation on the Terms and Procedure for Environmental Impact Assessment. As methodological basis for the elaboration of the EIA Report were used “Instructions for preparation of EIA of Investment Proposals”, Sofia 2002; Instructions and methodologies for the application of EU Environmental Impact Assessment Directive 2001/42/EC and other literature sources described in Appendix 5 - Used Literature.

As an appendix of the EIA Report it has been elaborating a Report on the impact level assessment of the Investment proposal with the subject and objectives for conservation of the protected areas in accordance with the Regulation on Assessment of the Compatibility of any Plans, Programmes, Projects and Investment Proposals with the Subject and Purposes of Preservation of the Protected Areas (Official Journal No 73/11.09.2007, last amended in OJ No 94/30.11.2012).

The EIAR has been produced on the basis of the contract concluded between SE "RAW" and “Ecoenergoproekt” Ltd. by a team of experts in order to assess the impact of the IP on individual environmental components and factors.

The EIA Reports takes into consideration all recommendations for additions and corrections presented in the statement of the Investor according to MoEW letter № 26-00-1943/05.12.2014 for defining an assessment of the quality of the EIA Report and the attached Report on the assessment of the impact degree of the Investment proposal “National disposal facility for disposal of low and intermediate active waste”(NDF).

1 ANOTATION OF THE INVESTMENT PROPOSAL FOR CONSTRUCTION, ACTIVITIES AND TECHNOLOGIES OF NDF

1.1 CLASSIFICATION OF RAW IN REPUBLIC OF BULGARIA

According to & 6, Item (1) of the Safety Regulation for the monitoring of the RAW, 2013, is applied classification of RAW, which is based on the separation of the hard RAW into categories and subcategories and is purposed for safety long-term monitoring and burial, and in Item (2) in accordance with the activity and specific characteristics, the hard RAW are classified as follows:

1. Category 1 – waste content radio nuclides with Low activities, for which is not required the application of radiation defense or it is not necessary to provide high level of insulation and detention; RAW in this category are subdivided in additional into:

   a)category 1a – waste, which respond to the levels for release from regulation under ASUNE;

   b)category 1b – a lot of short life waste, content preliminary radio nuclides with short period of half- destruction (not more than 100 days), which activity decreases below the release levels for regulation under ASUNE in result of suitable preserving on the site for limited period of time (usually not longer than few years);

   c)category 1c – a lot of Low Active Waste with levels of specific activity 4, exceeding in minimum the release levels for regulation under ASUNE and very low content of long life radio nuclides, which are a limited radiologic risk; for this waste category is not required the application of specific measures for radiation defense or for insulation and detention;

2. Category 2 – Low and Intermediate Active Waste: RAW, content of radio nuclides in concentration, which require measures for ensured insulation and detention, but not required special measures for take away the heat discharge when preserve and burial; RAW under this category are subdivide additionally into:

   a) category 2a – Low- and Intermediate Active Waste, content preliminary short life radio nuclides (with half-destruction period not longer than that of Caesium -137), as well as long life radio-nuclides radio nuclides at vastly lower levels of activity, limited for the long life alfa-emiters under 4.10^6 Bg/kg for each separate pack and maximum middle value of all packs in respective equipment 4.10^5 BQ/kg; for such RAW is required reliable insulation and detention for a period up to several hundred years;

   b) category 2b – low and medium active waste, content long lasting radio nuclides at activity levels of long lasting alfa-emiters, over the limits for category 2a;

3. Category 3 – high active waste: RAW with such concentration of radio nuclides, at which the heat discharge must be taken into consideration when preservation and burial take place; for this category is necessary higher stage of insulation and detention in comparison with the Low- and Intermediate-active Waste through burial in deep, steady geological formations.

The Classification is applied also for the liquid and gasiform RAW depending on the characterizations and the form of the suitable for burial hard RAW, which are expected to come out after the conditioning of the liquid and gasiform RAW.

1.2 NATIONAL DISPOSAL FACILITY FOR RADIOACTIVE WASTE (NDF) IN R. OF BULGARIA

NDF is purposed for burial of conditioned and packed low and medium active waste **category 2a,** which are received during exploitation of NP “Kozloduy”, new nuclear units, exploitation take off of NP “Kozloduy” as well as of RAW **category 2a**, which are generated when using of radioactive sources of ionizing emissions in the industry, medicine, agriculture and science researches.

With the construction of NDF is closed the cycle of monitoring of low and medium active waste category 2a in conformity to the requirements of the national legislation, the standards of safety of the International Atomic Energy Agency (IAEA), as well as the good practices for monitoring of radioactive waste in the EU. With the construction of NDF is aimed the save burial of low and intermediate active waste category 2a and their long-term and final isolation from the environment and humans.

The construction of NDF will be done in accordance of the obligations of R Bulgaria to United Convention for safety monitoring of Spent Nuclear Fuel (SNF) and safety monitoring of RAW[1]., Directive 2011/70/Evratom, dated 19.07.2011, for creation of Community frame for responsible and safe monitoring of the spent fuel and radioactive waste[2] and with strictly following the requirements of our Bulgarian Nuclear Legislation and the standards for safety of MOEW.

The construction of NDF has been assigned to State Enterprise “RAW” by the Government Decree (GD) No 683 / 25. 07.2005[3]. The last has been taken in accordance the requirements of Low on the Safe Use of Nuclear Energy[4] (ASUNE) – according with & 74, Item 3. Council of Ministers signed GD for construction of NDF. With GD No898/08.12.2011[5] NDF, for which construction as part of the procedure for define the location of NDF, is chosen the Site “RADIANA”, and it is considered as a Project of National importance following SDA directives and a National Project following the directives of SPA. With Decree No3/10.01.2013 NDF is defined as a strategic Project for National Security[6].

The activities connected to the construction of NDF – define a site, design work, construction work, initiate to usage and usage are an object of License Regime in accordance with the requirements of ASUNE[7] and the Regulation for issue of Licenses and Permissions for safe use of the nuclear energy[8]. SE “RAW” accomplishes all functions according with the permissions and the licenses.

1.3 EXISTING CONDITION OF RAW IN R.BULGARIA

A lot of society useful activities are connected to generating and gathering of RAW. Such activities are the production of electrical power in the nuclear plants, decommissioning the nuclear plants after the exploitation term has expired, use of the radioactive sources in the industry, medicine and the scientific researches, described below.

R. Bulgaria brings into exploitation the First Energy Block of Kozloduy NPP during October, 1974 and up to August, 1991 consecutively brings to work another 5 energy reactors. To implement the Memorandum between Bulgarian Government and European Commission, dated November, 1999, blocks 1 and 2 are stopped from operation on 31.12.2002, and blocks 3 and 4 – on 31.12.2006. Blocks 1-4 are due to be stopped from operation in accordance with the requirements of the Nuclear Legislation[9,10], internationally accepted commitments of R.Bulgaria and the Strategy for monitoring

[1] United Convention for safety monitoring of Spent Nuclear Fuel (SNF) and safety monitoring of RAW.. Ratified with Law, voted by the 38-th Parliament on 10.05.2000, SN, copy 42/23.05.2000

[2] Directive 2011/70/Euratom, dated 19.07.2011 for create a frame of the EU for responsible and save management of spent fuel and radioactive waste

[3] A Decree of CM No683/25.07.2005 for construction of National Disoosal for burial of radioactive waste.

[4] Low on the Safe Use of Nuclear Energy, SN, copy63/28.06.2002, last modification SN, copy 68/02.08.2013

[5] GD of CM No898/08.12.2011 for determing of NDF as a National Project

[6] GD of CM No3/1o.01.2013 for modification of Decree No181/2009 of Council of Ministers for determination of the strategic projects and tasks, which are with Meaning of the national security

[7] Act on the Save Use of Nuclear Energy, SN, copy 63/28.06.2002, last modification SN, copy 68.08.2013

[8] Regulation on the order for issue of licenses and permissions for save use of nuclear energy, SN, copy 41/18.05.2004, last modification SN, copy 76/05.10.2012

[9] Act for the Save Use of the Nuclear Energy, SN, copy 63/28.06.2002, last modification SN, copy 68/02.08.2013

[10] Regulation for save taking out of exploitation of the nuclear equipment, SN, copy 73/20.08.2004

of the worked out nuclear fuel and radioactive waste up to the Year of 2030[11]. Blocks 5 and 6 also will be stopped from operation after conclusion of their exploitation life. Kozloduy NPP develops a program to prolong the project life of blocks 5 and 6 for 20 years more[12].

According to the Energy strategy of R.Bulgaria up to the Year 2020[13] the country will continue to develop the nuclear energetic. The Project for construction of two energy blocks BBEP-1000 of NPP "Belene" has been suspended with Counsel of Ministers' Decree, confirmed by the 41-th National Assembly on 28.03.2012. With Decree No 250/9.03.2012 CM assigns to the Minister of Economy, Energetic and Tourism to introduce a Proposal for execution of new nuclear power at the Site of Kozloduy NPP . An agreement in principle for execution of new nuclear power unit in the meaning of Paragraph 45, Item 1 of ASUNE has been taken by the Council of Ministers on 11.04.2012. The Investment Proposal of "NNP Kozloduy-New Capacities" foresees construction of new nuclear capacity of new generation with installed electrical power around 1200 MW[14].

The activities for usage of radioactive sources of ionizing radiations in the industry, medicine and scientific research are developing in the country since the beginning of the sixties of the past sentry. They include usage of radioactive sources in a raw of apparatuses for technological control of the industrial processes, in metrological check and calibration of dissymmetric and radio metric equipment, radiation measurement apparatuses, fire alarm sensors and also permanently decreasing use in scientific researches. Vitally important is the use of radioactive sources in the medical diagnoses and therapy.

During all these activities are received radioactive waste, which have to be monitored in a safety way and reliable isolated from the environment and the humans in correspondence to the requirements of the Bulgarian Norms, the directives of EU and the safety standards of IAEA.

Radioactive waste Category 2a, which are collected in a result of the exploitation of Kozloduy NPP , as well as the waste, which will come out in a result of the activities for stop from operation the nuclear reactors, have to be securely and finally isolated from the environment through their burial in a Disposal for Low- and Intermediate radioactive waste.

1.3.1 HISTORY OF SE "RAW", STRUCTURE

The SA "Radioactive waste" was established in 2004 in correspondence with the requirements of ASUNE, 2002, aiming the monitoring of the radioactive waste to take place outside the projects, in which they were generated. The managing bodies of the SE are the Minister of Economy and energetic, the managing counsel of the enterprise and the executive director. SE "RAW" fulfils duties, determined by ASUNE as it is monitoring installations, committed to it with Decision of Counsel of Ministers or constructed by SE "RAW" itself[15].

With Decree of CM No 992/14.12.2004 from Kozloduy NPP to SE "RAW" were transferred the following units: Department for processing and conditioning of radioactive waste and Storage for preservation of the conditioned RAW. When the license for operation series E reg. No E01740 was issued, a Specialized Unit "RAW-Kozloduy" was established for monitoring of the radioactive waste, which come out from the operation of NPP "Kozloduj".

[11] Strategy on management of spent nuclear fuel and radioactive waste up to 2030, accepted with Protocol Decision of Council of Ministers, dated 05.01.2011, modified with Protocol Decision of CM, dated 25.06.2014

[12] Announcement for Investment Intention for prolongation of the exploitation term of 5 and 6 blocks of NPP"Kozloduy", NPP "Kozloduy", 2013, http://www.kznpp.org/ .

[13] Energy Strategy of R Bulgaria till 2020, June, 2011, accepted with Decision of the Parliament on 01.06.2011

[14] Envirinmental Impact Assessment Report (EIAR) over the Investment Proposal "Construction of new nuclear power new generation on the site of NPP "Kozloduy". NPP "Kozloduy-New powers" Ltd, 2013.

[15] Act on the safe use of nuclear energy prom. SG. 63/28.06.2002, last amendment 68/02.08.2013

With Decree of CM No 539/18.07.2006 from the Institute for nuclear researches and nuclear energetic in Bulgarian Scientific Academy was transferred to SE “RAW” the Permanent depot for RAW-Novi Han. When the license for operation series E reg. No 02088/14.07.2006 was issued; a Specialized Unit “SD NDW-Novi Han” was established for monitoring of the radioactive waste, which is generated in the industry, scientific researches and medicine.

With Decree of CM No 839/20.12.2008 blocks 1 and 2 of Kozloduy NPP were announcemented as equipment for monitoring by RAW, which are subjects to be taken out from exploitation, and they were transferred to SE “RAW”. When the licenses were issued for the operation of blocks 1 and 2 of Kozloduy NPP as equipment for monitoring of RAW, to be considered to be taken out from exploitation – license series E reg. No03492/18.10.2010 and license series E reg. No 03493/18.10.2010. Then starts the establishing of the third specialized unit of SE “RAW”, which is responsible for the decommissioning of blocks 1-2 of Kozloduy NPP . With Decree of Counsel of Ministers No1038/19.12.2012 blocks 3 and 4 of Kozloduy NPP were announcemented as equipment for monitoring by RAW to be considered to be taken out of exploitation, and were transferred to SE “RAW”. With the issuing of licenses for exploitation series E reg. No04152/26.02.2013 and reg. No04153/26.02.2013 comes to end the establishing of the third specialized unit of SE “RAW”, which is responsible for taking out of operation blocks 1-4 of NPP “Kzloduy”.

The specialized unit “National Disposal” was established on 1-st of November, 2012, on the basis of the group for monitoring of the project “National disposal” of SE “RAW” and after the property of the site “Radiana” for managing and monitoring was committed with a Decree No393/05.07.2013 of Council of Ministers[16].

SE “RAW” consisting main management and the above mentioned specialized units[17]. All specialized units are strategic projects in the sense of the national security.

The main task of SE “IE 1-4 Block” is to carry out the activities for taking out of exploitation of blocks 1-4 of Kozloduy NPP in accordance with the Strategy for monitoring of the spent nuclear fuel and the radioactive waste up to Year 2030[18] and the Actualized strategy for takeout of exploitation of blocks 1-4 of Kozloduy NPP [19].

SE “RAW-Kozloduy” manages RAW of Kozloduy NPP . This includes manipulation of RAW, preliminary process of hard RAW (gathering, classify, deactivation and parcel out), preliminary process of hard RAW (packaging in barrels, preliminary press and press), process and conditioning of liquid RAW using the method of cementing, conditioning of liquid and hard RAW through packaging in reinforced concrete containers, preservation of non-processed, processed and conditioned RAW, transport of RAW.

SE “NDF –Novi Han” manages the monitoring of RAW, which are generated when using radioactive sources in the industry, medicine diagnosing and therapy, scientific researches. This includes preliminary process of hard RAW (gathering, classify, deactivation and parcel out), preservation of non-processed and processed RAW, preservation of radioactive waste, including used covered radioactive sources, transport of RAW, processing of hard RAW, incl. packaging in barrels and pressing, processing and conditioning of liquid RAW through cementing, conditioning of liquid and hard RAW through packaging in barrels.

[16] Decree of CM No393/05.07.2013 on consignation of properties, which are public government property, for using and management by SE RAW for construction of National Disposal for burial of radioactive waste.

[17] Regulations on the structure and the tasks of SE RAW, SN, copy 5/ 2014.

[18] Strategy on management of spent nuclear fuel and radioactive waste up to 2030, accepted with Protocol Decision of Council of Ministers, dated 05.01.2011, modified with Protocol Decision of CM, dated 25.06.2014.

[19] Actualized strategy on the decommissioning of blocks 1-4 of NPP “Kozloduy”, 2006

SE “NDF” is established for managing the tasks for choice site, design, preparation of the site for construction of NDF, construction of NDF and bring into exploitation, exploitation of NDF.

All specialized units carry out their tasks, observing the legislation requirements, internal rules, procedures and instructions in SE RAW, strictly ensuring for safe exploitation of the equipment, ensuring the safety of the personnel and the population and protection of the environment. A strict internal control is provided over insurance of the requirements for safety during the monitoring of RAW, fulfilled as by the respective departments and sectors, responsible for the safety in the frames of the specialized units, as well on a higher level by the Managing unit “Security of nuclear equipment” under the Head Quarters.

The tasks are fulfilled any if the licenses and permissions for their execution by the Nuclear Regulatory Agency (NRA) are issued for their accomplishment and at strictly following the conditions in the licenses and permissions. NRA accomplishes continuous control for the observation of the conditions of the licenses and observation of the norms and rules for nuclear and radiation security, safety for the personnel and the population and safety for the environment.

1.3.2 ACTIVITY, EXPERIENCE IN MANAGING OF RAW AND EQUIPMENT, LOCATED ON THE SITE OF KOZLODUY NPP

Despite the fact that SE “Kozloduy” was established in 2004, the experience of the enterprise in managing of RAW and the equipment, which it operates, is based on the long years of experience of the qualified personnel, , which still operates the equipment for monitoring of RAW. Specialized units are based not only on the equipment, which was transferred into SERAW, but also on the base of the personnel, who has operated these equipments and has passed to SERAW together with the equipment in the sense of &123, Paragraph 1, Item 4 in the Labor Code. Thus, on these grounds we can affirm that the experience of SE RAW in the managing of RAW and the equipment is far above the 10 years history of SE RAW.

1.3.2.1 EQUIPMENT FOR MANAGEMENT OF RAW, EXPLOITED BY SE “RAW – KOZLODUY”

SE “RAW – Kozloduy” is located on the site of Kozloduy NPP and operates the following main equipments:

1. **Workshop for RAW processing (WRAWP)** – main project, mint for accomplishing the tasks for preliminary processing, processing and conditioning of RAW by Kozloduy NPP ;

Fundamental completing knot for forming of the packs of the conditioned RAW is reinforced concrete container (RCC), which is licensed for transporting and preservation of hard RAW 2-th category, and has outer sizes 1.95 x 1.95x1.95 m and useful volume 5 m3. Its walls are providing biological defense in such way, that the power of equivalent RAW of the gamma-radiation of RAW to be not more than 2 mSv/h in each point over the outer surface and 0.1 mSv/h at 1 m distance from the surface. The container is produced and passes tests according to the conditions of the issued by NRA permission.

The packs with the conditioned RAW are preserved temporarily in a storehouse for storage of conditioned RAW (SSCRAW), site No1 and site No2, as they be liable to burial without additional processing.

The basic systems of WRAWP are:

- Line “Hard RAW” – sorting and conditioning aiming degreasing their volume and preparation for following conditioning and packaging in reinforced concrete container. The hard RAW are preliminary pressed in 210 l big barrels with 50 t press and pressing of the barrels with super press at 910 t effort.

- Line “Liquid RAW” – processing and conditioning of the liquid RAW through evaporation in a two stages evaporation apparatus and coming cementing. A compose part of Line “Liquid RAW” is a “Line for packaging of RAW”.

2. **Storehouse for Storage of conditioned RAW (SSCRAW)** – meant for temporarily storage (to the burial) of the conditioned RAW from Kozloduy NPP . It represents over-ground reinforced concrete equipment, providing the necessary engineering barriers between the stored RAW and the environment and personnel. It is built near by the WRAWP on the site of Kozloduy NPP . The capacity is 1920 reinforced concrete containers with conditioned RAW (960 pcs in each of the fields “A” and “B”, at four rows one over the other). The transport operations in the warehouse are done with 2 travelling cranes with hoisting capacity 25 t each (one for each field), equipped with grasping appliances for arranging and positioning of the RAW containers.

3. Site “Lime area”

On the site “Lime area” are located:

- Ditch depot for temporarily storage of hard RAW - no processed and processed (pressed and closed in barrels). The depot is surface located, reinforced concrete structure, hopper type. It is divided into 40 cells with upper man-hole, each one with sizes 2.7x5.9x6.0 m and volume 96.5 m^3.
- Warehouse for storage of processed hard RAW. The warehouse is a building, reinforced concrete panel structure with receiving transporting corridor. The processed hard RAW (pressed and closed in barrels) are storage on metal pallets, arranged in 3 rows one over the other. The useful volume is 1130 m^3.
- Stage No1 and No2 for storage of hard RAW in reinforced concrete containers (RCC). They are meant for buffer storage of processed hard RAW, packed in RCC (packs RCC-1 or packs RCC-2, according the Technical specification of the packs of the conditioned RAW). The capacity of the two sites is 2000 packs;
- Stage for storage of hard RAW in big tonnage containers (BTC). It is meant for buffer storage of no processed and processed low hard RAW, The stage is with disposal capacity 14 BTC. Big tonnage standard ISO-container is with outer measures 5.8x2.2x2.4 m and useful volume 30 m^3.
- Disposal Facility for polluted earth masses (DFPEM) – meant for storage of low active polluted earth masses. The capacity is 8000 m^3.

1.3.2.2 EQUIPMENT, EXPLOITED BY EE “IE 1-4 BLOCKS”

EE “IE 1-4 blocks” is located on the stage of Kozloduy NPP and it is meant for takeout of exploitation of blocks 1-4 of Kozloduy NPP . Blocks 1 and 2 were stopped from exploitation on 31.12.2002, and blocks 3 and 4 were stopped on 31.12.2006. The spent nuclear fuel of the 4 blocks is taken out of them and it is stored in the Disposal for spent fuel of Kozloduy NPP . The blocks are announced as equipment for managing of RAW, subject to be taken out of exploitation. All four blocks represent Water-Water Energy Reactor-440 (WWER). Blocks l and 2 as well as blocks 3 and 4 were built like blocks–twins, which means, that they are located as pairs in one building with common central hall. The machine hall is common for the 4 blocks. Special corpus- 1 serves blocks 1 and 2, and special corpus-2 serves blocks 3 and 4. In the special corpuses are preserved liquid and hard RAW, received during the exploitation of blocks 1-4 of Kozloduy NPP , and systems for purifying of radioactive waters, which were operated during the work of the reactors for producing of electrical power.

1.3.3 EQUIPMENT FOR MANAGING OF RAW, EXPLOITED BY EE " ENDF- NOVI HAN"

EE " ENDF- Novi Han"is located 35 km away south-east from Sofia and 6.5 km from Novi Han village in the Lozen mauntain. It is meant for dispose of conditioned and no conditioned RAW from the nuclear applications in different branches of the industry, medicine, agriculture and science. It operates the following basic equipment;

1. Disposal for hard RAW

It is meant for preservation of no conditioned low and intermediate hard RAW, category 2a. The disposal is with capacity 237 m^3. It consists of 3 equal cells with measures 5x4.5x3.5 m. It represents dug into the earth reinforced concrete equipment with length 15.7 m, width 5.83 m, height of the over ground part is 1.2x1.6 m. The thickness of the walls is 300 mm, both sides hydro-insulated with 20 mm bitumen membranes and lined from the internal side with 4 mm thick stainless steel sheet. The outer hydro-insulation is additionally protected with brick wall with thickness 120 mm. The disposal was brought into exploitation together with the construction of EE " ENDF- Novi Han" during the 60-es of the past century and was exploited up to the middle of 90-es. At the moment it is under monitoring and control before it is taken out of exploitation.

2. Disposal for biological RAW

The purpose is to keep conditioned through stabilizing in gypsum matrix preliminary processed with formaldehyde low- and intermediate active biological waste category 2a. The capacity of the disposal is 80 m^3. Structure is analogical to that of the disposal for hard RAW. Geometrical measures – length 8.35 m, width 4.00 m, depth – 2.5 m and height over the ground (roof structure) 0.5 m. The disposal was brought into exploitation with the construction of " ENDF- Novi Han"

During the 60-es of the past century and operated up to the middle of 90-es last century. At the moment it is under monitoring and control before it is taken out of exploitation.

3. Disposal for covered sources

The purpose is to keep no conditioned covered sources, category 2a. Capacity 1 m^3. It represents reinforced concrete equipment, lined with stainless steel, located at a depth of 5.5 m under the surface. The sourced were coming in through serpentine from stainless steel with thickness of 5 mm. The protection of the ionizing radiation is executed by the heavy concrete and 5 lead plates, each one with thickness of 10 mm, placed between the disposal and the surface. The equipment is protected additionally with heavy roof structure. The disposal was brought into exploitation with the construction of " ENDF- Novi Han" during the 60-es of the past century and operated up to the middle of 90-es last century. At the moment it is under monitoring and control before it is taken out of exploitation.

4. Engineering trench for hard RAW

The purpose is for no conditioned low- and intermediate- hard RAW category 2a. Capacity 200 m^3 and measures: length 29 m and width 4.1 m. It contends 8 cells, built with precast reinforced concrete elements with thickness 300 mm, bitumen membranes, protected with brick wall. The trench was brought into exploitation during the 80-es of the past century and operated up to the middle of 90-es last century. At the moment it is under monitoring and control before it is taken out of exploitation.

5. Disposal for liquid RAW

The purpose is to keep liquid radioactive waste category 1 and 2a. Consist of 4 reservoirs made from stainless steel with thickness 4 mm, installed on concrete supports at 0.5 m over the floor of reinforced concrete cell with measures 5.7x7.4x4.3 m. The cell is completely dug in the earth. Capacity 48 m^3.

6. Stage No1 and 1A for dispose of hard RAW

The purpose is to keep hard RAW category 2a and 2b in standard ISO-containers. At the stage are kept ionization fire alarm sensors in transport packs, hard RAW and β, γ-spent sources with low specific activity in transport packs. The containers are with size 6.00x2.35x2.4 m. Capacity of the stage 14 containers with total volume 462 m^3.

7. Stage No 2 for dispose of hard RAW

For storage of solid RAW class 2a and 2b in concrete containers different type. On the site are stored spent sources in their transport packages in concrete receivers "PEK" type, sealed sources in reinforced concrete containers StBKKUB and not completely discharged gamma-irradiators in reinforced concrete containers StBKGOU. The site capacity is 171 StBKKUB with 248 m^3 total volume, 6 "PEK" with 74 m^3 total volume and 18 StBKGOU.

8. Stage No4 for dispose of low active RAW

The purpose is to keep RAW in 200 l barrels on euro-pallets. The capacity of the stage is 400 barrels, respectively 100 euro-pallets.

9. Accepting-preparatory laboratory complex.

For characterization and processing of hard RAW category 1, 2a, 2b and liquid radioactive mediums. Includes the following systems: a system for processing of liquid RAW; system for cementing of liquid and hard RAW; sorting of RAW; fragmenting of RAW, buffer disposal of RAW and laboratories.

1.4 CONNECTION WITH OTHER EXISTING AND APPROVED DEVELOPMENT PLANS OR OTHERS

1.4.1 EXISTING PLANNED ACTIVITIES OF SE RAW

The object of the investment proposal is in immediate connection with the accomplished and planned tasks, which are topics of the specialized units of SE RAW and they are executed in the existing or planned outfits.

1.4.1.1 WORKSHOP FOR PROCESSING OF RAW (WRAWP) AND WAREHOUSE TOR STORAGE OF CONDITIONED RAW (WCRAW) OF THE SPECIALIZED UNIT "RAW-KOZLODUY" OF SE RAW, FOR PROCESSING LOCATED ON THE SITE OF KOZLODUY NPP.

As it was said above in the Workshop for processing of WRAWP are processed low and intermediate active waste, which were piled up in the process of exploitation of Kozloduy NPP , as well the currently generated waste, which come out from the exploitation of blocks 5 and 6 of Kozloduy NPP . After temporarily disposal in the Warehouse for generating of conditioned RAW (SSCRAW) of reinforced concrete containers with conditioned low and intermediate RAW category 2a, they will be turned over for burial in NDF.

1.4.1.2 ACTIVITIES CONNECTED TO THE MANAGEMENT OF RAW COMING FROM THE INDUSTRY, AGRICULTURE, MEDICINE AND THE SCIENTIFIC RESEARCHES, DONE BY PERMANENT REPOSITORY FOR RAW – NOVI HAN

As it was said above in SE "ПХРАО- Нови Хан" is taking place temporary generation of the no processed waste, which are received during use of radioactive sources in the industry,medicine and scientific researches, their processing and conditioning, as well as temporary disposal of the conditioned RAW. Low and intermediate active RAW category 2a will be turned over for burial in NDF after their packaging in reinforced concrete containers in the existing outfits of SE "RAW-Kozloduy".

1.4.1.3 ACTIVITIES FOR DECOMMISSIONING OF BLOCKS 1-4, DONE BY SE “IE 1-4 BLOCKS”

Up to this moment SE RAW operates blocks 1-4 as equipments for managing of RAW, which are considered to be taken out of exploitation. In the frame of the active licenses, issued by NRA, SE RAW accomplishes dismantle of equipment and systems in the machine hall, which is common for blocks 1-4. Equipment and systems, which are not connected to the security, are dismantled and they are clean materials, which are liable for free out from control, limited quantities waste category 1imited quantities waste category 1, which are liable to be kept on specialized stages on the territory of NPP ‘Kozloduy”. During the dismantle are not generated waste category 2a.

The taking out of exploitation of blocks 1-4 will be done in the frames of licenses for takeout of exploitation, issued by NRA. During the taking out of exploitation will be generated radioactive waste. They are to sorted, preliminary processed to decrease the volume (cutting, deactivation), conditioning (putting into hard matrix, basically cementum), packaging in reinforced concrete containers and disposal. Low and intermediate active RAW category 2a after the packaging in reinforced concrete containers in the Workshop for processing of RAW and their temporary disposal in Warehouse for disposal of conditioned RAW, will be taken over for burial in NDF. The activities for taking out of exploitation are subject of EIAR[20], for which is received positively decision of EIAR No8-6/2013 of the Minister of MOEW.

1.4.1.4 PROJECT FOR EQUIPMENT FOR TREAT AND CONDITIONING OF HARD DECREASING OF RADIOACTIVE WASTE WITH HIGH COEFFICIENT OF REDUCE THE VOLUME

The Project has to provide e delivery of equipment for processing of hard low- and intermediate RAW with high coefficient of reduce the volume, which waste at the moment are disposed in the outfits of SE RAW on the site of Kozloduy NPP . The equipment has to be able to reduce the volume of no pressed, as well as of pressed and super pressed in barrels RAW. The equipment will be installed within the perimeter of the boundary of the site Kozloduy NPP . The suggested location is in special corpus 2 (SC-2), level +6.30 m, room VK 301. The plasma technology is high power technology, which can process wide range of waste. Using this technology plasma heat field is created through flow of electricity through air flow with low pressure. Low- and intermediate active RAW category 2a from the equipment for plasma burning will be additionally conditioned in cements matrix and packed in reinforced concrete containers in Workshop for processing of RAW. After their temporary disposal in Warehouse for conditioned RAW, they will be handed over for burial in NDF.

The Project for the equipment for treating and conditioning of hard radioactive waste with high coefficient of reduce of volume is a subject of EIAR[21], for which is received positive decision of EIAR No2-2/2014 of the Minister of MOEW.

1.4.2 EXSISTING AND PLANNED ACTIVITIES OF KOZLODUY NPP

1.4.2.1 BLOCKS 5 AND 6

At the site of Kozloduy NPP is taking place the exploitation of blocks 5 and 6 of Kozloduy NPP . The blocks are brought into operation respectively in 1987 and in 1991. They represent BBEP-1000, model B-320 with hermetic defense cover and triple reservation of the security systems. The production activity has been a subject of EIAR[22] with positive EIAR No 28-8/2001 of the Minister

[20] Environment Impact Assessment Report (EIAR) on the decommissioning of blocks 1-4 of NPP “Kozloduy”, 2013.

[21] Environment Impact Assessment Report (EIAR) on the Equipment for treating and conditioning and conditioning of hard radioactive waste with high coefficient for reduse of volum in NPP”Kozloduy”, 2013

[22] Report for EIA on NPP “Kozloduy”, 1999.

of MOEW. Projects are existing for the prolongation the operation period of blocks 5 and 6 and for increase of the heat power of the reactor installations of the two blocks to 104%[23].

As it was said above RAW, which are generated during the exploitation of blocks 5 and 6, are processed in SE RAW in Workshop for process of RAW (WRAWP). After temporal disposal in a Warehouse for conditioned RAW (SSCRAW) the low- and intermediate RAW, category 2a will be handed over for burial.

1.4.2.2 SFSF

A Depository for preserve of spent fuel (SFSF) ensures possibility for temporal disposal under water of the spent nuclear fuel (SNF) from WWER-440 and WWER-1000 for 10 years exploitation period of operation of all blocks of Kozloduy NPP and for execution of the logistic-technological operations, connected to its receive, its replenish in the areas for disposal, disposal and transport from SFSF accordingly with the requirements of ensured security.

1.4.2.3 DSFSF

The depository for dry preservation of spent nuclear fuel (DSFSF) REPRESENTS EXPANSION of the executed by now task of NPP- temporal disposal of the spent nuclear fuel in SFSF. In DSFSF will be kept cassettes with SNF in specially designed for this purpose containers with air cooling on the principle of natural convention type CONSTOR 440/84 with capacity 84 fired cassettes from WWER-440. The design period of exploitation of the equipment is minimum 50 years. For this design is prepared separate EIAR[24], over which there is positive decision for EIA No 14-7/2006 of the Minister of Environment (MOEW). During the exploitation of DSFSF are generated small quantities RAW, which are part of the waste from the exploitation of blocks 5 and 6 of Kozloduy NPP.

1.4.2.4 NEW NUCLEAR POWER- GENERATING CAPACITY – NNPGC

With the investment proposal of “Kozloduy NPP – New Build” EAD is predicted the construction a new nuclear unit of the latest generation (Generation III or III+) at the Kozloduy NPP with light/water reactor with pressured water (type PWR –Pressurized Water Reactor), with installed electrical power around 1200 MW.

The technological scheme of the new nuclear power capacity is double contoured and it will include:

⇒ **First contour** – with circulating radioactive medium, consistent of one power reactor and circulating pipelines.

The reactor represents pressured vessel, consistent of corpus and upper block (head) of the reactor. The internal outfits of the corpus are disposed inside the corpus (e.g. reactor support barrel, reflector of neutrons, etc.), and the control rod cluster drive mechanisms are located on the reactor head.

The fuel assemblies of the reactor are fully immersed in pressurized water, so that its boiling temperature is higher than the normal operational temperatures. The fuel is a slightly enriched uranium dioxide (UO_2) or MOX (nuclear fuel, which contains more than one oxide of a fission material).

In the core (active zone of a reactor), a chain reaction of fission takes place producing heat that is transferred to the coolant. The core consists of fuel assemblies, located in most cases

[23] Notification for Investment Intention for prolongation of the exploitation period of 5 and 6 blocks of NPP”Kozloduy”, NPP”Kozloduy”, 2013, http://www.kznpp.org/

[24] Report for EIA over Disposal for dry preservation of spent nuclear fuel in NPP “Kozloduy”, 2005.

in square or hexagonal meshes. The fuel bundle consists of fuel rods, guide thimble tubes, fuel alignment plates and rod holding plates.

The structure and the systems of the protection cover (containment) are designed in such way, that the reactor, first contour and all related equipment, important from the point of view of nuclear and radiation security, and located in the containment, to be protected against external events, which appearance cannot be eliminated with adequate stage of probability. The system of the containment also fulfils the function of biologic screen.

⇒ **Second contour –** with non radioactive medium, including the steam producing part of the steam-generator, turbine and subsidiary equipment of the machine department.

It is purposed to absorb the heat power from the First contour and to convert it to the kinetic power of the revolve of the steam turbine. The produced in the steam generators steam is collected in a steam collector and is directed toward the turbine. In the capacitors of the turbine, the worked out steam condenses and goes back to the steam generators.

Low- and intermediate active waste, category 2a from NNPGC shall be taken over for burial to NDF.

1.4.3 CONNECTION OF NDF WITH OTHER CONCOMITANT ACTIVITIES ON THE SITE OF KOZLODUY NPP

1.4.3.1 MONITORING OF THE ENVIRONMENT, CONDUCTED BY KOZLODUY NPP

NDF is located in the zone for preventive protection measures (LPPM) of Kozloduy NPP . The site is enveloped in the activities of the Program for monitoring of the environment of department “Radio ecological Monitoring” of Kozloduy NPP , in consequence of which there are a lot considerable data, connected with the radio ecological monitoring of the environment. Despite that in correspondence with the recommendation of IAEA[25,26,27,28] till the bring NDF into exploitation shall be conducted profound monitoring before to enter into exploitation, which will turn to routine task during the bringing into exploitation of NDF.

1.4.3.2 SYSTEM FOR PHYSICAL PROTECTION OF KOZLODUY NPP

Kozloduy NPP as a nuclear installation is a subject of physical protection in accordance with the requirements of the Regulation for insurance of physical protection of the nuclear installation, nuclear materials and radioactive substances[29], Regulation No7 for the systems for physical protection of the constructions, SN, no. 70 / 19.06.1998[30], and the special regulation of Ministry of Internal Affairs (MIA). The physical protection is accomplished by the specialized departments of MIA.

The specialized units of SE RAW, which are located on the territory of Kozloduy NPP site, are a subject of physical protection according to the agreement, signed between the two administrations.

[25] IAEA, Monitoring and surveillance of Radioactive Waste Disposal Facilities IAEA, Safety Standard Series SSG-31, 2014

[26] IAEA, Environmental and Source Monitoring for Purposes of Radiation Protection Safety Guide IAEA Safety Standard Series SR-G-1.8, 2005

[27] IAEA, Surveillance and Monitoring of Near Surface Disposal Facilities for Radioactive Waste Safet35, 2004y Report Series

[28] IAEA, Procedures and Techniques for closure of near surface disposal facilities for radioactive waste, IAEA TECDOC-1260, 2001

[29] Regulation for providing of physical defense of the nuclear equipment, nuclear material and radioactive substances, SN, copy 77/03.09.2004, last modif. SN, copy 44/09.05.2008.

[30] Regulation No7 / 08.06.1998 on the systems for physical defence of the constructions, SN, copy 70 / 19.06.1998.

As NDF borders with Kozloduy NPP , it is foreseen the system for physical protection of Kozloduy NPP to envelopes also NDF.

1.4.3.3 SYSTEM FOR RADIATION PROTECTION OF KOZLODUY NPP

The system for radiation protection of NDF is independent of Kozloduy NPP in accordance with the requirements of the nuclear legislation. In the organization structure of all specialized units of NDF are built departments, which are responsible for the radiation protection and dose metric control. The specialized departments are equipped with technical instruments for radiation protection, stationary and movable appliances for radiation and dose metric control and personal dose meters. The radiation and dissymmetric control are watched by the Head Management of NDF (Administration “Save Nuclear Equipment”) and from the regulating bodies – NRA and Ministry of health via National Centre of Radiobiology and Radiation Protection ((NC RRP) as a department of MH. This practice will be saved with the NDF.

1.4.3.4 SYSTEM FOR FIRE PROTECTION IN KOZLODUY NPP

NDF will be protected with its own system for firefighting defense and fire protection.

1.4.3.5 MANAGEMENT OF NO RADIOACTIVE WASTE IN KOZLODUY NPP

On the site of Kozloduy NPP are functioning specialized units of SE RAW – EE “RAW – Kozloduy” and EE “ IE 1-4 block”. That is why contract relations are established between SE RAW and Kozloduy NPP , under which SE RAW hands over to Kozloduy NPP no radioactive waste. It is foreseen this practice to continue also during the exploitation of NDF, except in case the ECONOMICAL RELATIONS APPLY BETTER VERSION OF HANDING OVER OF THE WASTE TO SPECIALIZED ORGANIZATIONS / COMPANIES.

1.4.4 INFRASTRUCTURE – ROADS, ELECTRICAL SUPPLY, WATER SUPPLY AND SEWERAGE

The region around the site has developed infrastructure. Site “Radiana” is accessible from south along II class road II-11 Kozloduy – Harlets, from north along the internal road of Kozloduy NPP , i.e. it is not necessary to build new roads to the site during the period for exploration of NDF. Within the frames of the site will be built internal roads. A fence will be built around the site. To make the site accessible during the construction period and to escape the use of the road, serving Kozloduy NPP , will be built temporary access – junction from road II-11.

The feed up with electrical supply will be realized from the electrical distribution net of the Electricity Distribution Joint Venture CHEZ or from the site of Kozloduy NPP , on which SE RAW has specialized units.

The Water supply with potable water will be done through new branch pipe from the potable water pipeline, feeding Kozloduy NPP .

The sewerage pipe line will connected to the sewerage canalization system of Kozloduy NPP .

1.4.5 PHISICAL AND JURIDICAL PERSONS, WHICH CAN BE AFFECTED BY THE REALIZATION OF THE INVESTMENT PROJECT

By the realization of the investment proposal will be affected:

→ Kozloduy NPP – with the realization of the IP will be provided the necessary volume for burial of RAW category 2a, generated in the process of electrical power production by NPP, according to the requirements of the regulatory base and the international requirements for management of RAW, because the low- and intermediate active waste category 2a generated in Kozloduy NPP , will be buried in RAW after processing, conditioning and packaging.

→ The contracting companies and enterprises, which will take participation in the eventual construction works.

→ The residents of the closely located towns and villages, who can be hired by the contracting companies to participate in the construction works.

→ The residents of the closely located towns and villages of Kozloduy Municipality, who will be offering service – accommodation, shops, restaurants, etc. during the construction works period and after during the exploitation of NDF.

→ Qualified specialists, who will participate in the exploitation of the future. NDF.

→ Enterprise “Water supply and Sewerge – Vratsa city”, who’s potable water pipe line passes through the site of “Radiana” and has to be shifted outside the area.

→ “BTC” SH (Vivacom), who’s telecommunication cables pass through site of “Radiana” and have to be shifted outside the area.

→ “CHEZ Distribution-Bulgaria” SH, who is an owner of air power cable ELBA, 20 KV. A part of the air power cable ELBA passes over the site of “Radiana” and has to be moved outside the area.

→ District Road Administration- Vratsa, who is responsible for the exploitation and the maintenance of second class republic road – road No II-11. The part of No II-11, who connects Kozloduy city and the village of Harlets will be refitted on the expenses of SE RAW;

→ The population of Kozloduy city and Harlets village, who will favored by the rexabilation of the above mentioned road, as it is in a very bad condition, and a part of the roundabout road is unusable, which means that the total transport traffic passes via Kozloduy.

→ Highly qualified companies, including Bulgarian Academy of Sciences, who can offer highly qualified services to the future NDF.

1.4.6 SCHEME OF NEW OR CHANGE OF THE EXISTING ROAD INFRASTRUCTURE

The site of “Radiana” is located in immediately to Kozloduy NPP . At north is the existing internal road of Kozloduy NPP . At south is the second class republic road – NoII-11, which connects Kozloduy with Halec village and continues to Misia city.

At this moment the access to site of “Radiana” is possible only from north via the internal road of Kozloduy NPP .

The second class road from south is in bad condition and there is no road junction (from road II – 11), which to ensure access to the site.

Because of society insistence in the Municipality of Kozloduy SE RAW has provided funds from International Fund “Kozloduy” for rehabilitation of a part of the republic road from Kozloduy to Harlets , which includes the following two sections, which are different on the road layers conditions:

(1) Rehabilitation of section from 83+899 km to 89+000 km – roundabout road of Kozloduy city with length 5,101 km. This section in practical is not finished, that is why it is not used. The section was built to level macadam bed (crashed gravel). From km 84+257 to km 89+000 was laid incompact concrete.

(2) Rehabilitation of section from km89+000 to km 95+089.68 with length 6.09 km. The road is in use, but the cover is in bad condition.

The rehabilitation of section from road II-11 is not a subject of the SE RAW tasks and it will be repaired by the responsible authorities, who are responsible for the condition of the road net in the country. The responsibility of SE RAW is up to the limits to provide of financial funds and helping Municipality Kozloduy in its efforts to provide normal transport connection between Kozloduy city and Harlets village. Also rehabilitation of the roundabout road aiming deviation of the traffic flow from the city center.

It is necessary to design and built a junction from the road to the site of “Radiana” in order to be used road II-11 for access to “Radiana”.

In accordance with the legislation requirements and procedures in the country SE RAW has worked out a Detailed Development Plan – plot plan to define the trace and the service zones for access road to site “Radiana” (it at the moment under approval). The plan is given in **Enclosure 8-I.1**. There is also working design for road junction – from road II-11 to the site of “Radiana”[31,32].

Newly designed access road starts from km 91+860 through newly designed T-shape junction II type and will connect with the internal road of site “Radiana”. The length is 244.42 m.The trace passes via two lands – that of Harlets village and that of Kozloduy city, Municipality of Kozloduy. From the total length of 244, 42 m, 148.8 m pass via the land of Kozloduy, Municipality of Kozloduy, and the rest 95.6 m – via the land of Harlets city, Municipality of Kozloduy. The plot plan is shown on the figure bellow. The size of the serving strip is determined according to Regulation norm No7 for rules and norms for the planning of the different kinds of territory and spatial zones, according to which the size of the necessary plot for road construction is determined as follows: The size of the limited serving strips on both sides of the road is added to the plot for the road itself. In our case the width of each serving strip is 1 m. The total area, necessary for the access road construction together with the serving strips is 11 406 m^2.

Newly designed access road will respond to the requirements for design speed of 30 km/h and a road III class in the republic road infrastructure or as called “local road”. The overall size of the road is 6/8 m, which includes road bed for two traffic lines, 3 m each and two serving strips, 1 m each. The road will be executed with bituminous concrete with the following construction layers:

- → Compact bituminous concrete for wear out layer - 4 cm
- → Incompact bituminous concrete layer(Binder) - 4 cm
- → Basic layer with cement stabilization - 25 cm
- → Non freezing layer from non sorted crashed stone - 25 cm

The chosen pavement corresponds to the requirements for “Very heavy traffic” 400 OA/day with axis load of 10 t on axe. The serving strips will be stabilized and will be built with non sorted crashed stone material.

[31] Design of Detailed Development Plan (DDP) for determine the trace and the serving strips of temporal access road to “Radiana site”, May, 2014

[32] Working design for construction of temporal access road to”RADIANA” site, October, 2014.

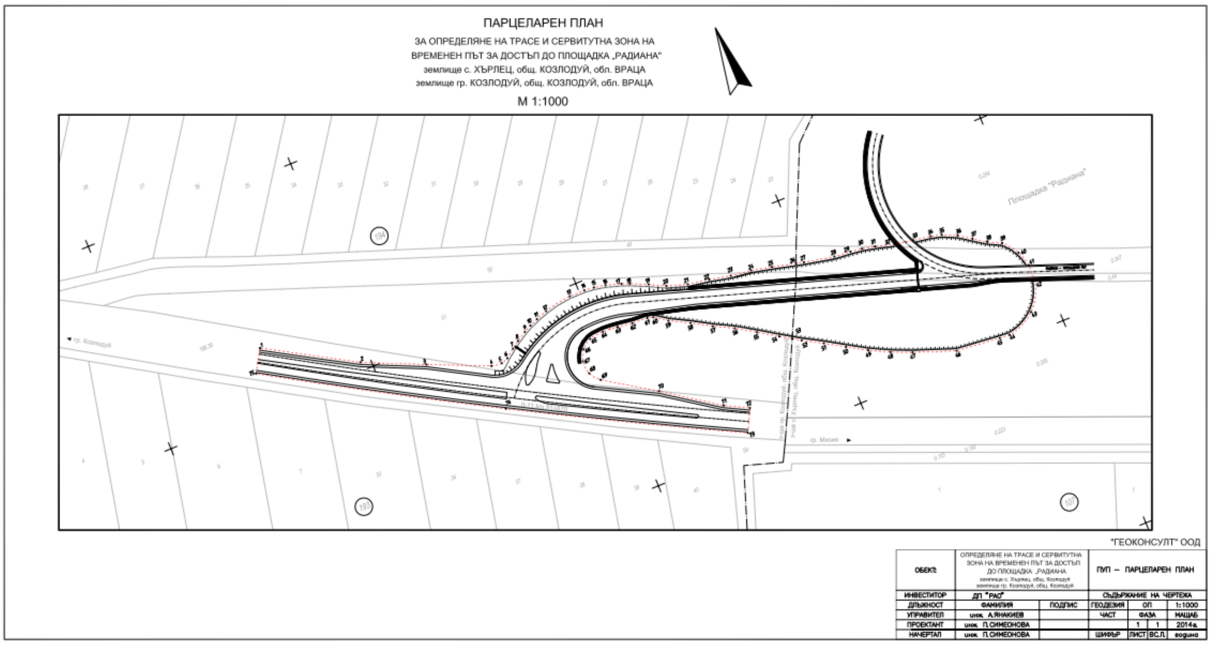

FIGURE 1.4-1 DETAILED DEVELOPMENT PLAN OF ACCESS ROAD TO SITE “RADIANA”

A Drainage of the road pavement has been foreseen through gravity way using the longitudinal and cross slopes of the road bed and the serving strips. After that the water will be taken away to the drainage system of “Radiana” site via faced drainage gutters to pipe culvert dia. 50 cm km 0+208.00. The foreseen faced drainage gutters will take up the water from the pavement as well as from the surface slope of the terrain.

The newly designed road starts with road juncture II type with road II-11 at km 91+860. To guarantee the safety of the traffic and the comfort of the travelers are designed the following elements:

→ On road II-11 is foreseen a line for left turn of the vehicles, coming in direction Kozloduy – “Radiana” site; a line for right turn of vehicles in direction Harlets village – “Radiana” site

→ On the newly designed road is foreseen a line for right turn of the vehicles.

The requirements of the Regulation for road design, part III “Design of junctures and knots”, Items 112-117, for geometrical decision of road junction are observed.

The road bed of road II-11 is to be widened on one side, in direction right of the increasing mileage. The widening of the road bed will be executed with the same pavement as it was foreseen in the design for rehabilitation of road No II-11.

In **Enclosure 8-I.2** is presented the lay-out plan of the newly designed road, and in **Enclosure 8-I.3** is shown survey map of road II-11 from the beginning of Kozloduy to the junction of Kozloduy NPP , from which map is visible the location of the newly designed road.

1.5 REASONS FOR THE NECESSITY OF THE INVESTMENT PROPOSAL FOR MATERIALIZE OF NDF

Managing And burial of radioactive waste, generated by the nuclear equipment in the energetic, industry, medicine and scientific researches, purposing to save the environment and the care for the health and safety of the humans, is logic reason for the Investment Proposal, using successfully the existing infrastructure and thee experienced and highly qualified personnel of SE RAW.

The necessity for building NDF is based on:

- ⇒ With the construction of NDF is provided save burial of low- and intermediate radioactive waste category 2a and their durable and final isolation from the environment and the humans and also the lack of such equipment by now.
- ⇒ The necessity to provide the required capacity for save burial of conditioned and packed low- and intermediate radioactive waste category 2a, which are generated during the exploitation of Kozloduy NPP , taking out from operation blocks 1-4 of Kozloduy NPP as well as and for safety monitoring of potential new nuclear power units on the site of Kozloduy NPP . IN NDF will be buried and also RAW, category 2a, which are generated when using of radioactive sources of ionizing radiations in the industry, medicine, agriculture and scientific researches.
- ⇒ An Effective management of low- and intermediate radioactive waste through closing the management cycle of RAW, observing the requirements of the national legislation and United convention for safety monitoring of spent fuel and safety management of RAW[33], (ratified with Law, voted by the 38-th Parliament on 10.05.2000, State Newspaper, copy 42/23.05.2000).
- ⇒ Obligation of R Bulgaria according to Directive 2011/70/Evratom, dated 19.07.2011 for establishment of frame of the EU for responsible and save management of spent fuel and radioactive waste[34];
- ⇒ The Standards for safety of the International Atomic Energy Agency (IAEA), as well as the good practices management of radioactive waste in the EU.

⇒ R Bulgaria has taken an engagement for construction of NDF in front the European Commission. The execution of the first stage, which has to provide save burial of the radioactive waste after the taking out of operation blocks 1-4 of Kozloduy NPP is financed by International Fund for supporting the decommissioning of blocks 1-4 of Kozloduy NPP . The construction of a Disposal for burial of low- and intermediate RAW has a highest priority according to the Strategy for management of spent nuclear fuel and the radioactive waste.[35]

1.5.1 MOTIVATION FOR THE IMPLEMENTATION OF THE INVESTMENT PROPOSAL AT THE RADIANA SITE

The nuclear legislation of the Republic of Bulgaria defines the requirements for the activities involved in the selection of the site for the building a radioactive waste repository.

Pursuant to art.74, para.3 of the SUNEA, the Council of Ministers adopted a decision for the construction of a National Repository for Radioactive Waste. This is CM Decision № 683/25.07.2005, with which the CM of the Republic of Bulgaria adopted the decision for the construction of a National Repository for Radioactive Waste and assigned the task to the SE RAW.

The activities included in the construction of the NDF are subject to approval by the Nuclear Regulation Agency (NRA). SE RAW started the process of selection of a site upon receiving the NRA permission in May 2005 for determining the location of a nuclear facility (site selection) in compliance with the provisions of art.15, para. 4, item 1 of the SUNEA. The permission was granted pursuant to an application for receiving approval for the selection of a site for NDF, filed by

[33] United convention for save monitoring of spent fuel and save monitoring of radioactive waste. Ratified with, accepeted by the 38-th Parliament on 10.05.2000, SN, copy 42/23.05.2000.

[34] Directive 2011/70/Euratom, dated 19.07.2011 for creation of frame of EU for responsible and save monitoring of spent fuel and radioactive waste

[35] Strategy for monitoringof spent nuclear fuel and the radioactive waste till 2030, accepted with Protocol Decision of CM, dated 05.01.2011, modified with Protocol Decision of CM on 25.06.2014

the SE RAW in August 2004 pursuant to the provisions of art.36, para.1 of the Ordinance on the terms and conditions for issuing licenses and permissions for safe use of nuclear energy, 2004г.[36]

Pursuant to the standards of the International Atomic Energy Agency (IAEA)[37], the international experience and the best practices in the management of RAW in the developed European countries, as well as the provisions of art. 25, para.1 of the Ordinance for safe management of radioactive waste, 2004[38] the site selection process followed four stages:

⇒ **Stage 1: Elaboration of a concept** for the disposal and planning of the selection of a site;

⇒ **Stage 2: Data collection and analysing of areas**, including:

a. **Analysis of regions –** analysis and assessment of the entire country territory was performed as major regions with unfavourable conditions for building a facility for disposal of RAW were excluded and regions for analysis were determined which represent large territories with favourable geological-tectonic, geomorphological (topographic), hydrogeological, engineering-geological, hydrological, climate and other features.

б. **Selection of prospective sites** –potential sites corresponding to the criteria for hosting a RAW repository will be identified in the regions for analysis and the prospective ones will be determined for further research.

⇒ **Stage 3: Assessment of sites –** the prospective sites will be assessed further and one preferred site will be selected;

⇒ **Stage 4: Confirmation of the site –** research related to the approval of the preferred site will be carried out.

The above stated activities in the four selection stages shall be subject to in-depth control by the NRA. This shall include:

1. SE RAW shall develop a plan for the implementation of the activities for each of the 4 stages, which shall include description of the objectives; description of the main activities and their sequence; description of the requirements and recommendations of national and international documentation which will be implemented during the execution of the activities; a list and description of the developed procedures for providing the practical implementation of the requirements and recommendations of the national and international documentation; a detailed time schedule for the implementation of the activities, an estimate of the necessary financial resources and sources of funding and a quality assurance program. The quality assurance plan and program shall be approved by the NRA before the implementation of the activities.
2. For each of the stages the SE RAW shall prepare a report with the results of the implementation of the planned activities. These activities shall be considered complete for each of the stages after the report for their implementation has been approved by the NRA.

The process of site selection shall be completed with the issuing of an ordinance by the Chairman of the NRA pursuant to the requirements of art.33, para.4 of the SUNEA and art.37, para.1 of the Ordinance on the terms and conditions for issuing licenses and permissions for safe use of nuclear energy, 2004. One of the conditions for issuing an ordinance of approval of the selected site is a decision for EIA.

[36]Ordinance on the terms and conditions for issuing licenses anf permissions for safe use of nuclear energy, prom. SG issue 41/18.05.2004 ., last am. SG issue76/5.10.2012 .

[37]IAEA, Siting of near surface disposal Facilities, IAEA Safety Series No.111-G-3.1, 1994

[38]Ordinance for safe management of radioactive waste, SG issue 76/ 30.08. 2013.

Further details are presented in section 1.10 – *Description of the licensing process*.

1.5.1.1 INFORMATION ON THE DEVELOPMENT OF THE SITE SELECTION PROCESS FOR IMPLEMENTATION OF THE NDF

Until the establishing of the SE RAW in 2004 the research for the selection of a site for the national repository was performed mainly by the Bulgarian Academy of Science. After 2004 the research for site selection was executed under the direction of the SE RAW with the active participation of the Bulgarian Academy of Science and the University of Mining and Geology “St. Ivan Rilski”. A very important circumstance is the adoption of the new Safe Use of Nuclear Energy Act in 2002 and the completion and adoption of all bylaws till 2004 so that SE RAW executes the site selection process in full compliance with the provisions of the modern nuclear legislation and with the conditions of the site selection permit issued by the Nuclear Regulation Agency.

