ENVIRONMENT IMPACT ASSESSMENT REPORT ON

INVESTMENT PROPOSAL

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

PART III

DESCRIPTION AND ANALYSIS OF THE ENVIRONMENTAL COMPONENTS AND FACTORS AND OF THE MATERIAL AND CULTURAL HERITAGE, WHICH WILL BE AFFECTED TO A LARGE DEGREE BY THE INVESTMENT PROPOSAL, AS WELL AS THE INTERACTION BETWEEN THEM

Sofia, January 2015

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3 DESCRIPTION AND ANALYSIS OF THE ENVIRONMENTAL COMPONENTS AND FACTORS AND OF THE MATERIAL AND CULTURAL HERITAGE, WHICH WILL BE AFFECTED TO A LARGE DEGREE BY THE INVESTMENT PROPOSAL, AS WELL AS THE INTERACTION BETWEEN THEM

3.1 CLIMATE AND AMBIENT AIR

3.1.1 CLIMATE

According to the climate zoning of Bulgaria the area concerned is situated in the western parts of two climatic regions – Northern and Middle climatic region of the Danubian hilly plain within the Temperate Continental climate subregion.

The climate in this region is characterized as pronouncedly continental due to the sharp contrast between winter and summer thermal conditions. The mean annual amplitude of the air temperature is between 24.5°C and 26°C – the largest amplitude countrywide. The continental character of the climate is also confirmed by the precipitation regime in the region. The annual precipitation amount is between 540 mm and 580 mm, with a maximum occurring in June and a minimum in February. The difference between the precipitation amount for the three summer and three winter months is between 70 mm and 120 mm, i.e. 15% - 20% of their annual amount. The absolute maximum twenty-four-hour precipitation occurs during the summer and its amount is about 100 mm – 130 mm. Summer precipitations however, are grouped in separate days and droughts are often observed, especially during the second part of summer. There is an average of 4 to 5 periods without precipitation during summer and autumn, with duration of over 10 days and an average duration of 16-20 days. In some years, even longer drought periods are not a rare occurrence.

The dynamics of the transfer of air in the surface layer is characterized by the wind rose. Essential to the local climate are the nature of the terrain and the proximity to the Danube River, which is considered a major aeration channel. It leads to substantial inconsistency regarding the values of the meteorological elements, particularly such elements as the minimum temperatures and the surface wind, which are highly sensitive to the shape and location of the terrain. The determination of these inconsistencies has a large significance for many meteorological tasks and for the distribution of pollutants in the ambient air in particular.

Up to 1997 the climatic characterization of the area was based on data determined on the basis of statistics from the regular weather observations carried out in the Kozloduy station for the period 1970-1982, as well as on the observations from the Lom station. Actual meteorological data have been used since 1997 and is obtained from three meteorological stations of Class III combined in an Automatic System for Meteorological Monitoring (ASMM). One of these stations is installed on the external radiation control point (Automatic Measurement Station – External Radiation Control [AMS–ERC]), which is representative for the area concerned, while the other two are located in the Blatoto locality and in the village of Harlets.

The data used for the assessment of the microclimate in the area will mainly include developments of reports on tasks assigned by Kozloduy NPP to the Meteorological Systems and Equipment Consortium, which were presented to SE RAW for the purposes of the EIA of NDF, as well as official publications, which are available on the Internet

3.1.1.1 CLIMATE PARAMETERS

Air temperature

The maximum air temperatures measured in 2011, 2012 and 2013 in the concerned area were respectively[1] 38.5°C, 44.1°C and 39.2°C, while the mean annual temperature varied from 13.1°C to 13.4°C. In 2012 the highest temperatures occurred during the summer, while the lowest were measured in the winter.

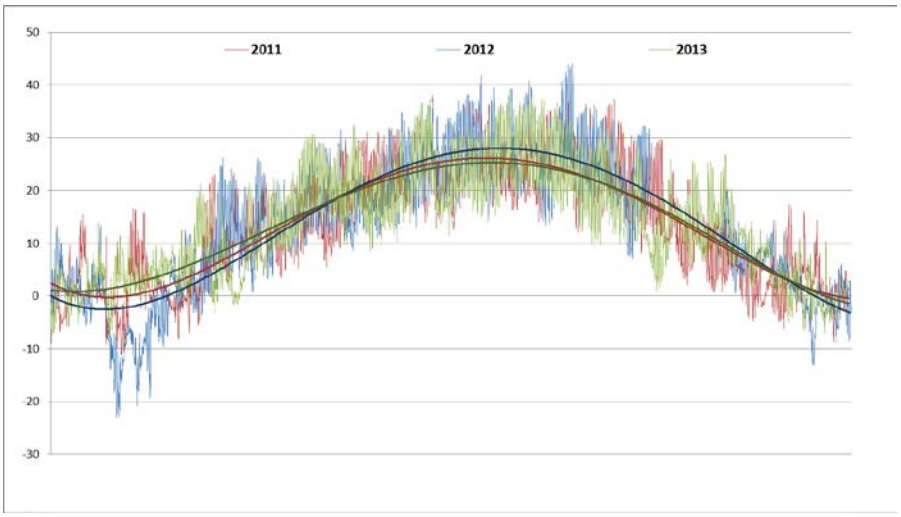


FIGURE 3.1-1: TEMPERATURES MEASURED IN 2011, 2012 AND 2013

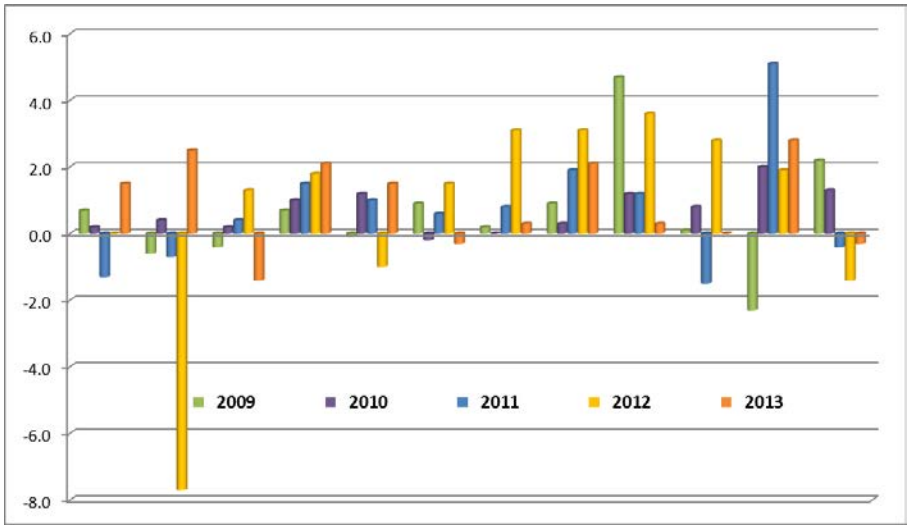


FIGURE 3.1-2: COMPARISON OF THE MEAN MONTHLY TEMPERATURE FOR THE PERIOD 1998÷2011 AND THE LAST 6 YEARS.