This in no way diminishes the importance of the research performed before 2004. On the contrary, there is continuity and SE RAW has used the research performed by prominent scientists before 2004 thus succeeding to reduce significantly the period of selection of a site for the nuclear facility.

1.5.1.1.1 DESCRIPTION OF THE SURVEYS PERFORMED BEFORE 2004.

The first serious steps were undertaken in 1979 with the establishing of an Interdepartmental commission for the selection of a site for building a national repository[39]. The commission consisted of scientist and experts from the Bulgarian Academy of Science, the Committee for Peaceful Use of Nuclear Energy (CPUNE), the State Committee for Environmental Protection (SCEP), the Ministry of People’s Health and the Ministry of Mineral Resources. Based on an extensive analysis of the natural conditions of the country, the commission initially determined the following regions as prospective in the search of a national repository site: Stakevski and Svetinikolovski plutons in North-eastern Bulgaria, Stara planina plutons between the villages of Leskov dol and Osenovlak east of Eliseyna RR station; the granites and metamorphic rocks in the central areas of Sredna gora south and west of Bogdan peak and around Bratan peak; the pluton north if Tvarditsa, traversing the diabase-phyllitoid formation; the granites in Sakar mountain north and north-west of Vishegrad peak; the powerful volcanic complex (up to 1000 m), composed mainly of riolites along the course of the Borovitsa River, Kardzhali region. The final prospective terrains determined by the commission at a technical and economical meeting of Energy Association were: the high loess terrace south of Kozloduy NPP; the loess greda ridges east of the village of Ostrov; the “Koshava” mine; the excavated levels of the “Chiprovtsi” mine. Preliminary surveys were performed only at the first two sites considering the reaction of the local authorities against research of the “Koshava” and “Chiprovtsi” mines. A “Complex programme for a comprehensive solution of issues concerning the treatment, storage and disposal of low and intermediate level radioactive waste from the NPP” was developed with chief executive body the Ministry of Energy and sub-executives the Institute of Nuclear Research and Nuclear Energy (INRNE) and the Laboratory of geotechinics at the BAS with implementation deadline 1985-1990. Due to the political changes in the late 1980’s and early 1990’s the programme was not implemented.

The activities were resumed in April 1991 when the Council of Ministers issued DMC No 7 and assigned to the BAS as an independent state institution to organize the development of a “Concept for a national radioactive waste repository” in a period of 14 months. The BAS concept contained an extensive resume together with 57 reports which reviewed all aspects of radioactive waste disposal - from their composition and features to the selection of prospective areas and sites[40]. In

[39] Report of the Chairman of the Commission for selection of a site for building a Central Disposal Facility for Processed Radioactive Waste from the NPP, 1979 , 55 pages

[40] “BAS Concept for a national radioactive waste disposal facility”. Bulgarian Academy of Science, 1993, BAS

the preparation of the Concept took part representatives of the following institutes of the Bulgarian Academy of Sciences: Institute of nuclear research and nuclear energy, Institute of Geology, Laboratory of Geotechnics, Institute of Geophysics, Institute of Geography, Institute of Water Problems, Central Laboratory of Seismic Mechanics and Seismic Engineering, as well as experts from other institutions – the Sofia University “St, Kliment Ohridski”, the University of Mining and Geology “St. Ivan Rilski”, the Ore and Mineral resources Science and Research Institute at the Committee of Geology and Mineral Resources, the Agricultural Academy, the Ministry of Environment, the Committee for Peaceful Use of Nuclear Energy, the National Radiobiology and Radiation Protection Committee. In the preparation of the Concept was used the experience of countries of the EU, the USA, Canada, Japan, Switzerland, Russia, India, etc. and the respective documents of the IAEA.

The BAS concept included analysis of: (1) the type, characteristics and quantities of RAW collected in the country; (2) the expected quantities of RAW from Kozloduy NPP until the end of the operation of the energy units and tentative estimates of the type, characteristics and volume of the waste generated during the decommissioning and elimination of the units; (3) the existing methods for treatment and conditioning of radioactive waste; (4) the condition of the facility operating at Novi Han for disposal of RAW from industrial, medical and scientific radioactive sources; (5) the types of disposal facilities used around the world depending on the type and specifics of RAW; (6) the expected impact of the disposal facilities on the geological environment and the methods and means for mitigation of this impact, including the utilization of various engineering barriers; (7) the radiological consequences of the construction of the repository as well as methods developed for their analysis and assessment; (8) emergency scenarios for RAW disposal facilities and their consequences.

The Concept adopts the centralized approach in the process of site selection which includes first an analysis of the entire country territory and determining of territories where prospective regions are expected to be found. Next comes defining suitable areas in each region and localization of several potential sites in some of them. All these activities are described in the relevant reports. The methodology for performing the research for determining prospective regions and suitable areas for defining potential sites includes: (1) analysis of the natural features of the territory of Bulgaria, including geological composition, geotechnical conditions, hydrological, hydrogeological, climatic and geomorphological conditions; (2) determining prospective regions and areas; (3) as detailed as possible characteristics of the prospective regions and areas and their categories using literary data.

The territory of Bulgaria belongs to two completely different tectonic regions. The first is located to the north of the Fore Balkan and belongs to the Moesian platform which is a marginal part of the large European – Russian tectonic platform. The second region is situated to the south of the Fore Balkan and belongs to the Alpine-Himalayan orogeny. In the Moesian platform the intensive tectonics expressed in folding processes and large faults subsided in the beginning if the Mesozoic whereas in the orogeny the mountain formation processes ended in the recent geologic past. These tectonic differences have naturally influenced the development of the site selection process for NDF. From the initial stages of the process the attention was directed mainly to terrains in Northern Bulgaria which exhibit much less tectonic activity than those in Southern Bulgaria. In Southern Bulgaria only terrains with no active faults and significant local seismic areas have been considered.

The regional research was facilitated by the well-examined natural environment in the country in all its aspects: geological, geophysical, seismologic, geographic, hydrological, hydrogeological, climatic, etc. This is particularly valid for the geological aspect – the geological surveys had started as early as the 1830’s. As a result of the work of a multitude of prominent geologists the entire territory of the country is mapped on geological and tectonic maps. The new geological map in scale 1:100 000 completed at that time offered a good enough representation of the distribution, composition and structure of the rock complexes. The National Geo Fund keeps unpublished maps of almost the entire country territory in scale 1:25 000. This information, along with the data for the tectonic structure and seismic conditions enabled the defining of zones of comparatively tranquil geological conditions from the Neogene till present days where there are a limited number of active faults and the seismic clusters have intensity less than VIII under the MSK scale.

The engineering geological and hydrogeological conditions in Bulgaria have also been mapped on a scale 1:500 000 map as well on larger scale maps. On one of them within the scope of the BAS research were mapped the lithological composition of the country, locations where dangerous geological processes occur, the hydrological basins and the main hydraulic and hydro-chemical parameters of groundwater.

Based on the available information and additional analyses a map for the categorization of areas on the territory of Bulgaria was created. Three large regions were distinguished on the territory of Bulgaria in the north-west and south-east parts as well as in the Fore Balkan which offer relatively better conditions. In these three regions after a comprehensive analysis were determined about 20 most prospective areas and an expert report was drawn up for each of them, summarizing all data for the geological composition and tectonics as well as the seismic-tectonic, engineering-geological, hydrogeological, geomorphological and other conditions. Arranging the areas and sites in order of importance and prospects for further survey was done based on a preliminary systemic analysis. Terrains offering better conditions than others for finding potential sites for building the National Disposal Facility (NDF) were determined. These are areas in the Fore Balkan and the transitional zone between the Fore Balkan and the Moesian platform, composed of thick marl formations, in the Moesian platform itself, in some effusive nappes in the eastern Rhodoppes, the granite batholith in Sakar mountain and the Belorechka gneiss structure in the Eastern Rhodoppes.

Since the BAS Concept reviews the in-depth (geological) disposal as well as the near surface location of the disposal facilities, in the period 1995-1997 the Institute of Geology at BAS based on the Concept [41, 42] performed an additional analysis for determination of areas suitable for the construction if a low and intermediate level radioactive wastes[43,44], which focused on areas and sites situated near the Kozloduy NPP and which also decreased the risk of accidents and failures during the transportation of tens of thousands of cubic metres of radioactive wastes and the related radiological consequences to the population. The located prospective terrains are related to lower Cretaceous marls situated at 60-80 km south of Kozloduy NPP, loess terrains situated south of Kozloduy NPP and Neogene clay terrains in the Lom depression situated west and southwest of Kozloduy NPP.

With the absence of an authorized state organization for the management of RAW at that time, the institutions which monitored and were concerned by the development of the process of site selection the disposal of low and intermediate-level radioactive waste were the Ministry of Energy and the Committee for Peaceful Use of Nuclear Energy (CPUNE, now NRA) and in particular their departments on the issues of RAW. After a discussion of the reports mentioned above, the CPUNE decided to fund a research which should focus on the areas and sites in close proximity to the Kozloduy NPP. During this research the focus was directed to the loess terrains in the immediate

[41] BAS Concept for a national radioactive waste disposal facility”. Bulgarian Academy of Science, 1993, BAS

[42] Evstatiev, D., D. Karastanev, R. Angelova. 1993. Report on the research for selection of sites for the construction of a low and intermediate-level radioactive waste. B: BAS Concept for a national radioactive waste disposal facility”. Bulgarian Academy of Science.

[43] Evstatiev, D., R. Angelova. 1997. Preliminary options for radioactive waste disposal in Bulgaria. - In: Proc. of the International Symposium on Engineering Geology and the Environment, Greek national group of AEG, Athens, Greece, June 23-27, 1823-1828

[44] Evstatiev, D., B. Vachev, R. Angelova, D. Karastanev. 1998. System analysis for low and intermediate level radioactive waste repository. – In: Review of the Bulgarian Geological Society, 59, part 1, 83-91

vicinity of Kozloduy NPP and south of it[45]. The most important conclusion of the research was that near the Kozloduy NPP to the south of it and in its safety zone under the loess was revealed a thick layer of Pliocene clays of the so called Brusarska formation which had good bearing capability and high isolation characteristics.

In 2001÷2003 the Institute of Geology at BAS carried out the project "Assessment of the geological conditions for long-term storage of RAW on the area of and around the Kozloduy NPP. Complex analysis and technical-economical assessment of the possibility for long-term storage of conditioned RAW at and near the site of Kozloduy NPP. – Reports in 3 stages under contract No 21371061/20.12.2001 of Kozloduy NPP with IG-BAS.(Evstatiev et al., 2003.)". the main tasks under this project were the localization of the "Marichin valog" site situated at about 2.5 km south of Kozloduy NPP, carrying out field surveys, research and analysis required in the regulatory documentation of the IAEA and localization, research and preliminary analyses of sites situated near the NPP. During the development of this project the collaboration with the Belgian Nuclear Research Centre SCK-CEN in the town of Mol was expanded as part of the tests were done in their laboratories.

In this way the research of the Interdepartmental commission for the selection of a site for the construction of a national repository[46], of the Concept[47], [48] and of the Institute of Geology at BAS [49, 50, 51] for finding suitable terrains near the Kozloduy NPP in loess formations on top of Pliocene clays was confirmed at a higher level. These results should not be surprising since the selection of the location of Kozloduy NPP followed similar, if not identical criteria to those for the selection of a site for the National repository.

1.5.1.1.2 DESCRIPTION OF THE PROCEDURES AND SURVEYS PERFORMED AFTER 2004 UP TO THE SITE SPECIFICATION STAGE

As already stated, in 2002 the new Safe Use of Nuclear Energy Act was adopted, and by 2004 all bylaws were drawn up and adopted as well. SE RAW was established in 2004 in compliance with the provisions of Chapter 4 of the Safe Use of Nuclear Energy Act (the SUNEA), 2002. Pursuant to the SUNEA SE RAW as the only subject with the responsibility for the management of RAW outside of the sites of its generation, shall have the sole responsibility for the selection of a site, the design, construction, commissioning and operation of a NDF. This called for a re-evaluation of all research carried out before 2004 for the selection of a site in compliance with the provisions of the SUNEA and its modern bylaws and taking into account the safety standards of the IAEA and the best practices in the developed European countries. The research of SE RAW for site selection was planned and carried out under the monitoring of the Nuclear Regulation Agency (NRA), which

[45]Evstatiev, D., D. Kozhuharov, D. Karastanev, Kr. Todorov, R. Angelova et al. 1999. Survey and research for reducing the number of prospective sites for the construction of a facility for disposal of low and intermediate-level radioactive waste from the NPP. Report under contract between the CPUNE and IG at BAS

[46]Report of the Chairman of the Commission for the selection of a site for the construction of a Central disposal facility for processed RAW from the NPP, 1979 ., 55 pages

[47]BAS Concept for a national radioactive waste disposal facility". Bulgarian Academy of Science, 1993, BAS

[48]Evstatiev, D., D. Karastanev, R. Angelova. 1993. Report on the research for selection of sites for the construction of a low and intermediate-level radioactive waste. B: BAS Concept for a national radioactive waste disposal facility". Bulgarian Academy of Science

[49]Evstatiev, D., R. Angelova. 1997. Preliminary options for radioactive waste disposal in Bulgaria. - In: Proc. of the International Symposium on Engineering Geology and the Environment, Greek national group of AEG, Athens, Greece, June 23-27, 1823-1828

[50] Evstatiev, D., B. Vachev, R. Angelova, D. Karastanev. 1998. System analysis for low and intermediate level radioactive waste repository. – In: Review of the Bulgarian Geological Society, 59, part 1, 83-91

[51]Evstatiev, D. et al., 2003. Assessment of the geological conditions for long-term storage of RAW on the area of and around the Kozloduy NPP - Reports in 3 stages under contract No 21371061/20.12.2001 of Kozloduy NPP with IG-BAS.(Evstatiev et al., 2003)

pursuant to the SUNEA is the only competent body responsible for the state regulation an safe management of radioactive waste part of which are all activities connected with disposal of RAW.

Pursuant to art.74, para.3 of the SUNEA the Council of Ministers issued a decision for the construction of a National repository for radioactive waste. This was DCM No 683/25.07.2005 with which the CM of the Republic of Bulgaria took the decision to build a National repository for radioactive waste and assigned the task to SE RAW. Right after the DCM No 683/25.07.2005 was issued and in compliance with the Ordinance on the terms and conditions for issuing licenses and permissions for safe use of nuclear energy, 2004 SE RAW filed at the NRA an Application for issuing a permit for site selection. The following documents were attached to the application: (1) concept description of the NDF, general characteristics and criteria for acceptability of the sites; (2) Terms of Reference for carrying out preliminary surveys which contained information for the scope of the planned feasibility studies; (3) quality assurance programme which continued descriptions of the overall measures for implementation of the studies for site selection, the methods for their execution and assessment as well as descriptions of the system for control and storage of documents related to the activity; (4) documents verifying that SE RAW has the funds sufficient for the implementation of the stated activities in compliance with the requirements, rules and regulations of nuclear safety and radiation protection; (5) documents verifying that SE RAW has the technical resources sufficient for the implementation of the stated activities in compliance with the requirements, rules and regulations of nuclear safety and radiation protection; (6) documents verifying that SE RAW has the material resources sufficient for the implementation of the stated activities in compliance with the requirements, rules and regulations of nuclear safety and radiation protection; (7) documents concerning the management and organization structure of SE RAW; (8) documents on the number, education and qualifications of the staff and distribution of duties; (9) motivation of the duration of the period for which the site selection permit is requested; (10) list of the applicable standards for site selection as well as other documents verifying compliance with the requirements for carrying out the activity.

Based on a profound analysis of the Application and the above listed documents attached to it carried out by the MRA within the lawful 9-month term under art.18, para.2, т.1 of the SUNEA, on May 4, 2006 the Chairman of the NRA issued a Permit for determining the location (site selection) of a facility for management of radioactive waste – NDF to SE RAW. All subsequent studies and surveys of SE RAW for the site selection have been carried out in full compliance with the requirements of the nuclear legislation, the safety standards of the International Atomic Energy Agency (IAEA), the best practices of the developed European countries and the terms of the Site selection permit issued by the Nuclear Regulation Agency.

Stage 1: Development of a NDF concept

In this stage SE RAW has developed and submitted for approval at the Nuclear Regulation Agency a Concept development plan[52] and a Quality assurance program[53].

The Radioactive waste disposal concept[54] further develops and improves the BAS Concept described above[55], relying on the modern requirements of the nuclear legislation, the safety standards of the International Atomic Energy Agency, and the latest scientific and technical developments and includes:

1. Analysis of the requirements of the national regulatory documents and the recommendations of the safety standards of the International Atomic Energy Agency, including the main standards

[52]Concept development plan for disposal of RAW, SE RAW, 2007

[53]Quality assurance program for the development of a concept for RAW disposal and planning the site selection, SE RAW, 2007

[54]Report on the radioactive waste disposal concept, SE RAW, 2010г.

[55]BAS Concept for a national radioactive waste disposal facility. Bulgarian Academy of Science, 1993, BAS

applicable in the selection of the site and the construction of the NDF as the Fundamental Safety Principles[56], the Principles of Radioactive Waste Management[57], Near Surface Disposal of Radioactive Waste[58], Safety Assessment for Near Surface Disposal of Radioactive Waste [59], Siting of near surface disposal facilities[60];

2. Analysis of the sources of radioactive wastes subject to disposal at the NDF in the country. It has been stated that the National repository is **designed only for the disposal of low and intermediate-level radioactive waste, category 2a**, pursuant to Ordinance for the safe management of radioactive waste;
3. An assessment of the volume and radionuclide inventory of low and intermediate-level radioactive waste, category 2a, which will be disposed at the National repository and was used to justify the capacity of the NDF. The data from this analysis has been included in section 1.7.3 “Specifics of the RAW subject to disposal at the NDF. Expected type and quantity of RAW for disposal at NDF. Productivity. Capacity” of the present environmental impact assessment report.
4. Definition of the NDF life cycle stages together with the main activities for each stage;
5. Definition of the safety objectives, the management principles for safety assurance, the safety requirements and criteria well as the ways for providing them. They have described in section 1.5.3 “Main safety objectives, principles and criteria” of the present environmental impact assessment report.
6. Definition of the concept foundations of the NDF and the applicable concepts for its construction.
7. Definition of the acceptability criteria in the site selection based on the requirements of the international standards and the provisions of the nuclear legislation;
8. Definition of the criteria for acceptance of RAW at the NDF in correspondence with the concept stage;
9. Development of requirements for preliminary safety assessment and methodology for its execution;
10. Development of an updated plan for the activities for site selection and a list of applicable legislation and regulatory documents, including documents of the International Atomic Energy Agency and the International Radiation Protection Committee.

The report on the development of radioactive waste disposal concept[61] has been approved by the Nuclear Regulation Agency, with which the activities for implementation of stage 1 of the site selection process are considered completed.

Stage 2: Data collection and regions analysis

In this stage SE RAW develops and submits for approval at the Nuclear Regulation Agency a Plan for implementation of stage 2 Data collection and regions analysis[62] and a Quality assurance program for the implementation of stage 2[63]. Pursuant to the provisions of Ordinance for the safe

[56]IAEA, Fundamental Safety Principles, Safety Fundamentals No.SF-1, IAEA, 2006

[57]IAEA, The Principles of Radioactive Waste Management, Safety Standard Series No.111-F, IAEA, 1995

[58]IAEA, Near Surface Disposal of Radioactive Waste, Safety Requirement, Safety Standards Series No. WS-R-1, 1999

[59]IAEA, Safety Assessment for Near Surface Disposal of Radioactive Waste, Safety Guide, Safety Standards Series No. WS-G-1.1, 1999

[60]IAEA, Siting of near surface disposal Facilities, IAEA Safety Series No.111-G-3.1, 1994

[61]IAEA, Siting of near surface disposal Facilities, IAEA Safety Series No.111-G-3.1, 1994

[62]Plan for implementation of stage 2 Data collection and regions analysis, SE RAW, 2007

[63]Quality assurance program for the implementation of stage 2 Data collection and regions analysis, SE RAW, 2007

management of radioactive waste the Plan for implementation of stage 2 includes: (1) description of objectives; (2) description of the main activities and their sequence; (3) description of the requirements and recommendations of national and international documents to be implemented during the activities; (4) a list and description of the developed procedures providing the practical implementation of the requirements and recommendations of national and international documents; (5) detailed time schedule for the implementation of the activities; (6) evaluation of the necessary financial resources and sources of funding.

The Plan for implementation of stage 2 Data collection and regions analysis and the Quality assurance program for the implementation of stage 2 have been approved by the Nuclear Regulation Agency.

SE RAW has carried out the necessary studies for the implementation of stage 2 Data collection and regions analysis in compliance with the Plan for implementation of the stage and the quality assurance program. The results are presented in a Report on the implementation of stage 2 Data collection and regions analysis [64]. The studies are based on all research carried out so far including the Concept for disposal of radioactive waste[65], the above stated surveys of the Institute of Geology at BAS, various literary sources and funding reports and develop further the main points, statements and achievements relying on the modern requirements and latest achievements of leading countries for the site selection.

The model of the analysis if presented on **Figure 1.5-1**.

The studies include:

(1). Development of a methodology for the selection of potential areas in compliance with the requirements for the activities, principles and criteria for description and analysis,

(2). Performing regional analyses which include analysis and assessment of the territory of the entire country and use exclusion criteria for eliminating large regions with unfavourable conditions for situation of the NDF and defining regions to be analysed which are large territories with favourable geologic-tectonic, geomorphological (topographic), hydrogeological, engineering geological, hydrological, climatic and other characteristics.

(3). The elimination criteria are: **seismicity** (territories with seismic intensity IX and higher under the MSK scale for a 1000-year period and seismic coefficient Qs>0.4 are eliminated); **hydrogeological** (territories with aquifers exceeding 5 m layer width and filtration coefficient over $1x10^{-4}$ m/s, the groundwater of which is at 4 or less meters from the surface are excluded); **geological-tectonic** (areas with complex geological-tectonic structure exhibited by high variability and unsoundness of the lithological formations, with fold and thrust fault structures, with tectonic activity and significant tectonic disruption) geomorphological (territories in the higher mountain belt – above 600 m altitude 600 m); **engineering geological (**regions with shallow karst and karst suffusion processes are observed as well as mud volcanoes and other dangerous geological processes (abrasion, landslides, etc.); hydrological and climatic (territories with historically proven floods and areas which are located within the flood range in cases of potential dam failures, as well as regions with exhibited extreme climate events such as tornadoes); social-economic (municipalities with population density above 80 inh./km^2, resort and tourist complexes of national importance, national and nature parks).

[64]Report for the implementation of stage 2 Data collection and regions analysis, SE RAW, 2007

[65]BAS Concept for a national radioactive waste disposal facility. Bulgarian Academy of Science, 1993, BAS

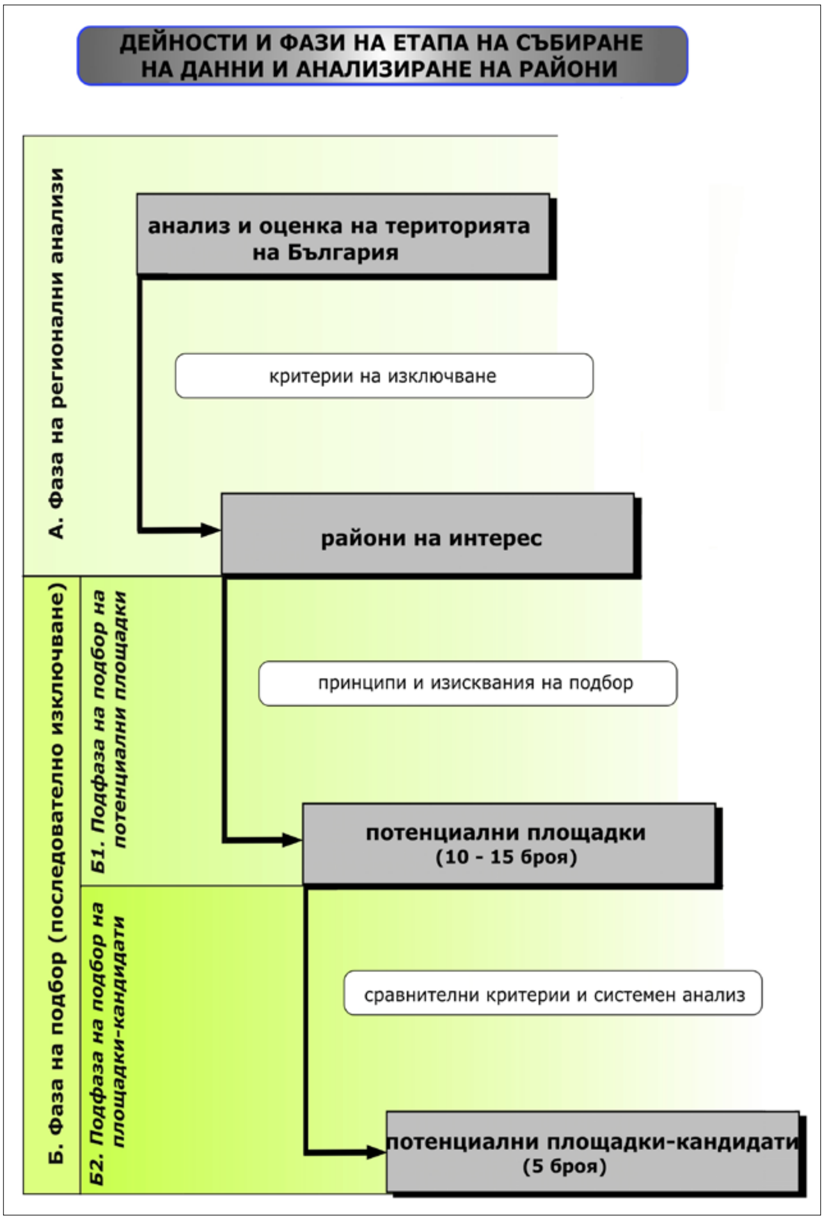

FIGURE 1.5-1 MODEL OF THE ANALYSIS IN STAGE 2 –DATA COLLECTION AND REGIONS ANALYSIS

For each of the elimination criteria a map of the entire country was drawn up in scale M 1:500 000. A summary map was drawn in scale M 1:500 000 by combining the elimination criteria.

Two regions of interest were determined, north and south. The northern region includes mainly the west and central parts of the Moesian platform and the Transitional zone of the Fore Balkan. The southern region includes Sakar and the Harmanly block.

Using the principles and requirements of screening were defined potential areas in both regions. In the northern region which includes parts of the Moesian platform and the Transitional zone of the Fore Balkan the following areas were localized: the territory of Kozloduy NPP and a 25-30 km zone surrounding it; the territory of the Belene NPP planned at the time and a 25-30 km surrounding it; the terrains covered with lower Cretaceous marls (the Sumerska, Gornooryahovska and Trumbeshka formations); the tributary valleys in North-western Bulgaria with shallow lying Neogene clayey sediments mainly of the Brusarska formation. The southern region of interest which includes Sakar and the Harmanly block has been reviewed as one due to its smaller area and similar natural conditions. In the process of the analysis in the above stated areas were first located 78 sites which were later reduced to 36 using the selection criteria.

Ultimately 12 potential sites were located, 10 of which in the northern region of interest (Kozloduy NPP, Belene NPP, "Marichin valog", "Dekov", "Varbitsa", "Zlatar", "Medovina", "Brestova padina", "Chernovrashka padina" and "Kovachitsa") and 2 sites in the southern region of interest ("Garvanski kamak" in Sakar and"Iseprik" in the Harmanly block). The locations of the sites are presented on **Figure 1.5-2**.

Significant volume of information about these 12 potential sites has been collected and they have been described in the same manner so as to provide data for carrying out multi-factor analysis and selecting up to 5 prospective sites. The description includes: location, geological-tectonic conditions; seismic and neotectonic conditions; geomorphological, engineering-geological, hydrogeological conditions; dangerous geological processes and phenomena, climatic and hydrological conditions, infrastructure characteristics, social-economic conditions (acceptability) and others, as the results have been presented on maps in scale 1:50 000 – 1:25 00.

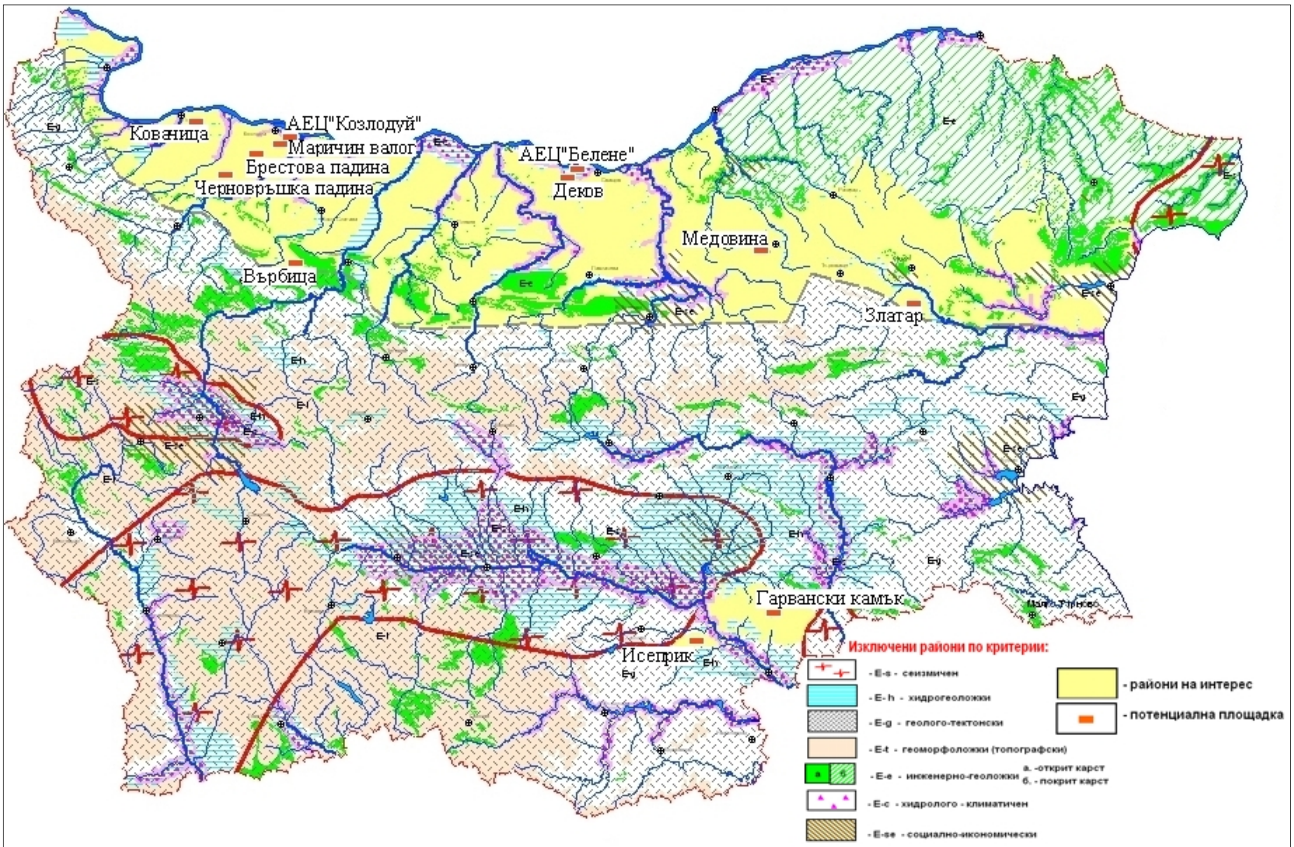

FIGURE 1.5-2:LOCATIONS OF THE POTENTIAL SITES DETERMINED AT STAGE 2 – “DATA COLLECTION AND REGIONS ANALYSIS”

Using the multi-factor analysis from the stated 12 potential sites were selected four sites for further analysis at the “Site specification” stage - **Figure 1.5-3**.

FIGURE 1.5-3:LOCATIONS OF THE POTENTIAL SITES SURVEYED AT THE “SITE SPECIFICATION“ STAGE

The following sites are most acceptable for the construction of a NDF:

- → **„Radiana“ site**, situated in immediate vicinity of Kozloduy NPP and within the boundaries of the 2-km preventive protection measures zone of Kozloduy NPP (PPMZ);
- → **„Marichin valog“ site,** situated at 2.5-3.0 km west of Kozloduy NPP and outside the 2-km PPMZ of Kozloduy NPP;
- → **„Brestova padina“ site,** situated at 20 km south-west of Kozloduy NPP, outside the 2-km PPMZ but within the 30-km Monitored zone of Kozloduy NPP (MZ);
- → **„Varbitsa“ site**, situated at 52 km straight-line distance from Kozloduy NPP (over 90 km road distance), outside of the 2-km PPMZ and outside the 30-km MZ of Kozloduy NPP.

Stage 3: Site specification

Pursuant to the provisions of the nuclear legislation – Ordinance for the safe management of radioactive waste, 2004, the selection of a site for a repository for radioactive waste is based on a comparative analysis of at least three sites. The prospective candidate sites defined at the previous stage are Kozloduy NPP, later renamed to “Radiana”, „Marichin valog“ site, „Brestova padina“ site, and „Varbitsa“ site.

During the implementation of stage 3 for NDF the “Varbitsa” site was eliminated from further review. The reason for this decision was the long distance between the site and the main source of radioactive waste – Kozloduy NPP as well as minimization of the potential hazard to the population during the transportation of conditioned radioactive waste to the site of the NDF. Pursuant to art.55, para.1, item 8 of the Ordinance for safe management of RAW, in force at the time of implementation of the Site specification stage – SG issue 72/17.08.2004, the location of the site for near-surface disposal of RAW must provide transporting the RAW to the facility at a minimum risk to the population. Research showed that the shortest road from Kozloduy NPP to the “Varbitsa” site exceeds 90 km, of which 68 km are along second-class road II-4 from Kozloduy to Vratsa and 22 km along third-class road III-1306, which needs repairs and a 4 km new road connection. This is significantly longer distance compared to the „Radiana” site (located immediately close to Kozloduy NPP as the transportation will be along an internal road), „Marichin valog” site (maximum distance along a new road of 2.5-3 km), and „Brestova padina” site (distance of 20 km, 6-7 km of which are new road). The transportation to “Varbitsa” site will require passing through 14 villages the largest of which is Borovan. This poses a significant risk for the population during the transport operations. In comparison the transportation of RAW from Kozloduy NPP to the „Marichin valog” site and the „Radiana” site will not involve passing through any settlements and specifically for the „Radiana” site the public road network will not be used. The transportation of RAW from Kozloduy NPP to the „Brestova padina” site will require passing through 3 settlements. It is obvious that the „Varbitsa” site does not comply with the regulatory requirements for providing minimum risk to the population during the transportation of RAW. The elimination of the „Varbitsa” site from further consideration was confirmed as correct by the provisions of the new Ordinance for the safe management of RAW, adopted with DCM No185/23.08.2013 and published in SG issue 76/30.08.2014 – pursuant to art.26, para.4 during the selection of a site should be considered also the existing road infrastructure for providing transportation of RAW to the facility at a minimum risk to the population.

The results of the performed detailed field and laboratory surveys of these sites (including „Varbitsa“)[66,67,68,69,70,71,72,73,74], as well as the results performed by Kozloduy NPP[75,76], have been

[66]Testing and methodological studies for verification of methods and methodologies for research and condirmation of the eligibility of sites for construction of a low and intermediate-level RAW, IG-BAS, 2007

[67]Complex analysis of regional geophysical fields and assessment of the seismic risk of potential sites for construction of NDFRAW, IGF-BAS, 2007

[68]Joint analysis of the results of the highly precise geodetic surveys, geomorphological and geotectonic observations in the regions of the sites proposed for the construction of NDFRAW, IG-BAS, 2007

[69]Engineering geological, hydrogeological and geophysical studies carried out of sites proposed for the construction of NDFRAW, IG-BAS, 2007

[70]Specification of site No 4, IG-BAS, 2007

[71]Geophysical surveys of the site situated in the slope south of Kozloduy NPP, UMG “St. Ivan Rilski”, 2007

[72]Preliminary engineering geological surveys of Radiana site, Geohydroconsult LTD, 2008

[73]Results of geological, geophysical, engineering geological, hydrogeological and laboratory studies carried out for Radiana site, Geotechnika ABC, December 2010

[74]Engineering geological and hydrogeological field and laboratoratory studies carried out in the plane area of Radiana site, MGY Engineering, 2011

[75]Complex analysis and technical-economical assessment of the possibility for long-term storage of conditioned RAW at and near the site of Kozloduy NPP, IG-BAS, 2003

systematically arranged and summarized in a report on the implementation of Stage 3 Site specification of NDF[77], which has been approved by Nuclear Regulation Agency, with which the activities for implementation of stage 3 of the site selection phase are considered complete.

The comparative analysis includes the Radiana, Marichin valog and Brestova padina sites, which complies with the provisions of art.25, para.1 of the Ordinance for the safe management of radioactive waste[78].

1.5.1.2 MAIN CHARACTERISTICS OF THE STUDIED SITES

Pursuant to the provisions of the nuclear legislation a comparative analysis of the potential sites has been performed for determining the preferred site.

1.5.1.2.1 „RADIANA“ SITE

„Radiana“ site is situated in immediate vicinity of Kozloduy NPP and within the 2-km preventive protection measures zone (PPMZ) of Kozloduy NPP. It is located at 3.3 km southeast of the regulatory border of the town of Kozloduy, at 4.3 km northwest of the residential borders of the village of Harlets and at about 4.2 km southwest of the right bank of the Danube River. Its location is shown on **Figure 1.5-3**, as determined by the coordinate registry in **Appendix 8-I.4**.

In geomorphological respect the site belongs to the western part of the Danube hilly plain. The region surrounding it is part of the loess plateau between the Tsibritsa and Ogosta rivers, which is crossed by relatively small tributary valleys, two of which are flow into the Danube River, and the rest into the Ogosta River, to the south of the village of Glozhene, near the villages of Butan, Kriva bara, Bazovets, Septemvriitsi and other, as well as river terraces (**Figure 1.5-4**).

The tributary valleys formed during the Pleistocene. There is accumulation of superposed loess with smaller thickness than at the plateau.

The loess plateau has plain topography and is genetically related to the so called old accumulation abrasion layer (OAAL). This layer cuts through some Pliocene (lower Romanian) clays. Its cross section is revealed along the high right bank of the Tsibritsa River near the village of Zlatiya, the town of Valchedram and the town of Madan. Lake and river sediments presented by sand base and top gravel-clay complex have deposited on the lower Romanian clays.

[76]Studies concerning “Reconstruction of a RAW disposal facility into a dry cask storage for solid RAW”, IG-BAS, 2004

[77]Exploration works in connection with “Reconstruction of a repository for RAW in a mound type repository for solid REW” GI-BAS, 2004

[78]Ordinance for the safe management of radioactive waste, SG issue 76/30.08. 2013

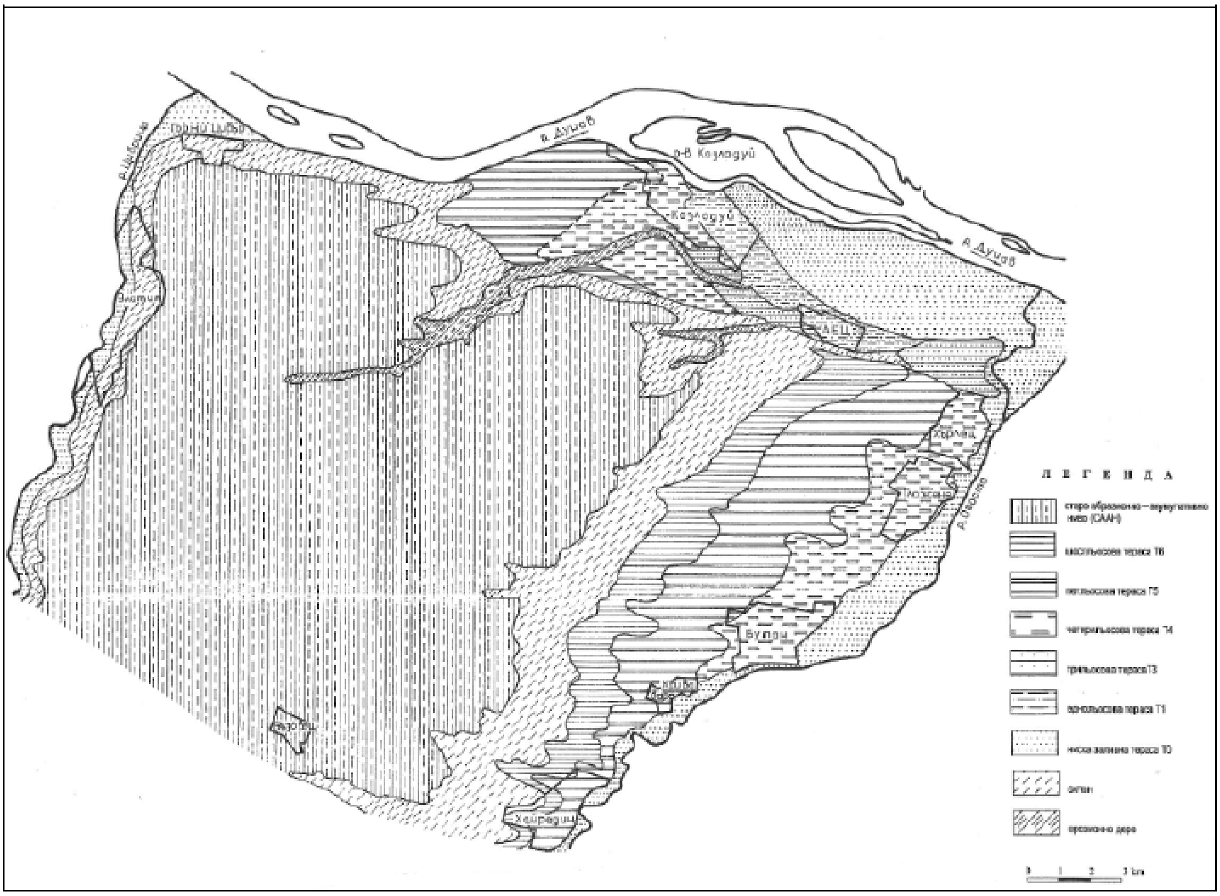

FIGURE 1.5-4 GEOMORPHOLOGICAL MAP OF THE REGION

The top layer of the alluvium has absolute elevation 125÷130 m and incline towards the Danube River. On top of it is the loess complex, presented by six loess layers divided by buried soils. To the south outside the border of the surveyed region, OAAL borders the Pliocene denudation surface. From the plateau to the modern river bed of the Tsibritsa, Ogosta and Danube rivers a number of river terraces have been found (from T_6 to T_0 according to the number of loess horizons) formed during the glacial Pleistocene and the Holocene.

In the loess plateau and the high river terraces around Kozloduy NPP are found a large number of saucer-shaped steppe hollows, small depressions and dry gullies. All those are the imprint of older depressions on the contemporary topography which were flooded by water during the Aeolic loess accumulation and therefore more or less modified and clayey loess has deposited in them.

The terrain surrounding the „Radiana“ site has reached its modern appearance under the influence of the abrasion and accumulation activity of the Dacian lake and river basin and later of the erosion-accumulation activity of the Paleo-Danube and Paleo-Ogosta rivers. In the western and southern part of the region is located the old abrasion-accumulation layer (OAAL). A significant part to the east is occupied by a low-grade slope formed in the sediments of the OAAL, and the river terraces are situated to the northeast.

The Radiana“ site itself and the area south of are part of a slope from elevation 38÷39 m to elevation about 120 m. The following geomorphological formations have been established there:

→ Low-grade slope between the OAAL and terrace T_6 in an altitude range of 98÷120 m;

→ terrace T_6 with width of 270÷380 m – from elevation 98 m to elevation 58 m;

→ low-grade slope between terraces T_6 and$_2$ with width 60÷100 m – from elevation 58 m to elevation 46 m;

→ terrace $T_2$with width 70÷120 m from elevation 46 m to elevation 38÷39 m.

The slope inclination is to the northeast. It is within the range of 4.8÷5.7° at terrace T_2, 9.5÷10° within the range of the low-grade slope and 9.3÷9.8° within the boundaries of terrace T_6. The average grade of the site from terrace T_2 to terrace T_6 inclusive ranges between 8.4÷8.6°.

Between terrace T_2 and the right bank of the Danube River are situated terrace T_1, on which is located Kozloduy NPP, and terrace T_0. The terrain within their boundaries is plain. It belongs to the altitude range of 28÷38 m at terrace T_1 and from 26 m to 28 m within the boundaries of terrace $T_{0.}$

In regional aspect Radiana site belongs to the Lom depression in the north-western part of the Moesian platform. Around the site on the surface are uncovered Quaternary landforms and Neogene sediments shown on **Figure 1.5-5**[79].

The geological cross section underneath is presented by Paleogene and Mesozoic deposits uncovered by deep structural boreholes.

The Mesozoic includes the Triassic, Jurassic, and Cretaceous layers, composed of various terrigenous and carbonaceous sediments: limestones, dolomites, marls, clays, sandstones, conglomerates, aleurolites and argillites. The Paleogene sediments are presented by marls, clayey and organogenic limestones.

In the Neogene cross section are differentiated the Deleynska, Krivodolska, Furenska, Florentinska, Smirnenska and Archarska formations of Miocene age as well as the Brusarska formation of Pliocene age.

The Deleynska, Krivodolska, Furenska and Florentinska formations are presented by calcareous and aleurolite clays with single layers of clayey limestones, aleurolites and sandstones and limestones with clayey-sandy layers, lying at a depth more than 300÷400 m.

The Smirnenska formation is composed mainly of grey and greyish-green, low calcareous and dusty clays with layers of clayey limestones, marls and sandstones in the lower layer of the cross section. The formation thickness in the region of Kozloduy is 100÷180 m.

The Archarska formation is composed of yellowish to rust-coloured or greenish, small to large particle sized oligomictic sands, often with slanting layers. In the lower layers the sands are mixed with dark-grey, low calcareous, thin-layered clays. The lower boundary with the Smirnenska formation is normal. The thickness of the Archarska formation is from 40÷50 m in the area of Kozloduy to over 100 m near the village of Septemvriitsi. It is covered by the Brusarska formation by a normal border or by Quaternary deposits with washed-away surface.

The Brusarska formation composes the pre-Quaternary layer. Its geological cross section is dominated by clays which are irregularly crossed by spatially unsound, often lens-like layers of small to medium-size particle clayey sands. The thickness of the layers varies from 1.0÷2.0 m to 8.0÷10.0 m.

The Quaternary is presented by lake-riparian, alluvial and Aeolic-eluvial formations which are genetically connected to certain geomorphological landforms.

[79]Filipov, L., E. Kuymdzhieva, N. Popov, 1989. Geological map of Bulgaria. Map sheet of Kozloduy, scale 1:100 000.

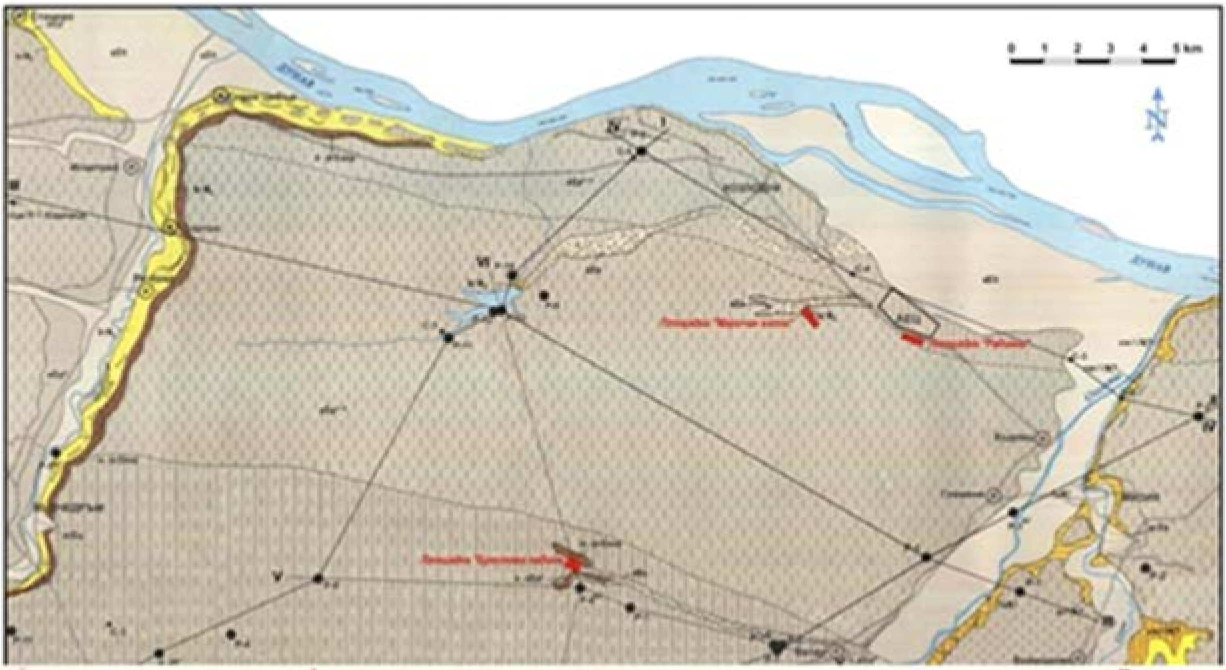

FIGURE 1.5-5 FRAGMENT OF THE GEOLOGICAL MAP OF BULGARIA IN THE REGION OF RADIANA SITE

1- alluvial deposits: gravels, sands, clays, superposed loess; 2- delluvial formations: clayey-sandy and loess-like materials; 3, 4-aeloc-elluvial formations: loess and loess-like clays; 5-Smirnenska formation (meot): clays with layers of sandstones and marls; 6- Brusarska formation (Pliocene): clays with sandy layers

The lake-riparian formations include gravels and sand base with thickness up to 10 m and top gravels with thickness of 2÷3 m and red-brownish sandy clays with thickness up to 5,0 m.

The *alluvial formations* include sandy-clayey deposits on river terraces.

The Aeolic-eluvial formations include the loess complex presented by loess dust and loess-like dusty-dandy clay crossed by buried Chernozem type soils.

The region of „Radiana“ site belongs to the eastern outskirts of the Lom depression which is the lowest part of Moesian platform – first-grade tectonic unit, situated on Bulgarian and Romanian territory. Its foundation in Bulgaria is composed of slightly folded Paleozoic rocks and its cover includes sub-horizontal Mesozoic and Neozoic sediments with joint thickness up to 7÷8 km. The tectonic development of the region underwent many stages which can be consolidated in three groups: *pre-Paleogene, Paleogene- Neogene and Quaternary*.

The pre-Paleogene tectonic development includes the forming of the slightly folded foundation of the Moesian platform till the mid-Paleozoic and the completion of the intensive tectonic activity at the end of the Triassic.

According to the multiple existing borehole data from the region, the movement of old faults in *the Paleogene-Neogene structural layer* hasn’t been proven with certainty. No evidence of faults impacting the modern relief have been found and no fold structures have been documented neither in the Miocene, nor in the Pliocene sediments.

The Neotectonic development is characterized with the lack of sharp gradients of the gravitational, geomagnetic and geothermal fields, as well as of local anomalies of these fields. Trends of relative subsidence in the ranges of (-1) to (-2) mm/y have been established. There’s no tension built-up in regional aspect. During the last 23.5 million years only fluctuation movements have been registered.

In a radius of 30 km around „Radiana“ site there are no active faults, including Neogene and pre-Quaternary with any relief forming significance.

The „Radiana” site is located in the stable part of the Moesian platform which is characterized with low seismic activity. The maximum expected earthquake in the sub region of the site is $M_{max} = 5.0$. The main seismic hazard sources are seismic areas outside the site. According to the earthquake maps for periods of 1,000 and 10,000 years the area can experience earthquake impacts of stage VII on the MSK-64 scale caused by events in the seismic zone Vrancea in neighbouring Romania (distance over 240 km) which has experienced events of stage M> 7.

The Quaternary landforms and the Neogene sediments of the Brusarska and the Archarska formations, in which the following engineering-geological layers are distinguished, are of importance in terms of the safety of the investment proposal implementation[80]:

- → *Modern soil,* grey-black in colour, with thickness of 0.5÷1.0 m;
- → *Layer 1* – collapsible loess II-nd type (dusty loess, light yellow, macro porous with fragile structure, the base turns into dark brown loess-like clay with macro pores). Composes the near surface part of terrace T_6 with thickness from 6.0 m to 16 m;
- → *Layer 1a* - collapsible loess I-nd type (dusty to dust-sandy loess, macro porous, light yellow, with fragile structure, occasionally crossed by clayey loess). Composes the near surface part of terraces T_2 and T_1 with thickness 5÷11 m;
- → *Layer 2* - non-collapsible loess from the high Danube terrace (dusty loess, with no macro pores, crossed by loess-like clay – buried soils). Lies under layer 1 with thickness up to 30÷33 m south of terrace T_6, to 32 m within the range of terrace T_6 and to 1.0 m within the borders of terrace T_2;
- → Layer 2a - non-collapsible (subsiding) loess (clayey loess, with no macro pores, with compacted structure, highly moist to waterlogged). Found within the borders of terraces T_2 and T_1 with thickness from 2÷4 m to 8.0 m;
- → *Layer 3* – sandy clay, alluvial (sandy clay, beige-brown, with occasional gravel parts). Found in the upper alluvium with thickness up to 2.0÷5.5 m at terraces T_6 and T_2 and thickness up to 2÷8 m at terrace T_0;
- → *Layer 4* – gravel, alluvial (gravel or gravel sand with clayey-sandy (terrace T_6) and sandy filling (terraces T_1 and T_0). Within the borders of terrace T_6 usually with thickness up to 1.0÷4.3 m. At terraces T_1 and T_0 the thickness varies – from 2÷5 m to 8÷13 m;
- → *Layer 4a* – alluvial sand (small to medium-sized, occasionally clayey). Found in the low terraces T_1 and T_0 with thickness from 1.0 m to 3.3 m shaped like lenses and layers in layer 4;
- → *Layer 5* – Pliocene dusty clay (Brusarska formation) – dusty clay, compacted, rusty yellow, parti-coloured to grey with deeper carbonaceous and single gravel pieces. Composes the plinth of the terraces and the larger part of the cross-section of the formation. The top lies at elevations from 48÷54 m within the borders of terrace $T_{6,}$ 24÷27 m – at terrace T_2, 13÷19 m - at terrace T_1 and 11÷17 m - within the borders of terrace T_0. The thickness of layer 5 with the sand layers contained in it and the other layers (layer 6) composes 48÷52 m within the borders of terrace $T_{6,}$ 25÷26 m – at terrace T_2,and 20÷25 m – at terrace $T_{1.}$

[80]Consortium Dicon-Acciona Ing., 2013. EIAR of IP Construction of a new nuclear unit of the latest generation at the site of Kozloduy NPP. Chapter 3, section 3.4. Geology and underground natural resources

- → *Layer 6* – Pliocene sand (Brusarska formation) – small to medium particle sized, clayey sand, beige to grey. Forms layers among the clays of the Brusarska formation (layer 5) with thickness from 0.5÷1.0 m to 12 m;
- → *Layer 7* – Miocene clayey sand (Archarska formation) – small particle size clayey sand, grey-greenish, water absorbent, thixotropic. Found below an altitude of (+4.7) to (-8.6 m).;
- → *Layer 8* – Miocene dusty clay (Archarska formation) – dusty clay, compact, blue-grey, transforming into clayey marl.

The average values of the physical-mechanical parameters of the described layers are presented in **Table 1.5-1**[81], with no data for layer 8 due to the lack of relevant surveys.

[81] Westinghouse, DBEtec, Enresa, IQI Bulgaria AD, 2013. Technical project. Section: Geotechnics and geomechanics. Geomechanical and geotechnical conditions and earth foundation.