The comparison of the mean monthly temperatures for the last 6 years (from 2009 to 2013) are presented in **Figure 3.1-2** along with the average temperatures for the period 1998-2011 with mean annual temperature of 12.4°C.

The differences in the mean monthly temperatures for this period and for the past 6 years show that the mean monthly temperatures from April to September were higher than the average for the period. The annual course for 2012 shows that the winter temperatures reached their lowest values in comparison to the period 1998-2011, while the summer and autumn temperatures were higher than the same temperatures for the rest of the years. The winter temperatures in 2011 were one of the highest.

[1]Reports on the Local Meteorological Conditions in the Area of Kozloduy NPP, from 2009 to 2013

Figure 3.1-3 shows the average rose of the frequency of temperatures presented in gradations of 22.5° for each of the sixteen sectors of wind direction for the period 2009-2013, the so called ‘temperature roses in gradations’. The temperatures within the interval of -5°C to +5°C for the west-southwestern winds have the highest share (2.97%). The positive temperatures (above +5°C) comprise 72.6%.

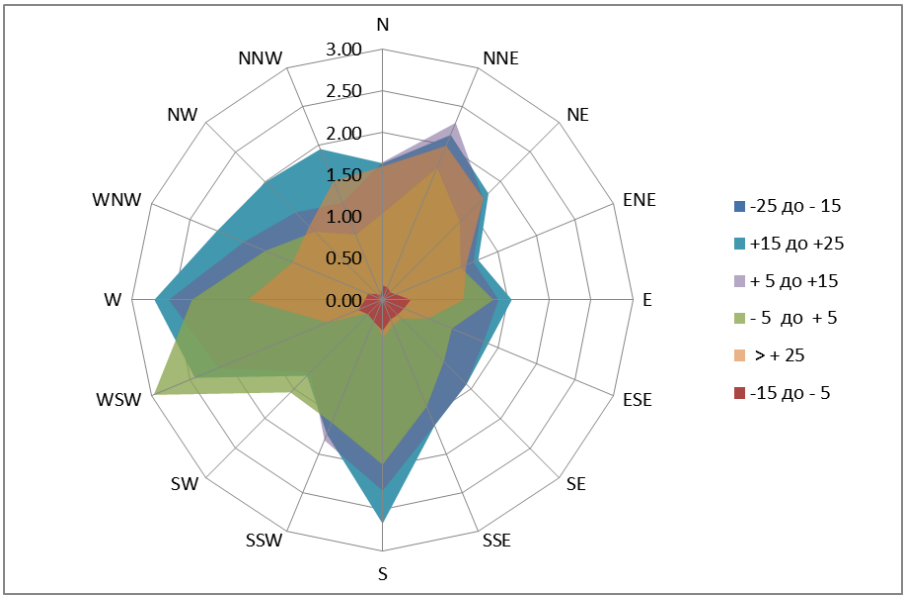


FIGURE 3.1-3: TEMPERATURE ROSES IN GRADATIONS FOR THE PERIOD 2009-2013

Table 3.1-1 presents the extreme temperature values in the area of Kozloduy NPP in 2009, 2010, 2011, 2012 and 2013. The Date [hour: min] column indicates the day and the exact hour they were recorded.

TABLE 3.1-1: EXTREME TEMPERATURES IN THE PERIOD 2009-2013

T [°C]	Minimum °C	Date [hour:min]	Maximum °C	Date [hour:min]
2009	-16.3	05.01.2009 [08:24]	38.8	24.07.2009 [17:50]
2010	-19.3	26.01.2010 [00:41]	39.8	28.08.2010 [16:50]
2011	-11.7	26.01.2011 [07:28]	38.9	16.07.2011 [15:23]
2012	-23.4	31.01.2012[02:52]	44.6	26.08.2012[15:44]
2013	-8.5	28.01.2013[00:40]	40.1	29.07.2013[15:44]

Precipitation

Table 3.1-2 presents the annual precipitation amount for a period of 10 years – 2004-2013, according to the **Local Meteorological Conditions in the Area of Kozloduy NPP** reports concerning these years.

TABLE 3.1-2: ANNUAL PRECIPITATION (MM) FOR A PERIOD OF 10 YEARS

Year	Amount mm	Year	Amount mm
2004	305.5	2009	676.7
2005	532.8	2010	801.8
2006	234.0	2011	363.2
2007	518.8	2012	376.8
2008	422.2	2013	472.8

The mean annual precipitation amount for the 10-year period is 470.46 mm, which is well below the climate 'normal' (1961-1990)[2] of 545 mm for precipitation in the area.

Figure 3.1-4 shows the deviation of the monthly precipitation amounts from the climate 'normal'.

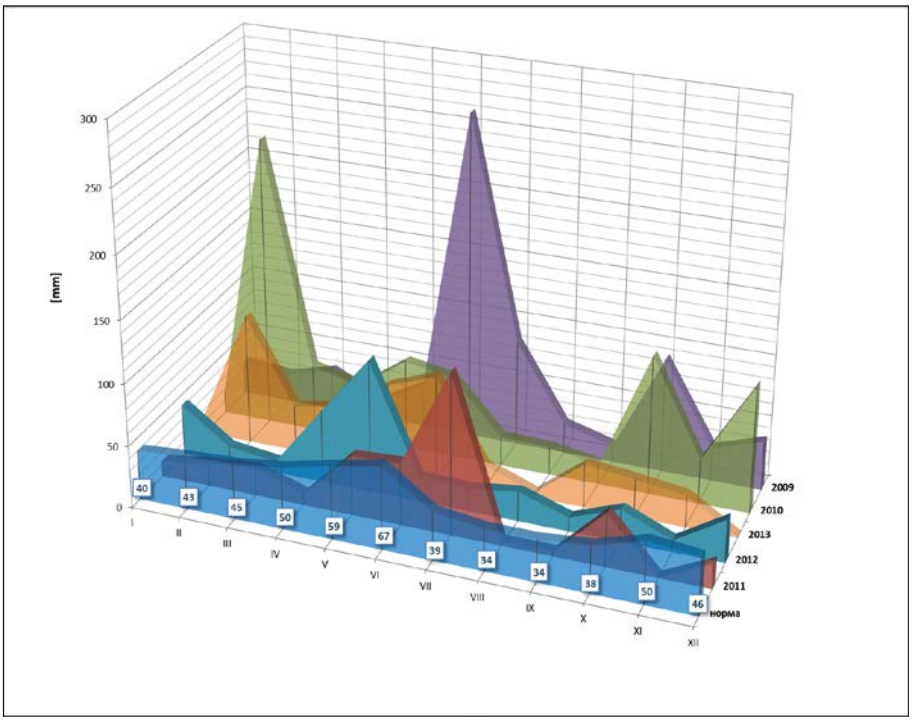


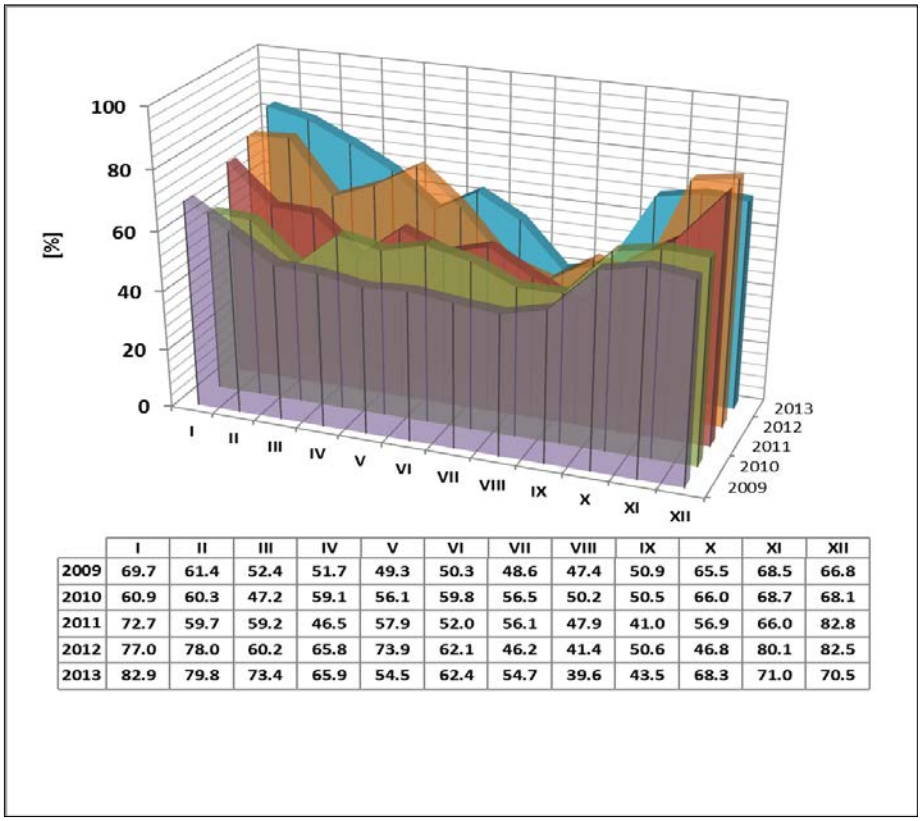
FIGURE 3.1-4: PRECIPITATION FOR THE PERIOD 2009-2013 AND CLIMATE NORMALS FOR THE PERIOD 1961-1990

Relative humidity

Relative humidity over 60% is observed during the winter months and the last two autumn months. The relative humidity reached its maximum in January 2013 and in December 2011 (over 82%), while the lowest mean annual relative humidity is the one registered in 2009 – 56.9% (**Figure 3.1-5**).

In August the frequency of the invasions of fresh and humid Atlantic air is relatively low, which is why the lowest values of the relative humidity occur precisely then.

[2] The World Meteorological Organization (WMO) has defined the climate 'normal' as the average value of a certain climatic element for a fixed base period of 30 years. The currently adopted base periods are 1901-1930, 1931-1960, 1961-1990.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2009	69.7	61.4	52.4	51.7	49.3	50.3	48.6	47.4	50.9	65.5	68.5	66.8
2010	60.9	60.3	47.2	59.1	56.1	59.8	56.5	50.2	50.5	66.0	68.7	68.1
2011	72.7	59.7	59.2	46.5	57.9	52.0	56.1	47.9	41.0	56.9	66.0	82.8
2012	77.0	78.0	60.2	65.8	73.9	62.1	46.2	41.4	50.6	46.8	80.1	82.5
2013	82.9	79.8	73.4	65.9	54.5	62.4	54.7	39.6	43.5	68.3	71.0	70.5

FIGURE 3.1-5*:* RELATIVE HUMIDITY FOR THE PERIOD 2009-2013.

Wind

The dynamics of the transfer of air in the surface layer is characterized by the wind rose – the speed and direction of the wind measured in 16 directions. The wind in a certain area is one of the meteorological elements, which strongly depends on the local conditions and especially on the topography. Hilly terrain leads to redistribution and deformation of the airflow and as a result both the speed of the wind and the frequency of the predominant directions are altered. An area, like the one considered, is also influenced by the presence of a large water body such as the Danube River (aeration channel).

Figure 3.1-6 presents the average wind rose for the wind speed gradations in the period 2009-2013. The area of the coloured sections for the different wind speed ranges indicates the share (in percentage) of the wind speed in this interval for all of the occasions when wind occurrence was registered throughout the year.

The largest area belongs to the southern winds with speed of 1 m/s to 3 m/s, which have a share of 5.7% of all speeds - **Figure 3.1-6**. The winds with speeds in the interval of 3 m/s to 5m/s are from north-northeast and their share is 2.9% of all the case of wind occurrence.