TABLE 1.5-1: SUMMARY TABLE OF THE AVERAGE VALUES OF THE PHYSICAL-MECHANICAL PARAMETERS OF THE LITHOLOGICAL TYPES AT „RADIANA“ SITE

No	Parameters	Unit	Lithological types									
			Layer 1	Layer 2	Layer 1a	Layer 2a	Layer 3	Layer 4	Layer 4a	Layer 5	Layer 6	Layer 7
1	Volumetric density ρ	g/cm^3	1.60	1.80	1.59	1.89	2.00	2.00	1.60	2.10	2.00	2.05
2	Frame volumetric density ρ_d	g/cm^3	1.40	1.50	1.40	1.56	1.70	1.80	-	1.70	1.70	1.68
3	Water content w	%	10.0	15.8	13.6	21.1	14.6	9.8	-	19.3	15.3	21.8
4	Pore coefficient	-	0.90	0.80	0.97	0.75	0.60	0.50	0.64	0.60	0.50	0.58
5	Layering indicator I_p	%	11.7	22.2	7.0	13.0	38.7	28.5	-	34.4	8.4	1.6
6	Consistency indicator I_c	-	> 1	> 1	> 1	-	> 1	0.84	-	> 1	> 1	-
7	Water saturation level S_r	-	0.294	0.567	0.39	0.77	0.693	0.708	-	0.896	0.815	1.00
8	Macro pore volume, $n_{mp0,4}$	%	7.1	4.1	2.39	-	-	-	-	-	-	-
9	Initial collapsible load P_{ini}	kPa	92	135			-	-	-	-		-
10	Inner friction angle φ	degree	27	17.5			17.1	17.1	32	22	27	27
11	Cohesion C	kPa	15	21.5			25.2	25.2	-	48	30	30
12	Compression module $M_{0,3}$	MPa	5.9	9.2	6.3	7.9	10.6	-	-	10.3	12.2	-
13	Total deformation module E_0	MPa	14	14	12.6	16	18	18	8-9	45	50	50

It is necessary to explain that during the various stages of the studies and surveys at the „Radiana“ site the differentiation of the engineering-geological layers has experienced changes due to the additional fragmentation of the engineering-geological profile. With regards to this fact in this EIAR and in **Table 1.5-1** is presented the latest most detailed division from the EIAR of IP Construction of a new nuclear unit of the latest generation at the site of Kozloduy NPP. **Chapter 3, section 3.4.** *Geology and underground natural resources*. It differs from the adopted older classification in “Technical project. Section: Geotechnics and geomechanics. Geomechanical and geotechnical conditions and earth foundation” of Westinghouse etc., as follows:

- → layers 1,2 and 3 of the technical project correspond to layers 1, 2 and 3 in Table 1.5-1**;**
- → layers 4, 5 and 6 of the technical project correspond to layers 5, 6 and 7 in Table 1.5-1***;***
- → in this EIAR and in Table 1.5-1 are included layers 1a, 2a, 4 and 4a, which have been differentiated additionally in EIAR ***of*** IP Construction of a new nuclear unit of the latest generation at the site of Kozloduy NPP, from which the physical-mechanical parameters of these layers, stated in Table 1.5-1 have been supplied.

The hydrogeological conditions in the *Lom artesian basin* where the “Radiana” site is situated are characterized by lithostratigraphic units from the Triassic to the Quaternary situated in layers of various water permeability. Out of these the only important for the investment proposal are the groundwater accumulated in the Quaternary formations and in the Neogene sediments of the Archarska and the Brusarska formations which lie on top of the thick clay sediments of the Smirnenska formation.

„Radiana“ site belongs to the region of the groundwater bodies “Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 and “Pore groundwater in the Quaternary – between the rivers Lom and Iskar” with code BG1G0000Qpl023 on the territory of the Danube region river basin management directorate (DRRBMD[82]). To the northeast of the site is situated groundwater body “Pore groundwater in the Quaternary – Kozloduy lowland” with code BG1G0000Qal005 (**Figure 1.5-6**).

[82]DRRBMD. Letter No 2915/05.06.2014 to SE RAW regarding: Consultations for updated Terms of Reference fore determining the scope and contents of an Envrioenmental Impact Assessment Report (EIAR) of investment proposal (IP) for construction of “National disposal facility for low and intermediate-level radioactive waste category 2A (NDFRAW)”

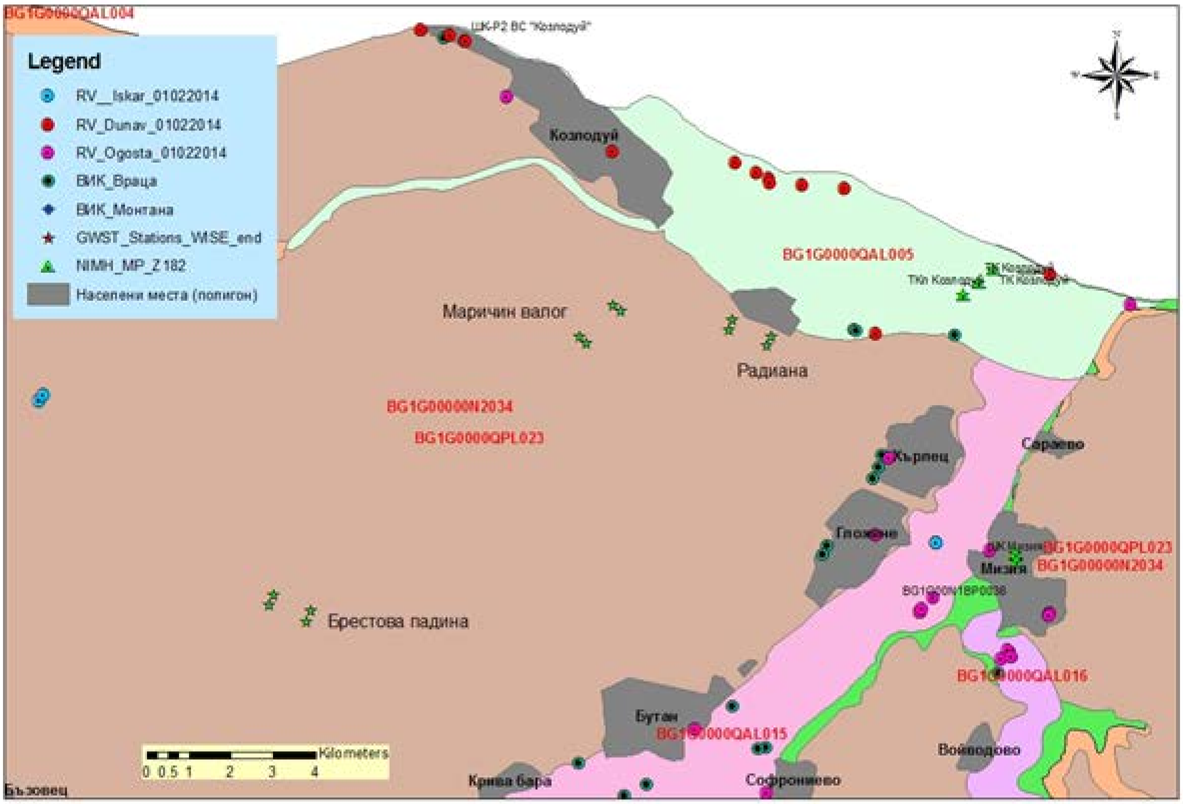

FIGURE 1.5-6:MAP OF GROUNDWATER BODY „PORE GROUNDWATER IN THE QUATERNARY - KOZLODUY LOWLAND“ WITH CODE BG1G0000QAL005 AND PARTS OF GROUNDWATER BODIES „PORE GROUNDWATER IN THE QUATERNARY – BETWEEN THE RIVERS LOM AND ISKAR” WITH CODE BG1G0000QPL023 AND „PORE GROUNDWATER IN THE NEOGENE-LOM-PLEVEN DEPRESSION“ WITH CODE BG1G00000N2034

Groundwater body „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 consists of two layers: upper low permeability layer and lower high permeability layer.

The upper layer has formed in the sediments of the Brusarska formation composed of clays alternating with clayey sand and sand. The hydrogeological parameters in regional aspect are characterized with the following values: thickness 70 m, permeability 140 m^2/d, filtration coefficient 2.0 m/d (RBMP of DRRBMD[83]). The filtration properties within the range of „Radiana“ site are low. They are exhibited by filtration coefficient for the sandy components К = 0.1÷1.0 m/d and for the clays К = 0.00÷0.01 m/d. The average permeability is estimated at about 3÷4 m^2/d .

The lower layer has formed in the sandy sediments of the Archarska formation, the top of which in the boundaries of „Radiana“ site has been established at an elevation of (+4.7) m to elevation (-8.4) m. The hydrogeological parameters in regional aspect are characterized with the following values: thickness 100 m, permeability 2500 m^2/d and filtration coefficient 25 m/d. The filtration properties of the upper layer of the Archarska formation, composed in small particle sized clayey sands in the range of „Radiana“ site are low. They are exhibited by filtration coefficient К = 0.1÷3.0 m/d. The overall thickness of the Archarska formation in the area of the site has not been established it is assumed to be about 40÷50 m.

[83]DRRBMD, 2010. Water management plan of the Danube region 2010-2015 .

Groundwater body BG1G00000N2034, pursuant to art. 7, item 1 of Directive 2000/60EC[84] and art. 119 of the Water Act[85], has been defined as a drinking water protection zone with code BG1DGW00000N2034, from which water for human consumption is abstracted with an average 24-hr capacity over 10 m³/d or used for water supply to more than 50 people. Its chemical condition is poor with deviations for the nitrates indicator due to pollution from diffuse sources (partially overlapping with the nitrate sensitive zone established under Ordinance No РД-930/25.10.2010 of the Minister of Environment and Water[86]), and the condition of the protection zone is good. The quantity status of the water body is good.

Groundwater body „Pore groundwater in the Quaternary – between the rivers Lom and Iskar” with code BG1G0000Qpl023 is differentiated in various size gravels with clayey-sandy filling and layers of sands at the bottom of the Aeolian landforms between the rivers Lom-Tsibritsa, Tsibritsa-Ogosta and Ogosta-Iskar. It is composed of pressureless groundwater streams whose flow direction is determined by the river-ravine network. The hydrogeological parameters in regional aspect are characterized with the following average values: thickness 25 m, permeability 13 m^2/d and filtration coefficient 2.0 m/d. The filtration properties at the „Radiana“ site are exhibited by average filtration coefficient values of 0.025 m/d for the clayey loess and the sandy clays, 0.25 m/d for the dusty collapsible loess and 7.6 m/d for the gravels with clayey-sandy filling. Groundwater body BG1G0000Qal023 is defined as a drinking water protection zone with code BG1DGW0000Qal023. The quantity condition and the chemical status of the GWN are good. The chemical condition of the protection zone is good.

Groundwater body „Pore groundwater in the Quaternary - Kozloduy lowland“ with code *BG1G0000Qal005* has formed in alluvial deposits in the flood and non-flood terrace of the Danube River in the Kozloduy lowland which in its eastern part are mixed with the alluvium at the mouth section of the Ogosta River. The hydrogeological parameters in regional aspect are characterized with the following average values: thickness 13 m, permeability 1155 m^2/d, filtration coefficient 89 m/d and average module of groundwater discharge 4.0 l/s.km^2.

The results of the filtration testing studied carried out at the site of Kozloduy NPP showed the following values of the filtration parameters:

- → - for the area of units 1 and 4 the filtration coefficient is 45 m/d to 100 m/d, average К = 70 m/d, permeability T = 500 m^2/d;
- → - for the area of units 5 and 6 the filtration coefficient is 45 to 135 m/d, average К = 100 m/d, permeability T = 700 m^2/d.

Groundwater body BG1G0000Qal005 is defined as a drinking water protection zone with code BG1DGW0000Qal005. At present the quantity condition of the GWB is poor, the chemical condition is good and the status of the protection zone is poor.

The above described groundwater bodies in the earth massif of the „Radiana“ site and around it due to their hydraulic connection form a joint groundwater filtration stream flowing from south-southwest to north-northeast to the overflood and flood terraces of the Danube River. The groundwater is recharged south from the site and from above (through infiltration within its boundaries). The drainage is through the existing water abstraction facilities (shaft and tube wells) and in the main drainage channel via which all water flowing from the south in the Kozloduy lowland, that is in the low flood terrace of the Danube, are led (pumped) into the Danube River. The groundwater level within the boundaries of the site is established within altitude of 50÷30 m with a

[84]"Directive 2000/60/EC of the European Parliament and of the Council of October 23, 2000 establishing a framework for the Community action in the field of water policy

[85]Water Act in effect from 28.01.2000 (prom SG issue 67/1999 , last am. SG issue 53/2014)

[86]MoEW. Ordinance No РД-930/25.10.2010 for defining water polluted or in danger of pollution with nitrates from agricultural sources and the sensitive zones in which water is polluted with nitrates from agricultural sources

gradient of 0.036 within the boundaries of terrace T_6 and south of it at 0.017 in the base of the slope in the north-eastern part of terrace T_2, and is at an average of 0.028. to the northeast towards the Danube River the water level is established at a depth of 0.5÷5.0 m in the flood terrace up to 8÷12 m in the non-flood terrace at an altitude of 24.4 m to 26 m with a gradient range of 0.001÷0.007 (**Figure 1.5-7**, Gerginov, 2014[87]).

The hydrogeological section of the Radiana site shows the following hydrogeological units: non-saturated (aerated) layer and pre-saturated layer - groundwater body “Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 with upper layer in the Brusarska formation and lower layer in the Archarska formation.

The clays of the Smirnenska formation serve as regional water barrier. Within the site boundaries this formation has not been reached. It is composed of compact, practically impermeable clays which are the lower water barrier of the water -bearing sediments of the formation.

According to the geomorphology the „Radiana“ site can be divided provisionally in two sections – slope section and plain section. A trench type repository can be constructed at both sections, i.e. within the boundaries of terrace T_6 and within terrace T_2, and a tunnel type repository can be built in the slope section:

- Construction of a trench or tunnel type of repository within the boundaries of terrace T_6 – slope section;
- Construction of a trench or tunnel type of repository in the lower plain section of the site within the boundaries of terrace T_2 – plain section.

[87]Gerginov, P., 2014. “Hydrodynamic map of the region of Kozloduy NPP and Radiana site”

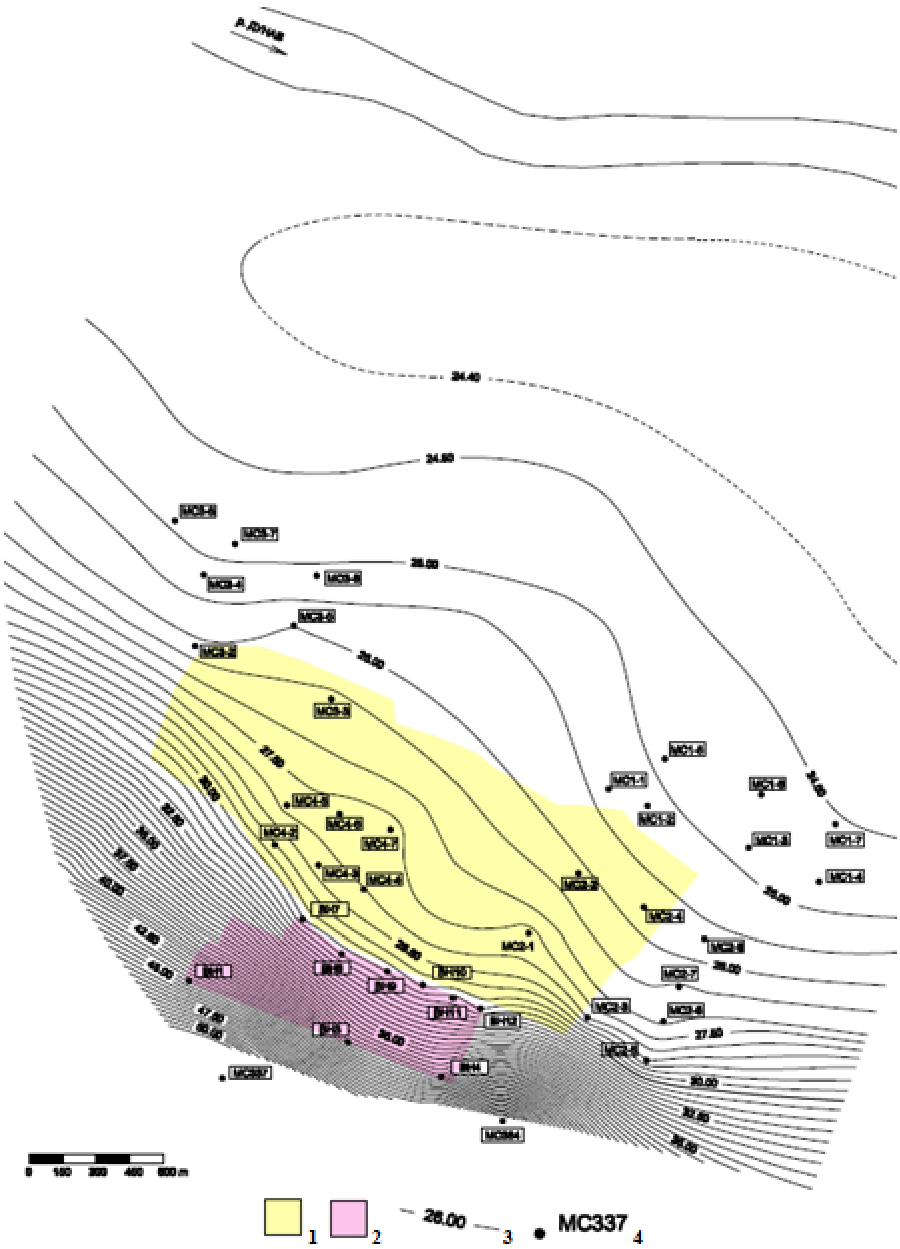

FIGURE 1.5-7: HYDRODYNAMIC MAP OF THE REGION OF KOZLODUY NPP AND „RADIANA“ SITE /GERGINOV, 2014/

1-Kozloduy NPP; 2-“Radiana“ site; 3-Hydro-isohypses; 4-Borehole

At the slope section of terrace T_6 the engineering-geological profile includes modern soil, layer 1 - collapsible loess II-nd type, layer 2 - non-collapsible loess, layer 3 – sandy clay, alluvial, layer 4 – gravel or gravel sand, alluvial, layer 5 – dusty clay, Pliocene (Brusarska formation), layer 6 – Pliocene sand (Brusarska formation), layer 7 – clayey sand, Miocene (Archarska formation) and layer 8 – dusty clay, Miocene (Archarska formation).

With a trench type of repository the trench swaths will be formed in layers 1, 2, 3 and 4. The lithological composition below the trench bottom at elevation 50 m includes:

- of the repository units: dusty Pliocene clay (layer 5) with thickness up to 32 m in 2/3 of its area and Pliocene sand (layer 6) with thickness of 5.5÷7.5 m in the east 1/3 of the area of the site;

- of the utility buildings: from layer 5 and layer 3 in the north-western half of the site and from layer 2 with thickness 5.5÷8.0 m and layer 1 with thickness 7.5 m in its north-eastern part.

Under the repository units are distinguished two hydrological units: non-saturated (aerated) zone and water-saturated zone.

The non-saturated (aerated) zone has total thickness from 11÷16 m in the southern part up to 13÷17 m in the northern part of the earth foundation below the repository units. This zone includes only clayey-sandy sediments of the Brusarska formation (layer 5 and layer 6).

The water saturated zone includes the groundwater in layers 2a and 3 and in the upper layer (Brusarska formation) and lower layer (Archarska formation). The water level is established at an altitude from 40÷45 m in the south-western part to 32÷38 m in the north-eastern part of the section.

With a tunnel type of repository the mine chambers can be situated in the top sections of layer 5 and layers 1 and 2. The non-saturated zone will included fully the loess formations (layers 1 and 2), the alluvial formations (layers 3 and 4) and partially the clays of the Brusarska formation (layer 5).

The geochemical parameters of the six lithological types have been analysed and their main values are presented in **Table 1.5-2** (SE RAW, 2013[88]).

TABLE 1.5-2:GEOCHEMICAL CHARACTERISTICS OF „RADIANA“ SITE

Geochemical parameter	Unit	Lithological type					
		Dusty loess	Loess-like clay	Sandy clay	Gravel-sandy clay	Dusty clay	Small clayey sand
Clay fraction content	%	6.9	14.5	10.1	9.0	42.1	6.0
Clay minerals content	%	58	59	81	75	81	73
Smectite content	%	36	33	42	41	25	32
Ion exchange capacity	meq/100 g	5.55	13.03	14.50	9.26	16.39	4.95
Organic carbon content	%	0.13	0.13	0.095	0.063	0.102	0.032
Carbonate content ($CaCO_3$)	%	34.4	28.5	10.5	6.6	3.3	0.52
pH of water sample	-	9	9	8.5	8.5	8.5	8.5
Content of:							
Ca^{2+}	mg/dm^3	15.8	8.0	14	7.6	10.1	6.
CO_3^{2-}	mg/dm^3	6	9.6	-	1.2	-	0.3
Sr^{2+}	mg/dm^3	0.05	0.04	0.05	0.07	0.12	0.04

Table 1.5-3 presents the distribution coefficient K_d of the forecasted radionuclides for the respective lithological types.

TABLE 1.5-3:DISTRIBUTION COEFFICIENT OF THE FORECASTED RADIONUCLIDES AT THE SLOPE SECTION OF „RADIANA“ SITE

Lithological type	Distribution coefficient $K_{d,}$ m^3/kg										
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	^{39}Pu	^{241}Am
Non-saturated layer 1	0	2E-2	1	0.3	0.07	0.16	1E-4	1E-3	0.20	0.11	10
Non-saturated layer 2	0	3.5E-3	5.5E-1	0.65	0.12	0.55	1E-3	1E-3	0.25	0.21	20
Non-saturated layer 3	0	3.5E-3	6E-2	0.65	0.14	0.55	1E-4	1E-3	0.23	0.16	20
Non-saturated layer 4	0	5E-3	0.5	0.40	0.075	0.16	1E-4	1E-3	0.14	0.15	20
Non-saturated layer 5	0	1E-3	5.5E-1	0.65	0.2	0.55	1E-3	1E-3	0.4	0.56	30
Non-saturated layer 6	0	5E-3	6E-2	0.3	0.04	0.16	1E-4	1E-3	0.1	0.1	8
Aquifer	0	1E-3	5.5E-1	0.65	0.2	0.55	1E-3	1E-3	0.4	0.56	30

[88]SE RAW, 2013. Preliminary assessment of the safety of the national disposal facility for low and intermediate-level radioactive waste

At the plain section of terrace the engineering-geological profile includes modern soil, layer 1a - collapsible loess I-st type, layer 2a - non-collapsible (subsiding) loess, layer 3 – sandy clay, alluvial, layer 4 – gravel, alluvial, layer 5 – dusty clay, Pliocene (Brusarska formation), layer 6 – sand, Pliocene (Brusarska formation) and layer 7 – clayey sand, Miocene (Archarska formation).

With a trench type of repository below the units are distinguished two hydrological units: non-saturated (aerated) zone and water-saturated zone.

The non-saturated (aerated) zone has total thickness from up to 5÷6 m. This zone includes only the Quaternary Eolic formations (layer 1a and layer 2a).

The water saturated zone includes the groundwater in the upper layer (Brusarska formation) and lower layer (Archarska formation) within groundwater body „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034. The water level is established at an altitude about 30÷38 m.

The geochemical characteristics are identical to those of the slope section.

Table 1.5-4 presents the distribution coefficient K_d of the forecasted radionuclides for the respective lithological types.

TABLE 1.5-4: DISTRIBUTION COEFFICIENT OF THE FORECASTED RADIONUCLIDES AT THE PLAIN SECTION OF „RADIANA“ SITE

Lithological type	Distribution coefficient $K_{d,}$ m^3/kg										
	^{214}Rb	^{14}C	^{60}Co	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	^{39}Pu	^{241}Am
Non-saturated layer 1	0.18	0.02	1	0.3	0.02	0.16	1E-4	1E-3	0.20	0.11	10
Non-saturated layer 2	0.27	0.02	1	0.5	0.07	0.55	1E-4	1E-3	0.25	0.21	20
Aquifer		0.005	1	0.65	0.2	.9	1E-4	1E-3	0.4	0.56	30

„Radiana“ site belongs to the temperate continental climate area. The average annual rainfall according to data from all nearby HMS is 550 mm. Only data from MS-Kozloduy shows the average annual rainfall for a 10-year period (1968÷1977) as 595 mm. According to the automatic meteorological monitoring system of Kozloduy NPP (AMMS) (1998÷2013) the annual rainfall amount varies from 277.4 mm (in 2004) to 681.8 mm (in 2010) with an average of 436.6 mm. The absolute maximum 24-hr rainfall at Kozloduy is 87 mm. The precipitation mode is of clearly exhibited continental nature. Precipitation is at its maximum level (65÷70 mm) in May and June and at minimum level (35÷38 mm) in February-March.

The average annual wind speed is about 3.5 m/s. The most quiet weather is in December with an average wind speed of 1.7 m/s, and the most windy is in April – average wind speed of 4.7 m/s. During the year the quiet periods are relatively rare – 8.7%. West and northwest winds are prevailing. Light and moderate winds (speed up to 15 m/s) tend to repeat more often. It has been established that the probable maximum wind speed can reach up to 33 m/s with an occurrence possibility once in 15 years. The pressure on the various facilities at such wind will reach up to 550 N/m^2. The probability of tornado occurrences is negligible.

The average annual air temperature is 11÷13 ^{0}C. during the winter the air temperature reaches up to -20÷25 ºC, and the absolute minimum temperature on single occasions has reached about 30 ºC below zero. The annual relative humidity maximum (December) is rather high - 86 %. The humidity minimum is in August and July (62÷64 %). Summer has average July temperature of 23.4÷24.3 ^{0}C, the average maximum temperature is 36°C, and the absolute August maximum is

39.8 °C. An average of 80 % of the summer days (in June, July and August) have maximum temperature above 25 ºC and 40 % of the days - above 30 ^{0}C.

The NDF site in the plain section at terrace T_2 is located at 15÷20 m, and in the slope section at terrace T_6 - at 26÷30 m above the level of the Danube River. According to the performed studies and analyses[89,90]„Radiana“ site is not under the risk of erosion caused by the Danube River and of floods for the entire period of existence of the NDF. The forecast calculations taking into account high risk factors and/or others of less probability such as the demolition of the hydro complex “Zhelezni vrata1” and “Zhelezni vrata 2” with simultaneous overflow of an eventual dam “Nikopol-Turnu Magurele” show that the groundwater level would rise up to 0.90 m at the low parts of terrace T_2 and is practically cancelled at terrace $T_{6.}$

There are no landslide processes and phenomena within the boundaries of the „Radiana” site. For the assessment of the slope stability multi-variant stability forecasts have been made using “SLOPE W”[91] software with basic loads combinations and with special loads combinations of (accounting for the seismic impact of various intensity (VII÷IX stage). The forecasted stability coefficients are significantly higher than the minimum permissible values.

Pursuant to the available information at the DRRBMD at Radiana site there are no drinking water sources or facilities for drinking and domestic water supply.

The site is located outside of the Zlatiyata area, which is one of the most fertile areas in the Danube plain and does not belong to any Natura 2000 protected areas.

1.5.1.2.2 „BRESTOVA PADINA“ SITE

„Brestova padina“ site is located at the area bearing the same name at 12 km southwest from Kozloduy NPP, at 6 km northwest of the village of Kriva Bara and at 7.5 km west-northwest from the village of Butan. Its altitude is 100÷120 m. Its location, shown above at **(Figure 1.5-8**), is defined by the following coordinates:

TABLE 1.5-5 COORDINATES OF „BRESTOVA PADINA“ SITE

	N	E	N	E
	DMS format		**D format**	
1	43°40′33.37″	23°38′11.68″	43.675936	23.636578
2	43°40′22.33″	23°38’51.36″	43.672869	23.647600
3	43°40′4.02″	23°38′46.83″	43.670561	23.646339
4	43°40′25.28″	23°38′07.28″	43.673689	23.635356

In geomorphological aspect the site belongs to the western part of the Danube hilly plain. The area around it includes part of the loess plateau at an altitude of 100÷120 m between the rivers Tsibritsa and Ogosta, crossed by relatively small tributary valleys two of which are tributaries of the Danube River, and the rest – of the Ogosta River south of the village of Glozhene, near the villages of Butan, Kriva bara, Bazovets, Septemvriitsi and other river terraces. The site is situated on a wedge-like watershed level area with an incline of 2÷3^0, between two dry gullies. The surrounding area in which the depression is jutted is a plain also sloping from the east to the west with average gradient

89 Evstatiev, D., Y. Evlogiev, 2011. Report on the assignment for “Forecast on the flood and erosion hazard from the Danube River at the Radiana site for NDFRAW”

90 Yotov, Il., 2011. Report on assignment “Assessment of the groundwater level at Radiana site with maximum elevation of the water of the Danube rivr”

91 Slope International Ltd. Calgary, Alberta Canada. Sofware SLOPE W.

about 5÷6^0. The modern topography has formed in the so called old abrasive accumulation layer (OAAL), formed at the end of the Pliocene and the beginning of the Pleistocene. The dry gully to the north is well exhibited and is considered the start of the depression. The southern dry gully is shallower and filled with superposed loess. At 250 m east of the site the two gullies merge and form the wide part of a tributary valley with depth up to 20÷25 m and orientation from the West to the East towards the village of Butan (**Figure 1.5-4**).

In regional aspect „Brestova padina“ site belongs to the Lom depression in the north-western part of the Moesian platform (**Figure 1.5-5**). Around the site at the surface are uncovered Quaternary landforms (**Figure 1.5-8**).

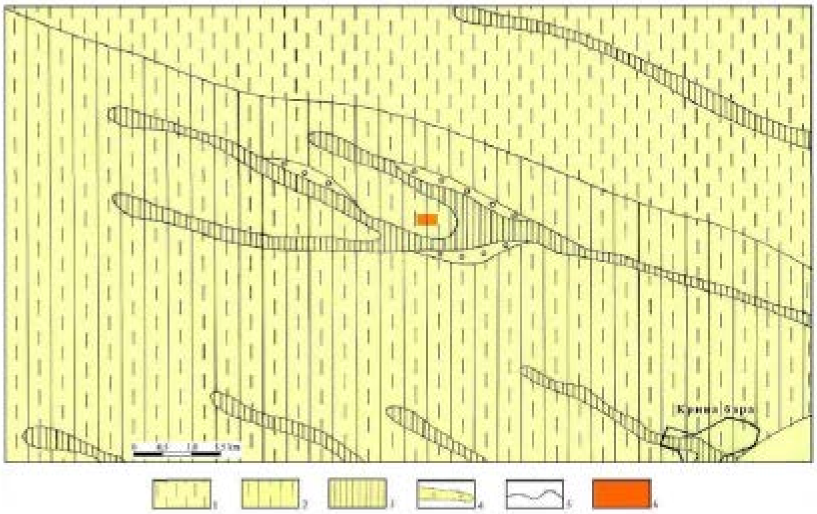

FIGURE 1.5-8: GEOLOGICAL MAP OF THE AREA OF „BRESTOVA PADINA“ SITE

1- Typical loess; 2-clayey loess; 3-modified loess, loess-like and other deposits; 4-pleistocene gravel from the plateaus and loess terraces;5-lithological border; 6-“Brestova padina“ site

The geological cross section underneath is presented by Neogene, Paleogene and Mesozoic deposits uncovered by deep structural boreholes.

The Mesozoic includes the Triassic, Jurassic, and Cretaceous layers, composed of various terrigenous and carbonaceous sediments: limestones, dolomites, marls, clays, sandstones, conglomerates, aleurolites and argillites. The Paleogene sediments are presented by marls, clayey and organogenic limestones.

In the Neogene cross section are differentiated the Deleynska, Krivodolska, Furenska, Florentinska, Smirnenska and Archarska formations of Miocene age as well as the Brusarska formation of Pliocene age.

The Deleynska, Krivodolska, Furenska and Florentinska formations are presented by calcareous and aleurolite clays with single layers of clayey limestones, aleurolites and sandstones and limestones with clayey-sandy layers, lying at a depth more than 300÷400 m.

The Smirnenska formation is composed mainly of grey and greyish-green, low calcareous and dusty clays with layers of clayey limestones, marls and sandstones in the lower layer of the cross section. The formation thickness is 200÷250 m.

The Archarska formation is composed of yellowish to rust-coloured or greenish, small to large particle sized oligomictic sands, often with slanting layers. In the lower layers the sands are crossed by dark-grey, low calcareous, thin-layered clays. The top boundary of the formation is at a depth of 60÷70 m from the surface. The lower boundary with the Smirnenska formation is normal. The thickness of the Archarska formation is from 40÷50 m in the area of Kozloduy to over 100 m near the village of Septemvriitsi.

The Brusarska formation composes the pre-Quaternary layer. Its geological cross-section is dominated by clays which are irregularly crossed by spatially unsound, often lens-like layers of small to medium-size particle clayey sands.

The Quaternary formations cover the sediments of the Brusarska formation. They are presented by lower Pleistocene clayey gravels with thickness of 0.5 - 2.0 m, on top of which are superposed loess-like clays and loess with thickness between 15 and 20 m.

The region of „Brestova padina“ site belongs to the eastern outskirts of the Lom depression which is the lowest part of Moesian platform – first-grade tectonic unit, situated on Bulgarian and Romanian territory. Its foundation in Bulgaria is composed of slightly folded Paleozoic rocks and its cover includes sub-horizontal Mesozoic and Neozoic sediments with joint thickness up to 7÷8 km. The tectonic development of the region underwent many stages which can be consolidated in three groups: *pre-Paleogene, Paleogene- Neogene and Quaternary.*

The pre-Paleogene tectonic development includes the forming of the slightly folded foundation of the Moesian platform till the mid-Paleozoic and the completion of the intensive tectonic activity at the end of the Triassic.

According to the multiple existing borehole data from the region, the movement of old faults in *the Paleogene-Neogene structural layer* hasn’t been proven with certainty. No evidence of faults impacting the modern relief have been found and no fold structures have been documented neither in the Miocene, nor in the Pliocene sediments.

The Neotectonic development is characterized with the lack of sharp gradients of the gravitational, geomagnetic and geothermal fields, as well as of local anomalies of these fields. Trends of relative subsidence in the ranges of (-1) to (-2) mm/y have been established. There’s no tension built-up in regional aspect. During the last 23.5 million years only fluctuation movements have been registered. In a radius of 30 km around „Brestova padina“ there are no active faults, including Neogene and pre-Quaternary with any relief forming significance.

„Brestova padina“ site is located in the stable part of the Moesian platform which is characterized with low seismic activity. The maximum expected earthquake in the sub region of the site is M_{max} = 5.0. The main seismic hazard sources are seismic areas outside the site. According to the earthquake maps for periods of 1,000 and 10,000 years the area can experience earthquake impacts of degree VII on the MSK-64 scale caused by events in the seismic zone Vrancea in neighbouring Romania (distance over 240 km) which has experienced events of degree M> 7.

The earth foundation of the site is composed of the sediments of the complexes – the Quaternary and the Pliocene (**Figure 1.5-9**):

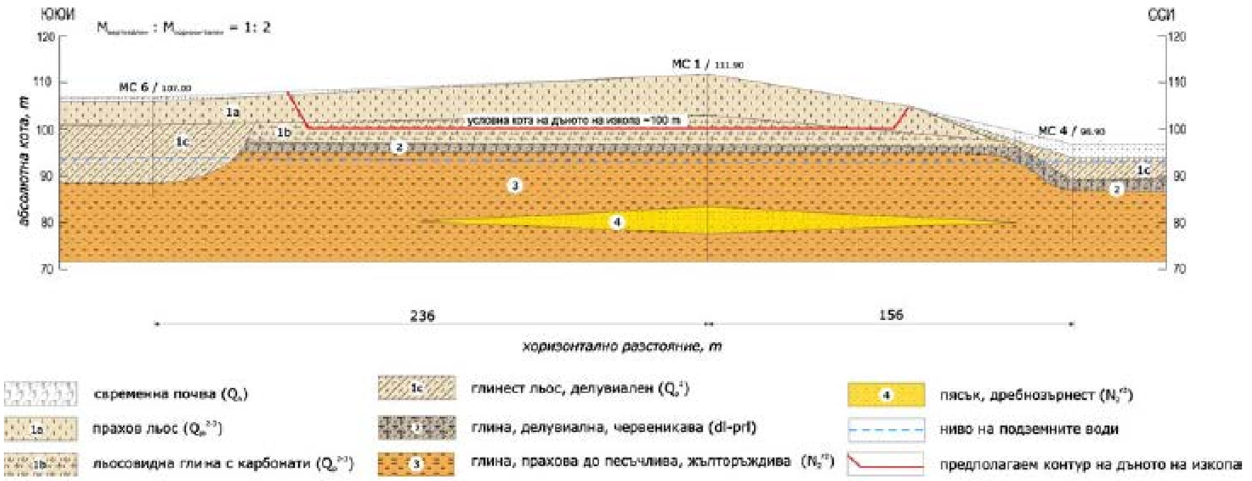

FIGURE 1.5-9: ENGINEERING GEOLOGICAL CROSS SECTION OF „BRESTOVA PADINA“ SITE

The Quaternary formations form four layers as follows:

⇒ *Layer 1a* – typical dusty loess. This layer covers the area of the entire site with thickness about 9 m. It is categorized as specific collapsible soil;

⇒ *Layer 1b* – loess-like clay. The thickness of the layer is 4÷6 m;

⇒ *Layer 1c* – delluvial clayey loess. Hasn't been established within the borders of the site itself but in the dry gullies to the north and south of the site. Its thickness varies from 4.0 m in the northern to 11.0 m in the southern dry gully. Composed of non-collapsible dusty loess superposed on the slope.

⇒ *Layer 2* – delluvial- proluvial clay with thickness of 1.5÷2.0 m;

Within the boundaries of the site the Pliocene complex (Brusarska formation) begins after 15 m depth (elevation around 97 m) and includes:

→ *Layer 3* – clay, dusty to sandy, rusty yellow. The overall thickness of the layer is around 20÷21 m (from elevation 95 m to elevation 74 m). Part of this thickness is occupied by layers of small-sized sand (layer 4);

→ *Layer 4* – small-sized sand. Forms horizontally unsound lenses and layers in layer 3. Its thickness is about 5.0÷5.5 m.

→ *Layer 5* – dusty clay, blue-grey. Within the borders of the site it is uncovered under elevation 74 m. Serves as a local water barrier.

The average values of the physical-mechanical parameters of the described layers are presented in **Table 1.5-6**.

TABLE 1.5-6: SUMMARY TABLE OF THE AVERAGE VALUES OF THE PHYSICAL-MECHANICAL PARAMETERS OF THE LITHOLOGICAL TYPES AT „BRESTOVA PADINA“ SITE

No	Parameters	Unit	Lithological types						
			Layer 1a	Layer 1b	Layer 1c	Layer 2	Layer 3	Layer 4	Layer 5
1	Volumetric density ρ	g/cm^3	1.65	1.88	1.99	2.00	2.02	2.13	2.07
2	Frame volumetric density ρ_d	g/cm^3	1.48	1.59	1.58	1.66	1.63	1.80	1.67
3	Water content w	%	11.5	18.2	26.2	21.2	23.6	8.4	2.7

4	**Pore coefficient**	-	0.86	0.72	0.75	0.66	0.69	0.54	0.67
5	**Layering indicator I_p**	%	7.3	15.4	11.0	25.0	28.1	-	27.6
6	**Consistency indicator I_c**	-	> 1	0.99	0.33	0.83	0.79	-	0.89
7	**Water saturation level S_r**	-	0.366	0.693	0.964	0.862	0.940	0.970	-
8	**Macro pore volume, $n_{mp0,4}$**	%	6.5	2.6	-	-	-	-	-
9	**Initial collapsible load P_{ini}**	кPa	79	143	-	-	-	-	-
10	**Inner friction angle φ**	degree	17.1	17.7	-	14	16.9	19.1	16
11	**Cohesion C**	kPa	26	34	-	1	50	37	53
12	**Compression module $M_{0,3}$**	MPa	6.5	8.5	-	9.6	17.3	16.5	34.4

The hydrogeological conditions in the *Lom artesian basin* where the „Brestova padina“ site is situated are characterized by lithostratigraphic units from the Triassic to the Quaternary situated in layers of various water permeability. Out of these the only important for the investment proposal are the groundwater accumulated in the Quaternary formations and in the Neogene sediments of the Archarska and the Brusarska formations which lie on top of the thick clay sediments of the Smirnenska formation.

„Brestova padina“ site belongs to the region of the groundwater bodies „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 and „Pore groundwater in the Quaternary – between the rivers Lom and Iskar” with code BG1G0000Qpl023 on the territory of the Danube region river basin management directorate shown on **Figure 1.5-6.**

In the hydrogeological cross section of the site are differentiated non-saturated (aerated) layer, part of groundwater body „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 and water barrier.

With a trench type of repository at elevation about 100 m below it will exist a non-saturated (aerated) zone with thickness about 7.0 m, composed of loess-like and delluvial clays (layers 1b and 2) and about 1.0 m Pliocene clays (layer 3).

Under the aeration zone is uncovered the top part of the upper layer of groundwater body BG1G00000N2034. The groundwater is contained in sand layers of irregular area and depth with low filtration parameters among impermeable clays of the Brusarska formation. Their static level is established at a depth about 12÷17 m below the surface in an altitude range of about 90÷95 m. The groundwater flows to the southeast with pressure gradient of 0.012 (**Figure 1.5-10**). Within the borders of the site it is recharged by the loess plateau from the west and is drained to the east-southeast under the site in the zone where the two dry gullies merge. The filtration capacity of the aquifer is low. It is exhibited by layer permeability of about 10 m^2/d, and the filtration coefficient is 0.9 m/d.

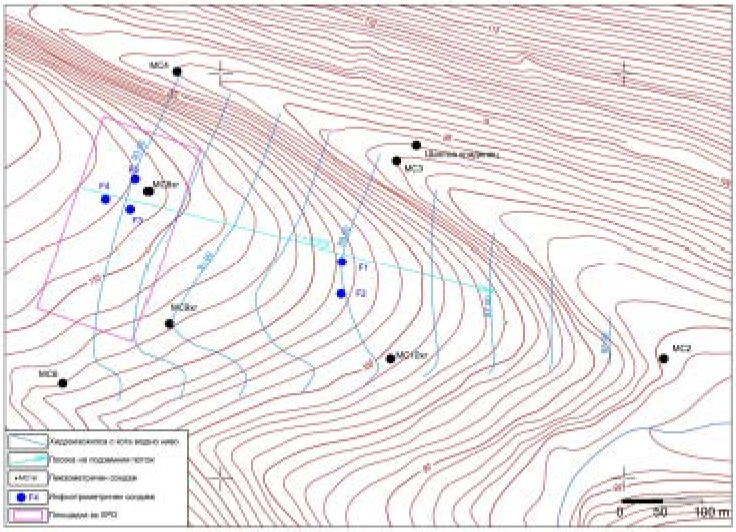

FIGURE 1.5-10: HYDRODYNAMIC MAP OF „BRESTOVA PADINA“ SITE

The aquifer in the sands of the Archarska formation (lower layer of groundwater body BG1G00000N2034) is located at about 40 m from the bottom of the eventual repository. Its thickness is 60÷80 m. It is recharged by the rainfall in the uncovered zones in southern and southeaster direction. The average values of permeability in regional aspect are 2500 m^2/d and filtration coefficient 25 m/d. The groundwater flows from the south-southeast to the north-northwest to the Danube River where it connects to groundwater body „Pore groundwater in the Quaternary-Kozloduy lowland“ with code BG1G0000Qal005.

Pursuant to the available information at the DRRBMD at “Brestova padina“ site there are no drinking water sources or facilities for drinking and domestic water supply.

The most important lithological types which serve as geological barrier against the distribution of radionuclides at „Brestova padina” site are the loess-like clay (layer 1b) and the dusty to sandy clay (layer 3). The main geochemical parameters of these types are presented in **Table 1.5-7**. **Table 1.5-8** presents the distribution coefficient K_d of the forecasted radionuclides for the respective lithological types.

TABLE 1.5-7: GEOCHEMICAL CHARACTERISTICS OF “BRESTOVA PADINA“

Geochemical parameter	Unit	Lithological type	
		Loess-like clay	Dusty clay
Clay fraction content	%	18.3	46
Ion exchange capacity	meq/100 g	13.1	24.1
Organic carbon content	%	0.113	0.120
Carbonate content ($CaCO_3$)	%	37	10
pH of water sample	-	9	8.9
Content of:			
Ca^{2+}	mg/dm^3	3.95	7.7
CO_3^{2-}	mg/dm^3	7.20	5.75
Sr^{2+}	mg/dm^3	0.06	0.06

TABLE 1.5-8: DISTRIBUTION COEFFICIENT OF THE FORECASTED RADIONUCLIDES AT THE SITE BRESTOVA PADINA

Lithological type	Distribution coefficient K_d, m^3/kg										
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	^{39}Pu	^{241}Am
Non-saturated layer 1	0	3.5E-3	5.5E-2	0.60	0.12	0.55	1E-4	1E-3	1E-1	0.4	10
Non-saturated layer 2	0	1E-3	3E-1	0.62	0.39	0.55	1E-4	1E-3	3.5E-1	1.70	30
Aquifer	0	1E-3	3E-1	0.65	0.39	0.55	1E-4	1E-3	3.3E-1	1.70	30

„Brestova padina“ site belongs to the temperate continental climate area. The average annual rainfall according to data from HMS-Hayredin is 590 mm. The precipitation mode is of clearly exhibited continental nature. Precipitation is at its maximum level (72÷76 mm in May and June and at minimum level (39 mm) in January and February. Only twice in 100 years a 24-hr rainfall exceeding 80 mm is considered possible.

The average annual wind speed is about 1.6÷2.0 m/s. Western and north-western winds are prevailing. Light and moderate winds (speed up to 15 m/s) tend to repeat more often. It has been established that once in 10 years a wind speed of 28 m/s could possible occur, once in 100 years the wind speed could reach 37 m/s and once in 10,000 years it could be 45 and more m/s. The probability of tornado occurrences is negligible.

The site is situated on a slope in the highest part of a tributary valley and is not under any flood threat. The Danube river and its tributaries in the area (Tsibritsa and Ogosta) are at a sufficient distance from the site (more than 10 km) and do not pose any threats to the safety of the eventual repository.

There are no landslide processes and phenomena within the boundaries of the „Brestova padina” site. It is not threatened by erosion of the gully located underneath. At the beginning of the Holocene the erosion jutting subsided and from then till present accumulation processes are prevailing in the gully. The slanting slope (about 2÷3°), on which the site is situated is characterized with an exceptionally low surface erosion potential.

The site belongs to the eastern part of the protected area BG0002009 “Zlatiyata” for the conservation of wild birds established with Ordinance No РД-548/05.09.2008 of the Minister of Environment and Water (SG issue 83/23.09.2008).

In the 5-km zone are predominant the carbonaceous Chernozems. The conditions for growing agricultural crops are very good. In the 10-km zone the arable lands exceed 85%.

1.5.1.2.3 “MARICHIN VALOG“ SITE

„Marichin valog“ site is located at about 3.5 km from the town of Kozloduy and at 2.5 km west-southwest from Kozloduy NPP. Its altitude is 90÷100 m. Its location, shown above at **Figure 1.5-3**, is defined by the following coordinates:

TABLE 1.5-9 COORDINATES OF „MARICHIN VALOG“ SITE

	N	E	N	E
	DMS format		D format	
1	43°44′00.38″	23°43′23.93″	43.733439	23.723314
2	43°44′25.66″	23°43′57.95″	43.740461	23.732764
3	43°44′21.12″	23°44′06.18″	43.739200	23.735050
4	43°43′55.99″	23°43′31.87″	43.732219	23.725519

In geomorphological aspect the site belongs to the western part of the Danube hilly plain. The area around it includes part of the loess plateau at an altitude of 90÷100 m between the rivers Tsibritsa and Ogosta, crossed by relatively small tributary valleys two of which are tributaries of the Danube River, and the rest – of the Ogosta River south of the village of Glozhene, near the villages of Butan, Kriva bara, Bazovets, Septemvriitsi and other river terraces. The site is situated on a low-grade slope with inclination of 5÷10^0 to the east-northeast surrounded by shallow erosion landforms. The denivelation of the site compared to the erosion base is below 30 m. The modern topography has formed in the so called old abrasive accumulation layer (OAAL), formed at the end of the Pliocene and the beginning of the Pleistocene. The surface water of the area is drained in the tributary valley of the same name without forming a permanent water flow **Figure 1.5-4**).

In regional aspect „Marichin valog“ site belongs to the Lom depression in the north-western part of the Moesian platform (**Figure 1.5-5**). Around the site at the surface are uncovered Quaternary landforms (**Figure 1.5-11**).

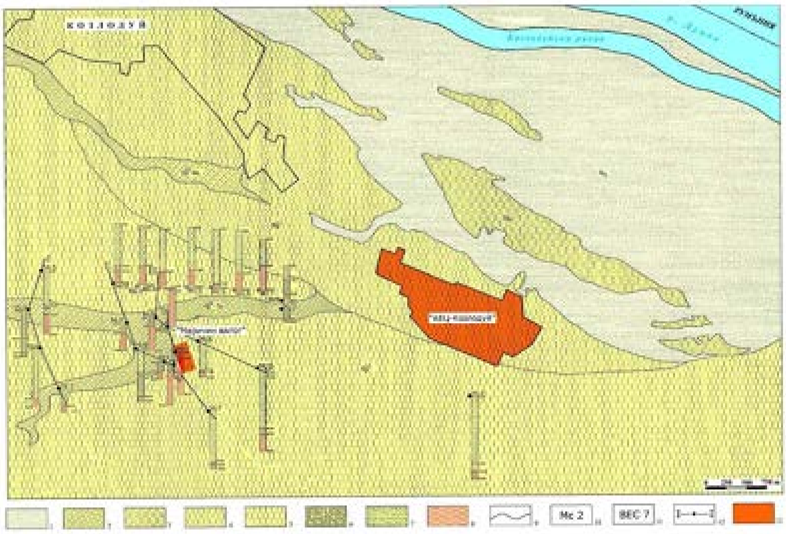

FIGURE 1.5-11: GEOLOGICAL MAP OF THE AREA OF „MARICHIN VALOG“ SITE

1-aluvial formations (gravel, sand, clay); 2-clayey loess; 3-loess-like sand; 4-sandy loess; 5-typical dusty-sandy loess; 6-top gravel-clayey complex; 7-aluvial formations in terrace T_1(sand and gravel); 8-clay (Brusarska formation); 9-lithologica boundary; 10-motor powered borehole; 11- vertical electrical powered borehole; 12-contour line; 13-“Marichin valog“ site

The geological cross section underneath is presented by Neogene, Paleogene and Mesozoic deposits uncovered by deep structural boreholes.

The Mesozoic includes the Triassic, Jurassic, and Cretaceous layers, composed of various terrigenous and carbonaceous sediments: limestones, dolomites, marls, clays, sandstones, conglomerates, aleurolites and argillites. The Paleogene sediments are presented by marls, clayey and organogenic limestones.

In the Neogene cross section are the Deleynska, Krivodolska, Furenska, Florentinska, Smirnenska and Archarska formations of Miocene age as well as the Brusarska formation of Pliocene age.

The Deleynska, Krivodolska, Furenska and Florentinska formations are presented by calcareous and aleurolite clays with single layers of clayey limestones, aleurolites and sandstones and limestones with clayey-sandy layers, lying at a depth more than 300÷400 m.

The Smirnenska formation is composed mainly of grey and greyish-green, low calcareous and dusty clays with layers of clayey limestones, marls and sandstones in the lower layer of the cross section. The formation thickness is 200÷250 m.

The Archarska formation is composed of yellowish to rust-coloured or greenish, small to large particle sized oligomictic sands, often with slanting layers. In the lower layers the sands are crossed by dark-grey, low calcareous, thin-layered clays. The top boundary of the formation is at a depth of 60÷70 m from the surface. The lower boundary with the Smirnenska formation is normal. The thickness of the Archarska formation is from 40÷50 m in the area of Kozloduy to over 100 m near the village of Septemvriitsi.

The Brusarska formation composes the pre-Quaternary layer. Its geological cross-section is dominated by clays which are irregularly crossed by spatially unsound, often lens-like layers of small to medium-size particle clayey sands.

The Quaternary formations cover the sediments of the Brusarska formation. They are presented by alluvial gravels, sands and clays with thickness of 6.0÷8.0 m, covered by Eolic loess with thickness 11÷13 m. The loess up to a depth of about 6.0 m from the surface is sandy and then gradually transforms into dusty and clayey.

The region of „Marichin valog“ site belongs to the eastern outskirts of the Lom depression which is the lowest part of Moesian platform – first-grade tectonic unit, situated on Bulgarian and Romanian territory. Its foundation in Bulgaria is composed of slightly folded Paleozoic rocks and its cover includes sub-horizontal Mesozoic and Neozoic sediments with joint thickness up to 7÷8 km. The tectonic development of the region underwent many stages which can be consolidated in three groups: *pre-Paleogene, Paleogene- Neogene and Quaternary.*

The pre-Paleogene tectonic development includes the forming of the slightly folded foundation of the Moesian platform till the mid-Paleozoic and the completion of the intensive tectonic activity at the end of the Triassic.

According to the multiple existing borehole data from the region, the movement of old faults in *the Paleogene-Neogene structural layer* hasn’t been proven with certainty. No evidence of faults impacting the modern relief have been found and no fold structures have been documented neither in the Miocene, nor in the Pliocene sediments.

The Neotectonic development is characterized with the lack of sharp gradients of the gravitational, geomagnetic and geothermal fields, as well as of local anomalies of these fields. Trends of relative subsidence in the ranges of (-1) to (-2) mm/y have been established. There’s no tension built-up in regional aspect. During the last 23.5 million years only fluctuation movements have been registered. In a radius of 30 km around „Marichin valog“ site there are no active faults, including Neogene and pre-Quaternary with any relief forming significance.

„Marichin valog“ site is located in the stable part of the Moesian platform which is characterized with low seismic activity. The maximum expected earthquake in the sub region of the site is M_{max} = 5.0. The main seismic hazard sources are seismic areas outside the site. According to the earthquake maps for periods of 1,000 and 10,000 years the area can experience earthquake impacts of degree VII on the MSK-64 scale caused by events in the seismic zone Vrancea in neighbouring Romania (distance over 240 km) which has experienced events of degree M> 7.

The earth foundation of the site is composed of the sediments of the complexes – the Quaternary and the Pliocene (**Figure 1.5-12**):

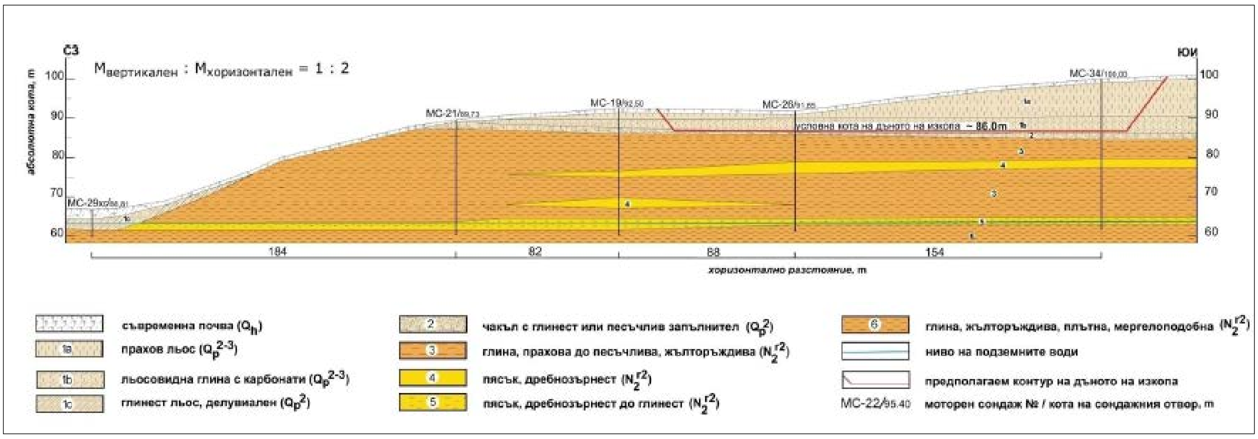

FIGURE 1.5-12: ENGINEERING-GEOLOGICAL CROSS SECTION OF „MARICHIN VALOG“ SITE

The Quaternary includes the modern soil with thickness 0.5÷1.0 m and loess sediments including:

- → Layer 1a – dusty loess with light brown to yellow brown colour;
- → Layer 1b – loess-like clays with thickness between 5 and 14 m (together with layer 1a);
- → *Layer 2* – gravel with clayey-sandy filling with thickness 0.5÷2.0 m;

Within the boundaries of the site the Pliocene sediments (Brusarska formation) are divided into four layers:

- → *Layer 3* - clay, dusty to sandy, rusty yellow. The overall thickness of the layer is from 16.5 to 18.0 m;
- → *Layer 4* –- small-sized sand. Forms horizontally unsound lenses and layers in layer 3;
- → *Layer 5* – small-sized sand to clayey sand, water-bearing. Developed everywhere below layer 3. Its thickness is between 1.5 and 3.0 m;
- → *Layer 6* – clay, rusty yellow to grey, compact with marly structure.

The thickness of the layer is about 60 m. Serves as a local water barrier.

The average values of the physical-mechanical parameters of the described layers are presented in **Table 1.5-10**.

The hydrogeological conditions in the *Lom artesian basin* where the „Marichin valog“ site is situated are characterized by lithostratigraphic units from the Triassic to the Quaternary situated in layers of various water permeability. Out of these the only important for the investment proposal are the groundwater accumulated in the Quaternary formations and in the Neogene sediments of the Archarska and the Brusarska formations which lie on top of the thick clay sediments of the Smirnenska formation.