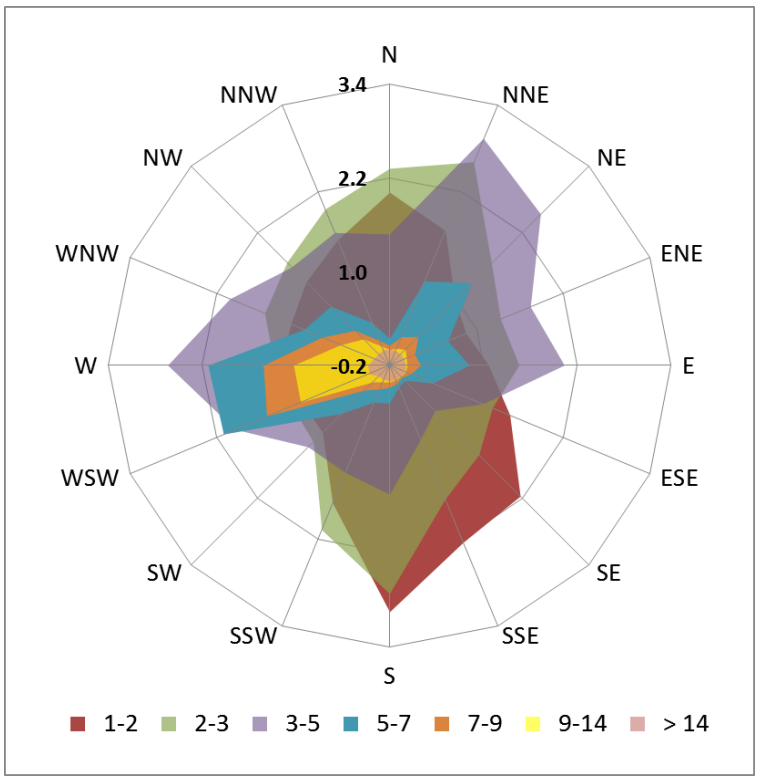


FIGURE 3.1-6: WIND ROSE IN GRADATIONS FOR THE PERIOD 2009-2013

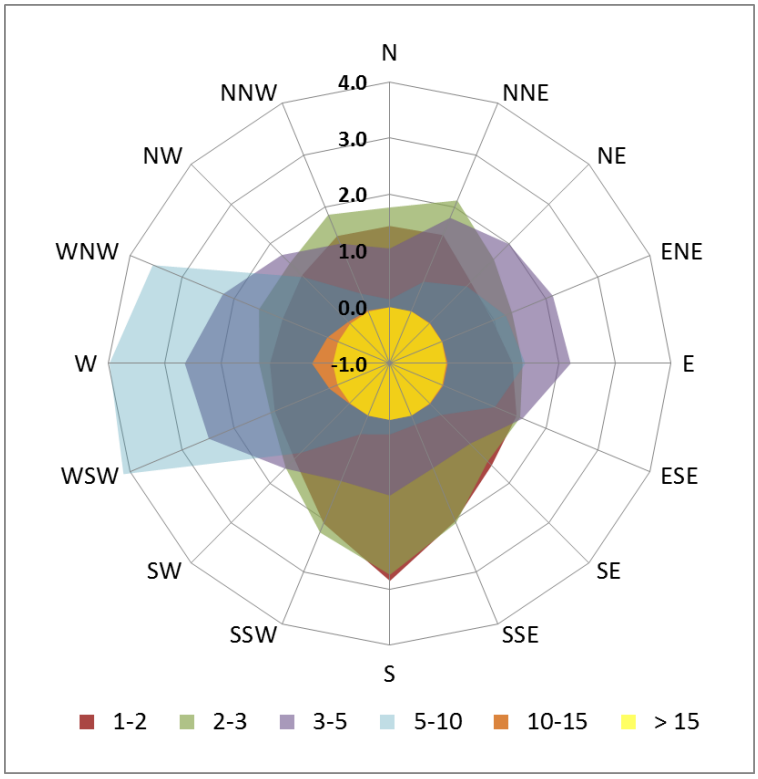


FIGURE 3.1-7: WIND ROSE IN GRADATIONS FOR THE PERIOD 1998-2011

Figure 3.1-7 presents the mean annual rose for the period 1998-2011. The largest share for this period belongs to the western, south-southwestern and north-northwestern winds (27.34% of the cases), followed by the winds from the southern 45° horizon (18.41% of the cases) and the winds

from the eastern 45° horizon (17.43%). This confirms the increase of the south winds as shown in the average rose for the period 2009-2013 - **Figure 3.1-6.**

The extreme values of the wind speed are presented in **Table 3.1-3**. It is indicative that during these years the winds are always coming only from the north. [3]

TABLE 3.1-3*:* EXTREME SPEEDS FOR THE PERIOD 2009-2013

Year	Maximum	Date [hour:min]
2009	34.6 m/s from direction 357º (north)	21.03.2009 [12:10]
2010	26.0 m/s from direction 357º (north)	09.12.2010 [22:35]
2011	23.5 m/s from direction 357º (north)	28.11.2011 [14:58]
2012	23.0 m/s from direction 357º (north)	04.12.2012[01:09]
2013	28.4 m/s from direction 357º (north)	22.03.2013[11:25]

Annual characteristics of the Pasquill atmospheric stability classes for the area of Kozloduy NPP

The calculation of the radiation exposure in the area of the Radiana site, located in the immediate vicinity of the Kozloduy NPP, requires information on the condition of the atmospheric turbulence, which determines the possibility of distribution of impurities in the ambient air. A Pasquill atmospheric stability class is used for the major part of the diffusion models. The atmospheric stability classes are six: ***A – very unstable, B – moderately unstable, C – slightly unstable, D – neutral, E – slightly stable and F – moderately stable.***

In the case of unstable atmospheric conditions (classes **A**, **B** and **C**), the diffusion of pollutants takes place much faster due to the strong turbulence in vertical direction, which leads to the rapid vertical mixing of pollutants with the surrounding ambient air quantities. Despite the fact that these conditions are favourable for the dispersion of pollutants, single occurrences of large surface concentrations can be observed near the source in times of low wind speed and in the early daylight hours in sunny weather.

Under stable conditions of the atmosphere (classes **E** and **F**) the lack of turbulence or the presence of a very low one prevents the spread of impurities in vertical direction and transfers them in horizontal direction, however in case of very light winds or the absence of wind, the pollution can remain in the area surrounding the source for a long time. Such conditions occur in the presence of inversions, in the late-night hours and during the night.

Neutral condition of the atmosphere (class **D**) is observed during cloudy weather or in sunny days in the hours between the breakup of inversions (increase of temperature with height) formed during the night and the development of unstable conditions during the day. In such cases lower surface concentrations are observed.

Figure 3.1-8 shows the rose of stability classes for 2009, 2010 and 2011, respectively. The area of the coloured sectors for the different stability classes indicates the share of a certain class (in percentage) in the total classes observed during the year.

The largest share for the period 2009-2013 belongs to the slightly stable atmospheric conditions (class **E**) – 35.3%, and the highest frequency is that of the south winds (3.7%) - **Figure 3.1-8**. The share of neutral atmospheric conditions (class **D**) is 29.5%, in which the western winds are

[3] Reports on Local meteorological conditions in the area of Kozloduy NPP, 2009, 2010, 2011, 2012 and 2013

predominant, with a frequency of 4.5%. The unstable conditions of the atmosphere (class **A**, **B** and **C**) have a share of 26.94% in all the cases.

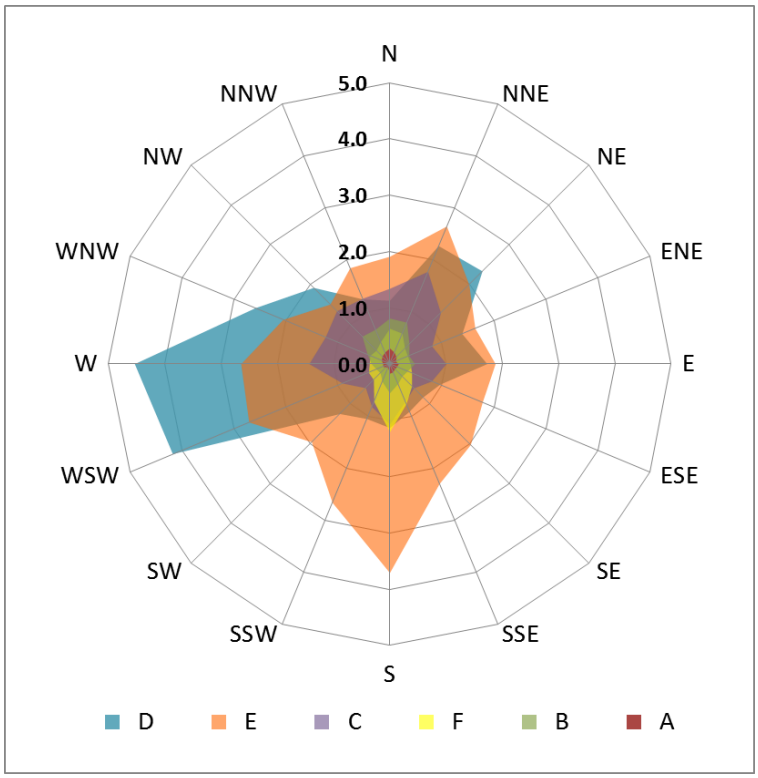


FIGURE 3.1-8: ROSE OF PASQUILL ATMOSPHERIC STABILITY CLASSES FOR THE PERIOD 2009÷2013

Table 3.1-4 shows the repeatability of the atmospheric stability classes in Kozloduy for the period 1998÷2011.

TABLE 3.1-4*:* STABILITY CLASSES, AVERAGE FOR THE PERIOD 1998÷2011

Classes	A	B	C	D	E	F
%	0.8	2.9	9.1	33.9	42	11.3

Cloudiness

The amount and type of cloudiness is determined by the nature of the baric systems and their interaction with the relief. The annual course of the cloudiness for the region is determined by the annual course of the atmospheric circulation, the humidity, and the air stratification. From the middle of autumn to the end of winter the amount of low and total cloudiness increases due to the increase in the atmospheric stability and the decrease in the height of the condensation level. The maximum of the total cloudiness (7.4 oktas) and of the number of “gloomy” days (with cloudiness of 8-10 oktas) – an average of 17 days, is observed in December. During the cold half of the year, the cloudiness is highest in the morning hours and lowest in the evening hours.

The annual minimum of the total cloudiness is in August, when the anticyclone weather is predominant. Cloudiness is mostly convective. In the considered area the mean total cloudiness for August is 2.4-2.8 oktas. The maximum of clear days (cloudiness of 0-2 oktas), which make about

50% of the days in the month, also occurs in this period. In August, the monthly number of cases with clear skies is smallest (about 15) in the noon hours, and greatest in the morning or evening hours (20-25).

Fogs

For Lom station and Oryahovo station, the data concerning the number of foggy days (**Table 3.1-5**) are quite close, which may provide grounds to assume that they are close to the values typical for the area and in particular for the area of Radiana site, which is located in the immediate vicinity of the Kozloduy NPP.

TABLE 3.1-5: NUMBER OF FOGGY DAYS BY MONTHS AND ANNUALLY

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Lom	7.7	6.2	3.5	0.6	0.4	0.1	0.1	0.1	1.0	5.6	6.4	9.8	41.3
Oryahovo	7.8	7.0	3.4	1.2	0.7	0.7	0.5	0.3	0.7	4.7	7.3	10.1	44.5

Another characteristic of fogs is their duration. For Lom station, the duration of fogs is most often less than 24 hours. Only in January 7% of the fogs occurring throughout the moth last 1-2 days, and only 1% of them lasts 2-3 days. In October, only 4% of the fogs last 1-2 days. The duration of fogs during the other winter months is within the same range. In Oryahovo station, the percentage for January is a bit different – 80% of the fogs last up to 1 day, 14% last 1-2 days, 5% last to 2-3 days, and only 1% lasts up to more than 3 days.

The differences in the fog duration lead to the conclusion that there are no grounds to assume that fog data from the adjacent stations should be accepted as characteristic of the Investment Proposal site. Therefore, observations of the regime of fogs, which are not currently included in the meteorological observations conducted by Kozloduy NPP EAD, should also be carried out. This also applies to the horizontal visibility.

Snow cover

Regarding the climatic characteristics of the *snow* cover in the area of the Radiana site, located in the immediate vicinity of the Kozloduy NPP, conclusions may be drawn from the data provided by the weather stations of the NIMH-BAS, located in the area. The results from the processing of these data are presented in details in the “Climatic Reference Book for the People's Republic of Bulgaria, Volume 2 (1979) – **Table 3.1-6.**

TABLE 3.1-6: CLIMATIC CHARACTERISTICS OF SNOW COVER

Snow cover (SC) parameter	Lom	Oryahovo
Average SC height in cm	XII – 5÷9; I – 9÷12; II – 8÷12; III – 3÷6;	XII – 2÷6; I – 6÷7; II – 10
Number of days with SC	XII–5; I–20; II–16; III–3	XII–7; I–16; II–14; III–4
Mean monthly SC height in cm	XII–13; I–25; II–25; III–11	No data available
Maximum monthly SC height (cm)	XI-27; XII–70; I–111; II–104; III–81; IV-8	No data available
Monthly number of days with SC height in cm: **a) 10÷20** **b) 20÷50** **c) ≥ 50 cm**	 XII–4; I–11; II–9 I–6; II–6 Not available	No data available

3.1.1.2 METEOROLOGICAL PHENOMENA

Hail phenomena

The greatest frequency of hail, which causes damages to the studied area, is observed in July (approximately 36%), followed by June (32%), and May (17%) – “Climate of Bulgaria”, 1991. The hail frequency is negligible in April, September and October. The 24-hour course of the beginning of hail precipitation displays a maximum in the interval 14:00-18:00 local time. Night hails between 22:00-24:00 and between 00:00-04:00 are also possible, and fall along cold atmospheric fronts. Overall, it can be said that, from statistical point of view, hails are a strongly expressed random phenomenon due to their large spatial and time variations. This makes the probability of annual manifestation of the above mentioned climatic characteristics rather small.