TABLE 1.5-10: SUMMARY TABLE OF THE AVERAGE VALUES OF THE PHYSICAL-MECHANICAL PARAMETERS OF THE LITHOLOGICAL TYPES AT „MARICHIN VALOG“ SITE

No	Parameters	Unit	Lithological types						
			Layer 1a	Layer 1b	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
1	**Volumetric density ρ**	g/cm^3	1.57	1.91	2.04	2.03	1.87	2.08	2.15
2	**Frame volumetric density ρ_d**	g/cm^3	1.40	1.59	1.76	1.70	1.66	1.87	1.81
3	**Water content w**	%	12.1	19.7	15.9	19.2	12.7	11.5	18.8

No	Parameters	Unit	Lithological types						
			Layer 1a	Layer 1b	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
4	**Pore coefficient**	-	0.94	0.72	0.55	0.61	0.60	0.43	0.54
5	**Layering indicator I_p**	%	11.7	16.7	13.0	19.1	6.9	-	19.7
6	**Consistency indicator I_c**	-	> 1	0.70	> 1	0.98	0.79	-	1.00
7	**Water saturation level S_r**	-	0.36	0.76	0.79	0.86	0.56	0.97	0.96
8	**Macro pore volume, $n_{mp0,4}$**	%	7.8	-	-	-	-	-	-
9	**Compression module $M_{0,3}$**	MPa	11.7	-	-	13	15.8	-	27.7

„Marichin valog“ site belongs to the region of the groundwater bodies „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 and „Pore groundwater in the Quaternary – between the rivers Lom and Iskar” with code BG1G0000Qpl023 on the territory of the Danube region river basin management directorate shown on **Figure 1.5-6**.

In the hydrogeological cross section of the site are differentiated non-saturated (aerated) layer, part of groundwater body „Pore groundwater in the Neogene – Lom-Pleven depression” with code BG1G00000N2034 and water barrier.

With a trench type of repository at elevation about 85 m below it will exist a non-saturated (aerated) zone with thickness about 20 m, composed of sediments of the Brusarska formation.

Under the aeration zone is uncovered the top part of the upper layer of groundwater body BG1G00000N2034. The groundwater is contained in small-sized sand layers of irregular area and depth the first of which has thickness of 1.5÷2.0 m at elevation about 65 m. Their static level is established at a depth about 30÷35 m below the surface in an altitude range of about 62÷63 m. The groundwater flows from south-southwest to north-northeast with pressure gradient of 0.0036÷0.01 (right below the site is 0.0045). Within the borders of the site it is recharged by rainfall and is drained in the low part of the tributary valley at a distance of about 300÷350 m from the north-eastern part of the site (**Figure 1.5-13**).

The filtration capacity of the aquifer is low. It is exhibited by layer permeability of about 12 m^2/d and filtration coefficient about 1.1 m/d.

The aquifer in the sands of the Archarska formation (lower layer of groundwater body BG1G00000N2034) is located at about 100 m from the surface. Its thickness is 60÷80 m. It is recharged by the rainfall in the uncovered zones in southern and southeaster direction. The average values of permeability in regional aspect are 2500 m^2/d and filtration coefficient 25 m/d. The groundwater flows from the south-southeast to the north-northwest to the Danube River where it connects to groundwater body „Pore groundwater in the Quaternary-Kozloduy lowland“ with code BG1G0000Qal005.

Pursuant to the available information at the DRRBMD at “Marichin valog“ site there are no drinking water sources or facilities for drinking and domestic water supply.

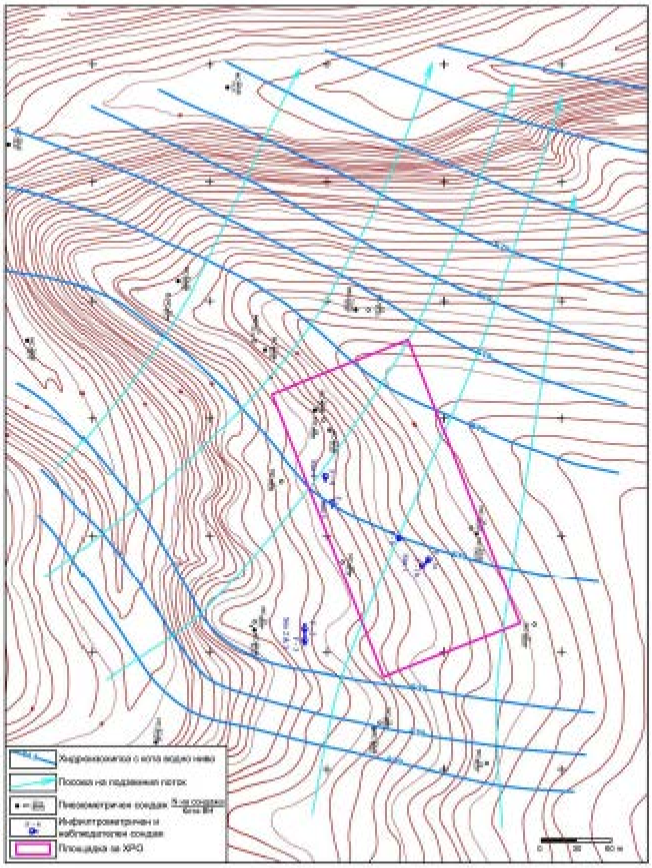

FIGURE 1.5-13: HYDRODYNAMIC MAP OF „MARICHIN VALOG“ SITE

The most important lithological types which serve as geological barrier against the distribution of radionuclides at „Marichin valog” are gravel with clayey-sandy filling (layer 2) and the dusty to sandy clay (layer 3). The main geochemical parameters of these types are presented in **Table 1.5-11**. **Table 1.5-12** presents the distribution coefficient K_d of the forecasted radionuclides for the respective lithological types.

TABLE 1.5-11: GEOCHEMICAL CHARACTERISTICS OF „MARICHIN VALOG“ SITE

Geochemical parameter	Unit	Lithological type	
		Gravel with clayey-sandy filling	Dusty to sandy clay
Clay fraction content	%	25	48
Ion exchange capacity	meq/100 g	10	22
Organic carbon content	%	0.135	0.082
Carbonate content ($CaCO_3$)	%	33	2
pH of water sample	-	9	8.5
Content of:			
Ca^{2+}	mg/dm^3	12.64	2.22
CO_3^{2-}	mg/dm^3	5.70	4.99
Sr^{2+}	mg/dm^3	0.14	0.02

The site belongs to the temperate continental climate area. The average annual rainfall according to data from all nearby HMS is 550 mm. Only data from MS-Kozloduy shows the average annual rainfall for a 10-year period (1968÷1977) as 595 mm. According to the automatic meteorological monitoring system of Kozloduy NPP (AMMS) (1998÷2013) the annual rainfall amount varies from 277.4 mm (in 2004) to 681.8 mm (in 2010) with an average of 436.6 mm. The absolute maximum 24-hr rainfall at Kozloduy is 87 mm. The precipitation mode is of clearly exhibited continental nature. Precipitation is at its maximum level (65÷70 mm) in May and June and at minimum level (35÷38 mm) in February-March.

TABLE 1.5-12: DISTRIBUTION COEFFICIENT OF THE FORECASTED RADIONUCLIDES AT „MARICHIN VALOG“ SITE

Lithological type	Distribution coefficient K_d, m^3/kg										
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	^{39}Pu	^{241}Am
Non-saturated layer 1	**0**	**5E-3**	**5E-1**	**0.40**	**0.24**	**0.16**	**1E-4**	**1E-3**	**0.15**	**0.10**	**10**
Non-saturated layer 2	0	1E-3	6.5E-1	0.65	0.39	0.55	1E-3	1E-3	0.33	1.70	30
Aquifer	0	1E-3	6E-2	0.30	0.015	0.16	1E-4	1E-3	0.10	0.55	19

The average annual wind speed is about 3.5 m/s. The most quiet weather is in December with an average wind speed of 1.7 m/s, and the most windy is in April – average wind speed of 4.7 m/s. During the year the quiet periods are relatively rare – 8.7%. West and northwest winds are prevailing. Light and moderate winds (speed up to 15 m/s) tend to repeat more often. It has been established that the probable maximum wind speed can reach up to 33 m/s with an occurrence possibility once in 15 years. The average annual air temperature is 11÷13 ^{0}C. During the winter the air temperature reaches up to -20÷25 ºC, and the absolute minimum temperature on single occasions has reached about 30 ºC below zero. The annual relative humidity maximum (December) is rather high - 86 %. The humidity minimum is in August and July (62÷64 %). Summer has average July temperature of 23.4÷24.3 ^{0}C, the average maximum temperature is 36°C, and the absolute August maximum is 39.8 °C. An average of 80 % of the summer days (in June, July and August) have maximum temperature above 25 ºC and 40 % of the days – above 30ºC.

There are no landslide processes and phenomena within the boundaries of the „Marichin valog” site. It is not threatened by erosion of the gully located underneath. At the beginning of the Holocene the erosion jutting subsided and from then till present accumulation processes are prevailing in the gully. The comparison of the modern soil thickness with the soil of the plateau located nearby shows that regardless of the location of the site on a slanting slope, the surface erosion from the beginning of the Holocene till nowadays is insignificant and can be neglected as a factor threatening the safety of an eventual repository.

The site is outside the protected area BG0002009 „Zlatiyata” for the conservation of wild birds established with Ordinance No РД-548/05.09.2008 of the Minister of Environment and Water (SG issue 83/23.09.2008.).

1.5.1.2.4 “VARBITSA“ SITE

„Varbitsa“ site is located at about 3.0 km southeast of the centre of the village of Varbitsa, Vratsa municipality, at 27 km from Vratsa and at 52 km south from Kozloduy NPP at straight-line distance with coordinates presented in **Table 1.5-13**:

“Varbitsa” site is located on a terrain with altitude 312÷336 m. It sits in a saddle between the heights Dragoevski chukar and Tepeto and is characterized as a closed topographic basin.

TABLE 1.5-13 COORDINATES OF „VARBITSA“ SITE

	N	E	N	E
	DMS format		D format	
1	43°16′35.58″	23°51′45.17″	43.276550	23.862547
2	43°16′17.40″	23°52′34.02″	43.271500	23.876117
3	43°16′07.16″	23°52′27.97″	43.268656	23.874436
4	43°16′23.62″	23°51′41.42″	43.273228	23.861506

The ridge on the slanting slope of which the site is situated is a water divide. To the west of it the water flows to the Skat River and to the east to the Gabarska river and via its tributaries to the basin of the Iskar river. To the southeast of the village of Varbitsa a relatively wide valley collects the water from the nearby heights. To the west are found Pliocene level areas. In general the topography is of erosion-denudation type. The denivelation of the site compared to the erosion base of the depression is below 30 m, the slope incline is up to 10°.

The lithostratigraphic cross section in the region of Varbitsa site uncovered by deep structural boreholes includes Triassic, Jurassic, lower Cretaceous and upper Cretaceous sediments with thin Quaternary cover (**Figure 1.5-14**[92]).

The Triassic and the Jurassic are composed of various terrigenous and carbonaceous sediments: limestones, dolomites, marls, aleurolites, argillites and tuffs lying at a depth under 3200÷3500 m.

In the lower Cretaceous are differentiated the Salashka, Mramorenska, Cherepishka, Lyutibrodska and Sumerska formations. The Salashka, Mramorenska, Cherepishka and Lyutibrodska formations are presented by limestones, marls and sandstones.

The Sumerska formation is uncovered within the boundaries of the site and the surrounding terrain. It is presented by dark grey carbonaceous marls with layers of fine particle sandstones. The thickness of the formation is 950÷1200 m.

The upper Cretaceous sediments are uncovered to the east and south of the „Varbitsa“ site. They are presented by limestones with flint inserts.

In regional aspect the „Varbitsa” site is located in the eastern part of the Western Fore Balkan and belongs to the north flank of the Varbishka structure which is defined in the complex Mramorenska anticline in the dome of the eastern part of the Belogradchik anticlinorium.

[92] Tsankov Ts., L. Nedyalkova, V. Angelov et al., 1991. Geological map of Bulgaria. Map sheet of Vratsa. Scale 1:100 000

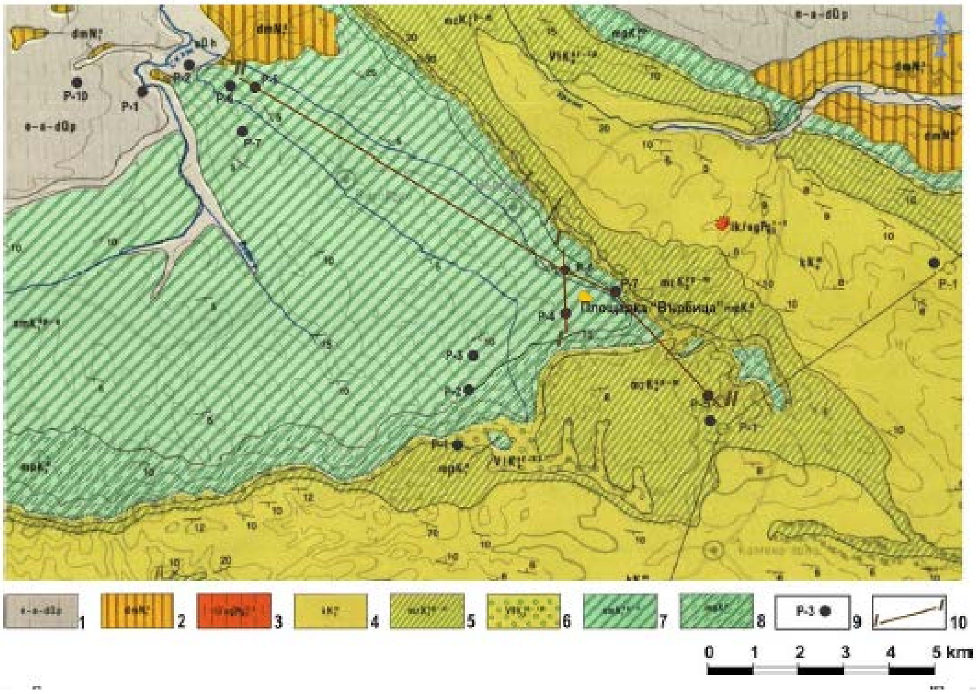

FIGURE 1.5-14:GEOLOGICAL MAP OF THE REGION OF VARBITSA SITE

1 – eolic-aluvial-deluvial formations – loess-like clays; 2 - Dimovska formation (sands, sandstones, limestones); 3 – Aglenski part of the Lukovitska formation (clays, marls); 4 – Kaylashka formation (quarry limestones); 5 - Mesdrenska formation (grainy limestones with flint deposits); 6 - Kuninska formation (limestones with marl layers); 7 – Sumerska formation (marls with sandstone layers); 8 – Malopeshtenska formation (glauconite sandstones and marls); 9 – borehole №; 10 – geological contour

It is exhibited on the surface of the upper Cretaceous limestones which east of the village of Varbitsa close the Borovan and Veslets upper Cretaceous rock cliff. In the dome part are uncovered the marls of the Sumerska formation. During the following geological ages, including the Neogene and Quaternary, there is no data for shifts along the deep faults and therefore the neotectonic environment of the area is considered as calm. The site is located within the borders of a tectonic block which has not been disturbed by active faults and geodynamic zones and lacking sharp gradients and clearly exhibited local anomalies of the gravitational, magnetic and geothermal fields.

The sub-region within a radius of 50 km around “Varbitsa” site is situated in the southern outskirts of the stable part of the Moesian platform and the northern divide of the Fore Balkan and includes the northernmost parts of the Sofia seismic zone. The maximum expected earthquake at the site is M_{max} = 5.5. According to the earthquake maps for periods of 1,000 and 10,000 years the area can experience earthquake impacts of degree VII on the MSK-64 scale. The most powerful seismic impacts with intensity over VI degree are caused by events in the Kresna seismic zone.

The earth foundation of “Varbitsa” site up to a depth of 50 m is composed of three engineering-geological layers (**Figure 1.5-15**):

→ *Layer 1*-deluvial-proluvial clays and clayey gravels with thickness from 4÷5 m in the north-eastern part up to 11.0÷11.5 m in the south-western part of the site;

→ *Layer 2*-weathered marl with thickness of the layer from 4.5 to 10 m;

→ *Layer 3*-fresh non-weathered marl. It belongs to the semi-rocky engineering-geological varieties. According to oil and natural gas research the thickness of the marls in the area of the site exceeds 1000 m.

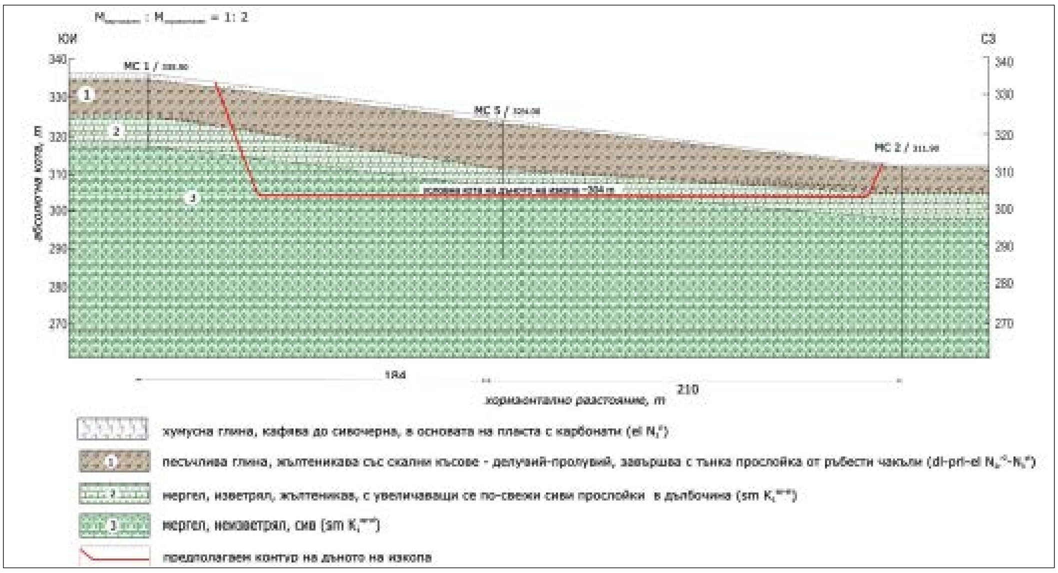

FIGURE 1.5-15: ENGINEERING-GEOLOGICAL CROSS SECTION OF „VARBITSA“ SITE

The average values of the physical-mechanical parameters of the described layers are presented in **Table 1.5-14**.

TABLE 1.5-14: SUMMARY TABLE OF THE AVERAGE VALUES OF THE PHYSICAL-MECHANICAL PARAMETERS OF THE LITHOLOGICAL TYPES AT „VARBITSA“ SITE

No	Parameters	Unit	Lithological types		
			Layer 1	Layer 2	Layer 3
1	**Volumetric density ρ**	g/cm^3	2.11	22.8	24.0
2	**Frame volumetric density ρ_d**	g/cm^3	1.77	12.8	8.6
3	**Water content w**	%	19.1	0.37	0.25
4	**Pore coefficient**	-	0.56	0.72	0.55
5	**Layering indicator I_p**	%	19.1	14.4	13.3
6	**Consistency indicator I_c**	-	0.94	> 1	> 1
7	**Water saturation level S_r**	-	0.938	0.957	0.60
8	**Inner friction angle φ**	degree	24.1	23.1	-
9	**Cohesion C**	kPa	19.6	44.4	-
10	**Compression module $M_{0,3}$**	MPa	18.0	20.4	-

The region of „Varbitsa” site belongs to the Fore Balkan part of the Moesian artesian basin. During boring studies for oil and natural gas several very deep aquifers have been established – Triassic aquifer, Upper Cretaceous- Lower Cretaceous aquifer and Aptian aquifer. These hydrogeological complexes play no part and would have no significance in the assessment of the safety of an eventual surface repository for RAW[93]. Actually in the area of the site there are no permanent aquifers which could have a direct relation to the operation of the repository. Only in the lower gravel part of layer 1 form temporary moist areas in which the infiltrated rainwater drains. Provided that the repository’s foundations are built at an elevation about 304 m, they will actually reach the weathered and/or fresh lower Cretaceous Aptian marls of the Sumerska formation. The latter serve as a local watertight slate. These are compact, very low permeability rocks. The results of the

[93] Pursuant to the Ordinance of safe management of radioactive waste, 2014.

performed field filtration tests show that the filtration coefficient of the marls varies within the range of $1.10^{-4} \div 1.10^{-5}$ m/d. Probably deeper, as some literary data shows, the lower Cretaceous marls become even more impermeable. At a significant depth of 1000÷1100 m below the Sumerska formation in the karstified Urgonian limestones is situated a Lower Cretaceous aquifer which is practically of no significance to the investment proposal.

Outside of the region of the „Varbitsa” site is established only the pressureless groundwater body *“Karst water in the Fore Balkan”* with code *BG1G0000K2s037*, which has formed in the Upper Cretaceous (Senonian) fractured and karstified limestones showing at the surface to the north, east and south of the site (**Figure 1.5-16**)

In it have formed the karst basins Gradeshnishko-Vladimirovski, Mezdrenski, Kamenopolski, Lukovitski, Tipchenski and Gabrovo-Trevnenski. “Varbitsa” site is within the boundaries of the *Kamenopolski karst basin.*

Groundwater body *BG1G0000K2s037* is defined as a drinking water protection zone with code BG1DGW*0000K2s037*. Its chemical and quantity status are good.

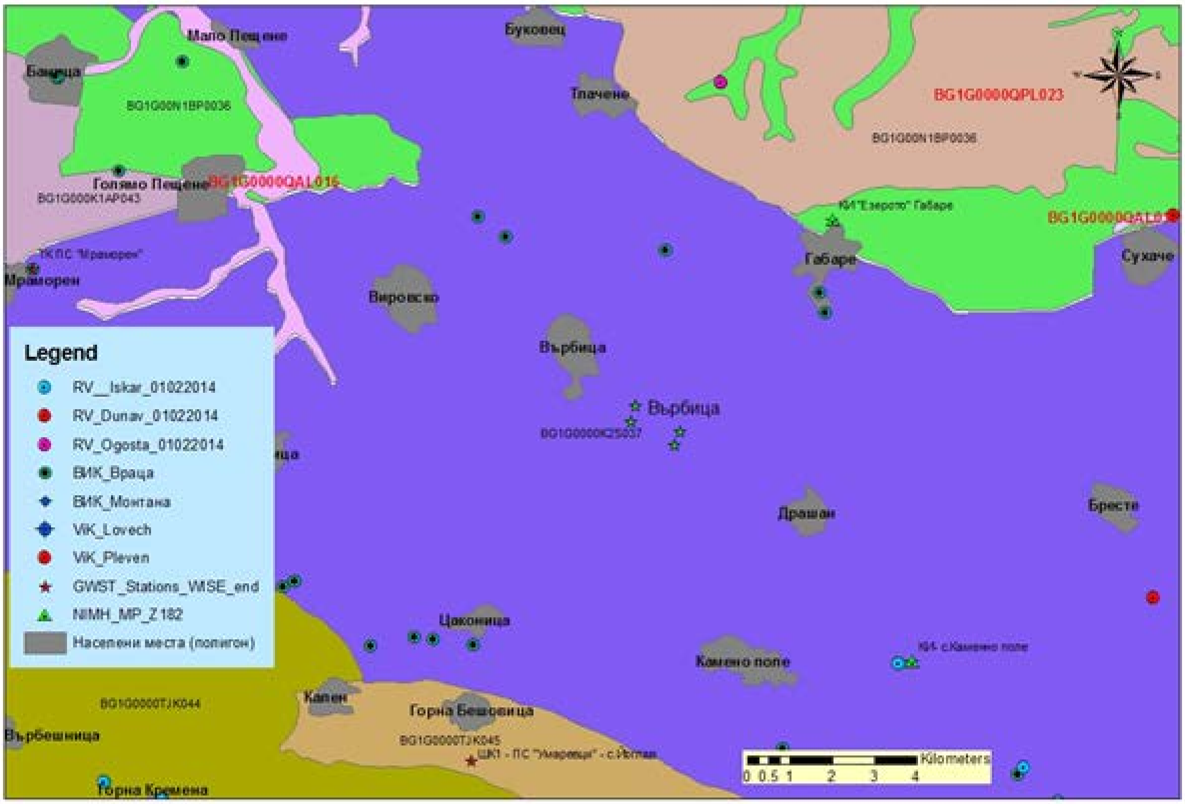

FIGURE 1.5-16:MAP OF PART OF GROUNDWATER BODY “KARST GROUNDWATER IN THE FORE BALKAN” WITH CODE BG1G0000K2S037

Pursuant to the available information at the DRRBMD at “Varbitsa“ site there are no groundwater sources or facilities for drinking and domestic water supply.

The most important lithological types which serve as geological barrier against the distribution of radionuclides at „Varbitsa” site are the weathered (layer 2) and fresh marls (layer 3). The main geochemical parameters of these types are presented in

Table 1.5-15. **Table 1.5-16** presents the distribution coefficient K_d of the forecasted radionuclides for the respective lithological types.

TABLE 1.5-15: GEOCHEMICAL CHARACTERISTICS OF „VARBITSA“ SITE

Geochemical parameter	Unit	Lithological type	
		Weathered marls	Fresh marls
Clay fraction content	%	30.25	29.25
Ion exchange capacity	meq/100 g	5.75	3.88
Organic carbon content	%	4.25	4.00
Carbonate content ($CaCO_3$)	%	17.70	13.28
pH of water sample	-	8.50	8.16
Electric conductivity of water sample	µS/cm	304	345
Dissolved Calcium	mg/l	35.53	41.95
Dissolved Potassium	mg/l	10.76	14.04
Hydro carbonates	mg/l	55.10	93.05
Carbonates	mg/l	6.6	3.6

TABLE 1.5-16: DISTRIBUTION COEFFICIENT OF THE FORECASTED RADIONUCLIDES AT „VARBITSA“ SITE

Lithological type	Distribution coefficient K_d, m^3/kg						
	^{59}Ni /^{63}Ni	^{90}Sr	^{94}Nb	^{129}I	^{137}Cs	^{39}Pu	^{241}Am
Weathered marls	0.3	0.18	0.16	3E-3	0.10	0.4	8
Fresh marls	4.3	0.16	0.16	3E-3	0.15	0.4	8

„Varbitsa“ site belongs to the temperate continental climate area. The average annual rainfall according to data from HMS – Gabare is 680 mm. The annual precipitation mode is of clearly exhibited continental nature. Precipitation is at its maximum level (87÷91 mm) in May and June and at minimum level (36÷40 mm) in February-March. During the past 100 years the biggest 24-hr rainfall (99 mm) was registered at HMS-Gabare in 1940. It was established that intensive 24-hr rainfall up to 25 mm can be expected annually. Only twice in 100 years a 24-hr rainfall exceeding 90 mm could be possible.

The average annual wind speed is about 1.8 m/s. The most quiet weather is in December with an average wind speed of 1.6 m/s, and more windy is in March and April with average wind speed of 2.1 m/s. West and northwest winds are prevailing during the year, followed by southwest. During the year the quiet periods are about 42%. The chance of strong winds (speed over 25 m/s) is small. It has been established that once in 10 years it is possible to have wind with speed 26 m/s and once in 100 years with speed 36 m/s. During the past 100 years tornadoes with devastating effect have not been registered in the region.

The average annual air temperature is 11.4°C. The average monthly maximum temperature is 22.6°C in July and August, and the average monthly minimum is (-1.8°C) in January.

Within the borders of the „Varbitsa” site and the surrounding area there are no unfavourable physical-geological gravitational processes and phenomena of (landslides, landslips). Outside of the area in the carbonaceous sediments of the upper Cretaceous have developed karst processes and phenomena.

The shortest road from Kozloduy NPP to „Varbitsa“ site is 90 km, 68 km of which are along a second-class road No 4 from Kozloduy to Vratsa and 22 km along third-class road No 1306, which needs repairs. The transportation along this route will cross 14 villages.

The site does not belong to any Natura 2000 protected areas.

1.5.1.3 MOTIVATION OF THE SELECTION OF “RADIANA” SITE FOR THE IMPLEMENTATION OF THE NDF

Pursuant to the provisions of the nuclear legislation the comparison of the potential sites „Radiana“, „Marichin valog“ and „Brestova padina“ has been performed using a multi-criteria system analysis based on a system of comparable criteria. The multi-criteria system has been developed based on the requirements for site selection in the Ordinance for the safe management of radioactive waste, 2004 and the Safety Standards of The International Atomic Energy Agency - Siting of Near Surface Disposal Facilities, Safety Standards Series No. 111-G-3.1 and Near Surface Disposal of Radioactive Waste, Safety Standards Series No. WS-R-1[94].

The multi-criteria analysis is a widely used method for comparison of sites which are assessed and compared on a number of criteria. The method is widely applied during the site selection in a number of developed countries. It has been used within the BAS Concept for a national repository for radioactive waste[95], it has been approved and recommended by international consultants from leading European radioactive waste management agencies which have examined the management of radioactive waste в Bulgaria, it has been applied during the implementation of stage 2 Data collection and regions analysis for reducing the number of prospective sites[96]. Its application for the purposes of site selection has been reported at a number of international forums[97],[98],[99].

The system of comparative criteria includes 23 comparative criteria divided into 4 groups: group A – Nuclear safety provided by natural conditions; group B – Impacts of unfavourable processes and phenomena; group C – Probable impacts on the environment; group D – Social-economic acceptability; all presented on **Figure 1.5-17**. The group division is provisional for the criteria in groups A, B, and C since ultimately the criteria in all three groups measure the capacity of the site to provide the safe construction and operation of the repository with minimum impacts on the population and environment.

The criteria represent detailed main safety requirements which have been stipulated by the nuclear legislation for sites designated for the construction of near-surface disposal facilities for radioactive waste.

[94]IAEA, Near Surface Disposal of Radioactive Waste, Safety Requirement, Safety Standards Series No. WS-R-1, 1999

[95]BAS Concept for a national radioactive waste disposal facility. Bulgarian Academy of Science, 1993, BAS

[96]Report on the implementation of stage 2 Data collection and regions analysis, SE RAW, 2007

[97]Evstatiev D. & B. Vachev. 1993. Site Selection Procedure for High Level Radioactive Wastes Disposal in Bulgaria. IAEA Experts Meeting under IAEA Regional Project for Technical Assistance PEP/9/010. Recommendation on management of radioactive wastes from VVER, Sofia, February 22-26

[98]Vachev, B., D. Evstatiev. 1994. Radioactive Wastes Management - AHP Application, In: Proc. 3rd Int.Symp. on AHP, Washington, DC USA, RWS, 585-596

[99]Vachev B. 2001. Radioactive waste disposal site selection, In: Proc. of 6 Int.Symp. on Analytic Hierarchy Process, ISAHP 2001, Berne, Switzerland, August 2-4, 491-500

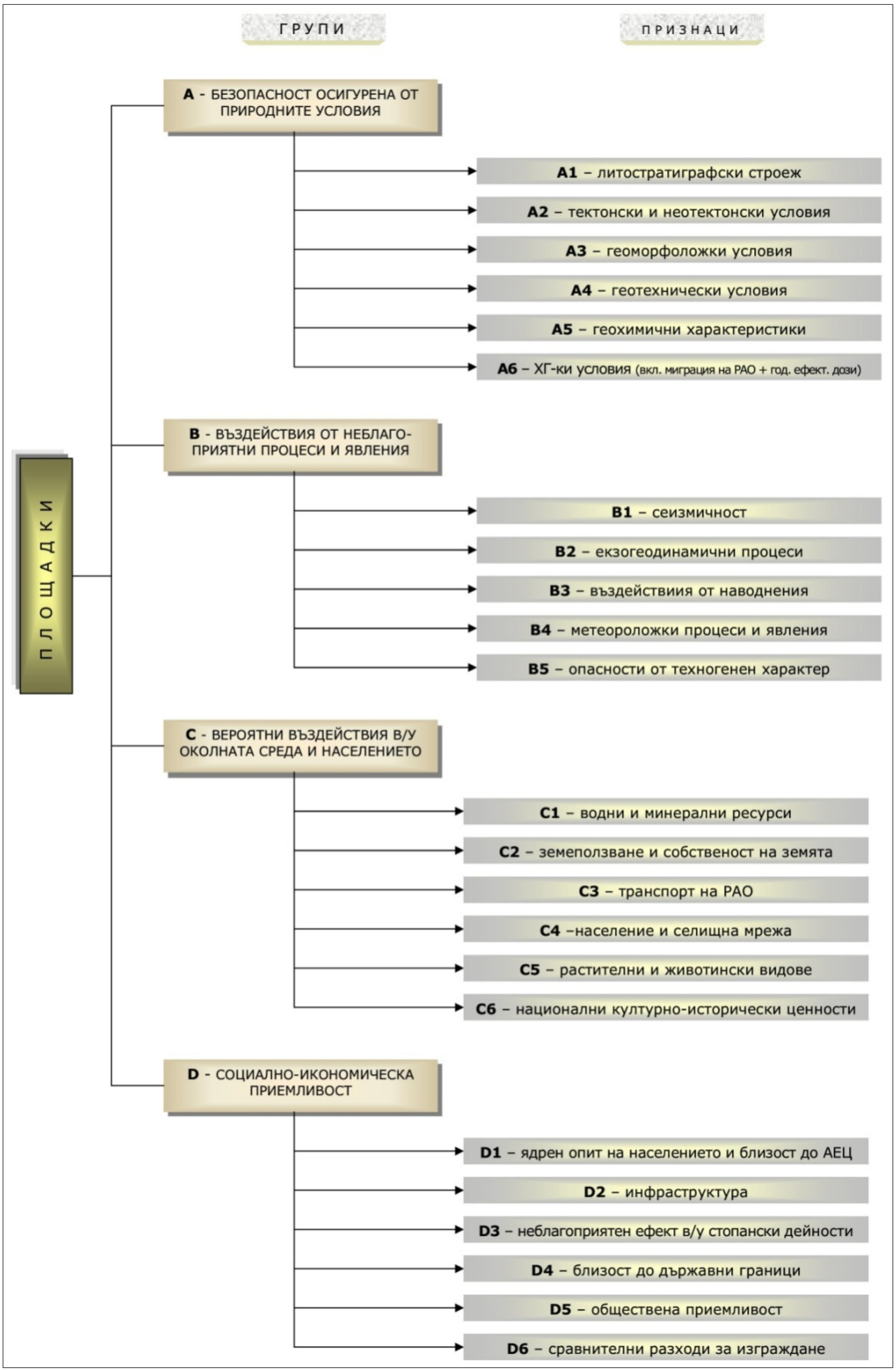

FIGURE 1.5-17 CHART OF THE GROUPS AND CRITERIA USED FOR THE COMPARATIVE ANALYSIS OF THE POTENTIAL SITES

Pursuant to the Ordinance for safe management of radioactive waste, 2004, the site for NDF must meet the following requirements:

(1) The geological structure of the site must contribute to the isolation of the RAW and for limiting the migration of radionuclides to the biosphere and also to provide stability of the

disposal system and to possess the necessary geotechnical characteristics for the construction of the facility;

(2) The hydrogeological features of the site must be characterized with low velocity and long travel routes of groundwater for limiting the migration of radionuclides;

(3) The geochemical characteristics of groundwater and the geological environment must contribute for the limited discharge of radionuclides from the facility and not to decrease significantly the protective barriers resources;

(4) The site must be located in an area of low tectonic and seismic activity which must not threaten the system isolation capacity;

(5) Processes evolving on the surface of the facility such as erosion, landslides and floods, as well as extreme weather conditions must not impact the capacity of the disposal system to perform the main safety functions;

(6) The site should be situated in such a manner so that the probability of compromising its isolation function as a result of the activities of the present or future generations at it or close to it should be low;

(7) During the selection of sites for disposal of RAW priority should be given to sites requiring a minimum of geological and hydrological studies and subject to simple and reliable mathematical modelling;

(8) In the selection of a site should also be considered the existing road infrastructure for providing the transportation of the RAW to the facility with a minimum risk to the population.

In the development of the criteria under which the sites should be assessed using the multi-criteria analysis have also been taken into account the requirements for environmental protection as one of the main principles in the management of radioactive waste, as well as of the democratic development of any democratic society, pursuant to which radioactive waste repositories cannot be constructed on sites where the population is against their construction.

1.5.1.3.1 DEFINING THE CRITERIA USED FOR THE ASSESSMENT AND COMPARATIVE ANALYSIS OF THE POTENTIAL SITES

Group A – Safety provided by natural conditions

The criteria in this group refer to the natural conditions of the site which contribute to its safety against the distribution of radionuclides in the environment. This group includes parameters referring both to the transmitters of radionuclides (hydrogeological conditions) as well as to the isolation capacity of the environment (lithostratigraphic composition, geochemical characteristics). The safety provided by natural conditions is evaluated also with criteria taking into account the geomorphological (topographic) and geotechnical conditions of the site.

Parameter A1 – Lithostratigraphic composition

Main principle: The lithostratigraphic composition of the earth foundation of the site must contribute in the highest possible degree for the isolation of the repository from the environment and for preventing the distribution of radionuclides to the biosphere.

Essence: Preference is given to sites with clear and simple composition and structure characterized by uniformity both vertically and horizontally and clear routes for eventual migration of radionuclides to the biosphere. The preferred foundation is built by rocks and minerals resistant to chemical and physical impacts.

Parameter A2 – Tectonic and neotectonic conditions

Main principle: the repository should be located in an area of relatively calm tectonic and neotectonic environment during the late Neogene and the Quaternary.

Essence: Sites in the areas of which the potential for unfavourable tectonic and neotectonic events is low enough in order to guarantee the invariability of the geological environment around the repository.

Parameter A3 – Geomorphological conditions

Main principle: the repository should be located on a relatively low altitude compared to the closest erosion base, in accessible terrains with relatively stable geomorphological conditions, which haven’t changed drastically during the Quaternary.

Essence: The location of the repository at a relatively high altitude compared to the erosion base would significantly increase the risk of radionuclide distribution. The area of the site must have good natural conditions for surface water drainage.

Parameter A4 – Geotechnical conditions

Main principle: The geotechnical conditions must allow the construction of the repository with accessible technologies confirmed in practice which can guarantee safe long-term operation of the system.

Essence: The geotechnical conditions of the site should allow for significant load determined by the weight of the RAW subject to disposal, but without major preliminary preparation or implementation of special techniques, i.e. the geotechnical conditions should be such as to facilitate to a maximum extent the execution of the construction works.

Parameter A5 – Geochemical characteristics

Main principle: the earth environment at the site must have geochemical and hydro chemical characteristics which help the retention of radionuclides and do not deteriorate the long-term stability of the engineered barriers.

Essence: Sites where the earth foundation is built of sediments facilitating the absorption processes, the retention of radionuclides and the preservation of the qualities of the engineered barriers will be preferred. Such features are characteristics mostly of the clays with predominant minerals from the smectite group and the clayey marls. At the other end of the provisional scale, i.e. materials with poorest absorption characteristics are the large particle unbounded soils (sands, gravels).

Parameter A6 – Hydrogeological conditions

Main principle: The hydrogeological conditions at the site must be characterized with the thickest possible aeration zone, with small saturation of the aquifer up to which eventual radionuclides may reach and longest possible route and lowest possible flow speed of the water in this aquifer.

Essence: Preference is given to sites whose natural conditions provide thick non-saturated zone (over 20 m) with low $k_f < 10^{-10}$m/s; lack or presence of low saturated aquifers at a depth up to 100 m; minimal flow of groundwater to the zone under the repository; longest and slowest possible flow of groundwater from the repository to the biosphere.

Group B – Impacts from adverse processes and phenomena

This group includes criteria accounting for the probability of occurrence of dangerous and risky processes and phenomena both of natural (exogenous and endogenous) as well as techogenic nature.

The reliable forecasting of such probability is of foremost importance for the correct selection of a suitable site.

Parameter B1 - Seismicity

Main principle: The site must be part of a region with the lowest possible seismic intensity and minimum hazard of seismic deformations.

Essence: Sites in regions with expected seismic impact of VII degree under the MSK scale for a 10,000-year period are preferred. Areas with zones of possible seismic activity (PSA) with magnitude of the earthquakes up to 5.0 where there is no hazard of seismogenic deformations on the earth surface such as activation of old fault surface, landslides, soil liquidification, changes in the hydrodynamic mode of groundwater are preferred.

Parameter B2 – Exogeodynamic processes

Main principle: The range and intensity of the exogeodynamic processes in the area of the site must have minimum impact on the stability of the natural geologic barriers and not pose risks to the safety of the repository and its infrastructure.

Essence: The construction of the repository in unstable or potentially unstable terrains where danger of development of intensive erosion processes, weathering or other exogeodynamic processes exist which can disturb the engineered barriers.

Parameter B3 – Flood impacts

Main principle: The site must not be under the risk of direct flooding from surface water. The impact of extreme hydrological phenomena including on the underground hydrodynamic environment must be minimal.

Essence: Sites where flood threats exist have been excluded at stage 2 Data collection and regions analysis. Here are considered changes of the level of groundwater due to extreme hydrological processes related mainly to breakdowns of dams, irrigation canals, mill tailing dams, etc. and difficulties even temporary in the access to the site due to hydrological phenomena outside the area of the site.

Parameter B4 – Climatic processes and phenomena

Main principle: In the selection of the site preference is given to regions with less precipitation amounts.

Essence: The precipitation quantity is a determining factor for the speed of migration processes through the non-saturated zone.

Parameter B5 – Technogenic hazards

Main principle: The location of the site must be such as not to allow various present or future technogenic activities to disturb the normal operation and the stability of the engineered barriers of the repository.

Essence: The technological processes in a number of industrial enterprises of the chemical, oil processing, military, etc. industries have certain degrees of risk and can cause major industrial failures which can impact significant territories including the area of the repository for RAW, category2a. The presence of mining areas in the area of the site is undesirable since these could cause collapsing of the terrain surface and facilitate the migration of radionuclides into the groundwater.

Group C – Possible impacts on environment and population

This group includes criteria for assessing the impact of the repository on the environment in normal and emergency scenarios. The main components of the environment are reviewed such as:

biosphere (impact on humans, animals and plants) and geosphere (impact on water and mineral resources, soils, etc.,). Preference is given to areas whose natural characteristics will provide minimal impact on the population and environment.

Parameter C1 – Water and mineral resources

Main principle: The repository must not obstruct the present and future utilization of important mineral resources and must not pollute waters.

Essence: Preference is given to sites where the probability of the host rock to contain precious natural resources such as oil, gas, ores, groundwater is minimal. The probability of pollution of surface water in the area is also considered.

Parameter C2 – Land use and ownership

Main principle: During the selection of a suitable site must also be taken into account the use, category and ownership of the land. It is necessary to consider also its future development and the regional planning for the respective area.

Essence: The ownership or the land rights in most countries are a significant factor for the approval of the site of the repository from the standpoint of economics and public reaction. Lands with low productivity which are of no interest to the national economy and foreign markets are preferred. Terrains owned by the state, municipality or state institutions and state corporations are preferred.

Parameter C3 – Transportation of RAW

Main principle: The site of the repository must be selected in such a manner so that the transportation of the RAW should create no risk for the population.

Essence: The transportation of radioactive waste to the repository can create hazard of exposure of the population to ionizing radiation and environmental pollution. The longer the distance for transportation of the waste, the greater the hazard. Sites located at shorter transportation distances are preferred, especially such where the transportation can avoid residential areas.

Parameter C4 – Population and settlement network

Main principle: Preference is given to areas with low population density and low urbanization and areas with no complicated environment.

Essence: Areas with underdeveloped settlement network near the site are preferred. This is determined not so much by the possibility of negative impacts on the population from the disposed radioactive waste, but from the negative psychological impact and limiting the expansion possibility of the settlements in the vicinity of which the repository is located.

Parameter C5 – Plant and animal species

Main principle: The constriction of the repository and its operation must not cause any adverse impacts on the populations of plant and animal species.

Essence: The construction and operation of the repository could alter the normal living conditions and reproduction of the plant and animal species. In order to prevent disruption of the ecological balance preference is given to territories with scarce and inferior vegetation which are inhabited by few animal species and located far from protected areas (including under Natura 2000).

Parameter C6 – National cultural and historical landmarks

Main principle: The constriction of the repository must not affect natural landmarks, historic and cultural monuments of national and world significance.

Essence: It is necessary to take into account the regions with historic and cultural monuments protected by the UNESCO and with national importance, natural phenomena and ethnographic reserves of big tourist and scientific value, etc. Near such areas it is not recommended to locate potentially suitable sites for a RAW repository.

Group D – Social-economic acceptability

This group includes criteria for the social-economic acceptability and admissibility of the repository: social (nuclear experience of population and necessary compensations, public acceptance), economic (infrastructure, interests of other economic activities, construction costs) and political (proximity to state borders). The priority is given to the level of public acceptance which in many countries was of foremost importance in the site selection.

Parameter D1 – Nuclear experience of population and proximity to NPP

Main principle: The attitude of the local population to the construction of a repository for RAW largely depends on their knowledge and nuclear experience.

Essence: The population near NPP and other nuclear facilities is better informed for the alleged and actual hazards related to the operation of nuclear facilities. This allows them to accept easier the construction of a repository for RAW on their territory. Due to this preference is given to sites within the range of existing nuclear facilities or in close proximity to them.

Parameter D2 - Infrastructure

Main principle: Sites with well-developed local and regional infrastructure which facilitates the safe operation of the repository are preferred.

Essence: The availability of roads guarantees the safe transportation of RAW. The existence of water supply and sewage, power supply and telephone connections are taken into account. The lack of well-developed communication infrastructure can significantly increase the cost of construction and operation of the repository.

Parameter D3 – Adverse impacts on other economic activities

Main principle: The construction of the repository must not disturb other economic activities and the trade interests of the country.

Essence: In the selection of site must be considered also the interests of all economic enterprises nearby and taken into account the ecological, commercial transport and other complications. Zones with intensive agriculture are less preferred than areas where agriculture is less developed.

Parameter D4 – Proximity to state borders

Main principle: Sites which are not close to state borders are preferred.

Essence: The location of the repository near state borders can cause certain political complications. If such a site is selected, the eventual negotiations for receiving consent from neighbouring countries would delay the process of construction of the repository.

Parameter D5 – Public acceptance

Main principle: The public acceptance is a necessary condition for the approval of a site. If no adequate public approval is achieved, the construction of a repository is impossible.

Essence: The regulatory documents contain no special instructions with regards to issues of public acceptance but international experience shows that public acceptance in most cases is a very significant factor for the final selection of a site for disposal of RAW. In all democratic states the social disapproval would be an insuperable obstacle.

Parameter D6 – Relative construction costs

Main principle: Sites which provide conditions for construction and operation of the repository system with minimum costs are preferred.

Essence: The main cost groups are determined by: (1) costs related to the transportation of RAW, including costs associated with the necessary construction of new roads and improvement of old ones; (2) costs for land purchasing; (3) costs for the construction of the repository itself, including the preparation of the earth foundations, vertical planning, drainage and sewage systems, necessary auxiliary infrastructure, buildings and other facilities.

1.5.1.3.2 COMPARATIVE ANALYSIS OF THE POTENTIAL SITES

Table 1.5-17 presents the result of the performed comparative analysis of the potential sites (without the „Varbitsa site which was excluded from further consideration during stage 3) with the groups of comparative criteria and their weight ratios, described in details in **Appendix 8-I.5**.

TABLE 1.5-17 COMPARATIVE ANALYSIS OF THE POTENTIAL SITES

Group	Group weight coefficient		Parameter	Weight coefficient of the parameter	Marichin valog					Radiana: → plain (½point) → slope (½ point)					Brestova padina				
	W			W_i	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
					A_{ij}														
Group A Safety provided by natural conditions	0.35	**A1**	Lithostratigraphic composition	0.045															
		A2	Tectonic and neotectonic conditions	0.055															
		A3	Geomorphological conditions	0.040															
		A4	Geotechnical conditions	0.060															
		A5	Geochemical characteristics	0.070															
		A6	Hydrogeological conditions (including radionuclides migration)	0.080															
Group B Impacts from adverse processes and phenomena	0.13	**B1**	Seismicity	0.030															
		B2	Exogeodynamic processes	0.020															
		B3	Flood impacts	0.020															
		B4	Climatic processes and phenomena	0.040															
		B5	Technogenic hazards	0.020															
Group C Possible impacts on environment and population	0.25	**C1**	Water and mineral resources	0.030															
		C2	Land use and ownership	0.060															
		C3	Transportation of RAW	0.065															
		C4	Population and settlement network	0.035															
		C5	Plant and animal species	0.035															
		C6	National cultural and historical landmarks	0.025															
Group D Social-economic acceptability	0.27	**D1**	Nuclear experience of population and proximity to NPP	0.050															
		D2	Infrastructure	0.040															
		D3	Adverse impacts on other economic activities	0.030															
		D4	Proximity to state borders	0.015															
		D5	Public acceptance	0.070															
		D6	Relative construction costs	0.065															
FINAL MULTI-CRITERIA EVALUATION (F_j)					**3.675**					**3.715**					**2.655**				

Based on the results of the comparative multi-criteria analysis the grading of the sites (in ascending order) is as follows:

1. **„Radiana“ site – both sections 3.715**
2. **„Marichin valog“ site 3.675**
3. **„Brestova padina“ site 2.655**

The results show that the “Radiana” site is in the lead and has been determined as the preferred site for the construction of NDF.

„Marichin valog“ site is ranked second with relatively small difference from the first site. The comparison of the results between the separate criteria groups shows that „Radiana“ site to some extent falls behind „Marichin valog“ site in the group A criteria mainly in the A4 criterion – *Geotechnical conditions,* which requires preliminary preparation of the earth foundation and reinforcement of the swaths and will ultimately affect the cost of construction works. „Marichin valog“ site falls behind „Radiana“ site in the C criteria group - *Possible impacts on environment and population,* and in the B criteria group – *Impacts of adverse processes and phenomena* both sites score equally. „Radiana” site also has advantage in the criteria group related to social-economic acceptability.

The analysis for comparing the sites and their ranking has been performed in compliance with the national and international requirements and best practices of the developed European countries using a number of criteria covering all characteristics of the sites.

The objective of the analysis – to select a site with *best possible natural and social-economic characteristics* for providing of maximum safety has been accomplished.

1.5.1.3.3 COMPARATIVE ANALYSIS OF THE POTENTIAL SITES IN TERMS OF RADIOLOGICAL SAFETY CRITERIA

According to the requirements of the nuclear legislation, SE RAW shall performed safety assessments which, according to Article 54, paragraph 1 of the Ordinance on the Safety of Radioactive Waste Management[100], shall evaluate the compliance of the facility or activity with the objectives, requirements and safety criteria. The safety assessment shall include a systematic analysis of the radiological hazards to demonstrate the ability of the facility to ensure safety during the normal operation of the facility in the event of anticipated operational events and design-based accidents. Safety assessments are related to an authorization regime under the Act on the Safe Use of Nuclear Energy, 2002 and are of the following types depending on the stage of implementation of the project:

1. **Preliminary safety assessment** - elaborated at the stage of site selection, when the concept of the facility is elaborated, but not the design of the repository project. It is aimed at demonstrating the ability of the selected site to ensure safety in accordance with the safety criteria. It should be noted that the stage of site selection is part of the stage of feasibility studies in accordance with the Spatial Planning Act, 2001 and Ordinance №4 on the scope and content of investment projects, 2001[101]. The preliminary safety assessment is part of the documentation, on the basis of which the Nuclear Regulatory Agency issues an order for approval of the selected site under Article 37, paragraph 1 of the Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, 2004.
2. **Interim safety assessment** - elaborated at the design stage of the NDF and aimed at demonstrating the ability of the design of the repository, together with the selected site, to ensure safety in accordance with the safety criteria. The interim safety assessment is part of

[100] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[101] Ordinance №4 on the scope and content of investment projects, SG issue 51 of 2011.

the documentation on the basis of which the Nuclear Regulatory Agency issues an order for approval of the elaborated technical design in accordance with Article 40, paragraph 1 of the Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, 2004.

3. **Final safety assessment** - developed at the operation stage of the nuclear facility, i.e. after the building and commissioning of the NDF. It is aimed at demonstrating the ability of the already constructed facility to ensure the safety in accordance with the safety criteria. It is developed on the basis of the interim safety assessment and takes into account the results of the commissioning of the NDF. The final safety assessment is part of the documentation on the basis of which the Nuclear Regulatory Agency issues a license for the operation of the NDF, according to Article 48, item. 1 of the Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, 2004.
4. **Updated (periodic) safety assessment –** the nuclear legislation of the Republic of Bulgaria permits the issuance of licenses for the operation of a nuclear facility for a maximum of 10 years. This means that the operating license of the NDF shall be renewed every 10 years (or at a shorter period depending on the decision of the competent authority - NRA). For each license renewal SE RAW shall develop an updated (periodic) safety assessment, which takes into account the experience in the operation of the NDF during the expired period. The updated (periodic) safety assessment is aimed at demonstrating the ability of the operating facility to ensure safety in accordance with the safety criteria and is part of the application for issuance of an operating license for the NDF, according to Article 48, paragraph 1 of the Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, 2004.
5. **Safety assessment upon decommissioning of a nuclear facility or closure of a repository** - elaborated at the closure stage of the NDF and aimed at demonstrating the ability of the closed facility to ensure safety in accordance with the safety criteria. It shall also demonstrate that the chosen technology of closing will provide safety during the disassembly of unnecessary facilities and the closure of the repository. It should be stressed that the closure of the repository shall be the subject of a separate technical design, which is developed in its final form 3 to 5 years before the closure of the repository and takes into account both the entire information and operational experience gained during the 60-year operation of the NDF, and the long-term field surveys to be conducted by SE RAW for testing the protective multi-barrier cover. It should also be emphasized that the closure of the repository shall be the subject of a separate environmental impact assessment under the Environmental Protection Act.

SE RAW has developed a preliminary safety assessment[102], which is part of the application to the Nuclear Regulatory Agency for issuance of an order for approval of the selected site. The preliminary safety analysis is aimed at demonstrating the ability of the selected site to ensure safety in accordance with the safety criteria.

The safety criterion is explicitly determined by the nuclear legislation - under Article 8, item 2, the individual effective dose for the respective critical group members of the public, as a result of a facility for surface disposal of RAW after its closure, may not exceed 0.1 mSv per year. It must be strongly emphasized that the chosen safety criterion, defined and proposed by the competent authority, the Agency for Nuclear Regulation, under the Ordinance on the Safety of Radioactive

[102] SE RAW, 2014, Preliminary safety assessment of the NDF

Waste Management, 2004, is significantly lower - more restrictive than that proposed by the International Committee on Radiological Protection[103].

The chosen methodology for preliminary safety assessment is based on the requirements of the nuclear legislation[104,105], the safety standards of the IAEA[106,107], and the conventional ISAM methodology of IAEA[108], as justified in the Report on the concept for disposal of radioactive waste[109], developed in the implementation of stage 1 of the site selection and approved by the Nuclear Regulatory Agency. The scheme of the approach used in the preliminary safety assessment is provided in **Appendix 8-I.6.** In accordance with the requirements of the Ordinance on the Safety of Radioactive Waste Management, a long-term safety assessment has been elaborated, covering a substantial period of time, sufficient to reach the maximum estimated dose for the critical group members of the public.

The approach in the generation of scenarios is based on the developed methodology and includes detailed analysis of the features, processes and events postulated in the documents of the International Atomic Energy Agency, screening out the irrelevant ones and defining the normal evolution scenario and intrusion scenarios.

Normally the evolutionary scenario includes the expected evolution of the repository and the surrounding environment and the gradual change in the safety functions. The conceptual model of the normal evolution scenario includes: (1) infiltration of part of the atmospheric water through the protective multi-barrier cover, with part of the infiltrated water returned back to the atmosphere through the process of evaporation and transpiration (back absorption by the vegetation cover that exists on the protective multi-barrier cover); (2) part of the infiltrated water reaches the cells of the repository as a result of gravitational forces; (3) dissolution of part of the radionuclides in the porous water; the dissolution is minimal because the solubility of radionuclides in the highly alkaline environment of the repository is minimal, defined by the concrete structures of the waste, the containers, walls, roof and bottom plates of the repository; (4) leakage of water out of the area of the repository in the unsaturated area (the area of the geological environment, located over the aquifer); (5) directed movement through the unsaturated area to the aquifer; (6) directed movement with the aquifer (saturated area); (7) reaching the release point - the point at which the radionuclide reach the human biosphere.