Icing of ground-level objects and facilities

The geographical location and the climate specifics of the country provide relatively favourable conditions for icing and frosting of ground-level objects or wet snowfall in the winter. The formation of ice on ground-level objects – accumulation of wet snow and ice depositions, typical of the non-mountainous parts of the country, have been poorly studied in Bulgaria in their role as climate elements. The most probable combinations of temperature, wind and humidity during the process are as follows: temperature between 0°C and -2°C to -4°C, wind speed between 3m/s and 5 m/s, and relative humidity along Danube River between 95% and 100%. In the period from November to March and mainly in the months of December and January, these meteorological conditions allow the preparation of long-term climate forecast for the process of icing, taking into account the predominant direction of the ice-carrying wind.

Dust storms

There is no data on dust or sand storms observed in the area surrounding the Radiana site, which is located in the immediate vicinity of the Kozloduy NPP. **Table 3.1-7** (Ivanov and Latinov, 1993) shows the number of registered dust storms by years countrywide and for the two meteorological stations closest to Kozloduy – Lom and Oryahovo.

TABLE 3.1-7: NUMBER OF DUST STORM OCCURRENCES BY YEARS

Station	1964	1970	1971	1972	1975	1976	1977	1978	1980	1983	amount
Lom	-	-	1	-	1	-	-	-	-	-	2
Oryahovo	-	-	1	1	3	2	-	-	-	-	7
nationwide	3	1	3	1	14	10	3	1	1	5	42

As shown in the study, these phenomena are determined by both the current weather conditions, as well as by the preceding climatic conditions – below-the-norm monthly precipitation amount for a given station. The probability of occurrence of dust storms obviously also depends on the nature of the soil and the vegetation cover.

Snow storms

This phenomenon occurs as a result of moderate or strong wind (with speed above 5 m/s) in the presence of strong snowfall (it is called common snowstorm and comprises the entire sub-cloud layer) or in the case of blowing away and transfer of freshly fallen “dry” snow (comprises surface air layer with height up to several meters – „ground snow storm“ or up to several dozens of centimetres – „low snow storm“). The phenomenon causes difficulties for land transport and other

activities due to the snowdrifts formed by wind-blown snow. Snow storms in the country are observed mostly during the period December–February. They are manifested most intensely and most often in North-Eastern Bulgaria, whereas snow transfer usually takes place from north and north- east (depending on the wind direction) of about 10m³ per linear meter away from the front. Snow storms are most often observed in synoptic circumstances related to the Mediterranean cyclones from the south and the Siberian winter anticyclone crest from the north-northeast.

Tornado

Although rare, tornadoes (or local tornadoes) can be formed in conditions of mesoscale convective storms – in the country this occurs most often above rugged mountainous terrains or above the sea aquatory[4]. Tornadoes are often mistaken for the so-called “falling” or squally wind.

A typical synoptic situation, favouring the development of tornado in the country, is the presence of a deep valley or a separate cyclonal whirlwind located west of Bulgaria, where the flow in the middle troposphere in the frontal part of the cyclone or the valley is directed from south-west to north-east. Strong convective systems are formed, whereas Coriolis force facilitates the development of tornado in them.

The tornadoes described in cases 1, 3, 5A and 5B from **Table 3.1-8** were formed under such synoptic conditions. Two cases were recorded during this period near the Radiana site– at about 20 km south of the site, near the village of Hayredin (case 5A), and at the village of Tarnava, at about 35 km south-southeast, which occurred on the same day. These tornadoes are the only cases observed over a period of over 100 years.

TABLE 3.1-8*:* NUMBER OF TORNADO OCCURRENCES IN THE PERIOD 2006-2009

No.	Affected area	Date	Beginning	Duration (min)	Direction of tornado's movement	Precipitation area (km^2)	Precipitation intensity (mm)	Daily precipitation amount (mm)	Maximum hailstone size (cm)	Damages caused by the tornado (USD)
1	Bobeshino	02.04.2006	05:20	31	W-E	200	64	3-11	1.5	80,000
2	Kalekovets	21.05.2007	13:20	10	NE-SW	232	45	6-40	6.0	110,000
3	Kostandenets	22.05.2008	13:55	80	SW-NE	320	237	2-14	6.0	640,000
4	Kyustendil	08.07.2008	16:02	12	NW-SE	500	100	2-24	3.0	68,000
5A	Hayredin	02.06.2009	15:58	75	SW-NE	600	225	14-32	9.0	134,000
5B	Tarnava	02.06.2009	13:35	75	SW-NE	600	225	14-32	7.5	225,000

The probability of tornado occurrences is estimated at ~ 10^{-6} cases a year, an average for the entire country.

3.1.1.3 WEATHER CONDITIONS ADVERSE TO THE DIFFUSION OF IMPURITIES INTO THE ATMOSPHERE

Temperature inversion

Temperature inversion in a specific area is observed when the low atmospheric layer is in strong stable equilibrium. A typical property of this atmospheric layer is the suppression of air movements

4 Analysis of powerful convective storms associated with the development of tornadoes in Bulgaria in the period 2006 – 2009, Petio Simeonov, Ilian Gospodinov, Liliya Bocheva, Rangel Petrov

originating in it, which leads to attenuation of the dynamic turbulence and thermal convection, on which the dispersion of pollutants in the air depends. In the cases with ground-level inversions (starting from the earth's surface), the low situated pollutant sources are of essential importance. Conclusions regarding the presence of this type of phenomenon can be drawn from the aerological sounding from the period September 1967 - August 1968, carried out before the commissioning of the Kozloduy NPP, in the vicinity of which the Radiana site of NDF[5] is located.