The processes described in paragraphs (1) to (4) inclusive are defined as near-field and include the repository and the adjacent surrounding. They are mainly determined by the characteristics of the NDF and are shown in **Figure 1.5-18.**

The processes described in paragraphs (5) to (7) inclusive are defined as geosphere. Their development is definitively determined by the characteristics of the respective site. The conceptual models of the geosphere at the sites "Marichin Valog", "Brestova Padina" and "Radiana" in its two varieties "Radiana" - flat section and "Radiana" - slope are given in the figures below (**Figure 1.5-19, Figure 1.5-20, Figure 1.5-21, Figure 1.5-22).**

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[103] ICRP, Radiation Protection Recommendations as Applied to the Disposal of Long-Lived Solid Radioactive Waste, Publication No. 81, Elsevier, Oxford, 1999

[104] Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, prom. SG issue 41/18.05.2004, last amend. SG issue 76/5.10.2012.

[105] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[106] IAEA, Safety Assessment for Near Surface Disposal of Radioactive Waste, Safety Guide, Safety Standards Series No. WS-G-1.1, 1999

[107] IAEA, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste, IAEA Safety Standards, Specific safety Guide No.SSG-23, 2012

[108] IAEA, ISAM Report Safety Assessment Methodologies for Near Surface Disposal Facilities, vol.1 Review and Enhancement of Safety Assessment Approaches and Tools, vol.2 Test cases

[109] Report on the concept for disposal of radioactive waste, SE RAW, 2010.

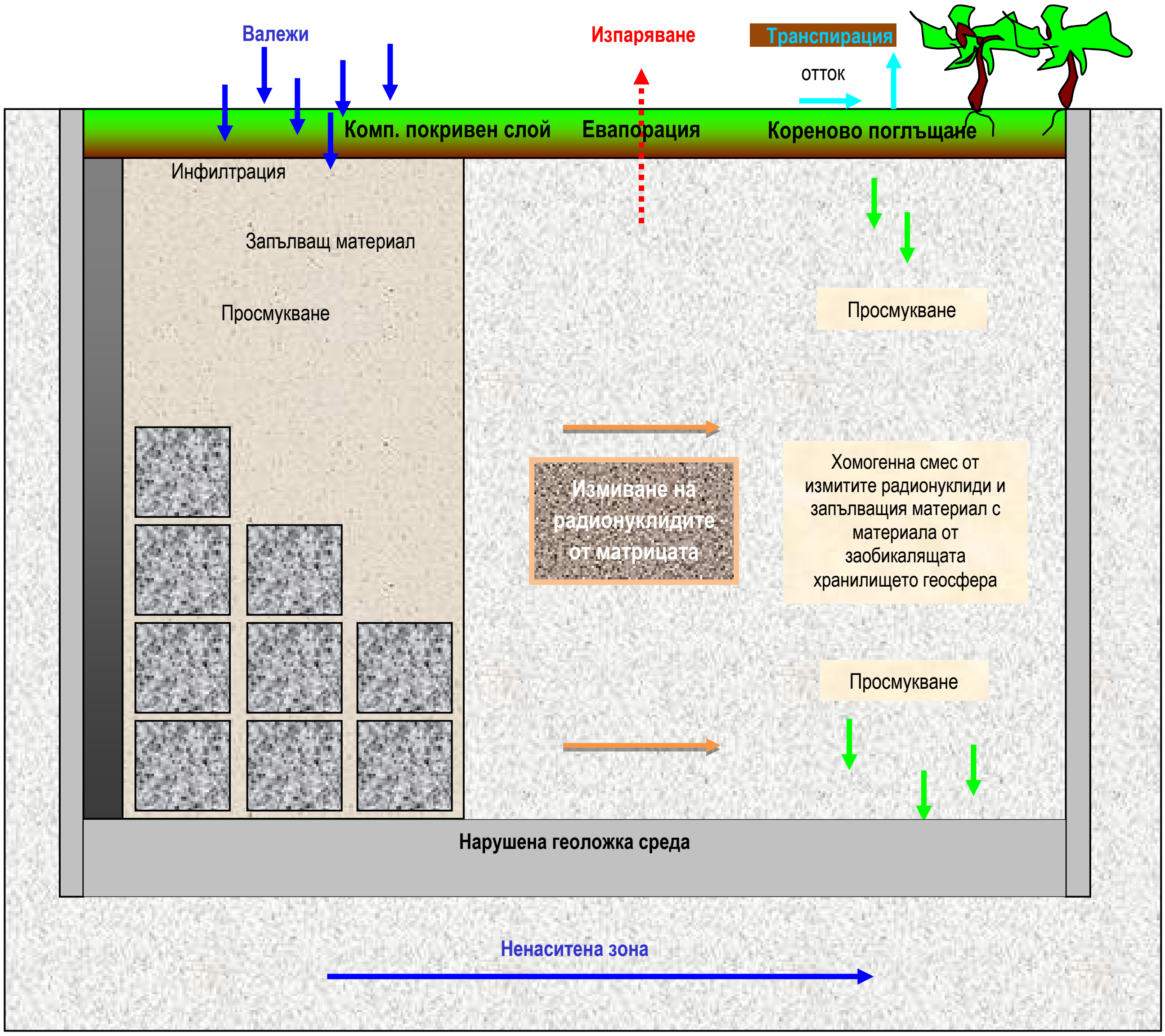

FIGURE 1.5-18 SCHEMATIC PRESENTATION OF THE CONCEPTUAL MODEL FOR “NEAR FIELD”

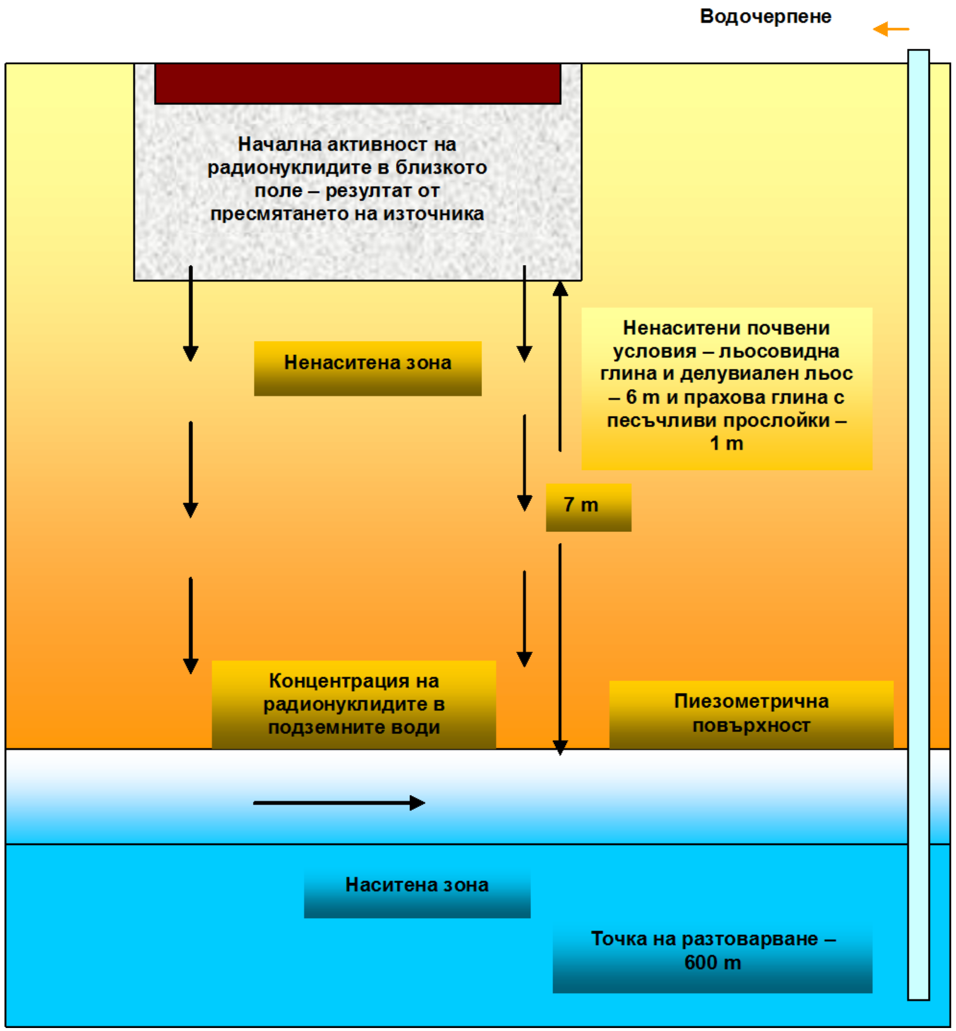

FIGURE 1.5-19 CONCEPTUAL MODEL FOR BRESTOVA PADINA SITE

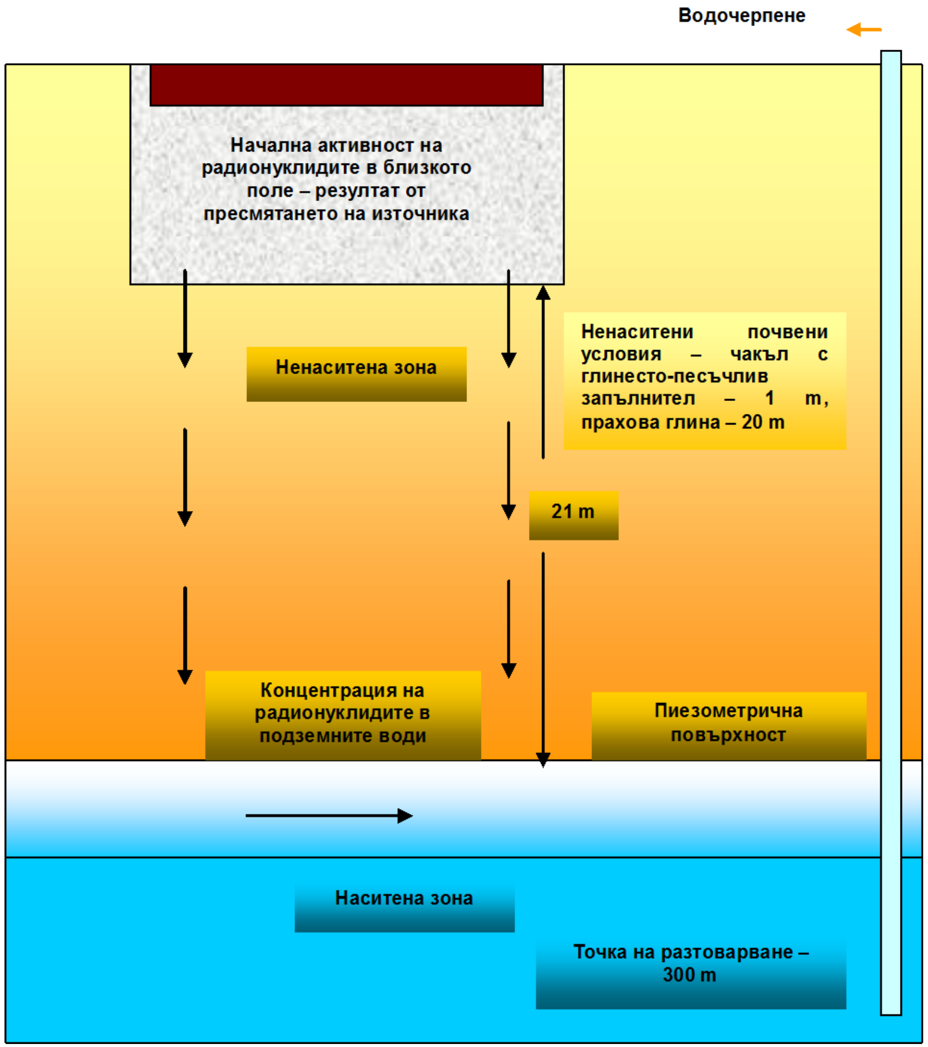

FIGURE 1.5-20 CONCEPTUAL MODEL FOR MARICHIN VALOG SITE

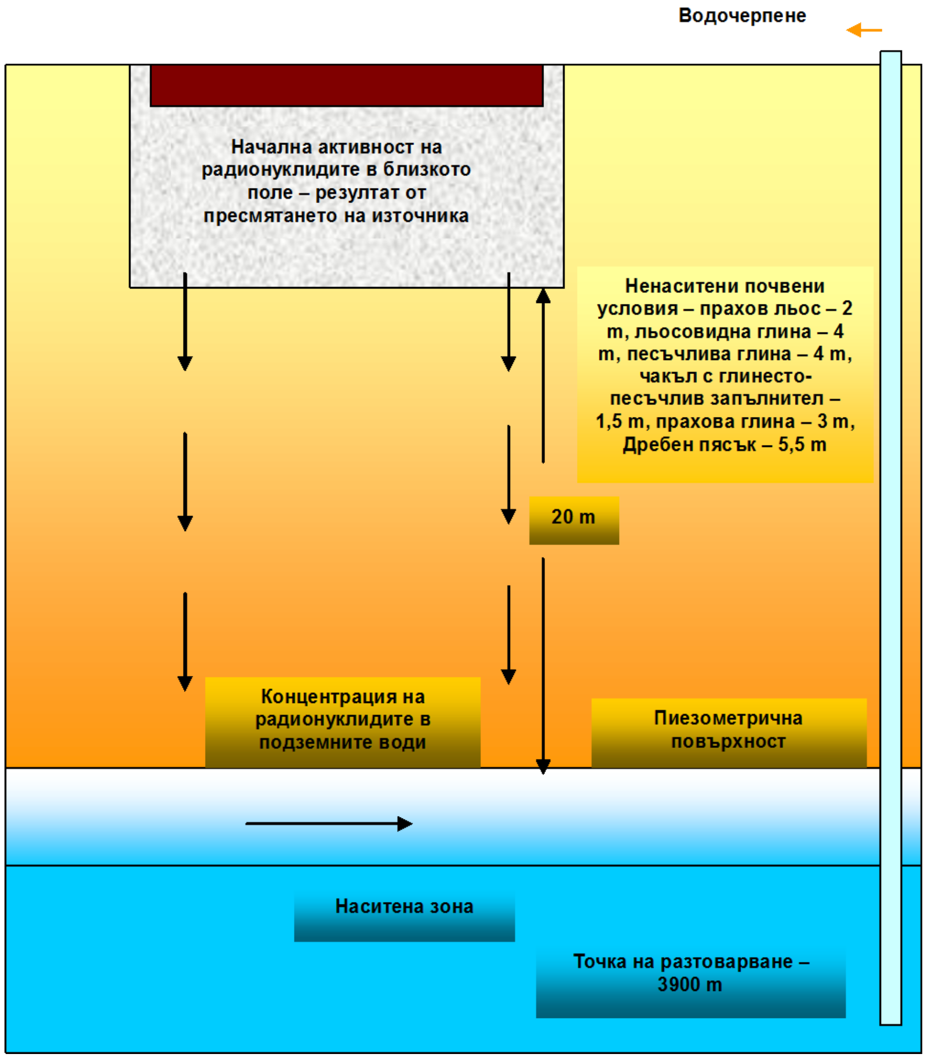

FIGURE 1.5-21 CONCEPTUAL MODEL FOR RADIANA SITE - SLOPE

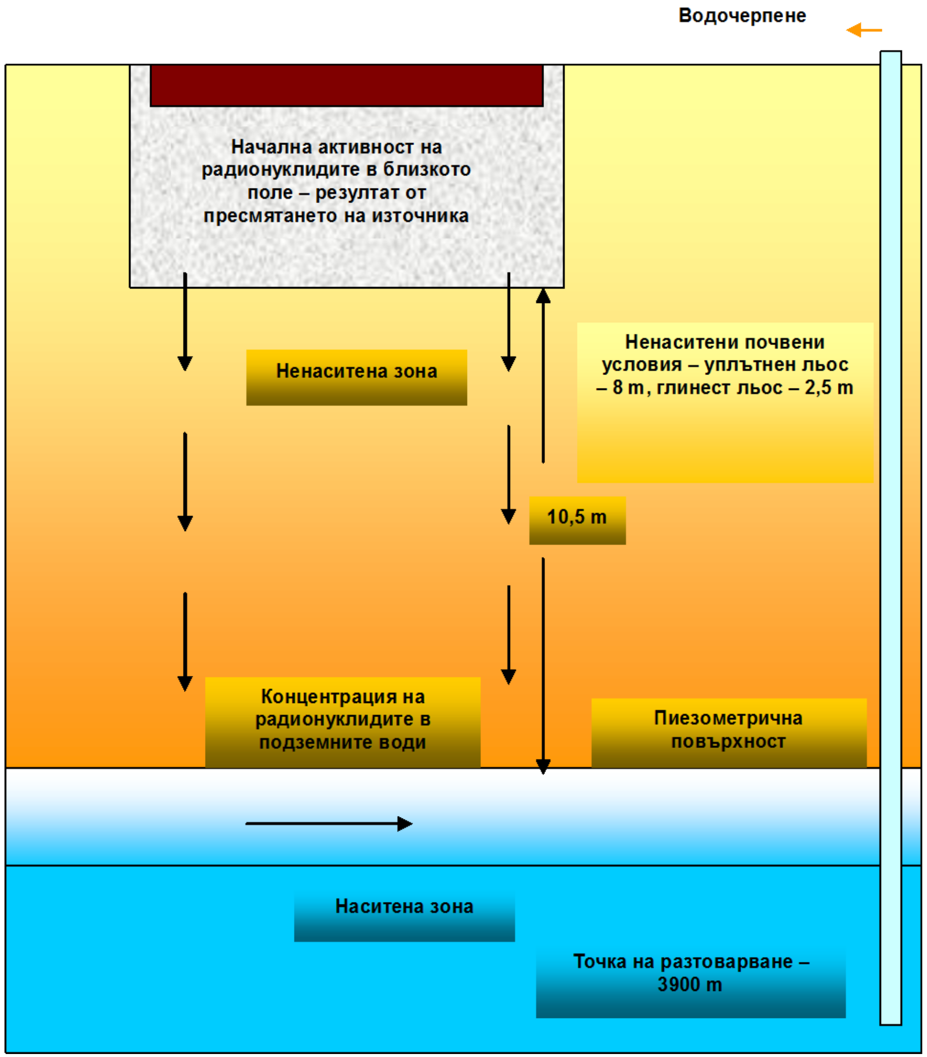

FIGURE 1.5-22 CONCEPTUAL MODEL FOR RADIANA SITE – FLAT SECTION

The results of the modeling of migration of radionuclides show that radionuclides are retained within the repository and in its immediate vicinity. Limited radionuclides in concentrations significantly lower than the concentrations of drinking water reach the release point, i.e. the human biosphere. The results are shown in **Figure 1.5-23** to **Figure 1.5-26** .

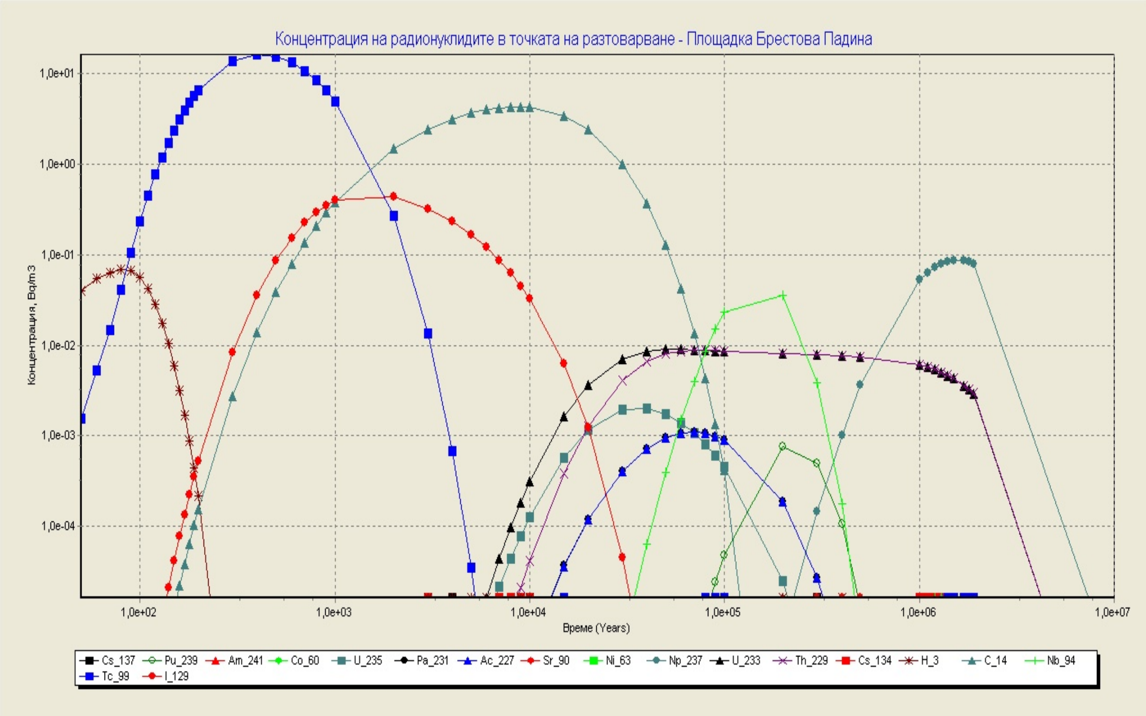

FIGURE 1.5-23 CONCENTRATION OF RADIONUCLIDES IN THE RELEASE POINT FOR BRESTOVA PADINA SITE

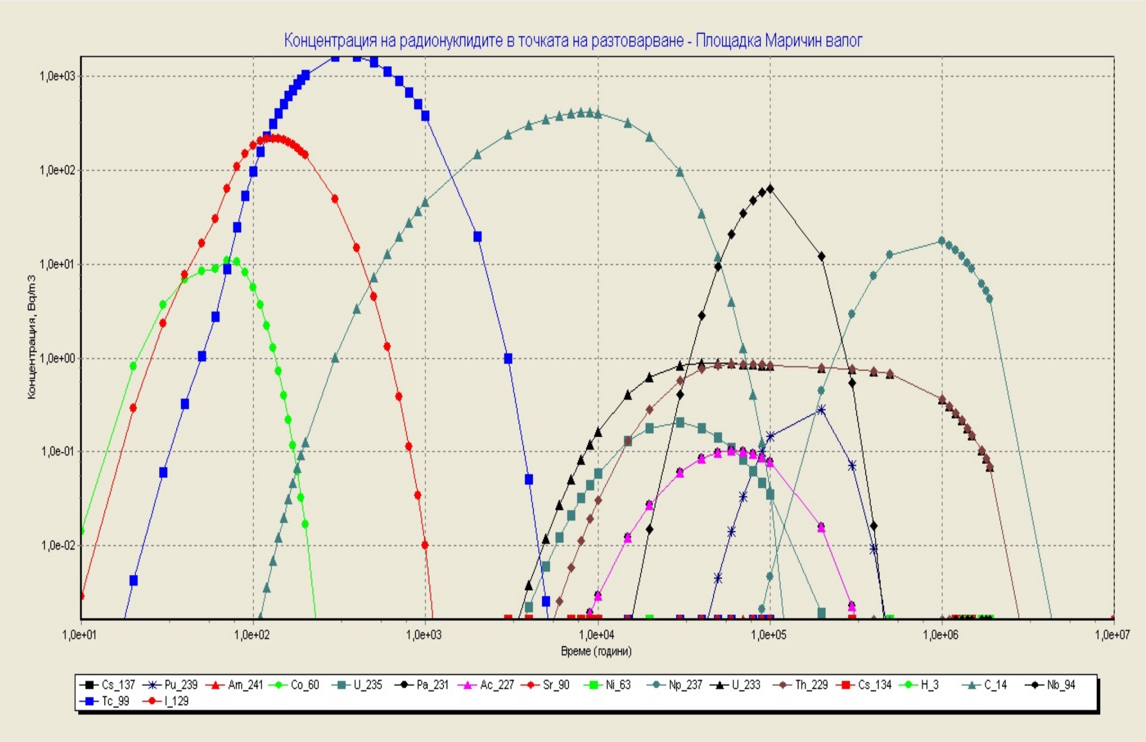

FIGURE 1.5-24 CONCENTRATION OF RADIONUCLIDES IN THE RELEASE POINT FOR MARICHIN VALOG SITE

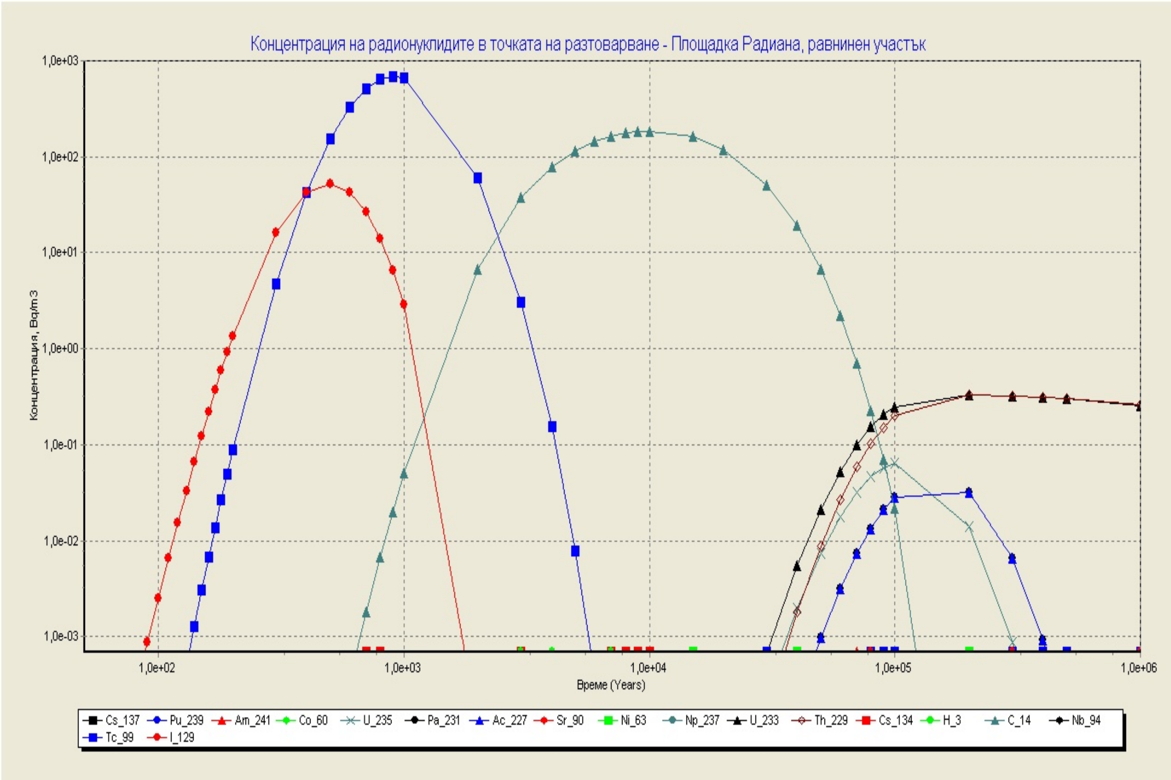

FIGURE 1.5-25 CONCENTRATION OF RADIONUCLIDES IN THE RELEASE POINT FOR RADIANA SITE – FLAT SECTION

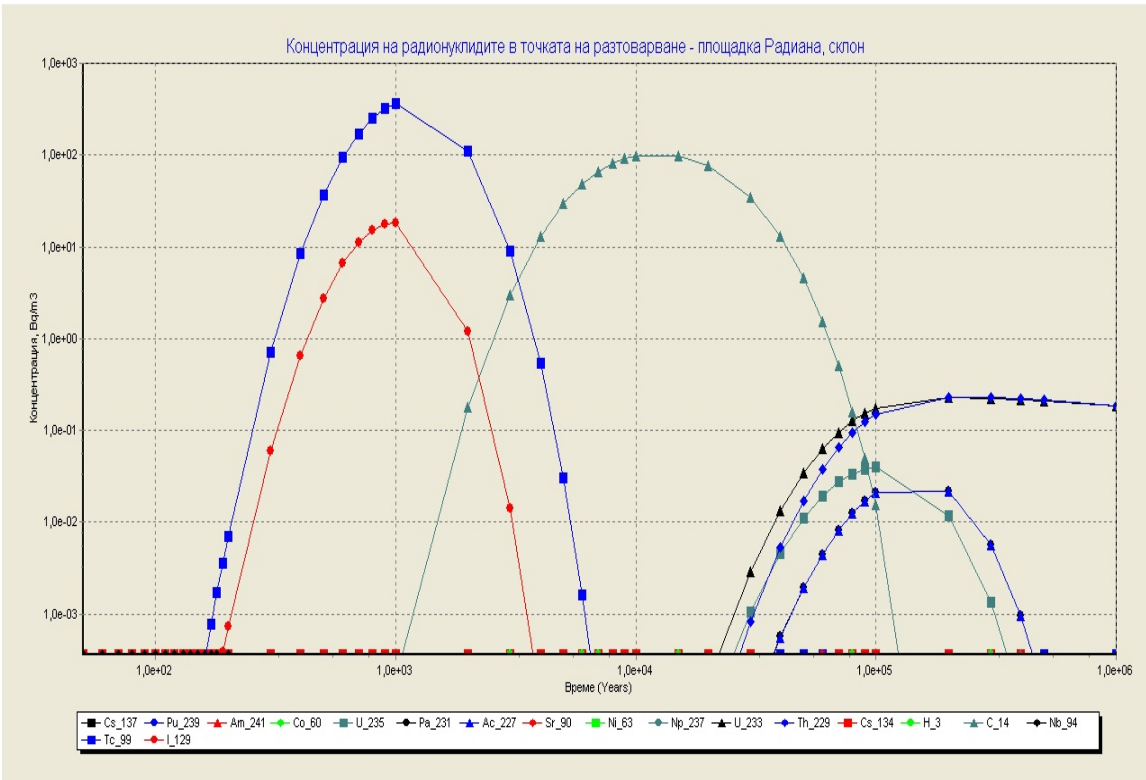

FIGURE 1.5-26 CONCENTRATION OF RADIONUCLIDES IN THE RELEASE POINT FOR RADIANA SITE – SLOPE

The obtained results indicate that only some radionuclides reach the biosphere in negligibly low concentrations. For the purposes of interpretation of the results in the preliminary safety assessment, the value 10^{-2} Bq/m^3 is selected as a criterion due to the obvious fact that lower concentrations have no physical meaning. The fast-moving short-lived radionuclides tritium (^3H) is retained within the repository at Radiana site (Radiana site – slope section and Radiana site – flat section). It reaches the biosphere in the case of construction of the NDF at Brestova Padina site in concentration $8x10^{-2}$ Bq/m^3 after 90 years and in the case of construction of the NDF at Marichin Valog site in concentration $1x10^1$Bq/m^3 after 80 years.

This concentration is at least 5 orders of magnitude lower than the maximum permissible concentration of tritium in drinking water - 100 Bq/L or 100 000 Bq/m^3, as defined in Ordinance № 9 on the quality of water for drinking and household purposes, 2001 [110].

The biosphere is reached by the long-lived radionuclides ^{99}Tc, ^{14}C and ^{129}I in concentrations significantly lower than the permissible limits. Ordinance № 9 on the quality of water for drinking and household purposes, 2001 does not standardize the content of radionuclides ^{99}Tc, ^{14}C and ^{129}I. The comparison below is made with respect to the maximum concentrations of critical group members of the public for drinking water in the Basic Standards for Radiation Protection (BSRP), 2012 [111].

^{99}Tc reaches the biosphere of Brestova Padina site with maximum concentration of $2x10^1$ Bq/m^3 after 700 years, the biosphere of Marichin Valog site with maximum concentration of $1.5x10^3$ Bq/m^3 after 500 years, the biosphere of Radiana site with maximum concentration of $5.3x10^2$ Bq/m^3 after 1000 years for the slope section and a maximum concentration of $9x10^2$ Bq/m^3 after 900 years.

This concentration is lower than the maximum permissible concentration for ^{99}Tc in drinking water - 80 000 Bq/m^3, determined in BSRP 2012.

^{129}I reaches the biosphere of Brestova Padina site with maximum concentration of $6x10^{-1}$ Bq/m^3 after 5000 years, the biosphere of Marichin Valog site with maximum concentration of $22.5x10^2$ Bq/m^3 after 120 years, the biosphere of Radiana site with maximum concentration of $1.8x10^1$ Bq/m^3 after 1000 years for the slope section and a maximum concentration of $8x10^1$ Bq/m^3 after 700 years for the flat section.

This concentration is lower than the maximum permissible concentration for ^{129}I in drinking water - 9600 Bq/m^3, determined in BSRP 2012.

^{14}C reaches the biosphere of Brestova Padina site with maximum concentration of $6x10^0$ Bq/m^3 after 10 000 years, the biosphere of Marichin Valog site with maximum concentration of $5.6x10^2$ Bq/m^3 after 9000 years, the biosphere of Radiana site with maximum concentration of $1.0x10^2$ Bq/m^3 after 12 000 years for the slope section and a maximum concentration of $2.0x10^2$ Bq/m^3 after 10 000 years for the flat section.

This concentration is lower than the maximum permissible concentration for ^{14}C in drinking water - 23 000 Bq/m^3, determined in BSRP 2012.

The results indicate that in terms of this safety criterion - concentration of radionuclides in water - all surveyed sites not only satisfy the requirements but are orders of magnitude lower than the requirements for drinking water.

To determine the compliance of the site with the radiological criteria - individual effective dose for the respective critical group members of the public, two dosimetric models (models of the biosphere) have been developed. The first model of the biosphere includes the use of water by the population in the point of release for drinking purposes, watering livestock and agricultural crops and is presented in **Figure 1.5-27**. The second model includes the use of the Danube River for

[110] Ordinance № 9 dated 16 March 2001 on the quality of water for drinking and household purposes, SG issue 30 of 28 March 2001, last amend. SG issue 15 of 21 February 2012.

[111] Ordinance on the Basic Standards for Radiation Protection, SG issue76 of 5 October 2012

recreation, fishing and swimming and the relevant absorption of water, consumption of fish and direct radiation, and is presented in **Figure 1.5-28**.

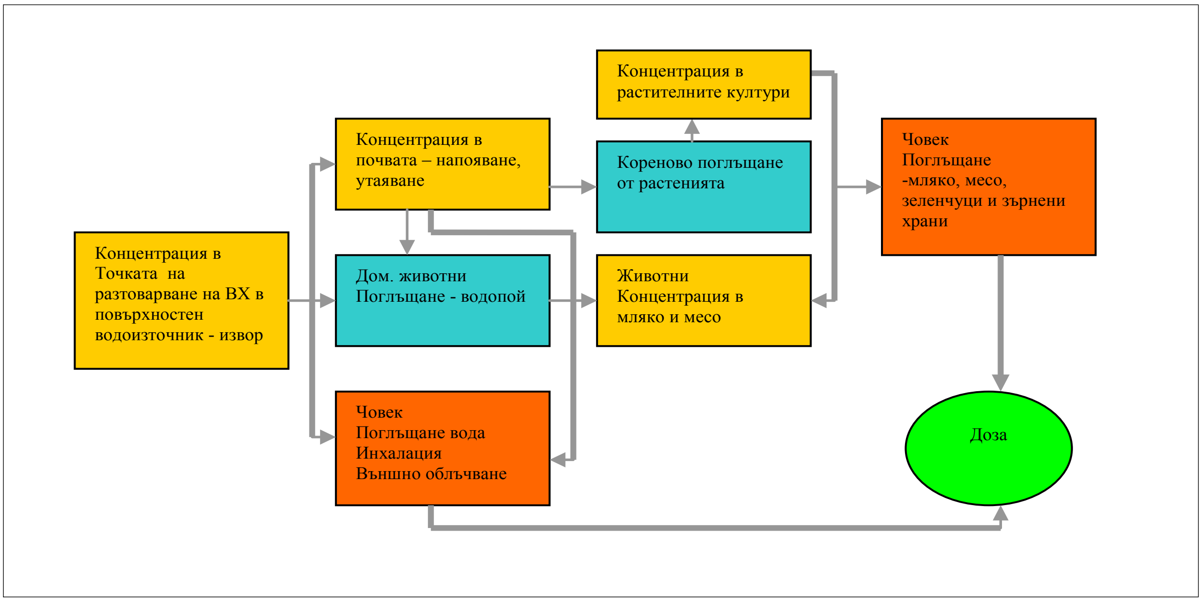

FIGURE 1.5-27 CONCEPTUAL MODEL OF THE BIOSPHERE №1.

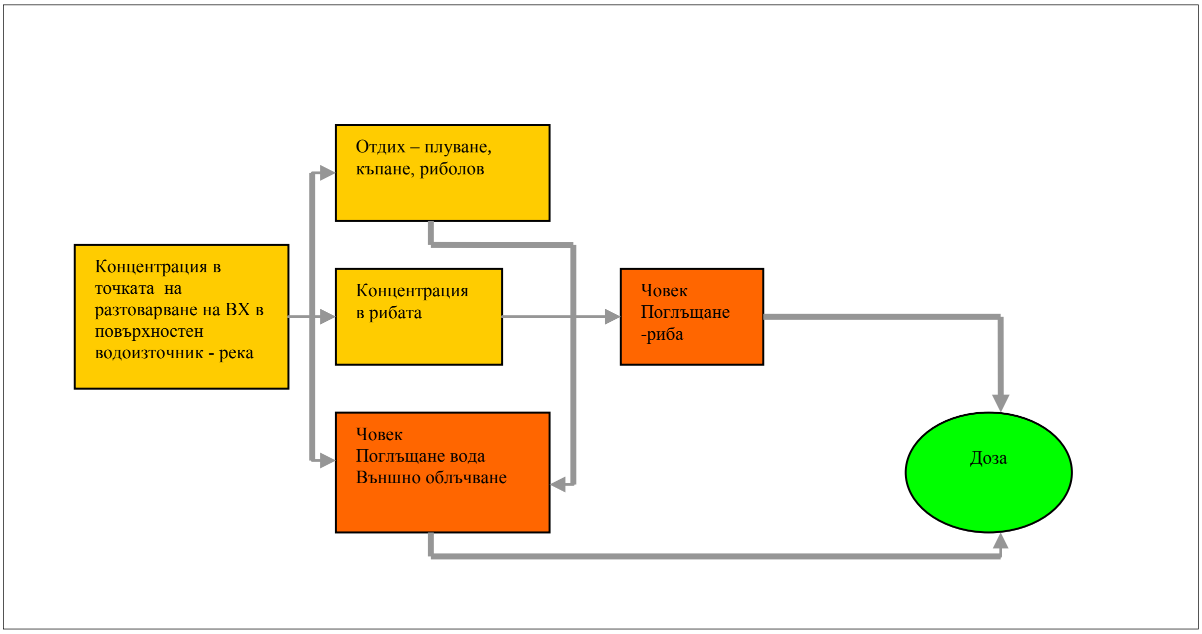

FIGURE 1.5-28 CONCEPTUAL MODEL OF THE BIOSPHERE №2.

Conservative assumptions have been made that the population uses water only from the point of release for drinking and watering purposes, consumes only products, which are its own production, cultivated with water from the point of release, and fish only from the Danube river.

The results for Marichin Valog site, Radiana site - slope section, Radiana site - flat section and Brestova Padina are shown in **Figure 1.5-29** to **Figure 1.5-36**.

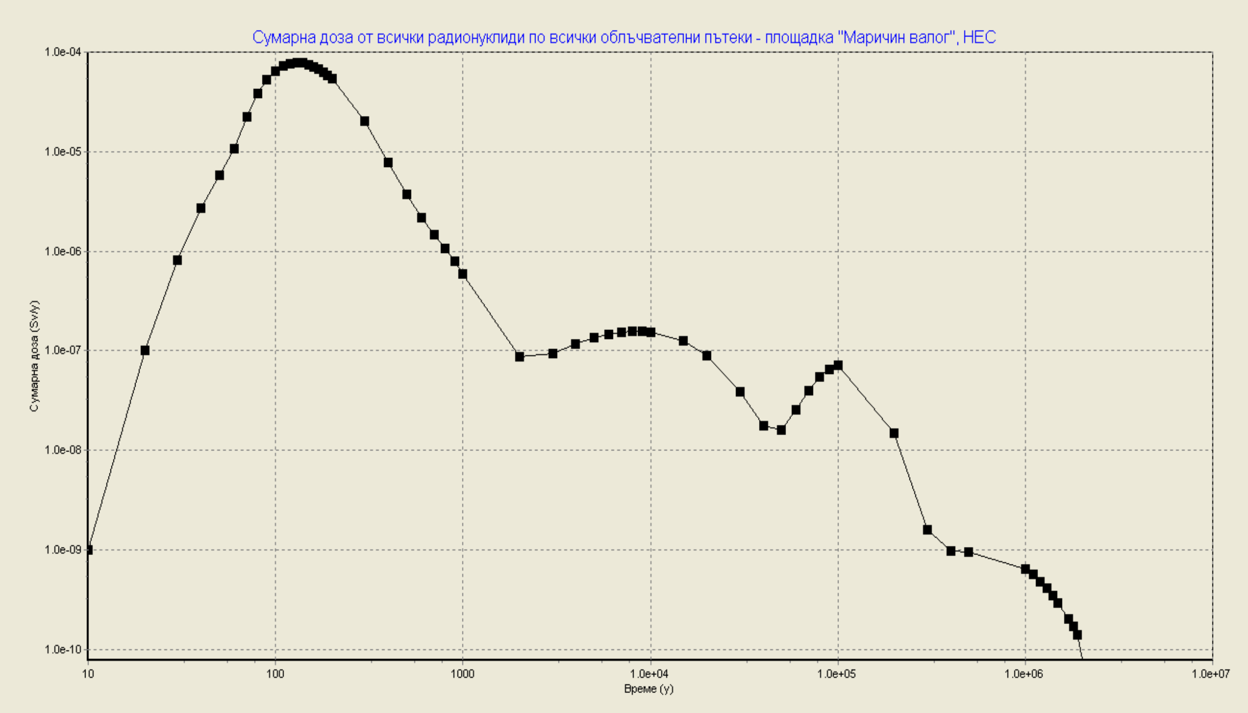

FIGURE 1.5-29 TOTAL EFFECTIVE DOSE FOR ALL RADIONUCLIDES FOR “MARICHIN VALOG” SITE

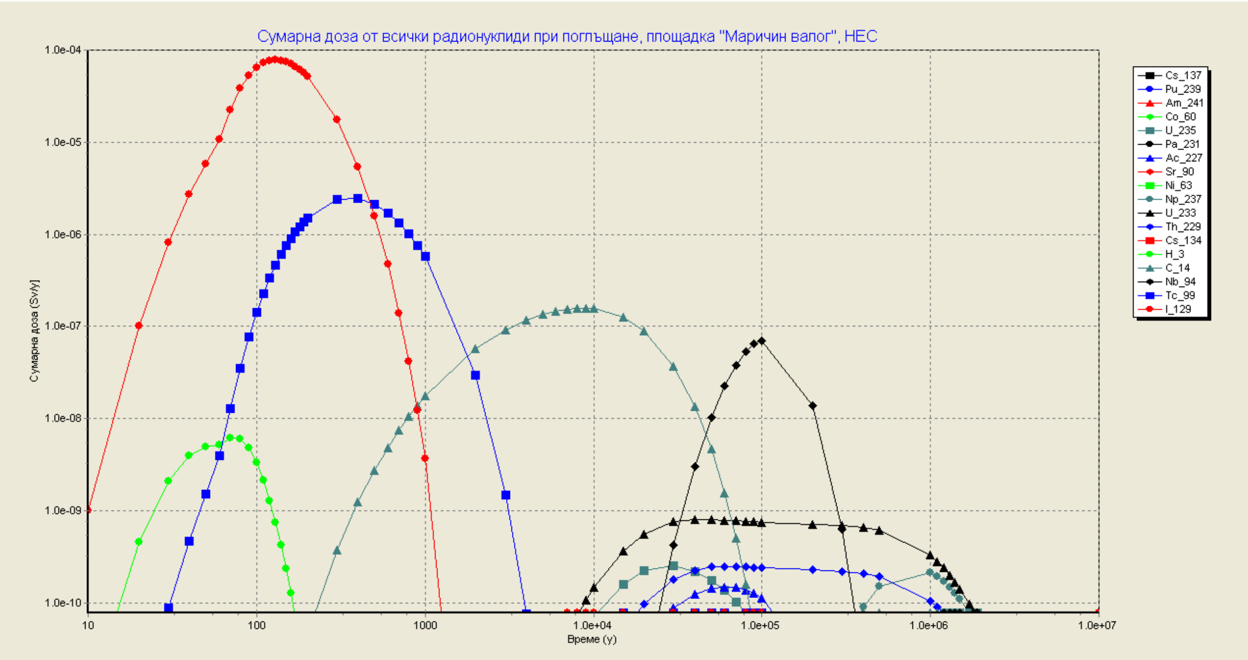

FIGURE 1.5-30 EFFECTIVE DOSE FOR THE INDIVIDUAL RADIONUCLIDES FOR “MARICHIN VALOG” SITE

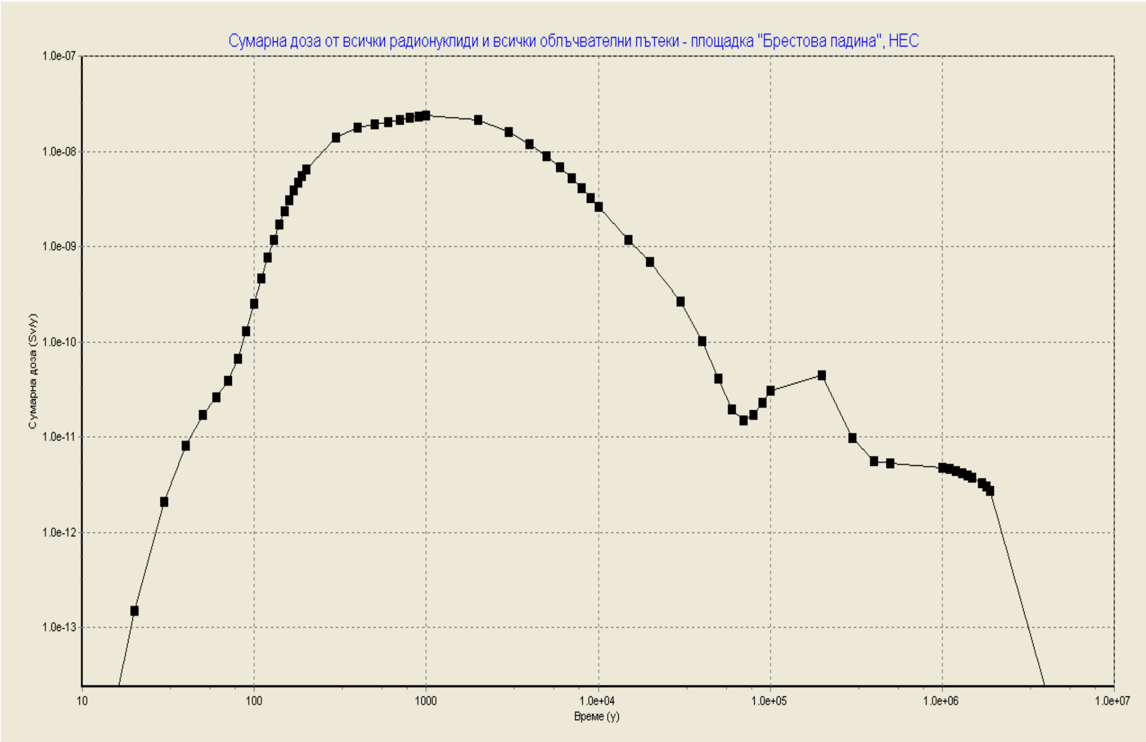

FIGURE 1.5-31 TOTAL EFFECTIVE DOSE FOR ALL RADIONUCLIDES FOR "BRESTOVA PADINA" SITE

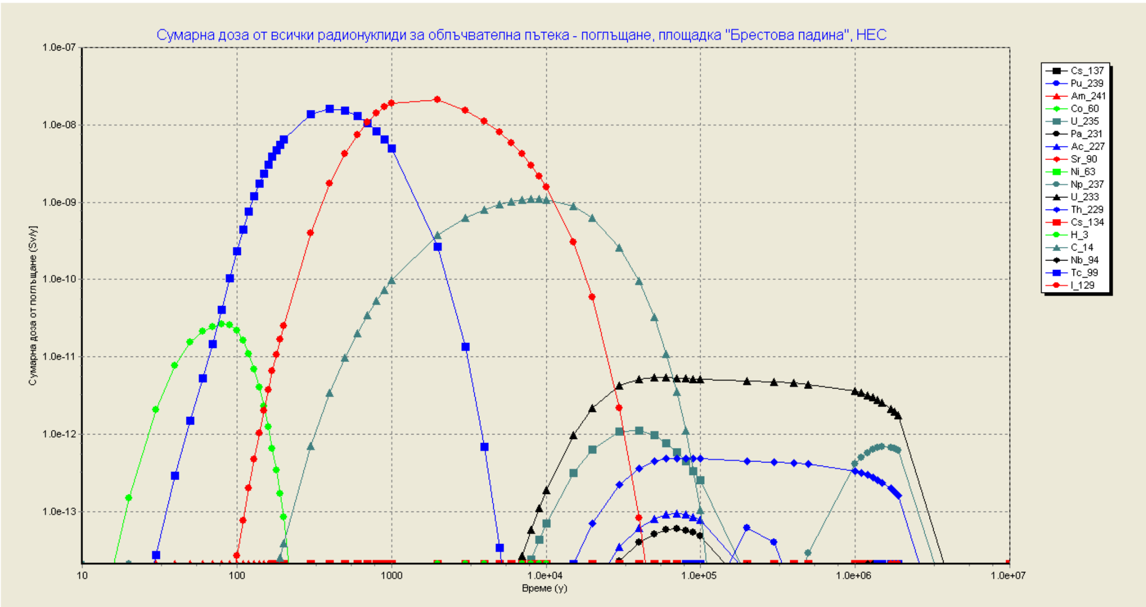

FIGURE 1.5-32 EFFECTIVE DOSE FOR THE INDIVIDUAL RADIONUCLIDES FOR "BRESTOVA PADINA" SITE

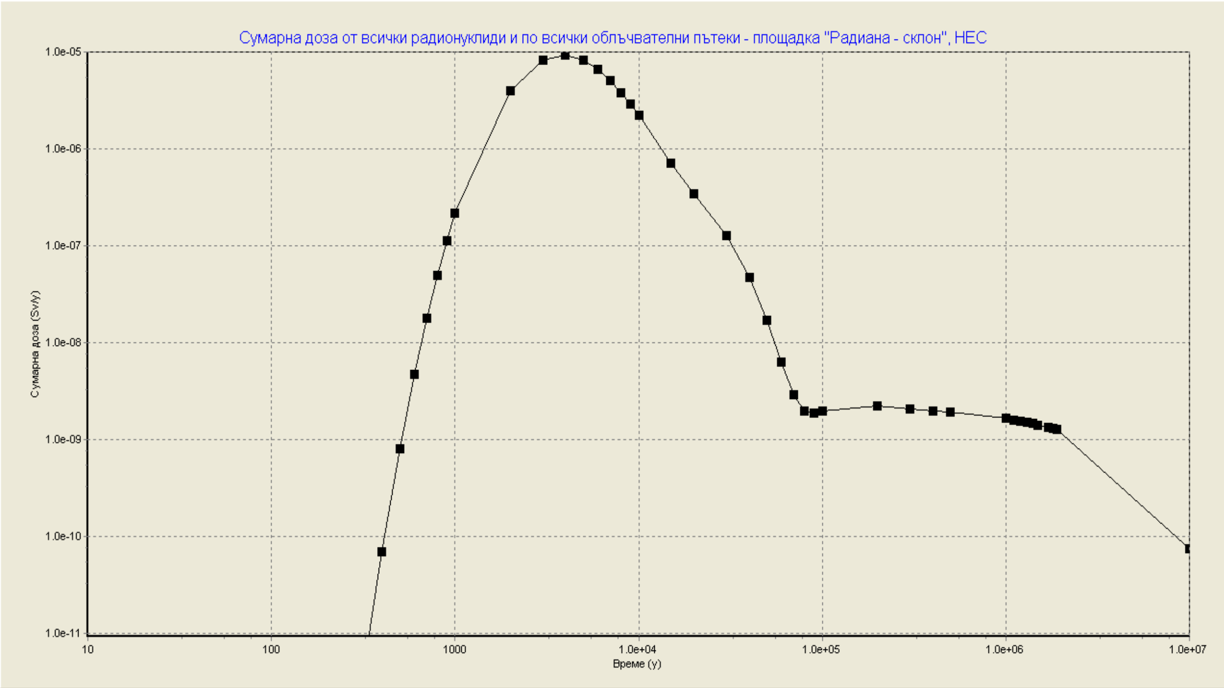

FIGURE 1.5-33 TOTAL EFFECTIVE DOSE FOR ALL RADIONUCLIDES FOR "RADIANA" SITE – SLOPE SECTION

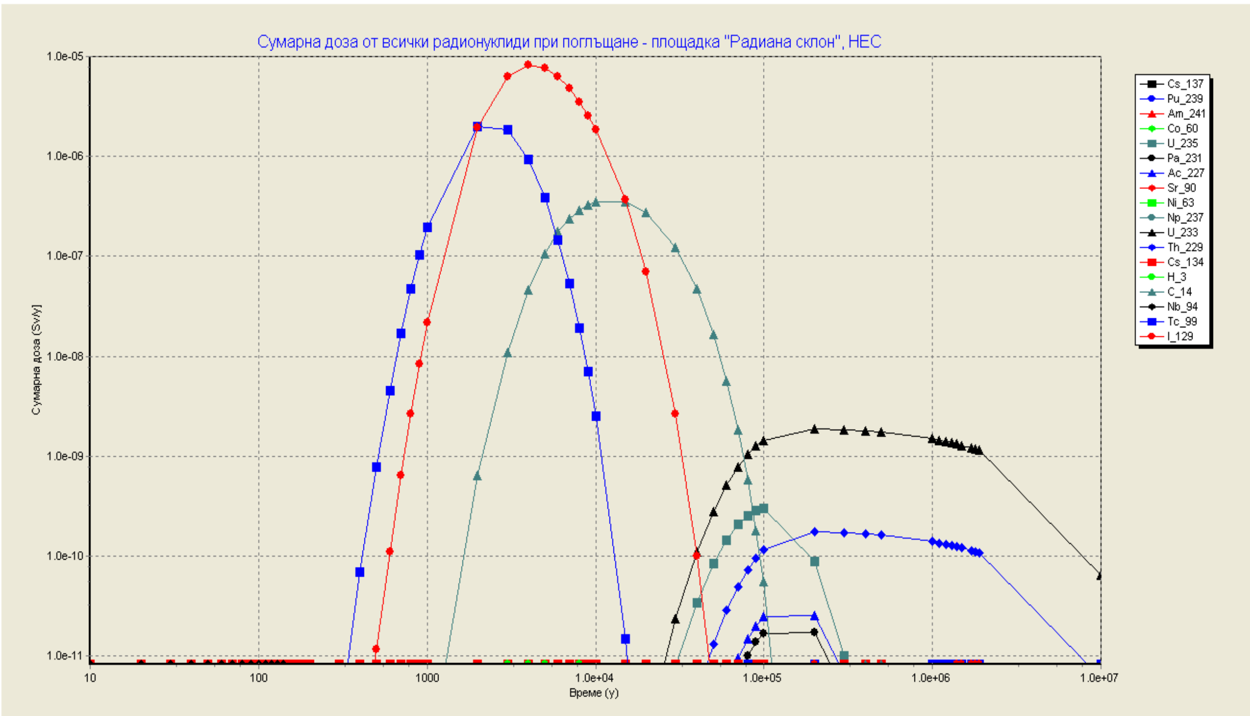

FIGURE 1.5-34 EFFECTIVE DOSE FOR THE INDIVIDUAL RADIONUCLIDES FOR "RADIANA" SITE – SLOPE SECTION

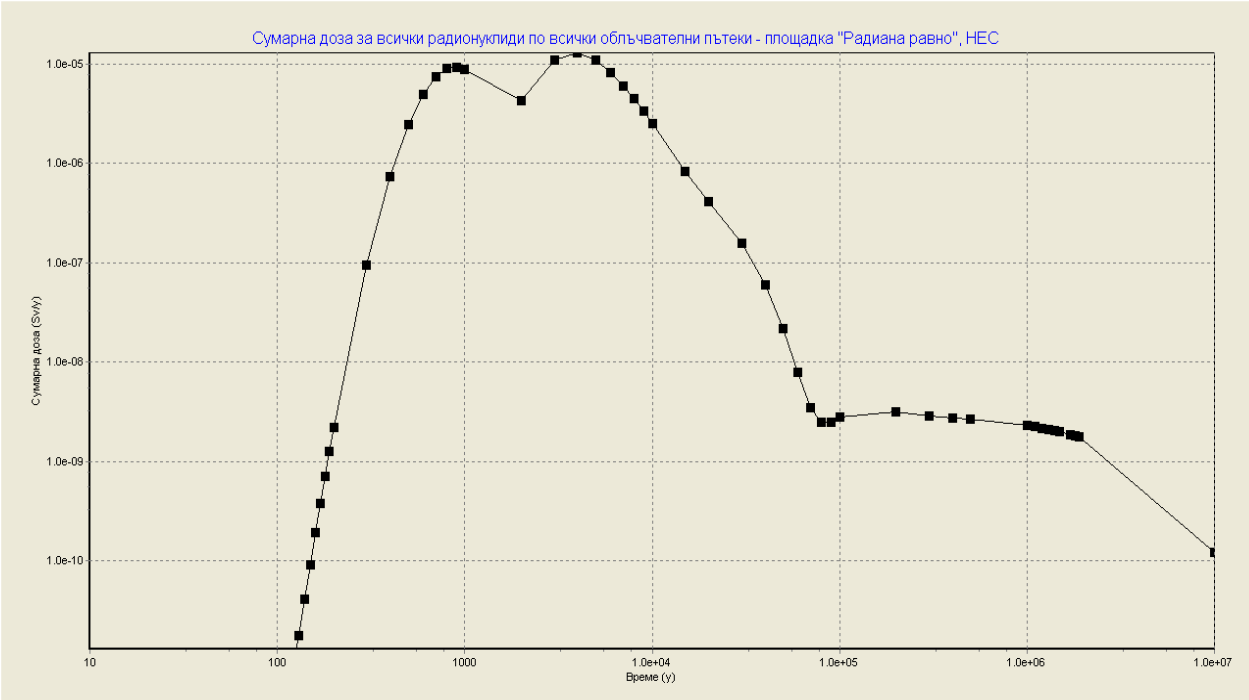

FIGURE 1.5-35 TOTAL EFFECTIVE DOSE FOR ALL RADIONUCLIDES FOR "RADIANA" SITE – FLAT SECTION

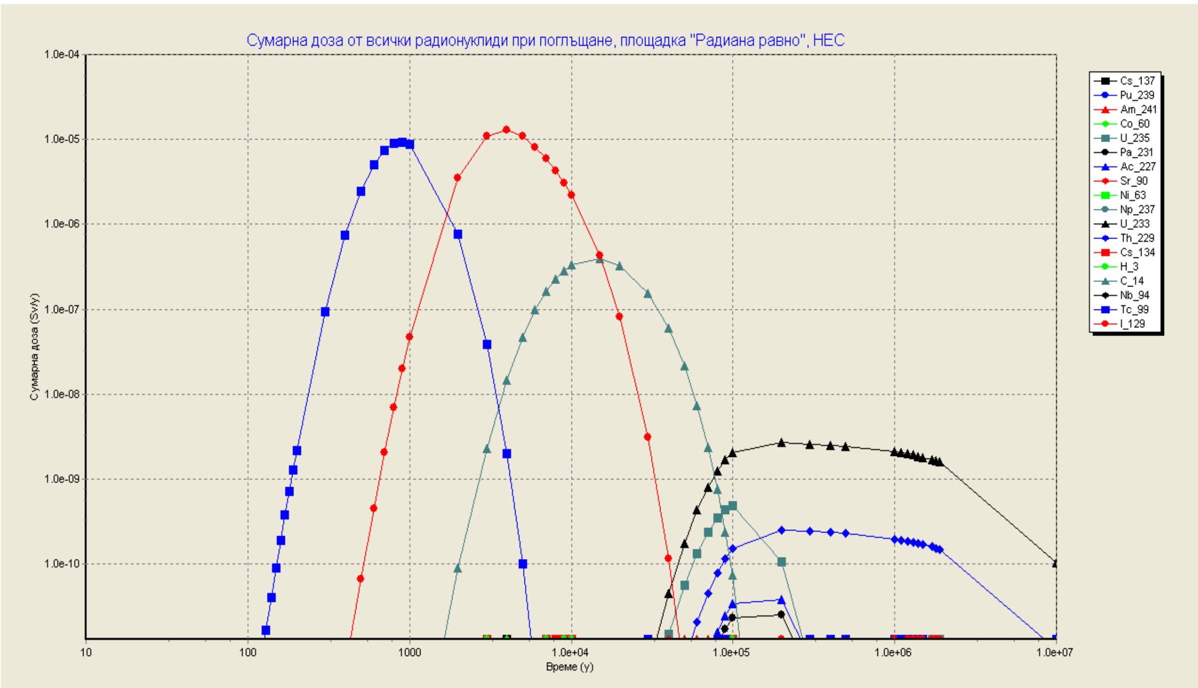

FIGURE 1.5-36 EFFECTIVE DOSE FOR THE INDIVIDUAL RADIONUCLIDES FOR "RADIANA" SITE – FLAT SECTION

The results indicate the following for the individual sites:

(1) The results for the maximum effective dose for the critical group members of the public for Marichin Valog site show three peaks with values 7.81×10^{-5} Sv/y after 130 years; 1.57×10^{-7} Sv/y after 9000 years and 7.12×10^{-8} Sv/y after 100,000 years, determined by the radionuclides ^{129}I, ^{99}Tc, ^{14}C and ^{94}Nb.

(2) The results for the maximum effective dose for critical group members of the public for Brestova Padina site show two peaks with values 2.4×10^{-8} Sv/y after 1000 years 4.4×10^{-11} Sv/y after…, determined by the radionuclides ^{129}I, ^{99}Tc and ^{14}C.

(3) The results for the maximum effective dose for critical group members of the public for Radiana site - slope section show one peak with values 9.20×10^{-6} 4000 and a second, substantially smaller peak in the long-term scale with a value $2{,}2.10^{-9}$ Sv/y after 200,000 years, determined by the radionuclides ^{129}I, ^{99}Tc, ^{14}C and ^{233}U (after the last 200,000 years).

(4) The results for the maximum effective dose for critical group members of the public for Radiana site - flat section show two peaks with values 1.29×10^{-5} and 9.34×10^{-6} Sv/y after 4000 years, determined by the radionuclides ^{129}I, ^{99}Tc, ^{14}C and another much smaller peak in the long-term scale with a value 4.04×10^{-7} Sv/y after 200,000 years, determined by ^{233}U.

These results show that the requirements in the safety assessment to cover a period of time sufficient to reach the maximum estimated dose for public exposure are met – the above-mentioned assessments for the sites Marichin Valog, Brestova Padina, Radiana - slope section and Radiana - flat section cover periods of time of 10^6 years. Highly conservative assumptions have been used, especially in the modeling of the biosphere, which means that the expected maximum effective doses will be significantly lower than the estimated ones.

The results indicate that in terms of this safety criterion (maximum effective dose for the critical group members of the public) all studied sites not only satisfy the radiological criterion for maximum effective dose of 0.1mSv per year, but are orders of magnitude lower. The time for occurrence of the maximum effective dose for critical group members of the public is considered favorable for Radiana site - slope section - after 4000 years, for Radiana site - flat section - also after 4000 years, less favorable for the Brestova Padina site - after 1000 years and unfavorable for Marichin valog site - after 130 years. The comparison of the different sections of Radiana site favors the slope section as a site for the NDF.

In accordance with the requirements of the nuclear legislation, the preliminary safety assessment considers the scenario of human intervention (intrusion) after closing the NDF for the sites Marichin Valog, Brestova Padina, Radiana - slope section and Radiana - flat section. Human intervention is associated with the destruction of the repository and the radiological criterion is the one applicable to accidents, as recommended by the International Commission on Radiological Protection[112,113]. A possible intrusion scenario with the highest potential of radiological risk is the scenario of settlement at the site after expiration of the period of institutional control on the repository. The scenario includes excavation works for laying the foundations of the house and landscaping of the yard, building a house and its settlement, with the settlers using only agricultural products (plants and animals) grown in the yard of the house, which is a very conservative assumption. It is also conservatively assumed that all agricultural production is irrigated with water from a well drilled at the site, and that animals and humans consume only water from this well.

As expected, the same results are obtained for the activities of excavating the site and for the building of the house and the landscaping of the yard, since they are determined by the concept of radionuclides in the repository, and not by the characteristics of the site. The results are 5.56×10^{-5} Sv/y for the scenario of excavating the site and 3.66×10^{-7} Sv/y for the scenario of building the house and landscaping of the yard and are obtained as a result of the external exposure of the excavated waste.

Specific for the sites are the activities of settlement, where the settlers use agricultural products - plants and animals, grown in the yard of the farm, and consume for all their needs water from the

[112] ICRP, Radiation Protection Recommendations as Applied to the Disposal of Long-Lived Solid Radioactive Waste, Publication No. 81, Elsevier, Oxford, 1999

[113] ICRP, Radiological Protection Policy for the Disposal of Radioactive Waste, Publication No. 77, Elsevier, Oxford, 1997

well dug in the yard of the farm. Results for the consumption of water from the well are shown in **Figure 1.5-37** and **Figure 1.5-38**.

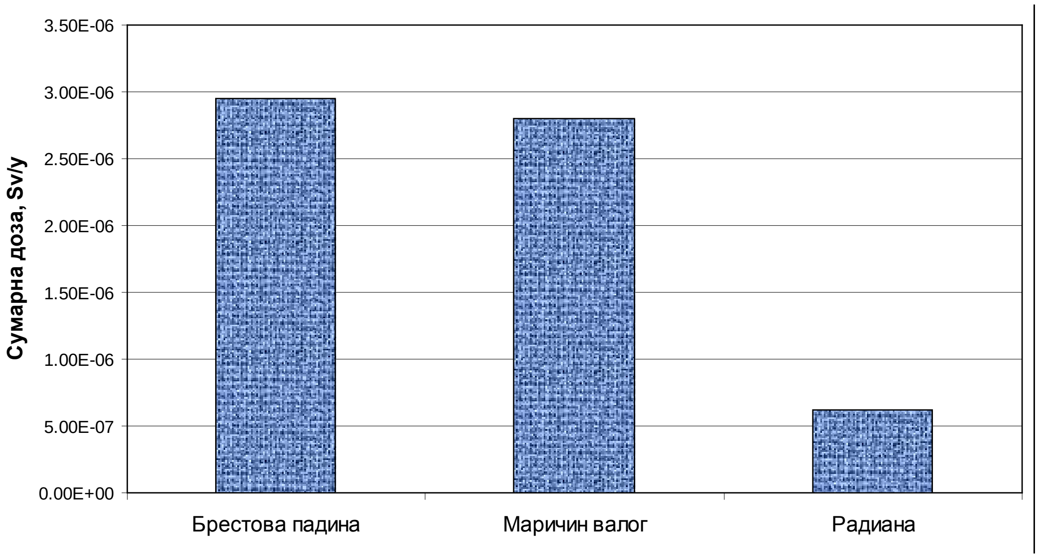

FIGURE 1.5-37 TOTAL DOSE OF EXTERNAL EXPOSURE AS A RESULT OF THE WASHING OF THE INDIVIDUAL SITES WITH WATER FROM THE WELL

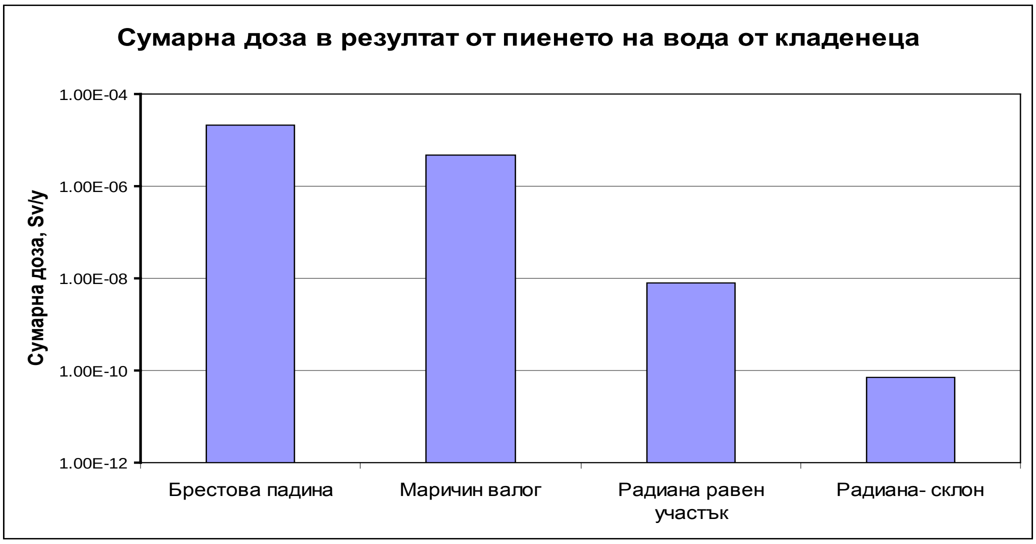

FIGURE 1.5-38 TOTAL DOSE AS A RESULT OF DRINKING WATER FROM THE WELL AT THE INDIVIDUAL SITES

The total effective dose in the case of settlement of the different sites is as follows: for Brestova Padina site 4.48×10^{-5} Sv/y; for Marichin Valog site 1.79×10^{-5} Sv/y; for Radiana site 7.64×10^{-6} Sv/y for the flat section and 7.64×10^{-6} Sv/y for the slope section.

The results indicate that in terms of this safety criterion - maximum individual effective dose for the critical group members of the public - all studied sites not only satisfy the radiological criterion for maximum effective dose of 1 mSv per year, but are orders of magnitude lower.

<u>The results of the safety analysis conducted within the preliminary safety assessment convincingly demonstrate the ability of the selected Radiana site to ensure the safe disposal of radioactive waste and its isolation from the environment.</u>

Phase 4: Confirmation of the site

The correctness of the choice made has been confirmed at the next, fourth phase (phase 4) of the stage of site selection – confirmation of the site.

In accordance with the requirements of the nuclear legislation SE RAW shall elaborate and submit for approval at the Nuclear Regulatory Agency a Plan for Implementation of Phase 4 Confirmation of the site for the NDF[114] and a Program for quality assurance in the implementation of Phase 4 [115]. In accordance with the requirements of the Ordinance on the Safety of Radioactive Waste Management, the Plan for Implementation of Phase 2 shall include: (1) description of the objectives; (2) description of the main activities in their sequence; (3) description of the requirements and recommendations of national and international documents, which will be implemented in carrying out the activities; (4) list and description of the developed procedures, ensuring the practical application of the requirements and recommendations of national and international documents; (5) detailed schedule for implementation of activities; (6) assessment of the necessary financial resources and sources of funding.

The Plan for Implementation of Phase 4 Confirmation of the site for the NDF and Program for quality assurance in the implementation of Phase 4 have been approved by the Nuclear Regulatory Agency.

SE RAW shall carry out the necessary studies to confirm Radiana site for building the NDF in accordance with the approved plan and program for quality assurance. The studies include analysis and evaluation of the activities conducted in the implementation of Phase 1 Development of a disposal concept and planning for site selection; analysis and evaluation of activities conducted in the implementation of Phase 2 Data collection and analysis of regions; analysis and evaluation of activities conducted in the implementation of Phase 3 Characterization of sites for the NDF; main analyzes and conclusions for confirmation of Radiana site; elaboration of programs for pre-operation monitoring at Radiana site - program for pre-operation radiation monitoring; program for pre-operation hydrogeological monitoring and program for pre-operation seismic monitoring of Radiana site.

The report on the implementation of Phase 4 Confirmation of the site for the NDF[116] is approved by the competent authority - the Nuclear Regulatory Agency, therefore the activities of the stage of site selection for the NDF are considered finalized.

1.5.2 JUSTIFICATION OF THE SELECTION OF SURFACE REPOSITORY FOR DISPOSAL OF LOW AND INTERMEDIATE LEVEL RAW

1.5.2.1 SURFACE REPOSITORY FOR DISPOSAL

The chosen option for disposal of low and intermediate level radioactive waste of category 2a is **surface multi-barrier engineering facility**. The choice of surface multi-barrier engineering repository is explicitly determined by the requirements of the nuclear legislation[117], according to which **"RAW of category 2a shall be disposed in surface engineering facilities for disposal of RAW"** (Article 18, item 4 of the Ordinance on the Safety of Radioactive Waste Management). The decision of the legislature, which is the basis for the choice of the SE RAW, is in line with the EU legislation. According to the Directive of the European Union 2011/70/Euratom of 29 July 2011 on establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, disposal of RAW near the surface, i.e. in surface repositories, is a typical concept for disposal of low and intermediate level waste. The strategy for management of spent nuclear fuel

[114] Plan for Implementation of Phase 4 Confirmation of the site for the NDF, SE RAW, 2011.

[115] Program for quality assurance in the implementation of the project “Construction of NDF for disposal of low and intermediate level radioactive waste” at the phase “Confirmation of Radiana site”, SE RAW, 2011.

[116] Report on the implementation of Phase 4 Confirmation of the site for the NDF, SE RAW, 2011.

[117] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

and radioactive waste[118], although an administrative and not a legislative act, also defines the NDF as a surface repository.

The analysis of various documents of the International Atomic Energy Agency (IAEA), including recommendations of the safety standards of the IAEA, demonstrates that the disposal in surface repositories is a proven and well-established method for disposal of RAW, which has proven the safe isolation of RAW from the environment and people during the dozens of years of operation of such repositories.

The analysis of the experience of leading countries in the European Union confirms the choice made for the disposal of low and intermediate level radioactive waste of category 2a in surface engineering facilities for RAW disposal.

1.5.2.2 LONG-TERM STORAGE IN A STORAGE FACILITY

The long-term storage of conditioned low and intermediate level RAW of category 2a is not a preferred option based on the experience of RAW management of the world's leading countries, and this is postulated in the documents of the International Atomic Energy Agency in Vienna. Essentially, the long-term storage is a storage in warehouses, similar to the existing Warehouse for storage of conditioned RAW in SU RAW-Kozloduy, but for a significantly longer period of time than the period of operation of such facilities, which is in the range of 30 to 50 years. The reasons for that are as follows:

(1). Inability to ensure long-term safety of the facilities;

(2). Essentially, the long-term storage in warehouses is a transfer of the responsibility for the safe management and disposal of RAW to the future generations, which contradicts the fundamental principles of the IAEA, according to which this responsibility in no way can be transferred to the future generations;

(3). Ultimately, the cost of RAW management, including long-term storage and subsequent disposal, will be significantly higher, which is unjustified given that the long-term safety of the facilities is not ensured;

According to Directive 2011/70/Euratom of 29 July 2011 on the establishment of a Community framework for the responsible and safe management of spent fuel and radioactive waste, "storage of RAW, incl. long-term storage, is a temporary solution and not an alternative to disposal". The Radioactive Waste Management Committee at the OECD Nuclear Energy Agency[119] explicitly postulates that this strategy of waiting, which was adopted by a single country in the world - the Netherlands, which does not develop nuclear energy and manages a limited amount of low and intermediate level waste, is unacceptable due to reasons of safety and due to ethical considerations.

1.5.2.3 DISPOSAL IN GEOLOGICAL REPOSITORY

The geological repository is not an option for the disposal of low and intermediate level RAW of category 2a. The geological repository is a repository built at considerable depth in the earth - depth of several hundred meters or more below the ground surface. The geological repository is designed for disposal of high-level and long-lived waste from the processing of spent nuclear fuel and/or disposal of spent nuclear fuel when it is declared as waste. The price for disposal of a unit volume of conditioned RAW in such a repository is disproportionately high and economically unjustified. The international experience demonstrates that the surface repositories are sufficiently reliable for the disposal of low and intermediate level RAW of category 2a. In confirmation of what has been

[118] Strategy for the management of spent nuclear fuel and radioactive waste by 2030, adopted by protocol decision of the Council of Ministers of 5 January 2011, amended by protocol decision of the Council of Ministers of 25 June 2014.

[119] OECD NUCLEAR ENERGY AGENCY, Moving Forward with Geologic Disposal of Radioactive Waste, A Collective Statement by the NEA Radioactive Waste Management Committee, NEA No. 6433, OECD, Paris (2008)

said is the fact that of all the countries in the world, which develop nuclear energy, only Germany and Switzerland bury low and intermediate level waste in a geological repository. An additional argument is the fact that the construction of geological repositories is associated with considerable technical difficulties. This is confirmed by the fact that there are only two geological repositories built in the world. One of them is in the US and is intended for the disposal of high-level and long-lived waste from the defense industry, and the other one is in Germany, where the process of licensing and construction lasted 40 years.

According to the Bulgarian nuclear legislation[120], disposal in geological repositories is allowed for the disposal of radioactive waste of category 2b and category 3. This is supported by the European Union Directive 2011/70/Euratom of 29 July 2011 on the establishment of a Community framework for the responsible and safe management of spent fuel and radioactive waste[121], according to which the geological repository is designed for disposal of high level waste and spent nuclear fuel. The European roadmap for disposal in geological repositories [122] confirms that the geological repositories are intended for disposal of high-level and long-lived waste from the processing of spent nuclear fuel and/or disposal of spent nuclear fuel when it is declared as waste.

1.5.3 MAIN GOALS, PRINCIPLES AND CRITERIA FOR SAFETY

The NDF is intended for disposal of low and intermediate level radioactive waste of category 2a according to the Ordinance on the Safety of Radioactive Waste Management. In its essence the NDF shall provide safe isolation of the buried radioactive waste for the entire period during which RAW is potentially a danger to humans and their environment.

In this sense, the **main goal** in the construction, operation, closure and post-operation period is **to ensure the safety and effective protection of the operating personnel, population and environment from the potential impact of disposed waste during the operation of the NDF and after its closure by preventing uncontrolled spread of radioactive substances and ensuring their isolation from the biosphere.**

Measures to ensure the safety shall be taken throughout the life cycle of the NDF – at the stages of site selection, design, construction, operation, closure and the period of institutional control.

In accordance with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management[123], the requirements of the Bulgarian nuclear legislation, safety standards of the IAEA [124, 125, 126, 127, 128, 129, 130, 131] and the recommendations of the International

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[120] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[121] Directive 2011/70/Euratom of 29 July 2011 on the establishment of a Community framework for the responsible and safe management of spent fuel and radioactive waste.

[122] EUROPEAN NUCLEAR ENERGY FORUM, WORKING GROUP “RISKS”, SUB WORKING GROUP “WASTE MANAGEMENT”, Roadmap to Successful Implementation of Geological Disposal in the EU, (2009)

[123] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Ratified by an Act, adopted by the 38th National Assembly on 10.05.2000, SG, issue 42/23.05.2000.

[124] IAEA, Siting of near surface disposal Facilities, IAEA Safety Series No.111-G-3.1, 1994

[125] IAEA, Fundamental Safety Principles, Safety Fundamentals No.SF-1, IAEA, 2006

[126] IAEA, The Principles of Radioactive Waste Management, Safety Standard Series No.111-F, IAEA, 1995

[127] IAEA, Near Surface Disposal of Radioactive Waste, Safety Requirement, Safety Standards Series No. WS-R-1, 1999

[128] IAEA, Safety Assessment for Near Surface Disposal of Radioactive Waste, Safety Guide, Safety Standards Series No. WS-G-1.1, 1999

[129] IAEA, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste, IAEA Safety Standards, Specific safety Guide No.SSG-23, 2012

[130] IAEA, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards IAEA Safety Standards Series GSR Part 3, 2014

[131] IAEA, Near Surface Disposal Facilities for Radioactive Waste, IAEA Safety Standards, Specific Safety Guide N.SSG-29, 2014

Commission on Radiological Protection (ICRP) [132, 133] the following **basic principles and requirements for safety** shall be observed during the construction, operation and closure of the NDF:

1. The NDF shall be located, designed, constructed, operated and closed in such a way that the exposure of the personnel and population does not exceed the limits specified in BSRP-2012 and the Ordinance on the Safety of Radioactive Waste Management, 2004;
2. The exposure of the personnel and population shall be limited and kept at the lowest possible, reasonably achievable level;
3. The measures for ensuring radiation protection shall be optimized so as to ensure the achievement of the highest possible, reasonably achievable level of protection;
4. The level of protection of the population outside the national borders shall not be lower than the level of protection of the population in the country;
5. The level of protection of the future generations shall not be lower than the level of protection of the current generations;
6. The future generations shall not be burdened by the existence of the NDF, making efforts to restore or maintain the level of safety of the facility;
7. The NDF shall be located, designed, constructed, operated and closed in such a way as to ensure the protection of the environment in accordance with the requirements of the Environmental Protection Act (EPA), 2002 and the international requirements in the field of environmental protection[134,135,136,137,138,139,140];
8. The principle of retention and isolation shall be applied in ensuring the safety of the NDF;
9. The construction of the NDF shall comply with the latest achievements of science and technology and world-recognized operational experience;
10. The safety of the NDF after its closure shall be ensured by passive engineering and natural barriers;
11. The safety of the NDF shall be based on the application of deep-echelon protection, which is based on the simultaneous application of a system of physical barriers and administrative measures, ensuring the following levels of protection:

[132] ICRP, Radiation Protection Recommendations as Applied to the Disposal of Long-Lived Solid Radioactive Waste, Publication No. 81, Elsevier, Oxford, 1999

[133] ICRP, Radiological Protection Policy for the Disposal of Radioactive Waste, Publication No. 77, Elsevier, Oxford, 1997

[134] Convention on Environmental Impact Assessment in a Transboundary Context (ratified by an Act adopted by the 37th National Assembly on 16.03.1995) SG issue 28/1995, effective from 10.09.1997 (Prom. SG issue 86/ 01.10.1995)

[135] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (ratified by an Act, adopted by the XXXIX National Assembly on 02.10.2003, SG issue 91/2003, effective from 16.03.2004, prom. SG. 33/23.04.2004).

[136] Directive 2011/92/EC of the European Parliament and of the Council dated 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (codified text).

[137] Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment, June 2001.

[138] Directive 92/43/EEC (1992) on the conservation of natural habitats and of wild fauna and flora (Natura 2000) – the Habitats Directive.

[139] Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life.

[140] Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.

⇒ System of consecutive physical barriers along the way of spreading of radioactive substances into the environment;

⇒ System of technical and organizational measures to protect the barriers and maintain their effectiveness;

⇒ System of technical and organizational measures to protect the operational staff;

⇒ System of technical and organizational measures to protect the population and the environment;

12. The system of physical barriers is based on a multi-barrier concept, with each barrier contributing to the ensuring of the safety through its safety functions. The NDF safety shall not depend primarily on one separate barrier. If a given barrier is unable to perform its safety functions, the system as a whole shall ensure the isolation of RAW in accordance with the safety criteria.
13. The construction of the disposal facilities shall be such as to allow removal of packages with RAW during the period of operation of the NDF;
14. The construction of the disposal facilities shall ensure easy and efficient operation, maintenance, monitoring and control;
15. The whole process of building the NDF shall be transparent and establish an open dialogue with the population. The requirements of the public shall be taken into account in the process of site selection and shall be included in the facility design to the extent that is technically feasible and economically viable;
16. The main safety criteria are the **radiological criteria** established in BSRP-2012 and in the Ordinance on the Safety of Radioactive Waste Management[141]:
    1. The individual effective dose for the critical group members of the public, resulting from the NDF after its closure, shall not exceed 0,1 mSv per year;
    2. The individual effective dose for the respective critical group members of the public, resulting from the operation of the NDF, shall not exceed 0,1 mSv per year;
    3. In case of design-basis accidents in the NDF, the estimated individual effective dose for the respective critical groups of the public at the boundary of the site shall not exceed 1 mSv per year;
    4. The limit of the effective dose for the personnel operating the NDF shall be 20 mSv for each year;
    5. The limits of the annual equivalent doses for the personnel operating the NDF shall be 20 mSv for the eye lens, 500 mSv for the skin and 500 mSv for the hands, armrests of the hands, feet and ankles.

The dose limits for the population during the operation of the NDF and after its closure (post-operation period) are lower than the limit for the annual effective dose for each individual of the population 1 mSv/a, determined by BSRP-2012. The safety criteria comply with the safety standards of the IAEA, International Basic Safety Standards - Radiation Protection and Safety of Radiation Sources[142] and the recommendations of the International Commission on Radiological Protection. [143,144].

[141] Ordinance № 7 of 8.06.1998 on the systems for physical protection of the buildings, SG. issue 70 of 19.06.1998

[142] IAEA, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards IAEA Safety Standards Series GSR Part 3, 2014

[143] ICRP, Radiation Protection Recommendations as Applied to the Disposal of Long-Lived Solid Radioactive Waste, Publication No. 81, Elsevier, Oxford, 1999

1.6 DESCRIPTION OF THE PHYSICAL CHARACTERISTICS OF THE INVESTMENT PROPOSAL AND THE REQUIRED AREAS

1.6.1 LOCATION OF THE SITE OF NDF AND THE EXISTING INFRASTRUCTURE

It is proposed, after a number of additional studies and comparisons made under all criteria with the other proposed sites, that NDF is located at Radiana site. As stated above, the site is located immediately next to Kozloduy NPP between two roads - one to the north controlled by the NPP and considered to be an internal road of the plant and a section of the national road II-11 Kozloduy-Hurlets-Mizia to the south - **Figure 1.6-1**. The area in orange ( ) indicates the area of Radiana site.

FIGURE 1.6-1 LOCATION OF RADIANA SITE

The site is located 3.3 km southeast of the border of the town of Kozloduy, 4.3 km northwest of the construction limits of the village of Harlets and about 4.2 km southwest of the right bank of the Danube River. Its area is about 46 hectares, with almost rectangular shape and a maximum size of 470 x 1250 m. It falls within the 2-km precautionary protective measures area (PPMA) of Kozloduy NPP - **Figure 1.6-1**. Restrictions on the land use have already been imposed in the 2-km precautionary protective measures area (PPMA) and the construction of the NDF does not lead to new or additional restrictions.

The site is located on the slope between the second and sixth loess terraces with displacement between them of about 55 m (from elevation +39 m to elevation +94 m), to the right of the Danube River. The lower terrace (T_2) is relatively flat with elevations between 39 and 45 m and occupies the northern and north-eastern part of the site. The upper terrace (T_6), with elevations between 65 and 94 m occupies the southern part. The average slope of the site is 8º30'. The slope outlines the Danubian plain of Kozloduy on its south.

[144] ICRP, Radiological Protection Policy for the Disposal of Radioactive Waste, Publication No. 77, Elsevier, Oxford, 1997

In view of the location of the site - located next to the improved site of Kozloduy NPP, there is infrastructure at the site and its immediate vicinity.

1.6.1.1 EXISTING TRANSPORT INFRASTRUCTURE

The site is accessible from the north along the internal road of Kozloduy NPP. A secondary republican road II-11 Kozloduy-Harlets-Mizia is located in immediate proximity of the site.

1.6.1.2 EXISTING WATER SUPPLY NETWORK

A water-conduit of the water supply network for drinking and domestic purposes, supplying Kozloduy NPP with water and owned by the water supply and sewerage company (WSSC)-Vratsa, is passing through the site. Drinking water is provided by three wells of "Raney" type, located on the terrace of the Danube river before the town of Kozloduy. They are also used for providing water to the villages Harlets and Glozhene. The Basin Directorate for Water Management in Danube Region (BDWMDR) has issued a water intake permit to Kozloduy Municipality for abstracting water from these facilities under the Water Act (WA). From the water tanks of the town of Kozloduy the water reaches by gravity a pumping station (PS) through a pipeline with length of 11 km, diameter of Ø500 mm and a maximum water quantity of 260 l/s. The pumping station re-pumps the water to the tank of the plant at elevation 93.0 m (with volume 2h2000 m^3), and from there by gravity it reaches the individual consumers. The length of the pressure water pipe from the PS to the tank is 0.5 km. The external water supply system - wells, pumping stations, pipelines and other facilities up to the first distribution shaft is maintained by WSSC-Vratsa.

The constructed system has sufficient capacity to ensure the drinking water supply of the NPP and to cover the drinking water needs during the construction, operation and closure of the NDF. The section of the water supply network, which passes through Radiana site, will be shifted to the north between the fence of the site and the existing internal road, while maintaining the existing capacity for supply of Kozloduy NPP and providing a water supply connection to the NDF. This water will be used in compliance with the regulatory requirements and contractual terms with WSSC - Vratsa.

1.6.1.3 EXISTING SEWERAGE NETWORK

A sewerage system for faecal, industrial and stormwater is constructed near Radiana site of Kozloduy NPP. The sewerage network covers the entire territory of the power plant and receives all types of wastewater. Kozloduy NPP discharges water in accordance with the terms and conditions of Permit №13750001/20.04.2007 with subsequent amendments, issued by the competent authority Basin Directorate for Water Management in Danube Region (BDWMDR) with main office in the city of Pleven. Under this permit Kozloduy NPP discharges water from its own sewage system to the main drain (MD) of "Blatoto" drainage system, managed by Irrigation Systems EAD - branch Mizia. The water from the drainage system "Blatoto" is transferred by means of a PS (pumping station) into the Danube River.

There are points for monitoring and control along the MD in accordance with the requirements of the regulations. The capacity of the system is sufficient to cover the needs of the NDF.

1.6.1.4 EXISTING IRRIGATION CANAL

Irrigation canal M-1 passes through Radiana site. This canal is part of the Irrigation System "Asparuhov Val". The canal is not a water body within the meaning of the WA. It is supplied with water from the Danube river by PS "Asparuhovo-1" and canal Mo. Its length is 30.239 km, its width is from 0.90 m to 1.00 m and its depth from 0.8 m to 1.40 m. The canal is tiled. It is sized for holding water quantity Q=3.6 m^3/s. With the implementation of the investment proposal, part of the canal will be moved outside the site.

1.6.1.5 EXISTING TELECOMMUNICATIONS NETWORK

Four armoured communications copper cables, owned by BTC (Vivacom), pass through the site as well as fiber optic cables in 1 HDPE pipe, which are also owned by BTC (Vivacom). The existing cables according to BTC data are shown in a drawing in **Appendix 8-I.7.**

The characteristics of the communication copper cables are as follows:

- ⇒ PC 306: TC of the Urban Telephone System (UTS) of the town of Kozloduy, providing telephone connection on the territory of Kozloduy NPP. Cable type: TZB 37x4x1.2. Located at a distance of 40 meters from the internal road of Kozloduy NPP;
- ⇒ PC 312: TC of UTS of the town of Kozloduy, providing telephone connection on the territory of Kozloduy NPP. Cable type: TZB 37x4x0.9. Located at a distance of 12 meters from the internal road of Kozloduy NPP;
- ⇒ PC 313: TC of UTS of the town of Kozloduy, providing telephone connection on the territory of Kozloduy NPP. Cable type: TZB 37x4x0.9. Located at a distance of 12 meters from the internal road of Kozloduy NPP;
- ⇒ Intra-regional cable (IRC) Kozloduy-Mizia. Cable type: MKKB 4x4x1.2+15x4x1.2. Located at a distance of 33 meters from the internal road of Kozloduy NPP;

Along the entire length of Radiana site there are optic cables stretched out in 1 HDPE pipe with the following characteristics:

- ⇒ Optic cable Vidin-Knezha, section Kozloduy-Mizia-Oryahovo: Cable type OK 12 FO (6x2). There is a deviation with cable OK 12 to Kozloduy NPP.
- ⇒ Optic cable BTC Kozloduy - RM 1 NPP: Cable type OK 60 FO (5x12). This cable is used to provide services on the territory of Kozloduy NPP and transfer of 3G of BS VZ 6168. The cable is within the easement area of the dirt road on the western boundary of Radiana site to TS (2)/PM 1.
- ⇒ Optic cable PM 1 NPP - BS 6168: Cable type OK 24 FO (6x4). The cable is in the section from TS (2) to TS (3).

The capacity of the communications network and of the optical network is sufficient to provide the telecommunication of the future NDF and an optical connection. In accordance with the legal requirements in the country, Agreement №31170/11.07.2012 has been signed between SE RAW and BTC (Vivacom) for protection of the electronic communications network owned by BTC. The Agreement sets out the specific technical conditions for moving the electronic communications network of BTC outside Radiana site and for provision of services to the future NDF. A detailed design has been prepared on the basis of the Agreement, which will be discussed in item 1.6.3.5.

1.6.1.6 EXISTING POWER SUPPLY

Given that Radiana site is in the immediate proximity of the improved site of Kozloduy NPP", the existing infrastructure also includes power supply. An overhead power line ELBA, 20 kV from Kozloduy substation, owned by CEZ Distribution Bulgaria, passes through the site.

The section of the existing power line ELBA, passing through Radiana site is subject to moving outside the boundaries of the site, which is owned by SE RAW. SE RAW has received instructions from CEZ Distribution Bulgaria on the way of displacement and power supply, which will be done through a diversion of the overhead power line. A power substation will be supplied in accordance with the legal requirements. A detailed design has been developed on the basis of the instructions.

1.6.2 AREA REQUIRED FOR THE IMPLEMENTATION OF THE IP DURING THE STAGE OF CONSTRUCTION AND THE STAGE OF OPERATION

The area required for the implementation of the investment proposal on Radiana site amounts to 46.4 hectares. The status of the land within the boundaries of the site and in its region, according to the latest information from the Agriculture and Forestry municipal office and the Geodesy, Cartography and Cadastre Agency is shown in **Figure 1.6-2** and **Table 1.6-1** - area.

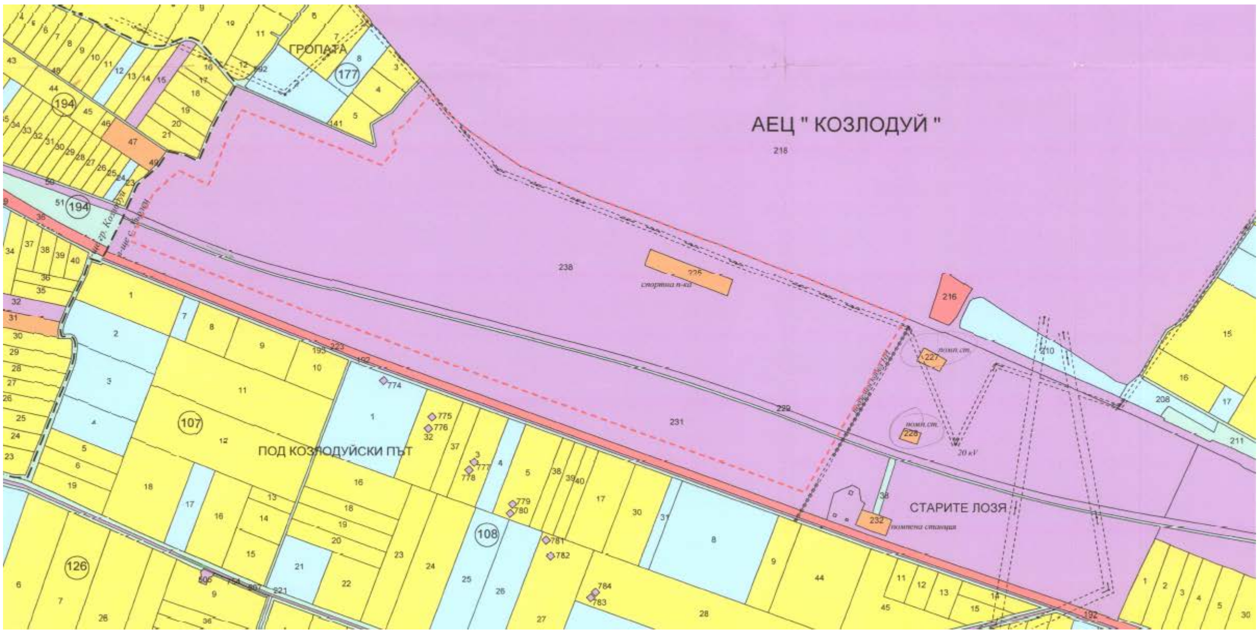

FIGURE 1.6-2 MAP OF THE OWNERSHIP OF RADIANA SITE AND ITS NEARBY AREA.

Legend by type of ownership: - state public; - state public; - municipal public; - municipal private; - private; - legal entities.

TABLE 1.6-1 STATUS OF THE PROPERTIES OF RADIANA SITE AND ITS NEARBY AREA

№ of the property	Owner	Way of permanent usage	Type of ownership	Area, dka
000254, formed by 000238	The state, provided to SE RAW for the purposes of construction of NDF, Decision of the Council of Ministers №393/5.07.2013	Other urban area	State public	309.633
000355 formed by 000231	The state, provided to SE RAW for the purposes of construction of NDF, Decision of the Council of Ministers №393/5.07.2013	Other urban area	State public	129.871
000229	Ministry of Agriculture and Food-Hydro-meteorological station	Irrigation canal	State private	15.606
000225	Kozloduy Municipality	Sports complex	Municipal private	4.26
000005	Kozloduy Municipality	Dirt road	Municipal public	4.656
			TOTAL	**464.026**

The table shows that the land is mostly state public property, provided to SE RAW for the purposes of the construction of the NDF with Decision of the Council of Ministers (DCM) №393/5.07.2013 by acts of public state property in the name of SE RAW №3220/03.09.2013 and

№3219/03.09.2013, issued by the District Governor of Vratsa district. There are also small parcels which are municipal private property, municipal public property and state private property.

The investment proposal affects:

⇒ property № 000355, owned by SE RAW, public state property, way of permanent use (WPU) "other urban area";

⇒ property № 000254, owned by SE RAW, public state property, WPU "other urban area";

⇒ part of property № 000005 with WPU "dirt road";

⇒ part of property № 000229 with WPU "irrigation canal";

⇒ property № 000225 with WPU "sports complex";

The investment proposal does not affect private property and is not bordered by private lands. The nearest private lands are located at a distance of 30 m. The balance of the territory, according to the project is shown in **Table 1.6-2**.

TABLE 1.6-2 BALANCE OF THE TERRITORY

Territory	Area, m^2	Percent, %
Cells of the repository – first stage	7 558.3	1.63
Cells of the repository – second stage	7 558.3	1.63
Cells of the repository - third stage	7 558.3	1.63
Buildings and facilities area	5 480.3	1.18
Landscaping area	244 480.0	52.69
Undisturbed areas	132 572.8	28.57
Pavement – roads and other	58 818.0	12.68
Total	464 026.0	100.00

There is a Detailed Development Plan prepared for the site – Zoning and development plan of NDF at Radiana site[145], site, shown in **Appendix 8-I.8.**

The main activities during the period of construction will be carried out at Radiana site. Additional area will be needed for temporary storage of 90,000 m^3 loess, which will be used to build the loess-cement cushion and 68 000 m^3 of humus, which will be used back on the site.

A study has been made on the location of a temporary landfill for humus and loess.[146] The site has been identified – it is near Radiana site, at a distance of 1 km. It is private state property with an area of 39.765 dka, WPU – other types of areas of urban nature, accessible for transport. The location of the site for temporary landfills of humus and loess is given in **Figure 1.6-3**. **Appendix 8-I.9** provides the location of the site, designated on the Map of Restored Property (MRP). Negotiations are being held with the property owner for its use during the construction of the NDF.

[145] Detailed Development Plan - plan for regulation and building-up of NDF at Radiana site, land of the village of Hurlets, Kozloduy Municipality, 2012.

[146] Study on the location of a landfill for redundant spoils and temporary landfills for humus and loess SE RAW, 2014.

FIGURE 1.6-3 LOCATION OF THE SITE FOR TEMPORARY LANDFILLS FOR HUMUS AND LOESS IN RELATION TO RADIANA SITE

The operation of the NDF and respectively the establishment of a precautionary protective measures area does not require additional areas besides the above-mentioned area of Radiana site. This is due to the explicit requirement of SE RAW that the design of the NDF be conducted so that the precautionary protective measures area will be within the boundaries of the site - within the terrain surrounded by an outer fence. The following figure provides a scheme of the outer fence of the NDF, within which the precautionary protective measures area will be situated.

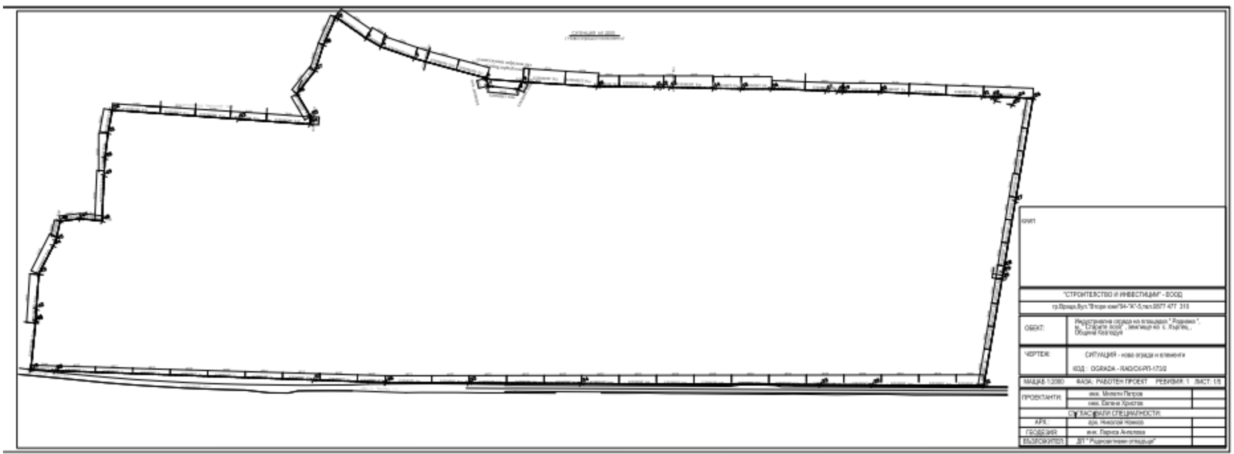

FIGURE 1.6-4 SCHEME OF THE FENCE OF NDF WITHIN WHICH PPMA IS SITUATED, RADIANA SITE.

The areas with special status in accordance with the Act on the Safe Use of Nuclear Energy (ASUNE) and the Ordinance on the conditions and procedures for determining the areas with special status around the nuclear facilities and sites with sources of ionizing radiation[147,148] will be discussed in detail in item 1.8.

[147] Act on the safe use of nuclear energy, prom. SG issue 63 of 28 June 2002., amend. SG issue 68 of 2 August 2013.

1.6.3 NECESSARY INFRASTRUCTURE

The infrastructure necessary for the operation of the NDF at Radiana site does not require large investments and is therefore not related to major construction and assembly activities, as it is located in immediate proximity of the developed site of Kozloduy NPP.

1.6.3.1 TRANSPORT INFRASTRUCTURE

The site is accessible from the north via the internal road of Kozloduy NPP. Near the site, to its south is located a secondary national road № II-11, which connects the town of Kozloduy – village of Harlets – town of Mizia.

The radioactive waste to be disposed in the NDF will be transported via the internal road of Kozloduy NPP in the following scheme: Storage facility for conditioned RAW, which is located at the site of Kozloduy NPP – the internal transport network of Kozloduy NPP - checkpoint of PP-1 - internal road of Kozloduy NPP - checkpoint of the NDF.

During the construction of the NDF the internal road of Kozloduy NPP will be used and mainly the secondary republican Road II-11 town of Kozloduy – village of Harlets – town of Mizia. For this purpose, a deviation will be made from road II-11 to Radiana site, amounting to 244.42 m, which is described in item 1.4.6.

1.6.3.2 WATER SUPPLY

The water supply of the NDF will be carried out through a connection from a drinking water conduit outside the site, owned by WSSC Vratsa. The scheme of the moving of the section of the conduit, according to data from the Detailed Development Plan - parcel plan for shifting the stretch of the drinking water conduit[149] , is presented in the figure below.

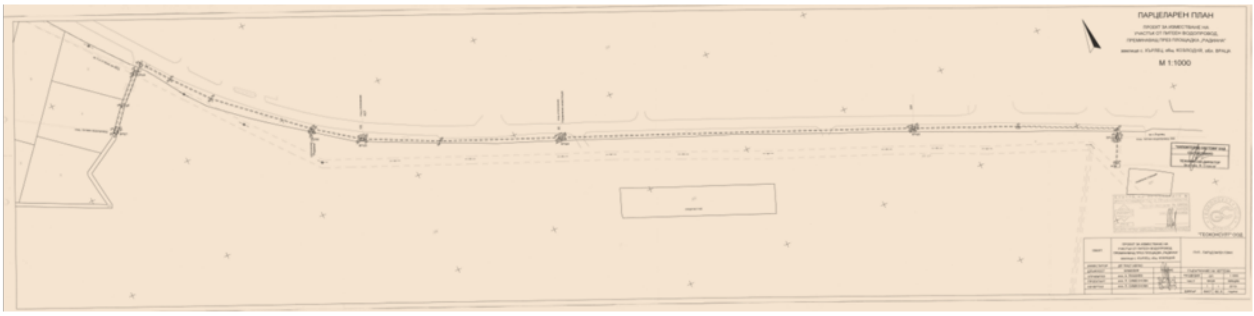

FIGURE 1.6-5 SCHEME OF MOVING A DRINKING WATER CONDUIT OUTSIDE RADIANA SITE

The newly designed water conduit will have a total length of 1120 m and will provide water to all existing consumers and a connection for supply of the NDF. The main pipeline will have a diameter of 400mm, and the connections for supplying the various consumers – diameter of 300mm or less depending on the consumer. Six shafts will be constructed along the route[150]. The required amount of water to supply the NDF is 5l/s. The details are given in **Appendix 8-I.10.**

An easement area of the water conduit is determined in accordance with the requirements of Art. 112, Paragraph 2 of the Water Act and is 0.50 m on both sides of the axis of the pipes with a

[148] Ordinance on the conditions and procedures for determining the areas with special status around nuclear facilities and sites with sources of ionizing radiation, prom. SG issue 69/06.08.2004, last. amend. SG issue 5 of 19.01.2010.

[149] Detailed Development Plan – parcel plan for shifting the stretch of the drinking water main, passing through Radiana site, SE RAW, 2013.

[150] Detailed design for drinking water conduit and water meter chamber with water metering unit for supply of Radiana site and displacement of a section of drinking water conduit, passing through Radiana site, SE RAW, 2013.

diameter of 400mm, 0.45 m on both sides of the axis of the pipes with a diameter of 300mm and 0.30 m around the contour of each shaft.

1.6.3.3 DISCHARGE OF DOMESTIC WASTE WATER AND SURFACE WATER

The IP envisages a separate sewerage network - for domestic waste water from the administrative area, for stormwater and from an internal drainage system from the cells of the repository that allows capturing and collecting possibly penetrated (infiltrated) water in the containers with conditioned RAW. The internal drainage system will be built in a way which allows to determine exactly in which cell with buried radioactive waste moisture has penetrated and to establish the status of the containers. In accordance with the requirements of the nuclear legislation, the water from the internal drainage system of the modules for disposal will be treated as potentially radioactively contaminated in the waste water part in radiation aspect.

The domestic waste water will be discharged into the domestic sewage of Kozloduy NPP. Given that part of the specialized divisions of SE RAW (SU RAW Kozloduy and SU Decommissioning of units 1-4) are located at the site of Kozloduy NPP, there is a signed contract between the two enterprises for waste water discharge into the sewerage network of Kozloduy NPP[151].

At present Kozloduy NPP discharges water from its own sewage system to the main drain. Water is discharged in accordance with the above-mentioned Permit №13750001/20.04.2007 with subsequent amendments issued by the competent authority Basin Directorate for Water Management in Danube Region (BDWMDR) with a main office in the city of Pleven. At the next stage of the IP, it will be assessed if the surface water from the NDF will be discharged directly into a main drain or indirectly through the sewage system of Kozloduy NPP, for which there is written consent by Kozloduy NPP [152]. In both cases, the discharge in the water body will be carried out in accordance with the requirements of the Water Act by a permit for use of a water site for discharge, issued to SE RAW or amended permit of Kozloduy NPP. In both cases, the prohibition on new discharges of waste water in the irrigation-drainage systems will be taken into account - Article 6, paragraph 1, items 3, item 4 of Ordinance №2 dated 08.06.2011 /SG., issue 47 dated 21.06.2011/ for issuing a permit for discharge of waste water into water bodies and setting individual emission limits for point sources of pollution.

Along the route to the sewerage network of Kozloduy NPP there will be points of monitoring and control, including controlling and measuring devices for determining the amount of discharged wastewater.

The surface (drainage) water will be discharged into the main drainage channel of the drainage system "Blatoto", managed by Irrigation Systems EAD [153].

Discharged surface water will come from the stormwater basin, which will be located near the road to Kozloduy NPP, in the lowest part of the site. Only stormwater from the site, clean water from the reservoirs for infiltration control and clean water from the deep drainage network will be directed towards the basin. <u>In the next phase of the design, the water quantity and scheme of water discharge will be specified in greater detail.</u>

1.6.3.4 IRRIGATION CANAL M-1

A design has been prepared for the displacement of the section of canal M-1, passing through Radiana site. According to the design, the new route will consist of pressure water pipe with diameter Ø800 mm and an open channel with a width of 2.50 m. The pipeline will have a total length of 650 m. 520m of them will pass through the land of the town of Kozloduy, Kozloduy Municipality and the remaining 130 m - through the land of the village of Harlets, Kozloduy

[151] Letter from Kozloduy NPP Ref. №2216/16.06.2014г

[152] Letter Ref. №3401-E/15.97.2009

[153] Letter by Irrigation Systems EAD, Mizia branch, Ref.№1011/06.06.2014

Municipality. The newly designed open channel will have a width of 2.50 m, length of 3440 m and will run entirely in the land of the village of Harlets, Kozloduy Municipality. According to the design, its route will pass along part of the route of the existing irrigation canals 3-S-6 and 3-G-24 in the land of the village of Harlets, Kozloduy Municipality.

An option is also proposed to build a pumping station before Radiana site and use it to pass water along the new route of the canal. The selected option is safer in terms of groundwater contamination in the event of an accident and easier with respect to the expropriation and compensation of the owners of the land affected during the construction. According to this option, a pumping station will be built before the site of the NDF on canal M-1, by means of which water will be directed into the existing irrigation canal, which is fed with water from canal M-2 of PS "Asparuhov Val-2". This option will partially affect several properties along the route of the pressure pipe from the pumping station to the beginning of the reconstructed channel and will not affect properties along the canal itself. It is envisaged that the new route of the connection to be performed along the route of an existing industrial channel, which is designed to supply water of 0.100 m^3/s. The existing canal will be reconstructed so that it can hold water quantity from the pumping station in the amount of Q = 0.8 m^3/s and serve the areas to be irrigated. It is sized to hold water quantity of 0.9 m^3/s. The removed part of canal M-1 in the section from the beginning of the site of the NDF until the place of discharge of the new shifted canal will be reclaimed.

1.6.3.5 TELECOMMUNICATIONS NETWORK

Communications copper cables and optic cables described above pass through the site. These cables will be moved out of the site, parallel to the shifted water conduit, and located between the fence of Radiana site and the internal road of Kozloduy NPP. The technical parameters of the cables will be maintained when they are moved. They will be placed in a cable network, made up of 6 PVC pipes according to the prepared detailed design. [154]. A scheme of the shifted cables is given in **Appendix 8-I.7.** As stated above, the shifting will be made on the basis of Agreement №31170/11.07.2012 between SE RAW and BTC on the protection of the electronic communications network owned by BTC. The detailed design is approved by BTC and agreed by the main consumer Kozloduy NPP.

1.6.3.6 POWER SUPPLY

The power supply of the NDF will be carried out by a connection from an overhead power line ELBA, 20 kV from Kozloduy substation, which is owned by CEZ Distribution Bulgaria.

Since part of the existing power line ELBA passes through Radiana site, it is subject to displacement outside the boundaries of the site, which is owned by SE RAW. SE RAW has received instructions from CEZ Distribution Bulgaria on the way of displacement and the way of power supply, which will be done through a connection from an overhead power line. A power substation will be delivered in accordance with the legal requirements.

The route of the displaced overhead power line ELBA is shown in the figure below and in **Appendix 8 I.11** to this part, according to data from the Detailed Development Plan - parcel plan for displacement of a section of the overhead power line. [155].

[154] Detailed design for displacement of existing communications cables SE RAW, 2014=

[155] DDP – parcel plan for displacement of a section of overhead power line ELBA from Radiana site, SE RAW, 2014.

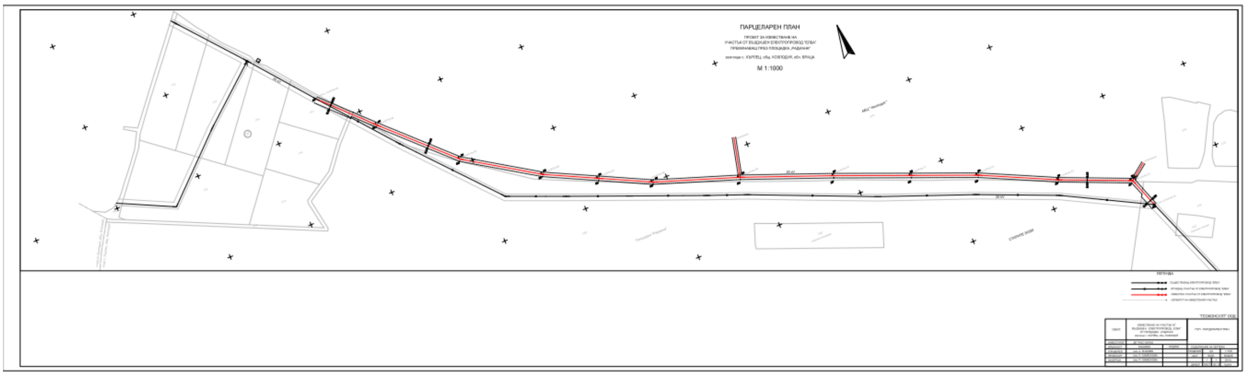

FIGURE 1.6-6 SCHEME OF DISPLACEMENT OF OVERHEAD POWER LINE ELBA OUTSIDE RADIANA SITE

The newly designed section will have a length of 992 m and 11 new pillars. The new route is between poles with numbers 63 and 75 and passes through the urban area. It is situated on the terrain between the fence of the NDF and the internal road of Kozloduy NPP.