Table 3.1-9 shows the number, thickness ***d***, and mean vertical temperature gradient γ obtained from the one-year period of single-time (at 08:00 AM) aerological sounding of the layer up to a height of 2 km. Inversions were observed in 30 % of the cases, this share being about 37 % during the cold half of the year and about 22 % during the warm half of the year. Ground-level inversions were registered in 15 % of the cases, their frequency being much lower during the warm half of the year – about 7 %, whereas in the cold season it was about 23 %.

TABLE 3.1-9: CHARACTERISTICS OF THE TEMPERATURE INVERSIONS IN THE AREA OF THE KOZLODUY NPP BY AEROLOGICAL SOUNDINGS DURING THE PERIOD SEPTEMBER 1967 – AUGUST 1968

Observation period	Ground-level inversions							High inversions									
	Number of cases with thickness, m				Total number of cases	Mean temperature gradient, °C/100m	Average layer thickness	Number of cases with thickness, m					Total number of cases	Average height H1, m	Mean temperature gradient γ	Number of soundings performed	Number of days with inversion
	$200 \le d_1 \le 300$	$301 \le d_1 \le 500$	$501 \le d_1 \le 1,000$	$d_1 > 1000$				$100 \le H_1 \le 150$	$151 \le H_1 \le 250$	$251 \le H_1 \le 500$	$501 \le H_1 \le 1,000$	$H_1 > 1,000$					
Warm half of the year	-	2	5	1	8	-0.29	757	-	5	8	4	2	19	462	-0.29	121	27
Cold half of the year	3	5	14	10	32	-0.62	801	1	3	6	9	6	25	720	-0.51	140	52
Total for the year	3	7	19	11	40	-0.46	779	1	8	14	13	8	44	591	-0.40	261	79

Even though it is based only on the data for a one-year period and from a single-time sounding, some notion can also be obtain regarding the degree of the atmospheric stability of the boundary layer above the Kozloduy station under the Pasquill's classification. The stability classes are determined according to ground-level data (radiation balance (non-radiation) and wind speed) and in accordance with the values of the vertical temperature gradient in the lower 200-meter air layer -γ [deg/100m]. In the cited study, it is indicated that the following classes have the highest frequency in total for the year:

→ **D** (neutral conditions) – 0.5 deg/100 m $\le\gamma\le$ 1 deg/100 m – in about 40 % of the cases;

→ **E** (slightly stable conditions) – 0.5 deg / 100 m $<\gamma<$ 0,5 deg / 100 m – in about 30 % of the cases;

→ **C** (slightly unstable conditions) – 1 deg / 100 m $<\gamma\le$ 1,5 deg / 100m - in about 25 % of the cases;

[5]Nikolova N., Assessment of the weather conditions in the area of the Kozloduy NPP in connection with the project for the construction of a nuclear power plant, Institute of Hydrology and Meteorology, Vol. XIX, 1972

→ **B** – moderately unstable conditions, (γ> 1.5 deg / 100 m) and F – moderately stable conditions, ($\gamma \leq$– 0.5 deg /100 m) have small frequency in the range 5 % - 8 % of the cases.

Based on the data and the analysis made, the following conclusions can be drawn about the processes and phenomena of interest to the site of the IP in relation to its specifics:

→ Due to the prevailing low wind speeds (in the interval between 2 m/s and 5 m/s), the wind field potential for transferring pollutants to great distances is low, i.e. there is no immediate danger of transboundary pollution on the territory of Romania;

→ Precipitations are below the climate 'normals', as a result of which the potential for purification of pollutants (wetting and raining down) in the atmosphere is low;

→ Icing of ground facilities in this part of the Danube River may occur under the combination of the following meteorological parameters: air temperature between 0°C and minus 2°C to minus 4°C, wind speed between 0 m/s and 3 to 5 m/s, and relative humidity between 95 % and 100 %;

→ Damage-causing hail events in North-Western Bulgaria were observed in the period 5 May – 31 July, but specifically with regard to the considered Radiana site of the NDF, which is located in the immediate vicinity of the Kozloduy NPP site, and from statistical point of view, they constitute a strongly pronounced accidental phenomenon, due to their great spatial and time variations;

→ The probability of occurrence of snow storms is much lower than in the North-Eastern part of the Danubian plain;

→ On average for the country, the probability of tornado occurrence is of the order of 10^{-6} cases annually;

→ Fogs are annually observed on average of about 45 days with a maximum of 120-140 days. They last up to 1 day in about 80 % of the cases in January.

3.1.2 AMBIENT AIR QUALITY (AAQ)

3.1.2.1 EMISSIONS IN THE AREA OF THE IP

The Kozloduy area comprises the municipalities of Kozloduy, Oryahovo, and Miziya. No preparation of a programme for pollutant level reduction is required for these municipalities, since according to Articles 30 and 31 of Regulation No. 7 on Ambient air quality assessment and management, the measured concentrations of harmful substances are not only lower than the established limit values, but they are also lower than the upper and lower assessment thresholds.

As a rule, the quality of the surface layer of the ambient air in the area is determined by the operation of the Kozloduy NPP, industrial activity, road transport, and household sources.

The more significant sources of ambient air emissions on the territory of Kozloduy Municipality are: the concrete plant with sieving facility of Patstroy Engineering AD, located in the village of Butan, the town of Vratsa, Atomenergo-Stroyprogress, Zavodski Stroezhi and Mehanizatsiya i Transport. These are sources of dust with local action. Transport is the greatest source of carbon monoxide, hydrocarbons, nitrogen oxides and other emissions. The roads in the municipality are characterized by relatively high traffic intensity. In peak hours, albeit briefly, conditions for increase of road transport emissions are created.

Territorially, the Valchedram Municipality belongs to Montana District and the major emission sources are concentrated in the district town and outside the 30 km Surveillance Zone (SZ).

3.1.2.2 EMISSIONS FROM INDUSTRIAL COMBUSTION AND MANUFACTURING PROCESSES BY MUNICIPALITY

According to the data provided by the National Statistical Institute (NSI), **Regions, Districts, and Municipalities in the Republic of Bulgaria, 2006, 2007, 2008[6],** an analysis of the emissions from industrial combustion and manufacturing processes for the municipalities of Valchedram, Kozloduy, Oryahovo, Miziya, and Hayredin has been performed - **Table 3.1-10**.