1.7 DESCRIPTION OF THE MAIN CHARACTERISTICS OF THE PRODUCTION PROCESS

1.7.1 FACILITY TYPE

The investment proposal of SE RAW for the construction of the NDF includes construction of **module repository** for disposal of low- and intermediate-level radioactive waste, category 2a, according to Ordinance on the Safety of Radioactive Waste Management[156], representing **multi-barrier engineering surface repository**. The selected type of repository is defined by the legislator with Ordinance on the Safety of Radioactive Waste Management, according to which (Article 18, item 4) radioactive waste category 2a must be buried in **surface engineering disposal facilities**. The type of the facility meets the safety standards of the International Atomic Energy Agency and the best practices of developed European countries.

NDF consists of disposal facilities and ancillary buildings and facilities. The site will be provided with physical protection, and the NDF will be surrounded by a fence, guarded and secured in accordance with the requirements of the Ordinance on the provision of physical protection of nuclear facilities, nuclear material and radioactive substances[157].

The site is divided into "controlled area" and "supervised area". The disposal facilities and the building for the reception and temporary operational storage of radioactive waste packages are located in the controlled area. The supervised area contains the administrative buildings and auxiliary facilities - building for access control (checkpoint), administrative building providing appropriate working conditions for the staff with offices, conference hall, archive and auxiliary equipment, laboratories - providing appropriate conditions for laboratory analysis of different potential or actual radioactive samples, building of service systems with workshops with various applications and industrial section, which houses the power supply systems and other service systems, building of physical protection and control room designed for 24-hour control and monitoring of the site, the main service building, situated on the border between the controlled and supervised areas designed for radiation protection, control of the access to the controlled area, radiation control of people and materials.

Access of personnel and vehicles to/from the territory of the NDF will be controlled and will be carried out through a checkpoint.

[156] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[157] Ordinance on the provision of physical protection of nuclear facilities, nuclear materials and radioactive substances, SG issue 77/3.09.2004, last. amend. SG. issue 44 / 9.05.2008.

Besides the building for the reception and temporary storage of packages with RAW, all other buildings have a similar structure consisting of reinforced concrete columns (40 x 40cm), beams and slabs. The external walls are made of 25cm ceramic hollow bricks with thermal insulation of 100 mm of mineral wool, finished with plaster. The roofs are flat with a second layer of concrete for a slope and are also insulated with a minimum of 100 mm mineral wool. The main internal partition walls are designed of plasterboard.

The building for the reception and temporary storage of packages with RAW is located in the controlled area, the disposal area being part of it. It is designed for reception, entry control and buffer storage of packages with radioactive waste before placing them in the cells of the repository. The dimensions of the building are 18.20 x 49.40 x 15.80 m, and the capacity for temporary (buffer storage) is 120 RCC. The building is built of reinforced concrete columns and concrete walls with a thickness of 50 cm, insulated with 100 mm mineral wool. The roof is a steel structure, above which there is a reinforced concrete roof slab, insulated and waterproof. The building is equipped with a 40 ton overhead crane for handling of radioactive waste packages.

Based on the current international practice, local and foreign regulations and recommended documents, a selection has been made for disposal of low and intermediate-level RAW of category 2a in a surface engineering facility [158, 159, 160], according to the Ordinance on the Safety of Radioactive Waste Management. Taking into account the specific conditions of Radiana site, the disposal facility will be located at a depth of 35 m below the ground surface.

The disposal facility is a multi-barrier engineering facility of modular type whose safety is ensured by passive means. Safety is based on the application of deep echelon protection, which is implemented by the simultaneous application of a system of physical barriers and technical and organizational measures, ensuring the following levels of protection:

- → System of successive physical barriers in the way of dissemination of the radioactive substances into the environment;
- → System of technical and organizational measures to protect the barriers and maintain their effectiveness;
- → System of technical and organizational measures to protect the operating personnel;
- → System of technical and organizational measures to protect the population and the environment.

The system of physical barriers (multi-barrier protection) will ensure the safety during the operation of the repository and after closure of the disposal facilities. In the after-operation period the safety of NDF will be ensured entirely by the engineering and natural barriers.

The multi-barrier system for insulation of NDF includes the following components:

- ➢ **The first engineering barrier** is the form of waste, which is cemented radioactive waste, some of which has already been put in steel drums with or without super pressure. A safety function of the form of waste (cement matrix in which the waste is placed) is related to the inclusion of radionuclides in the solid phase of the matrix, and retaining them by adsorption and sedimentation in the highly alkaline environment of the cement. The cement matrix is regarded as a chemical barrier that does not lose its safety functions for thousands of years.

[158] Strategy for managing the spent nuclear fuel and radioactive waste until 2030, approved by a protocol decision of the Council of Ministers on 5 January 2011, amended with a protocol decision of the Council of Ministers on 25 June, 2011

[159] IAEA, Near Surface Disposal of Radioactive Waste, Safety Requirement, Safety Standards Series No. WS-R-1, 1999

[160] IAEA, Near Surface Disposal Facilities for Radioactive Waste, IAEA Safety Standards, Specific Safety Guide N.SSG-29, 2014

- **The second engineering barrier** is a reinforced concrete container with thick walls, a bottom plate and a lid, where the cemented radioactive waste is put, with the free space between the cement matrix of the waste and the lid of the concrete container being filled with grout, forming a monolithic block. The reinforced concrete container should allow for the extraction of waste in the period until the final closure of the NDF. The safety function is to ensure complete retention by maintaining mechanical integrity, incl. integrity of the clamps, for the period of operation of the repository, which will be about 60 years. The reinforced concrete container maintains its functions of a chemical barrier for thousands of years.
- **The third engineering barrier** of the repository includes the disposal cells, which are made of reinforced concrete, the foundations, closing plates and filling material. The specified safety function is retention of the potentially released radionuclides from packages with RAW by maintaining the integrity of cells at reasonably achievable level for a period of 300 years. Concrete retains its functions of a chemical barrier for thousands of years, which ensures the operation of the barrier for a period considerably longer than the required one.
- **The fourth engineering** barrier includes an external loess-cement base and multilayer coating. Besides being a barrier to migration of radionuclides, the base also increases the thickness of the unsaturated zone and improves the overall condition of the base. The multilayer protective coating will be built from natural materials (clay, sand, gravel, etc.) and has many functions, the main ones of which are as follows:
  - To reduce the risk of infiltration of water in the cells of the repository, ensuring a very low coefficient of filtration - below 10^{-9} m/s and extremely low values of the coefficients of infiltration - below 1.5 l / m^2 per year.
  - To serve as a barrier against external disturbance of the system of barriers by humans, animals or plants;
  - To provide protection against prolonged erosion agents such as rain and wind.
- **The fifth (natural) barrier** is performed by the favourable characteristics of the site.

The disposal facilities are protected from surface water (precipitation, surface runoff due to rainfall and snowmelt) through a system of drainage of surface water and by means of a protective hall, lightweight construction over the facilities in operation.

It is envisaged that the equipment will have internal drainage system that allows capture and storage of potentially penetrated (infiltrated) water in the containers with conditioned RAW. The internal drainage system will be built in a way which allows to determine exactly in which cell with buried radioactive waste moisture has penetrated and to determine the condition of the containers.

In accordance with the best practices in the developed European countries and the legal requirements established by the Ordinance on the Safety of Radioactive Waste Management[161], the design of NDF provides a technical possibility to retrieve packages with radioactive waste during the period of operation of the repository[162]. The practice in developed European countries shows that the public acceptance is better for disposal facilities for which corrective actions can be implemented [163].

1.7.2 MAIN STAGES OF IMPLEMENTATION

The main stages of the investment proposal are as follows:

[161] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[162] IAEA, The Principles of Radioactive Waste Management, Safety Standard Series No.111-F, IAEA, 1995

[163] IAEA, Low and intermediate level waste repositories: socioeconomic aspects and public involvement, IAEA-TECDOC-1553, Vienna, 2007

1.	Selection of a site	2006 -2011;
2.	Design	2012 – 2014;
3.	Construction	2015 - 2020;
4.	Operation	2021 – 2075;
5.	Closure	2075 – 2090;
6.	Institutional control	2090 – 2390.

TABLE 1.7-1 PROGRAM OF THE ACTIVITIES DURING THE STAGES OF THE INVESTMENT PROPOSAL

Stages	Activities
Preparatory stage	Defining of RAW management strategy Adoption of governmental decision on the construction of the NDF – DMC No.683/25.07.2005. Analysis, preparation of documentation and submission of application to the NRA for the selection of site permit
Selection of site:	*Beginning of stage:* *Issuance of permit by the NRA for the selection of site*
(1) Development of a concept for disposal and planning	Elaboration of disposal concept; definition of safety requirements; definition of criteria for selection of suitable site; elaboration of detailed program.
(2) Data collection and analysis of areas	Execution of thorough analysis of existing information about the territory of the country, about the typical features of the environment; consideration of social and economic aspects; definition of potential areas and sites, subject to thorough field and laboratory research. Exclusion of areas unsuitable for construction of the repository by the method of exclusion. Definition of potential areas where sites are identified. Thus, initially on the basis of analysis, 78 potential sites were selected for the construction of NDF. After a thorough analysis they were limited to 12; out of which the 4 most suitable sites were defined: Marichin Valog, Brestova Padina, Radiana and Vurbitsa.
(3) Characterisation of sites	Conducting thorough field and laboratory studies on the potential sites of Marichin Valog, Brestova Padina, Radiana and Vurbitsa; During the implementation of stage 3 Characterisation of sites, Varbitsa site is removed from further consideration as it does not satisfy the radiological criterion for minimal radiation risk in the transport of RAW. Comparing their characteristics. On the basis of multi-criteria analysis, Radiana site is defined as the most suitable site
(4) Confirmation of site	Detailed studies are conducted for confirmation of the selected Radiana site. Preliminary projects on the NDF are elaborated according to the characteristics of the site. The preferred construction of the repository is defined. The EIA is executed. Application is submitted to the Chairman of NRA for obtaining an order approving the selected site and for design permit. The preliminary safety assessment is the basic document. Programmes are elaborated on pre-operational monitoring conducted before the repository is put into operation.
End of stage: ***Order of the NRA Chairman for approval of the selected site***	
Design	

(1) Elaboration of DDP	*Beginning: Order of the Minister of Regional Development and Public Works on the elaboration of DDP* The elaboration of detailed development plan (DDP) – zoning and development plan (ZDP) for Radiana site is aimed at an optimal volume and planning decision on the NDF site, organization and management of the territory of NDF, designed for engineering and technical purposes. On the basis of approved DDP, the purpose of use of the land is changed and ownership over it is acquired. Programs for pre-operational monitoring of the selected site are implemented. *End: Order of the Minister of Regional Development and Public Works for approval of the DDP - ZDP*
(2) Elaboration of conceptual design	*Beginning: Order of the Minister of Regional Development and Public Works for approval of the DDP - ZDP* The conceptual design shall follow the provisions of the detailed development plan and shall be elaborated in compliance with the requirements of Ordinance 4 on the scope and content of the investment projects and of the requirements of the nuclear legislation. The main technical solutions shall be specified in the conceptual design. Programs for pre-operation monitoring of the selected site are implemented.
(3) Elaboration of technical project	The Technical project shall be elaborated on the basis of the conceptual design approved by the Contracting Authority. An Interim safety assessment shall be elaborated, which is a main document for obtaining an order for approval of the technical project. Application shall be submitted to the NRA for the approval of the technical project and for the obtaining of building permit. Preliminary contracts shall be concluded with operational entities (electric power distribution company, water and sewage company). Application for approval of the technical project and for obtaining of building permit shall be submitted to MRDPW. Programs for pre-operation monitoring of the selected site are implemented.
End of stage: ***Approval of the technical project by MRDPW; Order of the Chairman of NRA for approval of the technical project***	
Construction	*Beginning: Building permit issued by MRDPW and NRA* Programs for pre-operation monitoring of the selected site are implemented. Building of disposal facilities, auxiliary buildings and facilities, connecting infrastructure systems to the points of connection, supply and installation of equipment. The building shall be implemented in three stages. During the first stage, the infrastructure of the NDF and the first module for disposal will be constructed, which will provide a fully functioning repository. Activities related to the construction of NDF are described in detail in item 1.7.2.1. At the present stage of the investment proposal it is accepted as optimal that the first module be put into operation upon its completion in accordance with the requirements of the Spatial Planning Act, and that the construction of the other two modules is carried out in parallel with the operation. At the present stage of the investment proposal it is accepted that the optimal term for the initiation of the 2nd stage of construction is to begin after the decommissioning of Units 1-4 of Kozloduy NPP. The construction of the second and third stages will be carried out using temporary roads, which have a separate entrance and provide direct access to the area of construction. These roads will ensure avoidance of crossing the stream of construction vehicles and transport vehicles with RAW packages during the operation.
End of stage: ***Obtaining a permit from the State Acceptance Commission for use of the construction***	

Operation	*Beginning: obtaining a permit from NRA for commissioning.* The commissioning shall be carried out in accordance with a detailed program. The commissioning results shall be included in the updated safety assessment which is the basis for the obtaining of NRA license for the operation of NDF. Receiving a license for operation with a maximum term of 10 years. The license shall be renewed on the grounds of documents proving the observation of safety requirements, basic document – updated safety assessment. Performing entry control of the incoming RAW, buffer storage and deployment of RAW in the disposal facilities; control of the status of the facilities and the disposed waste and monitoring of the site; the area for preventive measures, which coincides with the boundaries of the site, and monitoring of the supervised area. The free space of the filled module shall be filled with inert material and protective roofing tiles and a roof slab shall be built which is waterproof. Continuous control of the drainage system for controlling the infiltrated water shall be conducted.
End of stage: ***Filling of the disposal modules and construction of the roof slabs.***	
Closure of NDF	*Beginning: permission/license for closure issued by NRA Chairman* The closure project shall be elaborated on the basis of Part “Closure” of the technical project of the NDF, updated with the results from the site monitoring and control during the entire operational period of NDF, new knowledge, technologies and materials, developed during the operation of NDF, and long-term studies conducted on protective multi-barrier covers. The EIA on closure and updated safety assessment are the basic documents for applying for and receiving the closure license. The closure consists of decommissioning and dismantling or sealing of all building constructions, systems and equipment, used for the acceptance and deployment of RAW; disposal of RAW generated as a result of such activities; conditioning of the facility in status ensuring its long-term safety; establishing systems for monitoring and surveillance of the facility, the site, the precautionary protective measures area, and the monitored area; updating and archiving the information regarding the facility. The nuclear legislation allows phased closure of the filled modules, combined with the operation of the empty modules.
End of stage: ***Approval of the closure activity by NRA***	
Post-operational period	*Beginning: permission/license for entering into post-operation period* Includes a period of institutional control with total duration of 300 years. Monitoring, access control, minimal technical maintenance of the facility and related systems and infrastructure shall be conducted and, in case of proven need and efficiency, reconstruction activities and corrective measures shall be carried out; passive institutional control used to implement administrative control measures regarding the use of the land.
End of stage: ***Release of the site for unrestricted use***	

1.7.2.1 DESCRIPTION OF THE MAIN PROCESSES DURING THE CONSTRUCTION STAGE OF NDF

The construction of the NDF will be implemented in three stages. The first stage includes the construction of the infrastructure of the National repository and the first module of the disposal facility. The construction works of the second and third stages of the construction of the second and third module respectively is combined with the operation of the NDF (the start of the loading of the first module). The construction of the second and third stages will be carried out using temporary roads, which have a separate entrance and provide direct access to the area of construction without the physical possibility of access to the area for the operation of the NDF. These roads will ensure avoidance of crossing the stream of construction vehicles and transport vehicles with RAW packages during the operation.

This organization is determined by the requirement that the NDF be put into operation in 2021 in view of ensuring the activities of decommissioning of units 1-4 of Kozloduy NPP and is consistent with the time for filling the capacity of the Warehouse for storage of conditioned RAW at SU RAW Kozloduy. The phased construction of the repository takes into account the possibility for amendment of the project on the basis of the experience of the operation of the first module in accordance with the requirements of the nuclear legislation. Besides, the approach is far more efficient as it does not require long-term maintenance of the facilities before their loading with radioactive waste. The excavation works will be relatively limited in volume and can be accomplished within a single spring-summer season (approximately 6 months). The distancing of the construction works from the site with the module, which is in operation, their separation by a fence in accordance with the requirements of the nuclear legislation, as well as the use of temporary access roads during the construction of the second and third stages, provide conditions for safe operation and rhythmic implementation of the construction activities for the other two modules.

The construction and assembly works of the above stated approach will be organized as follows:

1. Implementation of preparatory activities at the site - shifting the existing infrastructure, providing points for connection of the infrastructure, construction of a temporary access road and implementation of programs for pre-commission monitoring before the start of construction and assembly works for the first stage of the NDF;
2. Construction of an industrial fence to the outer perimeter of the ownership of Radiana site;
3. Construction of the first stage of the NDF; in parallel with the construction, programs will continue to be implemented for pre-commission monitoring before the first stage is put in operation;
4. Operation of the first stage of the NDF;
5. Construction of the second stage of the NDF in parallel with the disposal of RAW in the module built during the first stage;
6. Construction of the third stage of the NDF in parallel with the disposal of RAW in the module built during the second stage;
7. Disposal of RAW in the module built during the third stage;

The sequence of implementation of the activities in the first stage of the NDF (construction of infrastructure and the first module) is as follows:

1. Clearing of the building site: removal of vegetation, construction of temporary roads and drainage ditches; geodetic network and benchmarking of the main items;
2. Removal of the surface humus layer and its temporary deployment outside the site, as it willl be used for the cultivation of the aesthetic environment of the site, including as a cover of the landfill for storage of earth masses, which will be used for backfilling during the closure of the repository;
3. Preparation for the excavation works - construction of drainage ditches along the periphery of the future excavation;
4. Performing the excavation works. Loess soil is excavated until the consolidated Pliocene sediments are reached;

5. Construction of the landfill for storage of earth masses, which will be used for backfilling during the closure of the repository;
6. Part of the loess, which will be used to build the loess-cement cushion is stored at the temporary depot outside the site;
7. Digging loess, which represents redundant spoils. Loess from the lower layers of the excavation (the last 6 m) contains more clay and is unsuitable for backfilling; it is transported off-site to landfills specified by Kozloduy municipality and is subsequently used for reclamation of areas that may be flooded;
8. Construction of the loess-cement cushion under the module for RAW disposal and under the building for reception and temporary storage of RAW packages. The thickness of the loess-cement cushion is 5 meters; It is executed in layers from 100 to 150 mm with a varying cement content from 3 to 7%. The foundations of the railway track of the moving roofs are executed.
9. Construction of galleries for control of the infiltrated water under the module for disposal and placement of installation collectors with set orifices in their cover plates, equipping them with pipes and devices for sampling of each camera; construction of collection tanks. The galleries have a slope of 2 ‰.
10. Improving the base under the auxiliary buildings by compaction and filling with crushed stone.
11. Execution of the reinforced-concrete structure of the modules including the bottom plate and the walls of the chambers. The continuity of the process of concreting is strictly monitored. There is also strict control of the quality of the materials. The bottom plates are with a specific slope to ensure drainage towards the drainage system;
12. Construction of the moving roof hall, the tracks below the crane and overhead crane;
13. Construction of auxiliary buildings;
14. Design of roads, technological sites and facilities; planting;

The time to build the first stage of the NDF, together with the accompanying buildings, facilities and infrastructure, is estimated at around 5 years.

The implementation of the activities of the construction of the second and third stage is similar to the activities of the first stage, with the difference that the auxiliary buildings and facilities are built during the first stage. At this stage of the investment proposal it is assumed that the second stage of the construction of the NDF will be executed after the decommissioning of units 1-4 of Kozloduy NPP.

1.7.2.1.1 PROPOSED BUILDING METHODS

As is evident from the above detailed description of the activities for the construction of the NDF, all activities, including excavation works, building and assembly works for the construction of the modules, activities for the construction of the ancillary buildings and facilities are standard and typical for this type of sites. The execution of the loess-cement cushion has been tested and proven during the building of Kozloduy NPP.

The concrete for the concreting works shall be delivered from the nearest concrete plant.

The reinforcement shall be prepared and delivered finished at the site. The building works shall be carried out by using advanced level building machinery.

All building activities shall be carried out under strict quality control of supplied materials and of the building process – quality certificates and additional sampling. The control shall be implemented not only by specialized companies licensed to exert control over the quality of the building activities, but also by the personnel of SE RAW. SE RAW is also planning to exert control on the quality of the building works with the help of non-destructive methods.

1.7.2.1.2 PERSONNEL NECESSARY FOR THE CONSTRUCTION OF THE NDF

The average number of the workers and employees of the Contractor will be 55 people. In addition, an average of 7 people shall be present at the site, who will be representatives of the Investor, Designer and the Construction supervision. The maximum number of workers and personnel on site will not exceed 75 people.

1.7.2.2 DESCRIPTION OF THE MAIN PROCESSES DURING THE STAGE OF OPERATION OF THE NDF

The essence of radioactive waste disposal in disposal facilities is the implementation of simple technological operations relating to deployment in disposal cells, strengthened control over the radioactive waste status, the facilities, the site, the precautionary protective measures area, which is within the framework of the fence, and the monitored area. **Activities related to the processing and conditioning of radioactive waste at the NDF site are not envisaged.** The radioactive waste transported to the NDF site is processed, conditioned and packed in reinforced concrete containers (RCC) with dimensions of 1.95 x 1.95 x 1.95 m, described in detail in the Report on the Environmental Impact Assessment (REIA). Solid waste or bulk materials are not envisaged for deployment and disposal in the disposal facilities.

Low and intermediate level radioactive short-lived waste (category 2a according to the categorization in the Ordinance on the safety of radioactive waste management, 2004) generated on the territory of Republic of Bulgaria will be disposed of in the NDF.

The NDF personnel of 64 people will be working in one-shift working mode, with the exception of the police security.

In accordance with the requirements of the Bulgarian nuclear legislation for the operation of radioactive waste management facilities and the IAEA standards on safety and good practices, the operational process in the NDF has two aspects:

→ Execution of technological activities related to the deployment of RCC in the disposal facilities;

→ Inspection and monitoring, control on the status of: buried RCC, disposal facilities, the site, the precautionary protective measures area, which is within the boundaries of the external fence of the NDF, and the monitored area.

1.7.2.2.1 TECHNOLOGICAL OPERATIONS RELATED TO THE DEPLOYMENT OF RCC IN THE DISPOSAL FACILITIES

(1) Transportation of reinforced concrete containers

The transportation of RCC to the NDF is carried out by a specialized transport vehicle (STV) with 20 t load capacity following a strict itinerary.

The itinerary includes: Warehouse for storage of conditioned radioactive waste (WSCRAW) of SE RAW (SU RAW-Kozloduy), situated at the site of Kozloduy NPP → gates of SE RAW-Kozloduy → Dose control gateway of Kozloduy NPP → Checkpoint of Kozloduy NPP → road controlled by physical security of Kozloduy NPP → Checkpoint of the NDF. The transportation is carried out over internal roads within the site of Kozloduy NPP, the road controlled by Kozloduy NPP, and the internal roads of NDF.

The transportation is carried out in accordance with the specially developed instructions and procedures, at a maximum speed of 20 km/h. It is carried out by specialized transport vehicles of SE RAW, which holds a license to transport radioactive substances. The specialized transport vehicle (STV) is accompanied by a car with accompanying persons, in accordance with the established practice at SE RAW. The RCC transport activities are carried out in accordance with the requirements of the Ordinance on the conditions and procedure for transportation of radioactive material[164], the provisions of the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [165] and the terms of the license issued by the NRA.

At the present stage of the investment proposal it is accepted that the radioactive waste from the new nuclear power capacity will be transported by the personnel of this power plant to the WSCRAW of SE RAW for control and monitoring for a certain period of time before transporting it to the NDF for disposal. This approach is subject to fine-tuning during the stage of operation or the new nuclear power capacity based on the control that the specialists of the NDF will carry out on the programs and technologies of the new nuclear capacity for management of their radioactive waste.

(2) Acceptance and entry control of RAW packages

The acceptance begins with control of the packages prepared for transportation at the place of their temporary storage – WSCRAW. Their acceptance on the territory of the NDF is carried out under a specified regulation by the person in charge of the acceptance and in the presence of the radiation control officer on duty. The police security guards check the RCC. The personnel of the NDF verify the completeness of the accompanying documentation and carry out the initial radiation control of the package. The transport vehicle with the package moves to the building for the acceptance and temporary storage of RCC, where the main entry control is conducted. For this purpose the package is unloaded from the truck and transferred to the entry control room. Inspection of the package is carried out, consisting in visual inspection, measurement of the strength of the dose, making smear-test to determine the surface contamination. If necessary, the corrosion protective coating of the drivers of RCC is replaced in order to ensure their sustainability during the period of operation of the repository. In the event that violations are noted in the protective coating against weather influences, it is removed and replaced.

The entry control is carried out to guarantee that the RCCs and their contents correspond to the requirements and criteria for acceptance of radioactive waste to be disposed of in the NDF. In general the preliminary criteria which correspond to the current stage of the investment proposal are given in the table below. They have been developed in accordance with the recommendations of the IAEA and the requirements of the Ordinance on the safety of management of radioactive waste, 2004. At subsequent design stages the criteria will be specified in accordance with the results of the safety assessment.

TABLE 1.7-2 CRITERIA FOR ACCEPTANCE OF RAW AND ITS CONTROL

Criteria		Verification of compliance
Waste type		
1)	Conditioned, low and intermediate level short-lived RAW category 2a shall be accepted for disposal.	Entry control – as per documents and by equipment
2)	RAW containing only natural radioactive substances, including technologically changed concentration of radionuclides, with the exception of disused Spent Radioactive Sources, shall not be accepted for disposal .	
3)	RAW which may be exempted from subsequent regulatory control shall not be accepted.	
Waste form requirements		
4)	RAW, conditioned by cement technology, approved by the repository operator shall be accepted for disposal in the NDF.	Entry control
5)	Chemical and physical compatibility between the waste, the matrix of the waste and the container.	Verification of documents and analysis

[164] Ordinance on the conditions and procedure of transport of radioactive material dated 22.07.2005, amend. and suppl. SG. issue 13 of 14.02.2014.

[165] European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), SG issue 73 dated 18 August 1995.

Criteria	**Verification of compliance**
6) Not less than the statutory rate of the washing away of key radionuclides from the matrix.	Analysis of samples from the matrix
7) The mechanical properties of the matrix shall not be lower than the statutory requirements.	Analysis of samples
8) Materials in RAW or the matrix which may cause matrix degradation or dangerous reactions and physical phenomena are not allowed	Analysis of samples
9) Chemically dangerous substances, except the protections of the processed sources conditioned in the package, shall not be allowed in the content.	Analysis of samples
10) The content of free liquid (aqueous solution) shall be limited to the extent practically possible, not higher than 1 vol.%. The content of organic solvents, oils and greases shall be limited to the extent practically possible.	Analysis of samples
Package requirements	
11) The suggested use of uniform package for RAW disposal on the basis of: ⇒ Waterproofing ferroconcrete container ⇒ with dimensions 1950 x 1950 x 1950 mm, ⇒ mass of filled container ≤ 20 t.	Verification of documents. Entry control of the marking, weight, surface condition, dimensions
12) MED gamma radiation must be ≤o т 2 mSv/h at any surface point, and at a distance of 1 m from the surface ≤ 0.1 mSv/h.	Verification of documents Entry control – checking for MED
13) Non-fixed contamination on accessible surface averaged over 300 cm2, ⇒ Up to 4 Bq/cm^2 for β-, γ-emitters and low-toxic α-emitters and ⇒ Up to 0.4 Bq/cm^2 for other α-emitters.	Entry control
14) The container must preserve its mechanical integrity and provide for the full retention of the radioactive substances over a period of not less than 50 years. For this purpose, the following requirements are defined for the concrete of the container: ⇒ Strength index not lower than 25 MPa, ⇒ Watertightness not lower than 0.8 and ⇒ Frost resistance F 100.	Review of the system ensuring the quality of the manufacturer of containers Tests of container Certificates Monitoring
Requirements for the activity and the radionuclide inventory of the package	
15) Maximum activity in one package, determined by the summing rule	Verification of documentation Entry control
16) The specific activity of long-lived alpha emitters in one package is limited to 4.10^6 Bq/kg.	
Requirements for marking and identification marks	
17) Each package must be marked with identification marks, to enable its identification and removal at any time during the lifetime of the repository.	Enrty inspection, verification of the compliance of the marking with the procedure
18) Each package must be accompanied by the corresponding documentation, enabling the identification of the package and containing as a minimum the origin, time, place and method of conditioning, activity and radionuclide inventory, properties of RAW and the matrix, strength of dose and radioactive contamination of the container surface, mass.	Review of the documentation, verification of the completeness and proper filling.

The implementation of control is the responsibility not only of the NDF Operator but also of the RAW Producer. The responsibility of the RAW producers, in this case SE RAW-Kozloduy and the potential future new nuclear power capacity, is to implement the technological activities related to processing, conditioning and packaging in RCCs in accordance with the technological regulations, subject to approval by the NDF Operator. The NDF personnel shall inspect the places for processing, conditioning and packaging. At the NDF site the personnel shall thoroughly review the documentation, check the marking, carry out visual control on RCCs (package integrity, lack of violations); perform radioactive and dose control (verification of the rate of gamma radiation dose, the surface contamination, etc.) and control the status of conditioned waste and the reinforced concrete container by non-destructive methods. It is not envisaged to use destructive methods of analysis which could cause the generation of secondary radioactive waste.

(3) Temporary buffer storage before disposal

The temporary buffer storage of RAW packages is carried out in order to optimize the technological process of deployment of the RCC in a disposal facility in accordance with the elaborated technological scheme. Buffer storage ensures continuity of the operational process as RCC are not transported to the NDF in bad weather. It is carried out in the building for the reception and temporary storage of RCC.

(4) Deployment of the packages with radioactive waste in the disposal facility

The package with radioactive waste is loaded on an internal transport vehicle. If entry control is satisfactory, the transport vehicle with the package is moved to the loading module and is positioned next to the place where the packed RAW shall be deployed. The driver of the STU and the rest of the personnel then leave the area and further operations are carried out remotely using a video camera monitoring system. The management is performed from a Control panel (CP), situated in the building next to the modules, by the NDF operators. Relevant records are kept during the transfer of the package. The driver of STU, accompanied by the Radiation control officer, leads the STU out of the module area (protective moving hall) and of the controlled area. The loading of RCC in the modules is carried out under a schedule ensuring the decrease of the dose load (self-shielding of the packages, using each one as biological shield) and even loading of the bottom slab of the modules.

(5) Recording

All operations are recorded. One of the prime tasks of the NDF is to maintain a database of the characteristics of accepted and stored packages and information about the specific properties of the facility as a whole about its operations. An archive is set up and maintained in electronic form and in hard copies of records/documents which must be stored throughout the entire operational period of the NDF.

1.7.2.2.2 INSPECTION AND MONITORING, CONTROL ON THE STATE OF: DISPOSED RCC, CONDITION OF THE DISPOSAL FACILITIES, THE SITE, THE PRECAUTIONARY PROTECTIVE MEASURES AREA AND THE MONITORED AREA

During the entire operation period before the decommissioning of a module, the state of the construction of the module and the packages (RCCs) disposed in it shall be checked. The control on the condition of the packaging is visual by a special manipulator, equipped with TV cameras, which moves easily along a movable structure over the controlled chamber, and by TV cameras, attached to a specially designed bar, suspended to the crane trolley. The outside condition is checked in order to identify the potential problems such as dents, holes, cracks, bulging, loss of integrity of the coating, corrosion of metal parts, signs of leakage (changed colour, stripes), and damaged elements of the packaging. The early detection of potential problems enables rehabilitation actions aimed at preventing further degradation of the barrier and release of radioactivity. Automatic measurement is carried out of the strength of the equivalent dose gamma radiation in the disposal modules and aerosol activity is detected. The drainage system of the disposal modules is monitored for possible presence of infiltrated water. In case of detected infiltrated water, its volume is determined and radiological measurements are conducted in order to determine its radioactivity. If there is no radionuclide contamination, the water is considered as waste drainage water. If radionuclides are detected in the drainage water, it must be treated as a secondary liquid radiation waste and must be processed in the installation of SE RAW-Kozloduy at the Kozloduy NPP site. The transport is carried out in accordance with the legal requirements for transport of radioactive substances.

Continuous radiation and dosimetric control is carried out on the territory of the NDF by using stationary and portable systems and equipment. The personnel situated within the controlled area or that carry out any activity related to exposure risk shall be equipped with individual dosimetric equipment. In accordance with the established practice in SE RAW, the maximum levels for personnel shall be stated, and these shall be significantly lower than the ones provided in the Ordinance on basic standards of radiation protection. The surface contamination of all people and transport vehicles leaving the controlled area and the NDF territory shall be controlled. The radiation field around any delivered packaging with RAW shall be measured. Periodic measuring of the radiation field is carried out in the controlled area.

The disposal modules and the site are controlled and measured by geodetic monitoring, control on the seismic behavior of the site and the construction materials and structures, and by meteorological monitoring. Particular attention is paid to the hydrogeological monitoring which controls the movement of underground water from the NDF site.

The radiation monitoring of the site, the radiation protected area and the monitored area include: detection of the gamma radiation background and control of possible radionuclides from the inventory of the NDF in the ground, air, precipitation, surface and underground water, water sources, soils, vegetation and agricultural products.

All activities and results are recorded. The information is stored in the database in printed and electronic form.

1.7.2.2.3 PERSONNEL REQUIRED FOR THE OPERATION OF THE NDF

The NRAAW will be an independent structure unit within the framework of SE RAW – Specialized unit SU NDF. The total number of personnel comes to 64 persons, distributed as follows: 24 administration staff, 26 operational staff and 14 maintenance staff.

1.7.2.3 DESCRIPTION OF THE MAIN PROCESSES DURING THE STAGE OF CLOSURE OF THE NDF

The closure of the NDF shall be carried out under a specifically developed technical project upon the completion of the environmental impact assessment and upon obtaining a permit/license from the NRA.

The objective of the closure is to safely isolate the radioactive waste from the environment and people by filling the empty space between RAW packages and establishing protection shields along the water flow around the modules. It shall be accompanied by assessment of NDF safety during the institutional control period and performance of post-operation monitoring.

The filling of the space between the modules shall be carried out with suitable loess-cement substances, containing natural non-organic absorbents. The mechanic stability of the construction and the waterproofing of the RAW containers must be ensured, as well as the maximum retention of the radionuclides in them. The modules shall be shielded by protective shields preventing water flow, gas transition, penetration of underground animals and plant roots. The shields shall be constructed of natural materials.

At the present stage of the investment proposal the activities related to the closure of the modules are as follows:

1. Analysis of the operational documentation, including the results from the packaging condition control and the construction elements of the disposal modules;

2. Comprehensive radiological survey of the repository site using modern technologies and methods and elaboration of a detailed plan for closing the facility and a technical project of the closure;
3. Removal of buildings and structures that are not intended to be used in the long term.
4. Detailed radiological studies to ensure that buildings and equipment can be exempted from control;
5. Removal of potentially contaminated equipment, implementation of measures to reduce the volume, conditioning and packaging in RCC, deployment in the last cell of the repository.
6. The gaps in the inner space of each cell are filled with an inert material;
7. After the filling of the cell with an inert material, it is closed with pre-cast protective concrete slabs. A reinforce concrete slab-lid of the module is cast and is covered with a suitable waterproofing material;
8. An adequate drainage system and side channel with gravel are built before the backfilling along the route of the stormwater sewerage system existing during the operation period in order to remove drainage water near the base of the southern slope of the terrain. This drainage system will be filled with clean gravel and covered with suitable materials to maintain its functionality;
9. Coating of the cells is built over the disposal modules, consisting of: (1) base material, which is grained soil with low ductility; the thickness of the layer is about 30 cm; (2) lower impermeable barrier of clay with low filtration coefficient of around 10^{-9} m/s;
10. The empty space between the covered modules is filled with improved loess soil and backfilling is done with improved loess soil up to a level of about 3 meters below the original elevation of the terrain. The improvement can be implemented with a modification with additives such as natural sorbents (bentonite) or a modification with cement to form loess-cement.
11. A multi-barrier protective cover is built, consisting of: (1) one or more solid barriers based on slightly permeable material such as compacted clay, designed to reduce the flow of water into the disposal cells; (2) a conductive barrier which uses capillary barrier phenomenon to direct the water away from the waste. The barrier must be composed of a highly permeable material such as gravel, fine material in the base, conductive layer. Due to the differences in the saturated hydraulic conductivity between the two layers (ideally about a factor of 1000), an interruption is formed of the capillaries on the surface of the two layers. The water is deflected laterally in the soil with a fine texture over the surface of the layer when it has a negative capillary pressure. Under these conditions, the barrier prevents the entry of the liquid into the interrupted capillary; (3) soil cover using humus deposited on the site; vegetation cover of the soil plays an important role in water management by protecting the surface of the soil against erosion, mainly by removing soil moisture due to evaporation from plants. The restoration of the natural (original) slope of the terrain ensures the drainage of surface water and its subsequent control. If radionuclides are spotted in the drainage water they should be treated as liquid radioactive waste and processed in the installation of SE RAW-Kozloduy. The drainage water from the inspection galleries is controlled in the same way.
12. Programs for post-operation monitoring are elaborated. They will meet the requirements of the nuclear legislation defined in the Ordinance on the Safety of Radioactive Waste Management[166] and the Ordinance on the conditions and procedures for determining the special-statute areas around nuclear facilities and sites with sources of ionizing radiation, the recommendations of the REIA and the best practices defined in the recommendations of the IAEA[167,168].

[166] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

[167] IAEA, Surveillance and Monitoring of Near Surface Disposal Facilities for Radioactive Waste, Safety Reports Series No.35, 2004

At the present stage of the investment proposal it is accepted that the closure activities will be carried out within 15 years. This period will be followed by 300-year period of institutional control.

The period of institutional control will begin upon the receipt of a license issued by the NRA.

A programme for radiation monitoring and programme for environmental monitoring will be implemented during the period of institutional control. The monitored parameters will be carefully selected, so as to ensure efficient monitoring without burdening future generations.

The aims of the monitoring are to ensure early detection of system failure, which could lead to unacceptable impacts on people and environment. Besides, monitoring can serve to confirm the envisaged behavior of the disposal system. Finally, it also plays the role of creating confidence among the public that the system is operating as planned.

The monitoring during the period of active institutional control includes:

1. Monitoring and control of the facility – state of the multi-barrier cover, including control of the vegetation cover and removal of plants that can be strongly rooted, drainage system, periodic inspection of the galleries of the network for control of infiltrated water and the control tank; geodetic monitoring in full volume in accordance with the requirements of the design of the facility.
2. Environmental monitoring aimed at detecting all unexpected changes in the environment (meteorological conditions, hydrology and hydrogeology, including the gradient of groundwater and the direction of drainage, geochemistry of water, stability of earth layers, erosion, fast and slow movements, i.e. earthquakes, vibrations if necessary);
3. Control of potential releases in the immediate vicinity of the facility – measuring the gamma-dose, control of water with an emphasis on the potential paths of distribution, including control of the volume of infiltrated water, radiation monitoring for potential release of radionuclides into the environment through the groundwater by means of a system of hydrogeological observation wells;
4. If necessary, radiation monitoring shall be performed at the end points – springs, rivers, soils and vegetation
5. Monitoring and control on agricultural production – upon request by the local authorities;

For the period of passive control it is envisaged that the radionuclides have disintegrated to an extent that the normal and changed evolution of the system will not lead to the release of radionuclides into the environment. The potential releases are related to human intrusion, which is prevented through restrictions in the land use. Monitoring is not envisaged. Passive control is limited to observations ensuring that the restrictions on land use are met.

It is possible to modify the monitoring programme if necessary, in case of unexpected observations or changes in the regulatory requirements. The final monitoring programme will be elaborated at the closure stage of the facility along with the final report on its safety analysis.

The stable acceptable monitoring results over a long period of time may serve as a criteria for pre-term termination of the active control. This notwithstanding, the monitoring programme will be elaborated for the envisaged term of this control. The final decision regarding the termination of the control will be made by future generations, taking into account the scientific and social factors of the time.

The responsibilities of the operator include the provision of a mechanism for making such a decision, and in particular, for preservation of information regarding the results of the monitoring throughout the entire lifetime of the repository, including the period after the closure of the facility.

[168] IAEA, Monitoring and Surveillance of Radioactive Waste Disposal Facilities, IAEA Safety Standards, Specific Safety Guide No.SSG-31, 2014

1.7.2.3.1 PERSONNEL NECESSARY FOR THE CLOSURE OF THE NDF AND THE PERIOD OF INSTITUTIONAL CONTROL

The personnel necessary for the closure of the NDF is estimated at approximately 40 people. During the period of institutional control, similarly to existing repositories that have entered into such a period, the personnel required is estimated at 15 people.

1.7.3 CHARACTERISTICS OF RAW SUBJECT TO DISPOSAL IN THE NDF. EXPECTED TYPE AND QUANTITY OF RAW FOR DISPOSAL IN THE NDF. PRODUCTIVITY. CAPACITY.

As mentioned above in the text, only low- and intermediate-level waste of category 2a will be buried in the NDF, according to the classification of radioactive waste under Article 6 of the Ordinance on the Safety of Radioactive Waste Management[169]. The Ordinance on the Safety of Radioactive Waste Management defines waste of category 2 as follows:

"Category 2 – low- and intermediate-level waste: RAW containing radionuclides in concentrations that require measures for reliable isolation and detention, but do not require special measures for heat removal during storage and disposal; RAW from this category is further divided into:

a) Category 2a – low- and intermediate-level waste containing primarily short-lived radionuclides (with a period of semi-decomposition not longer than that of cesium-137) and long-lived radionuclides at significantly lower levels of activity, limited to long-lived alpha emitters under $4{,}10^6$ Bq/kg for each individual package and maximum average value of all packages in the respective facility $4{,}10^5$ Bq/kg; reliable isolation and retention for a period of up to several hundred years is required for such RAW;

b) category 2b – low- and intermediate-level waste containing long-lived radionuclides at levels of activity of long-lived alpha emitters, exceeding the limits for category 2a."

Only radioactive waste of category 2a will be disposed in the National repository. RAW of category 2b will not be disposed in the NDF. Waste of category 2b should be disposed only in geological repositories in accordance with the requirements of the nuclear legislation - Article 25, paragraph 5 of the Ordinance on the Safety of Radioactive Waste Management.

Only waste generated on the territory of Bulgaria will be disposed at the NDF.

The origin of waste subject to disposal in the NDF is:

1. Waste generated during the operation and decommissioning of Kozloduy NPP;
2. Waste which will be generated during the operation of the new nuclear power capacity;
3. Waste which will be generated in the decommissioning of the stopped research reactor RR-2000;
4. Waste obtained by the use of radioactive sources in the industry, agriculture, scientific research and medicine, which is stored in SU Permanent repository for radioactive waste (PRRAW) - Novi Han.

Radioactive waste is generated during the operation and decommissioning of Kozloduy NPP, such as:

- ✓ **Solid RAW** - contaminated clothing and personal protective equipment, contaminated equipment and tools, earth masses, construction waste, laboratory waste;
- ✓ **Liquid RAW -** cubic residue resulting from the treatment and concentration of different types of radioactively contaminated water, generated by the operation of the power plant, spent ion-exchange resins and sorbents;

[169] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

RAW is processed in the Workshop for processing RAW of the Specialized Unit of SE RAW (SU RAW-Kozloduy), which is located at the site of Kozloduy NPP. The processing is described in section 1.3.2 of this REIA. The processed conditioned radioactive waste is stored in the Warehouse for storage, described in the same section. The radioactive waste generated in the decommissioning of the units of Kozloduy NPP, after it has been processed in the Workshop for decontamination and volume reduction, will be conditioned and packaged in the Workshop for processing of radioactive waste of SE RAW Kozloduy and stored in the Warehouse for storage. The conditioned waste generated during the operation and decommissioning of Kozloduy NPP is cemented waste packed in reinforced concrete containers (RCC).

The radioactive waste from the new nuclear power capacity will be conditioned also by the method of cementing and will be packed in RCC in the future power plant.

The concrete which forms the cement matrix has a strength class of at least B25. The cement matrix, in which the radioactive waste is conditioned, has mechanical parameters not lower than the following:

- → Compressive strength after the 28th day – more than 3.5 MPa;
- → Water resistance – the compressive strength must not reduce by more than 10% after the 90th day under water;
- → Resistance to thermal cycles – the compressive strength of the end product - more than 0.30 MPa after the 30th cycle from minus 15°C to plus 60°C;

The washing out of the main radionuclides from the cement matrix must not exceed:

- → 1 x 10^{-3} g/cm^2/d for Cs-137 and Co-60.

These characteristics of the conditioned radioactive waste ensure the functions of the matrix as a first protective barrier.

RCC with the following characteristics will enter the NDF:

- → Overall dimensions 1950 x 1950 x 1950 mm,
- → Useful volume 5 m^3,
- → Total volume 7.41 m^3,
- → Mass of filled container not more than 20 t,
- → Wall thickness not less than 10 cm,
- → Bottom thickness not less than 14 cm,
- → Cover thickness not less than 8 cm,
- → Strength of the equivalent dose gamma radiation on the surface ≤ 2 mSv/h,
- → Strength of the equivalent dose gamma radiation at a distance 1 m≤ 0.1 mSv/h.

RCC are equipped with four brackets for handling (loading, unloading, transfer). The minimum requirements for the brackets in the manufacturing of RCC are that there will be no corrosion of the metal parts within 50 years.[170]. The program of SE RAW on the inspection and control of the state of the packages includes periodic inspection and replacement of the corrosion protective coating of the brackets to ensure its longevity.

The RCC are made of concrete with a minimum strength class of B25 and are equipped with a protective coating on the outside. The packages have sufficient structural rigidity to arrange four of

[170] Technical project "Reinforced concrete container for transportation and storage of RAW"; i.d.№DTR-ENPR-0622

them in height, on top of each other. The requirements for the design properties of the concrete are defined as:

→ Compressive strength indicator not less than 25 MPa;

→ Water-tightness not less than 0.8;

→ Frost resistance class F 100;

In addition, the packages are seismically qualified to withstand 0.20g maximum horizontal ground acceleration when stacked 4 pieces one on top of the other.

RCC are produced by the staff of SE RAW in strict compliance with the requirements of the technical documentation and the programme for quality assurance. Strict control is carried out on their quality under a testing program [171], developed in accordance with the Bulgarian State Standard (BSS) and the requirements of the International Atomic Energy Agency. Under the program, every 50th container is subjected to a testing programme, including:

→ Tests of water-tightness consisting of two types of tests: (1) pour water over the RCC, imitating intense rain; (2) fill the volume of RCC with water and leave it to stay for at least 48 hours;

→ Tests of free fall - RCC is dropped on a flat surface, imitating the free fall of a filled container;

→ Tests of drilling - a steel rod is dropped on the upper surface of the container;

→ Tests of pressure - the container is subjected to pressure, which exceeds more than five times its own weight;

→ Tests of mechanical damage - falling from a height of 6m on a foundation;

→ Tests of mechanical damage - falling from a height of 1 m on a vertical steel rod;

→ Tests of mechanical damage- a steel plate with dimensions 1m x 1m and a mass of 500 kg is placed on the container;

→ Tests of fire resistance - the container is placed for 30 min in burning hydrocarbon fuel at a temperature of 800ºC.

→ Tests of radiation protection using a particular methodology;

Figure 1.7-1 shows some of the tests to which the containers are subject.

[171] SE RAW, Program on conducting factory tests of reinforced concrete container (RCC) for transportation and storage of processed radioactive waste, 2013.

FIGURE 1.7-1 TESTS OF REINFORCED CONCRETE CONTAINERS

RCC meet the requirements of the Ordinance on the conditions and procedures of transport of radioactive material[172] and the Safety Standards of the International Atomic Energy Agency[173,174] and are certified by the Nuclear Regulatory Agency.

It is not envisaged to conduct additional processing and/or conditioning of the incoming containers with radioactive waste at the NDF site.

The national repository for disposal of low and intermediate level waste of category 2a must provide:

→ capacity for disposal of accumulated radioactive waste, which is generated in the country and stored in the place of its generation and in the facilities for radioactive waste management of SE RAW;

→ capacity for disposal of waste, which are to be generated by 2075.

The preliminary assessment of the quantity of radioactive waste which is to be disposed of and stored in the NDF amounts to 18 615 RCC (138 200 [175] m^3 or 345 500 t). The assessment is carried out within the framework of Task 3 “Update of the radionuclide inventory of NDF” of the agreement under PHARE[176]. The assessment is conservative and does not take into consideration future programmes for minimizing the generation of radioactive waste or the future implementation of new technologies leading to minimization of the volume of radioactive waste. The results of the assessment are provided in **Table 1.7-3**. The capacity of the repository is determined on the basis of the evaluation of PHARE with some storage and amounts to 19 008 packages of RAW (142,000 m^3).

[172] Ordinance on the conditions and procedure of transport of radioactive material dated 22.07.2005, amend. and suppl. SG. issue 13 of 14.02.2014.

[173] IAEA, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, Safety Safety Standards Series SSG-26, 2014

[174] IAEA, Regulations for the Safe Transport of Radioactive Material (2012 Edition) Safety Standards Series No. SSR-6, 2012

[175] The volume includes both the actual volume of radioactive waste and the volume of the reinforced concrete containers, in which it is packed.

[176] Update of the radionuclide inventory of the NDF (Task 3) Final Report, BG 2004 / 016-815.01.05, December 2007 - July 2008; Worley Parsons; TVO Nuclear services; TVO Risk Engineering LTD

TABLE 1.7-3 VOLUME OF RAW SUBJECT TO DISPOSAL IN THE NDF

Conditioned RAW stream	Number of packages with conditioned RAW	Volume, m^3
Raw from the entire operational period of Kozloduy NPP	**11 756**	**87 169**
Conditioned solid RAW, DE1	2 298	17 039
Conditioned liquid RAW:	8 714	64 613
Conditioned liquid RAW – decantat from CPU, DE21	2 070	15 349
Conditioned liquid RAW – “solid stage” from CPU, DE22	6 644	49 264
Conditioned sorbents and slurry DE3	744	5 517
RAW from the decommissioning of Kozloduy NPP	**5 690**	**42 191**
Conditioned RAW in the preparation stage for safe storage and safe keeping DD1	187	1 387
Conditioned RAW from dismantling of equipment DD2	**5 503**	**40 804**
TOTAL FOR RAW FROM KOZLODUY NPP	**17 446**	**129 360**
RAW from research reactor RR-2000 DD	**54**	**400**
RAW from operation of new power capacity , DE	**810**	**6 000**
RAW from nuclear applications, DA	**305**	**2 440**
TOTAL	**18 615**	**138200**

The radionuclide composition is the most important characteristic defining the main properties of the radioactive waste. The radionuclide inventory of the NDF is also defined within the framework of the above mentioned project[177], additionally updated by SE RAW within the framework of the studies at the stage of selection of a site[178,179]. It is presented in **Table 1.7-4**.

In accordance with the recommendations of the IAEA and the good practices in the area of the radioactive waste management, the radionuclide inventory is subject to further specification and update by defining the different waste streams and the implementation of analysis methods. It is a mandatory condition throughout the lifetime of NDF to maintain records and store information about the properties of the disposed radioactive waste.

The output of the NDF is from 3 to 4 RCC/day. This is defined with reference to the positioning within two years of existing RCC, which are currently stored in the Warehouse for conditioned RAW at the site of SU RAW-Kozloduy on the territory of Kozloduy NPP. The output also takes into account the planned increase of RAW processing output on the territory of Kozloduy NPP due to the activities related to the decommissioning of Units 1 to 4 of Kozloduy NPP.

The maximum annual output is 800 RCC, defined on the basis of receipt of RAW **200 days annually**, taking into consideration the fact that the transport of RAW is performed only on working days and that the transport shall not be performed in poor meteorological conditions.

[177] Update of the radionuclide inventory of the NDF (Task 3) Final Report, BG 2004/016-815.01.05, December 2007 - July 2008; Worley Parsons; TVO Nuclear services; TVO Risk Engineering LTD

[178] Report on the concept for disposal of radioactive waste, SE RAW, 2010

[179]Report on the implementation of phase 3 - Characterization of the NDF site, SE RAW, 2011

TABLE 1.7-4. RADIONUCLIDE INVENTORY OF RAW

Radionuclide	Stream / radionuclide composition, Bq							Total for radionuclide, Bq
	DE1	DE21	DE22	DE3	DD1	DD2	DA	
^{3}H	N/A	1.85E+11	9.58E+10	N/A	N/A	N/A	N/A	**2.81E+11**
^{54}Mn	2.10E+11	7.90E+10	N/A	2.9E+11	1.70E+10	5.00E+11	N/A	**1.10E+12**
^{59}Fe	2.00E+11	7.50E+10	N/A	N/A	1.70E+10	4.90E+11	N/A	**7.82E+11**
^{58}Co	2.00E+11	5.60E+10	N/A	N/A	1.70E+10	4.90E+11	N/A	**7.63E+11**
^{60}Co	1.40E+12	1.50E+12	7.00E+12	1.90E+12	1.10E+11	3.40E+12	N/A	**1.53E+13**
^{110m}Ag	4.80E+11	1.60E+10	N/A	N/A	3.90E+10	1.20E+12	N/A	**1.74E+12**
^{134}Cs	3.70E+11	9.10E+12	N/A	9.70E+12	3.00E+10	8.80E+11	N/A	**2.01E+13**
^{137}Cs	6.00E+11	4.60E+13	6.00E+13	3.20E+13	4.90E+10	1.40E+12	6.00E+11	**1.41E+14**
^{95}Nb	1.00E+11	N/A	N/A	N/A	8.20E+09	2.40E+11	N/A	**3.48E+11**
^{233}U	N/A	1.10E+07	7.70E+06	N/A	N/A	N/A	N/A	**1.87E+07**
^{234}U	N/A	2.00E+07	8.50E+07	N/A	N/A	N/A	N/A	**1.05E+08**
^{235}U	N/A	1.10E+07	7.90E+06	N/A	N/A	N/A	N/A	**1.89E+07**
^{238}U	N/A	1.40E+07	3.90E+07	N/A	N/A	N/A	N/A	**5.30E+07**
^{238}Pu	N/A	1.70E+07	5.20E+09	N/A	N/A	N/A	N/A	**5.22E+09**
$^{239/240}$Pu	N/A	1.50E+07	8.70E+09	N/A	N/A	N/A	N/A	**8.72E+09**
^{242}Pu	N/A	1.10E+07	2.60E+07	N/A	N/A	N/A	N/A	**3.70E+07**
^{242}Cm	N/A	1.10E+07	8.60E+07	N/A	N/A	N/A	N/A	**9.70E+07**
^{244}Cm	N/A	1.20E+07	3.00E+09	N/A	N/A	N/A	N/A	**3.01E+09**
^{241}Am	N/A	1.60E+07	1.30E+10	N/A	N/A	N/A	N/A	**1.30E+10**
^{129}I	N/A	2.40E+07	6.10E+07	N/A	N/A	N/A	N/A	**8.50E+07**
^{14}C	N/A	6.40E+10	2.60E+12	N/A	N/A	N/A	N/A	**2.66E+12**
^{90}Sr	N/A	2.70E+10	3.10E+11	N/A	N/A	N/A	3.00E+11	**6.37E+11**
^{63}Ni	N/A	9.80E+11	3.40E+12	N/A	N/A	N/A	N/A	**4.38E+12**
^{55}Fe	N/A	1.40E+10	1.40E+13	N/A	N/A	N/A	N/A	**1.40E+13**
^{99}Tc	N/A	2.10E+08	1.60E+09	N/A	N/A	N/A	N/A	**1.81E+09**
^{94}Nb	N/A	1.10E+08	3.20E+09	N/A	N/A	N/A	N/A	**3.31E+09**
$\sum\alpha$	3.90E+08	N/A	N/A	3.90E+13	3.20E+07	9.40E+08	N/A	**3.90E+13**
$\sum$ for the stream	**3.56E+12**	**5.81E+13**	**8.74E+13**	**8.29E+13**	**2.87E+11**	**8.60E+12**	**9.00E+11**	**2.42E+14**

1.8 SPECIAL STATUS AREAS

1.8.1 AREAS AROUND KOZLODUY NPP

The establishment of special status areas around Kozloduy NPP is related to the need to create a tool for planning and management of the territory in accordance with the laws and regulations of the country and the European standards for safety and security, in accordance with the requirements of Article 104, Paragraph 1 of the Act on the Safe Use of Nuclear Energy (SG issue 63 2002, last. amend. SG issue 82, 2012).

Based on the analysis and estimates made of the maximum possible design-basis accidents and accidents related to the design extension conditions of units BBEP-440 (B-230) and BBEP-1000 (B-320), and the radiological consequences, in accordance with the risk categories I, II, III and the limit dose criteria under the Ordinance on emergency planning and emergency preparedness for nuclear and radiological accident (Prom. SG. Issue 94 of 29.11.2011), the following areas for emergency planning have been defined in accordance with Appendix 3.1-1 of the Emergency Plan of Kozloduy NPP:

→ **Emergency planning area at the site** - *protected area* № 1, Kozloduy NPP site;

→ **Precautionary protective measures area (PPMA) - Area № 2**, with a radius of 2 km and geometric center between the ventilation pipes of units 5 and 6. The area is occupied by the production site of Kozloduy NPP, the site for storage and handling of radioactive waste of SU RAW Kozloduy and Radiana site - **Figure 1.8-1**. Its aim is to reduce radiation in case of accidents,

→ **Emergency protective measures area (EPMA)** [180] **- area № 3**, with a radius of 30 km around Kozloduy NPP. Its role is to perform the necessary control for radiation protection purposes - **Figure 1.8-2**.

The emergency planning zones are divided into 16 sectors of 22.5˚ and are labelled with the first 16 letters of the Latin alphabet from the north in a clockwise direction (A, B, C, D, E, F, G, H, J, K, L, M, N, P, R and S). Depending on the emergency situation, different in nature measures for protection of the personnel and population are implemented in the emergency planning areas.

[180] EPMA of 30 km is defined for the purposes of emergency planning. For the purposes of radiation monitoring the same area of 30 km is called "Observed area" (OA)

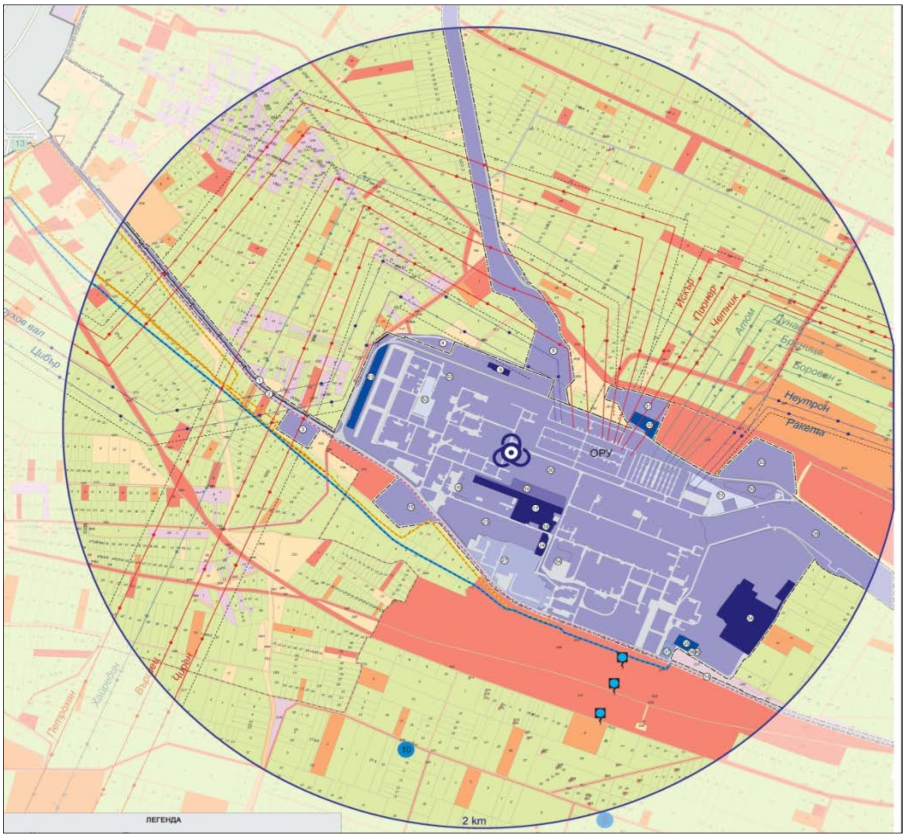

FIGURE 1.8-1 SCHEME OF THE 2 KM PRECAUTIONARY PROTECTIVE MEASURES AREA (PPMA) OF KOZLODUY NPP, WITHIN WHICH RADIANA SITE IS SITUATED

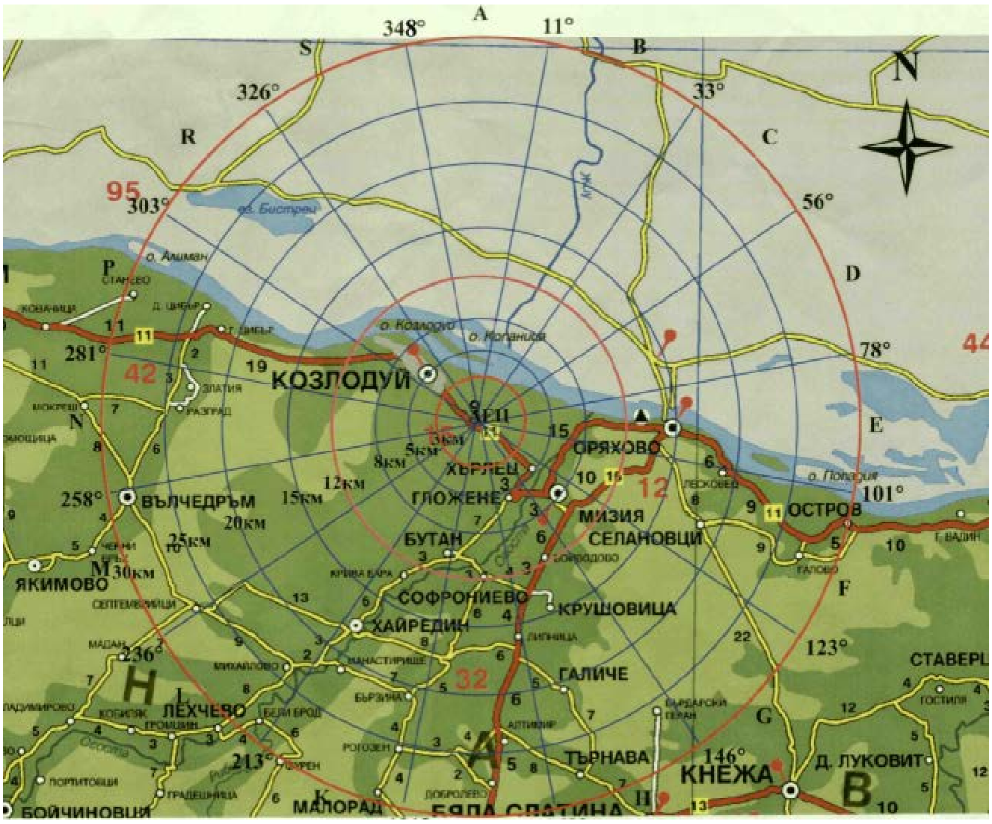

FIGURE 1.8-2 EMERGENCY PLANNING AREAS – EPMA WITH 30 KM RADIUS

On the territory of the Republic of Bulgaria the Observed Area includes entirely the municipalities: Kozloduy, Valchedram, Hayredin, Mizia and partially the municipalities Lom, Byala Slatina, Oryahovo, Boychinovtsi, Krivodol and Borovan. There are no major Bulgarian industrial and military sites within the scope of the area.

The following 23 settlements from the districts of Dolzh and Olt are located within the 30 km area on the Rumanian territory: Bechet, Nedeia, Gighera, Zaval, Ostroveni, Sarata, Călăraşi, Dabuleni, Listeava, Piscu Sadovei, Sadova, Gângiova, Măceşu de Jos, Măceşu de Su, Sapata, Plosca, Bistret, Brandusa, Goicea, Barca, Horezu Poenari, Toceni, Valea Stanciului.

1.8.2 RADIOECOLOGICAL MONITORING

Radiological monitoring is performed in certain areas around Kozloduy NPP, which covers all major components of the environment (air, water, soil, vegetation, food, agricultural products, etc.) within a radius of 100 km around the power plant on the Bulgarian territory.

The volume, scope and control parameters are specified in a long-term programme for radiological monitoring during normal operation of the NPP, which is agreed with the control and supervisory authorities in the country - the NRA, the National Centre of Radiobiology and Radiation Protection (NCRRP) of the Ministry of Health (MoH) and the Executive Environment Agency (EEA) of the Ministry of Environment and Water (MEW). The programme fully complies with the national and European regulation requirements in the field, including Art. 35 of the EURATOM Treaty, the EU Recommendations 2000/473/EURATOM and 2004/2/ EURATOM.

The monitoring area includes benchmarking posts within a 100 km radius around the nuclear power plant, and the control is carried out mainly in 36 control posts. Outside these places, monitoring of the Danube River and other water reservoirs is conducted, as well as control of groundwater, drinking water and typical for the region foods - fish from the Danube River, milk from farms etc.

1.8.3 AREAS AND PRE-OPERATIONAL MONITORING OF RADIANA SITE

Within the framework of the conducted analysis of the safety assessment of the NDF in the Interim report for safety analysis[181] it has been proven that, for the assessed design basis accident scenarios in the NDF, the estimated individual effective dose for the respective critical groups members of the public at the boundary of the site does not exceed 1 mSv for one year, which satisfies the statutory requirement in Art. 9 of the Ordinance on the safety of RAW management. As a result, and in accordance with the assessment of the potential dose loads near the facility which has suffered a design basis accident, the NDF should be classified in risk category 3 – nuclear facilities and sites with radioactive sources, in which postulated emergency events on the site can lead to radiation or radioactive contamination of the environment above the established limits, requiring the implementation of urgent protective measures **only** within the boundaries of the site, according to Art. 2 (2) of the Ordinance on emergency planning and emergency preparedness.

In this regard and in pursuance of Article 4 (4) of the Ordinance on the subject of risk category 3, only the territory within the boundaries of the facility site is defined as emergency planning area.

According to the requirements of Art. 104, para. 2 of ASUNE for special status areas, which are created around nuclear facilities and sites with IR for limiting the public exposure of the population to radiation in case of accidents analyzed in the project, and for radiation monitoring of the population and the environment, and after an analysis has been conducted of the safety assessment of the NDF, the following areas are defined:

1. Precautionary protective measures area (PPMA) within the boundaries of Radiana site;

[181] Interim report for safety analysis (IRSA), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

2. Observed area (OA) – defined according to the conducted analysis of the safety of the NDF, as a semicircle with a radius of 3.9 km to the north of the axis of repository cells.

Pursuant to the requirements of the Ordinance on the basic standards for radiation protection within the performed analysis on the safety assessment of the NDF, a supervised area and a controlled area are defined in order to minimize the radiation exposure of workers and visitors of the facility.

According to the Interim report for safety analysis, the strength levels of the dose outside the fence of the repository during normal operation are estimated at below 0.01 μSv/h, thus fulfilling the requirement of 0.1 mSv/year, assuming constant presence of people from the outside of the fence (8760 h). As discussed in IRSA, the distances from the potential sources of ionizing radiation to the outer territory of the NDF, as well as from the shielded walls of the building for the reception and temporary storage of packages and from the disposal cells, are designed so as to meet the requirement for maximum values indicated above.

The radiation monitoring at the site and observed area includes determining the radiation gamma background, control of the presence of radionuclides from the inventory of the NDF in the components of the environment, for which there is a potential possibility for contamination. The monitoring before and during the construction of the NDF (pre-operation monitoring) is regulated by the Programme for pre-operational radiological monitoring at Radiana site (№ TK.D-142-D3/2012, NH-PEM-MP-001). On the basis of the pre-operational monitoring programme, a monitoring programme will be elaborated for the period of operation of the repository, which is one of the main licensing documents to obtain permission from the NRA for the commissioning of the NDF, as required by ASUNE.

Independent supra-departmental monitoring of the key environmental parameters will be carried out in the Observed Area by the control and supervisory authorities in the country - the Executive Environment Agency (EEA)/MEW and the National Centre of Radiobiology and Radiation Protection (NCRRP)/ MH.

1.9 CHARACTERISTICS OF THE EXPECTED EMISSIONS AND WASTE

NDF will be located at Radiana site (the area in orange / ▬ /), which is located next to Kozloduy NPP and which falls into the 2-kilometer precautionary protective measures area (PPMA) of the power plant - the red circle / ▬ /. The site is located 3.3 km southeast of the regulation line of the town of Kozloduy, 4.3 km northwest of the construction boundaries of the village of Hurlets and about 4.2 km southwest of the right bank of the Danube River - **Figure 1.9-1**.

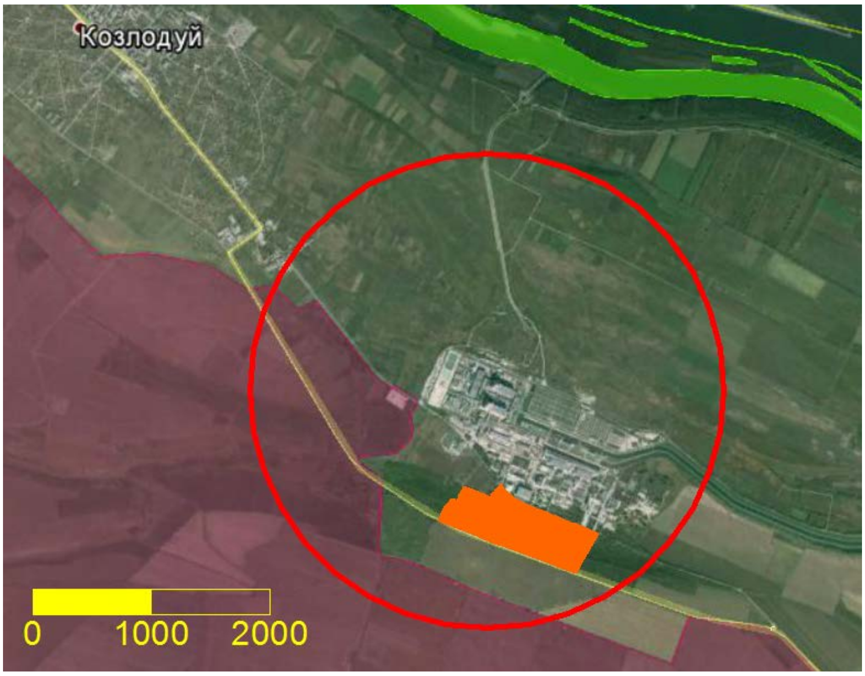

FIGURE 1.9-1 LOCATION OF NDF

Two options for the construction of the NDF are considered - trench and tunnel type.

1. The adopted building approach for a **trench type** repository is based on stage-by-stage implementation:

⇒ The auxiliary buildings and the first platform with disposal cells are built during the **first stage.** This will provide a repository that is in full compliance with the requirements and design criteria, but without a full number of disposal cells.

⇒ During the **second and third stages** the repository will be extended to reach its full capacity by building a second and third platforms and their respective infrastructure.

The project envisages construction of the second and third stages in parallel with the operation of the auxiliary buildings and the first platform with disposal cells. When the auxiliary buildings and the first platform are ready for commissioning, it will be possible to start receiving RAW packages for disposal, along with the construction of the other platforms. In this connection it is envisaged to construct temporary roads, which have a separate entrance and provide direct access to the area of construction. These roads will help to avoid crossing the flow of construction vehicles and transport vehicles with RAW packages during the operation.

2. NDF construction of a **tunnel type**

It consists of two gallery modules, each of which has a number of tunnels (galleries) for deployment of containers. The passing and fastening of tunnels (galleries) to be deployed is done by digging the mining mass by a gallery mining combine.

The construction continues in parallel with the storage of containers in the prepared in advance galleries (tunnels) for deployment. In order to combine in time the construction activities of the next stages and the storage of containers with RAW, two sites are built on the surface: a reception-dispatching site for containers located in the eastern part of the repository and a construction site, located in the western part.

The transport of the mine mass to the construction site on the surface is carried out by a battery locomotive (type 4.5 ARP 2M) along a mining railway tramroad. The trams have removable baskets, which are detached from the chassis at the construction site and are unloaded in a dump truck by tower crane or gantry and special unloading platform. The same machinery and equipment is used back to the forehead of the galleries (tunnels) along the tramroad to transport people, materials, spare parts and assemblies and components of mining equipment.

1.9.1 EMISSIONS IN THE AIR

1.9.1.1 EMISSIONS DURING CONSTRUCTION AND OPERATION

The construction of the NDF by both alternative methods - tunnel or trench type of repository will be carried out in stages. The operation of the NDF will continue 60 years.

1.9.1.1.1 DUST EMISSIONS – AREA SOURCES

The intensity of dust formation largely depends on the weather conditions during the period of construction activities and on the season during which the construction works will be carried out, the climatic and meteorological factors (wind, humidity, temperature, atmosphere stability), the characteristics of soil particles and many other conditions.

When using the spray system to maintain adequate moisture at the construction areas, the levels of particulate emissions (controlled emissions) are reduced by 80% [182] by the formula:

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

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

For the tunnel type the dust impact due to the earth excavation works in the tunnels is minimal, since the larger-scale construction is indoors (tunnel), therefore the dust emissions are localized and limited in space - from the openings of the mine ventilation system.

For the trench type the dust impact during the construction is coming from the unorganized construction areas outdoors at Radiana site itself, but it is also local and negligible.

1.9.1.1.2 GAS EMISSIONS

1.9.1.1.2.1 Construction equipment – area sources

The assessment of the emissions can be conducted in terms of **Tier 2**[183] using the methodology **EMEP/EEA air pollutant emission inventory guidebook 2013** for off-road mobile sources and machinery (area emissions), SNAP code **0808**, and carbon dioxide - by IPCC (**NFR**[184] code **1.A. 5.b.iii**), in the exhaust gases from internal combustion engines.

1.9.1.1.2.2 Transport activity – linear sources

The assessment of the emissions from transport flows (*supply of raw materials and transportation of waste and scrap*) can be done at **Tier 2** of the European Guidebook for inventory of emissions **EMEP/EEA air pollutant emission inventory guidebook 2013** for key pollutants from heavy-freight vehicles over 15 tons (**1.A.3.b.iii**).

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

[183] In **EMEP/EEA air pollutant emission inventory guidebook** the methodology for determining the emission levels uses methods of varying complexity, which describe the main activities in the emissions inventory. The level of complexity of the method is indicated by Tier X, i.e. the higher number X is, the more complicated and more accurate the method is.

[184] **NFR** (Nomenclature for Reporting) – nomenclature for reporting the processes generating emissions, which allows full compatibility and compliance of all national reports under the Convention on Long-range Transboundary Air Pollution (CLRTAP); before the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) and the European Environment Agency (EEA).

Significant reduction of the emissions of harmful substances can be expected if construction machinery is used during the construction, which meets at least the EURO IV standard, as well as the transport vehicles for the delivery of raw materials and disposal of excess spoil.

1.9.1.1.2.3 Emissions during asphalt laying – area sources

According to the future technical projects for construction of the NDF, it is envisaged to lay asphalt both on the technological areas and the by-pass and operational road. The level of emissions of non-methane volatile organic compounds (**NMVOC**), total suspended particles (**TSP**) and particulate matter up to 2.5 (**$PM_{2.5}$**) and up to 10 microns (**PM_{10}**) during the laying of the asphalt mixture may be calculated using the **Tier 1** methodology **EMEP/EE Air pollutant emission inventory guidebook, 2013** (**NFR** code **2.D.3.b - Road paving with asphalt**), where the emission factors are in expressed in grams per tonne laid bituminous mixture.

1.9.1.2 EMISSIONS DURING CLOSURE

The closing of the modules filled with RCC will also be carried out in stages. It is envisaged that the final closure of the facility will 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.

The closure of the NDF will be followed by a 300-year period of institutional control, during part of which a programme for control of the status of the facilities and radiation monitoring will be implemented in the PPMA, which is within the boundaries of the site - within the terrain surrounded by an outer fence.

The area on which these works will be carried out will be a source mainly of dust and to a lesser extent of emissions from the exhaust gases of internal combustion engines (ICE) of the equipment used.

1.9.1.3 EMISSIONS OF RADIOACTIVE PRODUCTS

Sources of organized gas-aerosol radioactive releases into the atmosphere are not expected.

In accordance with the requirements of the nuclear legislation NRA has set a quota of 0.1 mSv (=1,000 μSv) for the annual individual effective dose /Permission HX-3593/04.05.2012/ under all operating conditions of the NDF.

1.9.2 EXPECTED WASTE

1.9.2.1 NON-RADIOACTIVE GENERATED WASTE

The waste from the construction and excavation works is from Group with code 17 05 00 Soil (including excavated soil from contaminated sites, stones and dredging spoil, with code 17 05 04 - soil and stones other than those mentioned in 17 05 03*.

The implementation of the construction works, including removal of waste from the steel-concrete structure, will generate waste from Group with code 17 01 00 - concrete, bricks, roof tiles, tiles, porcelain and ceramic matter with codes as follows: - code 17 01 01 - concrete from removing concrete flooring and demolition of reinforced concrete structures – with code 17 03 02 - asphalt mixtures containing substances other than those mentioned in 17 03 01*, generated when laying the asphalt – from Group with code 17 04 00 - metals (incl. their alloys) with code 17 04 05 iron and steel.

During the operation of the NDF it is expected that predominantly **domestic waste** will be generated, which will be collected in containers or standard buckets and transported to the landfill for solid domestic waste by a company with subject of activity collection, transportation, deactivation and disposal of solid domestic waste.

In addition, **industrial, construction and hazardous waste** is periodically generated, primarily during repair works, as every year in the workplaces and at the sites during different operating activities, repairs, reconstruction of buildings and premises, etc. conditions are created to generate radioactive waste of different type and quantity. According to Art. 7, paragraph 1 of the WMA[185] persons whose activities generate waste and holders of waste shall treat it individually or make it available for collection, transportation and treatment to persons who are authorized to carry out these activities in accordance with this Act.

Hazardous waste such as packaging of fuel and lubricant materials (FLM), paints and varnishes, etc., burned luminescent and mercury lamps, batteries from equipment, chemicals form laboratory tests will be collected and stored on site in accordance with the regulatory requirements and will be transferred to licensed companies for disposal.

According to Art. 8, para. 8 of the WMA the transfer and reception of industrial, construction and hazardous waste will be carried out only on the basis of a written contract with persons having authorization, complex permit or registration document under Art. 35 of the WMA for the respective activity and waste site with the appropriate code in accordance with Ordinance 2 (2014) on waste classification.

The REIA specifies the type and approximate quantities of the types of non-radioactive waste. The corrective quantities may be provided in the subsequent stages of design. The effective management of this waste is also described. It meets all requirements of the current legislation, the method of collection, temporary storage and treatment of waste. Specific measures are identified to ensure the environmentally sound management of waste in order to minimize its negative impact.

1.9.2.2 RADIOACTIVE WASTE

The proposed disposal technology might lead to the possible generation of secondary RAW from drainage water, working clothing, laboratories etc.

Radioactive waste enters the site in solid form during its entire period of operation - conditioned in a cement matrix and packed in RCC. RCC is licensed as "reinforced concrete container for transportation and storage of processed radioactive waste" and is classified as package of type IP-3 under the Safety Standard of IAEA (*Regulations for the Safe Transport of Radioactive Material, 2012 Edition, Safety Requirements No. SSR-6*). This means that the operations of handling and deployment of RCC in the disposal modules during normal operation are not expected to lead to the generation of secondary RAW from the packaging.

Minimal amounts of potentially contaminated radioactive materials are formed during the operations of entry control and control of the status of engineering barriers of the disposal facilities.

According to preliminary assessment, the estimated amount of solid radioactive waste (cotton sheets, filter paper, gloves, working clothing and personal protective equipment, laboratory samples, glassware, tools) will amount to no more than 1.5-2 m^3/a and is expected to be of category 1b according to the Ordinance on the Safety of Radioactive Waste Management. It will be transported to the specialized unit of SE RAW – SU RAW-Kozloduy, located in the immediate vicinity of Kozloduy NPP site, for subsequent treatment.

It is expected that during the operation period radioactive waste will be generated in general, but in very limited quantities established after dosimetric control:

- Personal protective equipment (protective clothing, shoes, gloves, etc.) – will be in relatively small quantities - not more than 40 sets annually around 0.05 m^3/y maximum and will be processed by the existing facilities in SE RAW for processing of solid waste. Personal

[185] Waste Management Act, promulgated SG issue 53 of 13.07.2012, in force from 13.07.2012, amend., issue 66 of 26.07.2013, in force from 26.07.2013; amend. with Decision № 11 of 10.07.2014 of CC of RB, issue 61 of 25.07.2014.

protective equipment will be treated as radioactive waste only if it is contaminated after dosimetric control.

- Minimum amount of solid waste – cotton sheets, filter paper, gloves, contaminated working clothing (40 people) and personal protective equipment, laboratory samples, glassware, tools.

RAW is collected in plastic bags and transported along a certain route in freight containers on a transport vehicle, accompanied by a vehicle with equipment for radiation control, personal protective equipment, decontamination and fire-extinguishing equipment and other equipment required for responding to accidents. For each activity with RAW there are instructions, the observance of which is essential for the radiation safety and protection of personnel.

Liquid radioactive waste - not generated during normal operation. Radioactively polluted wastewater can be generated in laboratories during the laboratory tests and analysis. The expected amount will be no more than 300 dm^3 per month and up to about 1.0 m^3/y. In accordance with the requirements of the nuclear legislation, water from the internal drainage system of the disposal modules is examined and its impact is assessed as if it is potentially radioactively contaminated. It is subject to radiation control. In case of presence of radioactive isotopes in concentrations exceeding the allowed limits, it is subject to purification in the facilities of SE RAW at the site of Kozloduy NPP. At this stage of the investment proposal its amount may be taken as indicative, as it will be refined in the next stages of design.

The solid form of the waste and its packaging in reinforced concrete containers does not assume generation of aerosol emissions in the air. Water and soil pollution is prevented by means of a multi-barrier system, collection and control of drainage water in the internal drainage system, radiation control on the site.

Chapter 4 of the REIA contains an assessment of the potential impacts of radioactive waste generated during the execution of activities.

1.9.3 EMISSIONS IN WATER

It is envisaged that the Danube River will be the main receiver of all types of non-radioactively contaminated waste water from the NDF (domestic waste water and controlled storm water) through the sewers and treatment facilities of Kozloduy NPP.

The Danube River is the second largest river in Europe with more than 80 million people living arount it. It passes through 13 countries, provides a river link among them as a water transport corridor and provides fresh water to the economies of the countries. There are a significant number of hydro-technical facilities using its hydropower potential, including the nuclear power plant, but it is also a source of fresh water for their technological needs, and a receiver of the waste water and heat. Water quality in the river is of enormous importance for everyone and therefore ICPDR (International Commission for the Protection of the Danube River) has been created, with main office in Vienna. The Republic of Bulgaria is an active member of ICPDR.

According to the Bulgarian legislation – the Water Act (WA) and the Water Framework Directive (WFD) 2000/60 of the EU, the elaborated River Basin Management Plan (RBMP) for basin management in the Danube region defines the Bulgarian section of the Danube river as a river category named Danube RWB01, code BG1DU000R001 and type R6, according to Ordinance No H-4/2012 on the characterization of surface waters. This water body is of type "highly modified water body" with moderate ecological potential and poor chemical status. The objectives and measures in RBMP require that these parameters be adjusted in the coming planning years to achieve good status and good potential. The Danube River and the whole Danube region for water basin management in the country have been defined as a sensitive area in terms of anthropogenic pollution under Order RD-970/28.07.2003 of the Minister of Environment and Water, therefore the requirements to the users of the water bodies are stricter.

The sewerage network of the National Radioactive Waste Repository will be separate for the different types of waste water. According to Ordinance №2/08.06.2011 on the issuance of permits for discharge of waste water into water bodies and setting emission limits for point sources of pollution, Article 6, paragraph 1, item 3 and item 4 prohibits new inclusions of waste water, and no permits are issued for discharges of waste water into irrigation-drainage systems and of industrial waste water into the drainage systems.

1.9.3.1 NON-RADIOACTIVELY CONTAMINATED WATER

1.9.3.1.1 DOMESTIC WASTEWATER

Such wastewater will be generated by all administrative, main and ancillary buildings outside the "controlled area". It will pass through the sewerage network to the Waste Water Treatment Plan (WWTP) of the NPP, which has a modern technological scheme of treatment, guaranteeing at the outlet of the treatment plan the parameters specified in the permit for Danuber River as a receiver of this wastewater, issued under the WA. The expected amount will be justified in accordance with the effective rules, determining the required amount of drinking water according to the number of consumers. At this stage of the investment proposal it is assumed that the whole amount of drinking water, which will be used, will generate a waste flow of domestic wastewater. It will be discharged into the sewers for domestic wastewater of Kozloduy NPP.

Chapter 4 of the REIA provides a description of the types and quantities of such wastewater and an assessment of the proposed method of discharge in compliance with the regulatory requirements of the WA and Ordinance №2 /2011 on the issuing of permits for discharge of wastewater into water bodies.

1.9.3.1.2 STORMWATER

The expected quantity of stormwater is determined by the method of marginal intensity for 5-minute rain and the drainage rate, and depends on the arrangement of the buildings and facilities, the landscaping, lawn areas, terrains covered with a durable surface, etc.

A system will be constructed at the NDF site for discharge and control of stormwater from the surface runoff from the site and from the protective rain gutters. A pool for stormwater will be built, where water from the stormwater and drainage sewerage will be collected and controlled. It is envisaged to be discharged via the stomwater sewerage of Kozloduy NPP to the receiver of the main drain. Chapter 4 of the REIA provides estimates of the quantities of surface water and the proposed method of discharge.

1.9.3.2 RADIOACTIVELY CONTAMINATED INDUSTRIAL WASTEWATER

The normal operation of the NDF is not expected to generate radioactively contaminated wastewater. Working clothing will be washed/decontaminated in special washing machines, available in SU RAW-Kozloduy on the territory of Kozloduy NPP if the contamination is above the levels permitted in the Ordinance on basic norms of radiation protection (OBNRP)-2012. If contamination is irremovable, which is unlikely, that PPE will be treated as radioactive waste.

All potentially contaminated water streams are collected by specialized sewerage in special volumes, they are measured and if contamination is above the permissible norms, they are transferred for processing to SU RAW-Kozloduy before entering the pool for drainage and stormwater. These systems are evaporating installations designed to purify radioactively contaminated water before it is discharged into the Danube River. This process is regulated and implemented by special permission of the NRA. The expected amount is 20l x 52 weeks = 1040l/y = 1.04 m^3/y, i.e. maximum 1.5-2 m^3/y.

Minimal amounts of radioactively contaminated wastewater (liquid radioactive waste) is generated - from laboratories and other sources - up to 300 dm^3 per month.

Potentially contaminated water from the drainage of the trenches is not normally expected in regular quantities. There is a reservoir for its collection and radiological control. The treatment of this water is clear – collection, control and then draining or removing for treatment outside the NDF. The maximum amount of such water is less than the volume of the reservoir.

The updated REIA for the implementation of the NDF proposes measures to minimize the impacts on the environment and ensure the safety of the aquatic ecosystem and the population in the area.

1.9.4 CONTAMINATION OF SOILS

Wind is one of the elements that have a direct impact on the distribution of emissions and deposition of radioactive elements on the soil. The region is characterized by a year-round predominance of winds from the west and northwest. The wind regime for a given place is strongly influenced by the local conditions. The hilly terrain leads to redistribution and deformation of the air flow, resulting in a change in both the wind speed and the frequency of dominant directions. No less important is the role of a large water basis such as the Danube River, which in this case can be seen as a large aeration channel.

The long-term studies of the atmospheric radioactivity in the environment show a negligible impact of the emissions from the power plant on the radioactivity of the air in these areas and its contribution to soil contamination respectively.

No soil contamination is expected of adjacent lands of the site, designated for implementation of the IP in radiation and non-radiation aspect during the period of construction of the modules of the repository, the period of operation and the long-term closure.

1.9.5 NOISE AND VIBRATIONS

The used construction and assembly equipment, the main and auxiliary technological equipment and the servicing transport activities in connection with the project for construction and operation of the NDF will be a source of environmental noise. Noise emissions in the environment will be determined on the basis of passport data for noise characteristics of the planned facilities. If such data is not available, the Bulgarian legislation (Ordinance №6 on the indicators for environmental noise, taking into account the degree of discomfort during different hours of the day, the limit values of environmental noise indicators, the methods of assessing the values of noise indicators and the harmful effects of noise on human health, MH, MEW, SG 58/2006, which is in accordance with European Directive 2002/49/EC) allows using data from a similar site (with technology and equipment similar to those in the considered investment proposal). The transport, servicing the operation of the site, will also be considered as a source of noise, and the expected equivalent noise level, created by it, will be defined based on data for the expected intensity of traffic.

The design does not assume that the future technological equipment will be a source of vibrations in the environment. The used construction and assembly equipment will not be a source of vibrations in the environment. Vibrations are a factor of the work environment when working with certain types of machinery. Vibrations are characteristic of large-sized machine parts at high speed of rotation. The reduction of the spread of vibrations outside their source, for machinery and equipment, is achieved with the implementation of specific technical requirements during their installation: anti-vibration treatment of their foundations by rubber pads, insulation joints from vibration-reducing materials, removal of the solid connection between the vibrating platforms and the structural elements of the premises etc. Vibration in industrial facilities are a factor only of the working environment.

The transport vehicles servicing the activities of the NDF are not expected to be a source of vibrations in the environment. They will use roads of the national road network class II, designed in compliance with the relevant category of traffic, with vibrations of heavy-freight vehicles subsiding at short distances around the road route.

For these reasons, the REIA - stage Operation of the NDF does not consider the technological and transport vibrations to be a factor of the environment.

1.9.6 RADIATION

1.9.6.1 IONIZING RADIATION

Ionizing radiation is radiation which, upon interaction with the substance /organic or inorganic material/ leads to the formation of electrical loads. It could be of two types:

1. Corpuscular - stream of elementary particles of different mass, with and without electric charge – these are mainly alpha, beta and neutron particles.
2. Electromagnetic /photon/ radiation - gamma rays and X-rays.

The ionizing radiation is caused by nuclear interactions and/or disintegration of the nuclei of natural and artificial radionuclides. This radiation has an impact on living organisms through its ionization component. In its impact on the matter, ionizing radiation transmits part of its energy to the matter. The energy transmitted to a unit of matter is designated as a dose. The unit of transmitted energy or unit dose is Gray [Gy] equal to one J/kg.

Ionizing radiation is a manifestation of the radioactivity of radioisotopes. Radioactivity is the arbitrary disintegration of atomic nuclei of chemical elements by changing their physical and chemical properties and by emission of ionizing radiation. Such elements are called radioactive - natural and artificial radionuclides. Currently, 80 natural and about 2000 artificial radionuclides are known. Each of them has a constant period of semi-disintegration - T, which may range from fractions of a second to millions of years.

The source of ionizing radiation in the considered project is the packaged solid low- and intermediate-level radioactive waste to be finally disposed of at the national repository. The sources of radiation or ionizing radiation are principally divided into:

- Covered, which exclude the possibility for radioactive substances to fall into the environment under normal /accident-free/ conditions.
- Uncovered, where this possibility is real.

The source of ionizing radiation in the National repository is covered and the type of radiation is gamma as the packaging eliminates the distribution of alpha and beta particles outside it.

1.9.6.2 NON-IONIZING RADIATION

The main sources of extremely low frequency (ELF) electric and magnetic fields (power frequency 50 Hz) in the working environment are the transformer systems, bus rod systems, switches and power lines. Sources of ELF fields (mainly magnetic) can be current rectifiers, power supply systems with a low voltage etc.

Sources of radio frequency and microwave (ultra-high frequency - UHF) electromagnetic radiation in the NDF are present in:

- ✓ Security systems;
- ✓ Systems for mobile communication;
- ✓ Warning systems in case of an emergency.

1.10 DESCRIPTION OF THE LICENSING PROCESS AND RESPONSIBILITIES OF VARIOUS INSTITUTIONS

The description of the licensing process, including responsibilities of the different institutions for ensuring the safety, physical protection and financing of the NDF, has been prepared as a response to the recommendations of the Romanian side - letter from the Romanian Ministry of Environment, ref. №7439/EGU/16.11.2009.

In accordance with the requirements of the Act on the Safe Use of Nuclear Energy, 2002, SE RAW is responsible for the management of RAW outside the premises in which it is generated.

The scope of activity of the enterprise is:

(1). radioactive waste management, which includes all activities related to the handling, pre-treatment, processing, conditioning, storage or disposal of radioactive waste, including decommissioning of the facility for radioactive waste management;

(2). construction, operation, rehabilitation and reconstruction of facilities for radioactive waste management;

(3). transportation of radioactive waste outside the site of the respective nuclear facility provided it has obtained a permit of license for transportation under this Act;

(4). decommissioning of nuclear facilities.

Under ASUNE, according to which the management of RAW outside the sites where it is generated is carried out only by SE RAW, the enterprise has full responsibility for the selection of a site, design, construction, commissioning, operation and closure of the NDF.

SE RAW carries out these activities in compliance with the requirements for nuclear safety and radiation protection based on the permits issued by the NRA Chairman for selection of a site, design, construction, commissioning and obtaining a license for operation of a facility for radioactive waste management. The RAW management activities are financed by "Radioactive waste" fund and the activities of the decommissioning of nuclear facilities - by "Decommissioning" fund. Both funds are created in accordance with the provisions of the Act on Safe Use of Nuclear Energy.

The activities under the NDF project are financed by "Radioactive waste" fund and by an International Fund for support of the decommissioning of units 1-4 of Kozloduy NPP, called in short Kozloduy International Fund.

According to Article 74, paragraph 3 of ASUNE, the Council of Ministers (CM) takes a decision for the construction of a national repository for radioactive waste disposal. This is Decision of the CM № 683 dated 25.07.2005, by means of which the CM of the Republic of Bulgaria took a decision to build a national repository for radioactive waste disposal and assigned the activity to SE RAW.

The activities of the construction of the NDF are subject to authorization regime by the Nuclear Regulatory Agency (NRA) pursuant to the requirements of the Act on Safe Use of Nuclear Energy and the Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy (OPILPSUNE) [186]. Permits/licenses shall be obtained for all stages of the life cycle of the NDF:

(1). Permit for selection of a site;

(2). Permit for design of the NDF;

(3). Permit for construction of the NDF

(4). Permit for commissioning;

[186] Ordinance on the procedure for issuing licenses and permits for safe use of nuclear energy, prom. SG issue 41/18.05.2004, last amend SG issue 76/5.10.2012.

(5). License for operation;

(6). License for closure of the NDF.

Below there is a description of the conditions for obtaining the relevant permits and licenses, the evidence that SE RAW must present to prove that it has the necessary capacity to implement the stated activities, and the conditions that SE RAW must meet to obtain approval from the Nuclear Regulatory Agency for the respective stage.

Application for obtaining a permit for determining the location of a nuclear facility (site selection)

To obtain a permit for selection of a site for the NDF, SE RAW shall submit an Application under Article 33, para. 1, item 1 of ASUNE for issuing a permit for determining the **location of the nuclear facilities (site selection)**.

According to **Article 4 of OPILPSUNE**, SE RAW shall submit to the Chairman of the NRA a written application containing:

1. Identification data of the applicant;
2. Type of the requested license or permit and a general description of the work to be performed;
3. Period for which the license or permit is requested;
4. General description of the main characteristics of the site where the activity will be carried out and its location if operation of such facility is intended;
5. Data for the administrative acts related to the stated activity, which have been issued by other government bodies;
6. List of the documents attached to application.

According to **Article 35 of OPILPSUNE** the following documents shall be attached to the application:

1. Copy of the act, certifying commercial registration of the applicant;
2. Certificate, proving that no bankruptcy proceedings have been initiated against the applicant - trader;
3. Declaration by the members of the board of directors of the applicant - legal entity that they have not been sentenced to imprisonment for a criminal offense;
4. Documents certifying that the applicant has the financial resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
5. Documents certifying that the applicant has the technical resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
6. Documents certifying that the applicant has the material resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
7. Documents about the management and organizational structure of the applicant;
8. Documents about the size, education and qualification of the staff and the distribution of positions;
9. Justification for the duration of the period for which the license or permit is requested;

10. List of the standards applicable for the respective activity, as well as other documents that certify compliance with the requirements for carrying out the respective activity.

According **to Article 36 of OPILPSUNE** the following documents shall be attached:

1. Conceptual description of the nuclear facility, general characteristics and criteria for acceptability of the sites;
2. Plan-assignment for preliminary studies, which contains information on the scope of the planned feasibility studies, according to Ordinance № 4 of 2001 on the scope and content of investment projects (SG issue 51 of 2001);
3. Description of the activity management system.

According **to Article 25, paragraph 1 of the Ordinance on the Safety of Radioactive Waste Management (OSRWM)**[187] the selection of a site for a facility for RAW disposal shall be based on a comparative analysis of at least three sites and shall be conducted in the following stages:

1. Development of a disposal concept and planning of activities for site selection;
2. Collection of data and analysis of regions, including:
    a. Analysis of the regions - conducting analysis and evaluation of the whole country, excluding large regions with unfavourable conditions for locating a facility for RAW disposal; identifying regions for analysis, which are large areas with favourable geological-tectonic, geomorphological (topographic), hydrogeological, geotechnical, hydrological, climatic and other characteristics;
    b. Selection of promising sites - potential sites, which meet the criteria for locating a facility for RAW disposal, are localized in the regions for analysis. Promising sites for thorough examination are identified.
    c. Characterization of sites – the sites identified under item 2 are examined thoroughly and one site is selected;
    d. Confirmation of the site.

According to **Article 25, paragraph 2 of OSRWM** the activities in each stage are planned and justified in a plan that includes:

1. Description of the objectives;
2. Description of the main activities in their sequence;
3. Description of the requirements and recommendations of national and international documents, which will be implemented during the activities;
4. List and description of the developed procedures, ensuring the practical application of the requirements and recommendations in Item 3;
5. Detailed schedule for implementation of activities;
6. Program of quality assurance;
7. Assessment of the necessary financial resources and sources of funding.

According to **Article 25, paragraph 3 of OSRWM**, at the end of each stage under paragraph 1 a report shall be prepared on the results from the implementation of the plan under paragraph 2

<u>Request for issuance of an order for approval of the selected site</u>

[187] Ordinance on the Safety of Radioactive Waste Management, SG issue 76 of 30 August 2013.

According to **Article 37 of OPILPSUNE**, the following documents shall be attached to the request for issuance of an order for approval of the selected site:

1. Preliminary report on the analysis of the safety of the nuclear facility which includes at least the following data:
    (1). General description and characteristics of the nuclear facility;
    (2). Main objectives, principles and safety criteria applied in the justification of the safety of the nuclear facility;
    (3). Types and quantities of RAW expected to be generated as a result of the operation of the facility, method of management up to its final disposal or release from regulatory control;
    (4). Comparison of the proposed sites in terms of nuclear safety and radiation protection and selection of an option, taking into account: the impact of factors of technogenic and natural origin on the safety of the facility; radiological impact of the nuclear facility on the population and the environment; specific characteristics of the site relevant to the migration and accumulation of radioactive substances; opportunities for implementation of measures for protection of the population in case of an accident in the nuclear facility; dimensions of the special status areas and the emergency planning areas;
    (5). Results of the study of the characteristics of the selected site, including: geographic, topographic and demographic conditions; technogenic factors; hydrometeorological conditions; geological, hydrological, seismic and geotechnical conditions; specific characteristics of the site and the region for the purposes of emergency planning, accident management and physical protection;
    (6). List of references of the data and information used in the justification of the proposed site;
    (7). List of the persons who have participated in the preparation of the documents and in the study of the site, including information about the qualification of these persons;
2. Monitoring programs at the site, including: seismic monitoring, mode of groundwater and surface water , and monitoring of other natural phenomena;
3. Decision on the environmental impact assessment (EIA) or decision of the competent environmental body with a conclusion that it is not necessary to carry out EIA in accordance with the Environmental Protection Act;
4. Program for further research at the selected site if the presented report on the safety analysis demonstrates the need for such research;
5. Other documents confirming the compliance with the requirements set out in the provisions of Art. 26, para. 2 of ASUNE, and fulfilment of the conditions of the permit for site selection.

Application for issuance of a permit for design of a nuclear facility

According to **Article 49 of OPILPSUNE**, the Application for issuance of a permit for design of a nuclear facility must meet the requirements of **Art. 35, para. 1**. The application shall be accompanied by the following documents:

1. Terms of Reference for the design or contract for the design;
2. Description of the system for activity management;
3. List of applicable standards that will be used in the design of the nuclear facility.

Request for issuance of an order for approval of the developed technical design

According to **Article 40 of OPILPSUNE**, the request for issuance of an order for approval of the developed technical design of the nuclear facility shall be accompanied by the following documents:

1. Interim report on the safety assessment of the nuclear facility, which includes:
   (1). Interim report on the safety analysis of the nuclear facility, based on a preliminary report on the safety analysis and the technical design of the facility; the scope of the report on the safety analysis shall include as a minimum the subjects listed in Annex № 1 of OPILPSUNE;
   (2). Results of the verification of the design for compliance with the requirements, standards and rules for nuclear safety and radiation protection, including the requirements for safety management, and the results of the independent verification of the safety analysis;
2. Technical design of the nuclear facility;
3. Other documents confirming the fulfilment of the conditions of the permit for design;

Application for issuance of a permit for construction of a nuclear facility

According to **Article 41 of OPILPSUNE**, the application for issuance of a permit for construction of a nuclear facility shall meet the requirements of Art. 35, para. 1 and contain the registration numbers of the orders under Art. 33, para. 4 of ASUNE. The application shall be accompanied by the following documents:

1. Preliminary summary schedule for implementation of the construction and assembly works;
2. Technical and/or detailed design for construction of the nuclear facility;
3. Description of the system for activity management;

Issuance of a permit for commissioning of a nuclear facility

To obtain a permit for commissioning of the NDF, SE RAW shall submit an Application under Art. 33, para. 1, item 4 of ASUNE which, according to **Article 4 of OPILPSUNE**, shall contain:

1. Identification data of the applicant;
2. Type of the requested license or permit and a general description of the activity to be performed;
3. Period for which the license or permit is requested;
4. General description of the main characteristics of the site, where the activity will be carried out, and its location, if operation of such facility is envisaged;
5. Data for the administrative acts related to the stated activity, issued by other government bodies;
6. List of the documents attached to application.

According to **Article 35 of OPILPSUNE** the following documents shall be attached to the application:

1. Copy of the act, certifying commercial registration of the applicant;
2. Certificate, proving that no bankruptcy proceedings have been initiated against the applicant - trader;
3. Declaration by the members of the board of directors of the applicant - legal entity that they have not been sentenced to imprisonment for a criminal offense;

4. Documents certifying that the applicant has the financial resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
5. Documents certifying that the applicant has the technical resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
6. Documents certifying that the applicant has the material resources to the extent necessary to carry out the stated activity in accordance with the requirements, standards and rules for nuclear safety and radiation protection;
7. Documents about the management and organizational structure of the applicant;
8. Documents about the size, education and qualification of the staff and the distribution of positions;
9. Justification for the duration of the period for which the license or permit is requested;
10. List of the standards applicable for the respective activity, as well as other documents that certify compliance with the requirements for carrying out the respective activity.

According **to Article 43 of OPILPSUNE**, the application shall be accompanied by the following documents:

1. Decision of the Council of Ministers under Art. 129, para. 1 of ASUNE on a nuclear installation within the meaning of Vienna Convention on Civil Liability for Nuclear Damage;
2. Document certifying the availability of a financial guarantee covering the civil liability for nuclear damage in accordance with Art. 132 of ASUNE;
3. Permit for use of the construction, issued under the Spatial Planning Act;
4. Program for commissioning of the nuclear facility, which defines the different stages of commissioning, the activities to be carried out at each stage, and the planned duration of each stage. The program for commissioning shall contain information ensuring that
    a. all necessary tests for confirming the design characteristics of the nuclear facility, referred to in the interim report on the safety assessment, are envisaged;
    b. tests are planned in stages, so that the nuclear facility may be subject to lighter loading conditions before moving to heavier loading conditions;
    c. periods of retention are envisaged in the process of commissioning, whereby the facility is operated under certain conditions in a predetermined period;
    d. a list has been prepared of the systems and equipment needed for the different stages of commissioning;
5. Description of the system for activity management;
6. Description of the approved changes in the technical design of the nuclear facility;
7. Description of the results of the pre-commissioning single tests of the systems, equipment and facilities;
8. Technical specifications for operation of the nuclear facility, which contain limits and operating conditions, including: safety limits; values of the parameter for activation of the safety systems; limits and conditions of operation; tests, inspections, supervision and operational control of the systems important to safety; minimum number of operating personnel for various operational states, including qualified and authorized personnel in the main control room; personnel actions in case of deviations;

9. List of the internal rules, instructions and procedures governing the operation of the nuclear facility
10. List of the positions in the organizational structure of the applicant with functions of provision or control of the nuclear safety and radiation protection, for which a certificate of qualification is required pursuant to Art. 64, para. 2, item 1, letter "a" of ASUNE;
11. Program for radiation monitoring of the site of the nuclear facility and in the special status areas during the operation of the nuclear facility;
12. List of the systems, equipment and facilities which are essential for the safety of the nuclear facility;
13. List of the systems and equipment needed for the different stages of commissioning;
14. Methodologies and programs for conducting tests and experiments in the different stages of commissioning of the nuclear facility;
15. Instruction for ensuring nuclear safety during the commissioning and operation of the nuclear facility;
16. Instruction for ensuring radiation protection during the commissioning and operation of the nuclear facility;
17. Instruction for physical protection of the nuclear facility;
18. Instruction for the access regime;
19. Instruction for liquidation of accidents during the operation of the nuclear facility;
20. Document certifying that the applicant has sufficient staff with the necessary qualifications and competence for all activities of the commissioning and operation of the nuclear facility;
21. Description of the applicant’s system for providing staff training and for improvement and control of the qualifications of the staff;
22. Internal emergency plan of the nuclear facility;
23. Documents governing the special status areas and the controlled access areas;
24. Program for radiation monitoring of the environment;

After conducting the tests and experiments for commissioning under **Article 46, paragraph 1 of OPILPSUNE** protocols shall be prepared, containing:

1. List of the works carried out at the respective stage;
2. Analysis of the compliance of the design characteristics with the actual characteristics of the equipment, obtained during the tests and experiments;
3. Description of the defects and failures that have occurred;
4. Analysis and conclusions about the causes and permissibility of the deviations of the actual characteristics from the design characteristics and measures for their removal;

The fulfilment of the conditions of the permit for commissioning shall be verified by a commission of NRA inspectors, established by an order of the NRA Chairman, which shall check the documents submitted by the applicant and shall carry out an on-site inspection.

Issuance of a license for operation of a nuclear facility

To obtain a license for the operation of the NDF, SE RAW shall submit an Application under **Article 35, paragraph 1, item 1 of ASUNE**, which contains the documents under **Article 4 and Article 35 of OPILPSUNE**, described above.

According to **Article 48 of OPILPSUNE**, the application shall be accompanied by the following documents:

1. Final report on the safety analysis of the nuclear facility, based on the report under Art. 40, para. 1, item 1, which contains records of the results of the commissioning of the nuclear facility;
2. Documents under Art. 43, para. 1, items 7, 14, 16, 17, 20, 22, 24, 27 and 28, which take into account the results of the commissioning of the nuclear facility;
3. Schedules and instructions for testing and control of the status of the systems essential to safety;
4. Plan-schedule for technical maintenance and repair of the main equipment;
5. Program for RAW management for the duration of the requested license and for the entire operation period of the nuclear facility;
6. Rules, procedures and programs for training of the staff and for improvement and control of the qualifications of the staff;
7. Analysis of the activities performed by external parties, as well as the positions in the organizational structure of the applicant, which organize and control these activities, the necessary minimum number and qualifications of the persons who occupy these positions;
8. Description of the system for management of the operation activity of the nuclear facility;
9. Documents adopted by the governing body of the applicant, which determine the safety policy, including for achieving and maintaining a high level of safety culture;
10. Instruction for the procedures for reporting and the methods of analysis of the operational events;
11. Program and schedule for conducting training of the staff of the applicant, related to the implementation of the internal emergency plan of the nuclear facility;
12. Program for management of the resource of the equipment of the nuclear facility for the duration of the license and during the entire period of operation, including control of the status of components essential for the safety of the equipment;

According to **Article 54 of OPILPSUNE**, the application shall be accompanied by the following documents:

1. Criteria for acceptance of RAW for disposal;
2. Procedures for the transmission and reception of RAW for disposal;
3. Program for inspection of RAW packaging in the acceptance for disposal;
4. Plan for closure of the facility, including control after closing.

Renewal of the license for operation

According to **Article 35, paragraph 3 of OPILPSUNE** licenses shall be issued for a period up to 10 years. When renewing the license, the complete set of documents described above shall be submitted. The report on updating the safety analysis takes into account the operational experience gained during the operation of the nuclear facility.

Issuance of a license for decommissioning (closure of a nuclear facility)

To obtain a license for decommissioning (closure of the NDF), SE RAW shall submit an Application under **Article 35, paragraph 1, item 1 of ASUNE**, which contains the documents under **Article 4 and Article 35 of OPILPSUNE**, described above.

Pursuant to **Article 43 of OSRWM** the closure of the facility for RAW disposal shall be carried out in accordance with a detailed plan for closure of the facility, which includes:

1. Description of the facility - site, special status areas, structures, systems and components (SSCs) essential to the safety, level of radioactive contamination of the SSCs and the components of the environment;
2. Operating history of the facility - description of important operating circumstances and events, related to the closure;
3. List of applicable standards;
4. Complete inventory of RAW in the facility;
5. Plan-schedule of the stages and activities of the closure;
6. Description of the decontamination and rehabilitation activities, related to radioactively contaminated SSCs, soil and groundwater;
7. Classification of SSCs in terms of their importance to safety during the closing activities;
8. Description of the necessary major changes in the existing SSCs, including the introduction of new SSCs if needed specifically for the purpose of closure;
9. Program and schedules for supervision and maintenance of SSCs that need to be available during the process of closure;
10. Description of available and planned technologies and technical means for disassembly of SSCs and their decontamination if needed;
11. Program for management of operating RAW, including their disposal;
12. Description of the management system, including personnel management;
13. Program for radiation protection of the personnel and population and environmental protection;
14. Description of the organization and responsibilities of emergency planning and preparedness;
15. Duties and responsibilities for ensuring the physical protection of the facility;
16. Updated estimates of the cost of closure of the facility, funding mechanism and available resources;
17. Description of the monitoring programs, the methods and technical means for surveillance of the site after completion of the closing process;
18. Definition of the end point of the stage of closure of the nuclear facility;
19. Plan-schedule for reporting interim and final results of the closure to the NRA.

According to **Article 44 of OSRWM** the closure of a facility for RAW disposal is based on a technical design for implementation of the activities and on a safety assessment of the facility after its closure.

According to **Article 60 of OPILPSUNE**, it is mandatory to have a Decision on EIA in accordance with the EPA.

LIST OF APPENDICES

PART I

APPENDIX 8-I.1 - Plot plan to determine the route and easement zone of a temporary access road to Radiana site, land of the village of Harlets, Kozloduy municipality, Vratsa district, M 1: 1000.

APPENDIX 8-I.2 – Elaboration of detailed design for construction of a temporary access road to Radiana site - situation and tracing plan.

APPENDIX 8-I.3 – Elaboration of detailed design for construction of a temporary access road to Radiana site - overview map.

APPENDIX 8-I.4 – Coordinate register of the bends of Radiana site, village of Hurlets, Kozloduy municipality.

APPENDIX 8-I.5 - Comparative analysis of the potential sites.

APPENDIX 8-I.6 - Scheme of the approach used in the preliminary safety assessment.

APPENDIX 8-I.7 - Design for displacement of existing communication cables - new route of communication cables - tracing plan.

APPENDIX 8-I.8 – Detailed Development Plan (DDP)-building plan of Radiana site.

APPENDIX 8-I.9 - Scheme of temporary landfills according to the Map of recovered property.

APPENDIX 8-I.10 - Design of drinking water supply at Radiana site - situation of water conduit.

APPENDIX 8-I.11 – DDP-plot plan for displacement of a section of overhead power line, running through Radiana site.