TABLE 3.1-10: EMISSIONS FROM COMBUSTION AND MANUFACTURING PROCESSES (IN THOUSANDS OF TONS) FOR THE MUNICIPALITIES IN THE AREA OF KOZLODUY NPP IN THE PERIOD 2006÷2008

Statistical areas, statistical regions, districts and municipalities	Sulphur oxides	Nitrogen oxides	NMVOC	CH_4	CO	CO_2	N_2O
			2006				
Kozloduy	4.9	3.0	62.1	59.7	0.537	2,121.0	0.2766
Oryahovo	5.5	1.9	10.9	16.5	0.479	1,633.6	0.1980
Miziya	7.1	1.0	5.6	13.4	0.319	448.3	0.0705
Hayredin	10.0	1.3	0.8	0.3	0.547	406.4	0.0456
Valchedram	0.19	0.0203	3.1	0.04	0.0087	7.12	0.0007
			2007				
Kozloduy	6.9	2.8	21.2	12.2	0.811	1,619.2	0.0287
Oryahovo	0.8	0.7	1.4	2.0	0.023	830.1	0.0205
Miziya	0.2	0.1	4.4	6.6	0.004	112.1	0.0005
Hayredin	3.6	0.4	0.4	0.012	0.007	206.9	0.0358
Valchedram			2.1				
			2008				
Kozloduy	4.4	32.3	21.3	8.2	2.985	12,026.4	0.3093
Oryahovo	1.2	1.1	5.8	2.945	0.024	651.5	0.0315
Miziya	0.1	0.0	0.5	6.4	0.002	68.9	0.0003
Hayredin	0.7	0.0	0.3	0.0	0.001	37.0	0.0072
Valchedram			1.7				

The data from **Table 3.1-10** show clearly that Kozloduy Municipality has the best developed production activity, which accounts for the greatest share of combustion emissions. These are not caused by the NPP, which is located next to the Investment Proposal site, since nuclear production generates no conventional pollutant emissions. The combustion emissions are due to both the auxiliary manufacturing activities at the NPP, as well as to the favourable business environment in the municipality, which contributes to the development of small industries related to combustion processes, whose production is intended mainly for the NPP – asphalt plant, concrete plant etc. Statistically, the residential combustion for heating purposes is not included in the above mentioned emissions.

3.1.2.3 EMISSIONS FROM ROAD TRAFFIC ON SECONDARY ROAD II-11

The site of the Investment Proposal is located in the immediate vicinity of a secondary road of the republican road network, which is asphalted and has two-way traffic and good marking. This is road II-11, Oryahovo-Miziya-Kozloduy-Lom section, which passes south of Kozloduy NPP and the site

[6] The data that were used are up to the year 2008 because since 2009, emission data for combustion and production processes for the each municipality have been confidential and are not accessible according to the Statistics Act, Article 22.

of the National Repository for NDF and continues along the non-flooded terrace of the Danube River. Thus the inter-settlement passenger traffic, including transit freight traffic, is relocated.

The emissions from the regular traffic around the area of the NDF[7] have been assessed according to the data on the mean annual 24-hour intensity of the vehicle traffic for 2010, as measured at the counting points of the Road Infrastructure Agency for road II-11 of the Republican road network: at additional counting point (ACP)-205 in the Kozloduy-Lom section and at ACP-496 in the Miziya-Kozloduy section.

Table 3.1-11 presents the data on the mean-24-hour intensity of the vehicle traffic in 2010 and the forecast for 2015 and 2020 by the 6 major vehicle classes: Passenger cars, Light-duty trucks, Medium-duty trucks, Heavy-duty trucks, Buses (out-of-town) and Heavy-duty trucks with Trailers[8].

TABLE 3.1-11: MEAN ANNUAL 24-HOUR INTENSITY OF VEHICLE TRAFFIC – DIAGNOSIS FOR 2010 AND FORECAST FOR 2015 AND 2020

Year	Counting point	Passenger cars	Buses	Light-duty trucks	Medium-duty trucks	Heavy-duty trucks	Tracks with trailer and road tractors with semi-trailers	Total trucks	Total number of vehicles
2010	**ACP-205**	798	17	267	24	13	38	342	1,157
	ACP-496	6,185	252	964	166	48	150	1,328	7,765
2015	**ACP-205**	938	18	314	25	14	45	398	1,354
	ACP-496	6,958	277	1,084	187	52	172	1,495	8,730
2020	**ACP-205**	1,102	19	369	27	16	53	465	1,586
	ACP-496	8,002	312	1,247	215	57	202	1,721	10,035

The assessment of the projected levels of emissions caused by road transport for 2015 was carried out according to Tier2[9] of the EMEP/EEA air pollutant emission inventory guidebook 2013 on the main pollutants caused by: **(a)** passenger cars (**NFR code 1.A.3.bi**), **(b)** light-duty trucks bellow 3.5 tons (**1.A.3.b.ii**), **(c)** heavy-duty trucks above 15 tons and **(d)** interurban buses **(1.A.3.b.iii)** presented in section **Road Transportation.** The calculation of the following emissions was carried out on the above mentioned basis:

- → Ozone precursors - CO, NO_X, NMVOC (non-methane volatile compounds),
- → Greenhouse gasses (CO_2, CH_4, N_2O),
- → Acidifying substances (NH_3, SO_2),
- → Particulate matter (PM) – only the PM2.5 fraction, since the presence of the higher PM2.5÷10 fraction is negligible in the soot from the exhaust gases,
- → Carcinogenic compounds:

[7] EIAR on Building of a New Nuclear Unit of the Latest Generation at the Kozloduy NPP Site, 2013

[8] Road Infrastructure Agency , letter 53-00-9813 from 20.08.2014

[9] In determining the emission levels of greenhouse gases (GHG) according to the methodology of the IPCC, methods of varying complexity are used. The level of complexity of the method is designated as Tier X, i.e. the larger the number of X, the more complex and precise the used method.

- ✓ PAH - polycyclic aromatic hydrocarbons (Benzo (α) pyrene, Benzo (b) fluoranthene + Benzo (k) fluoranthene, indeno (1,2,3-cd) pyrene - for unleaded petrol),
- ✓ POP - Persistent organic pollutants,
- ✓ Toxic substances (DIOX - Dioxins and furans (unleaded petrol),

→ Heavy metals

The above estimation does not include emissions such as gasoline evaporation from vehicles (**NFR code 1.A.3.b.v**), tyre wear and brake wear (**NFR code 1.A.3.b.vi**), or road surface wear (**NFR code 1.A. 3.b.vii**).

Table 3.1-12 shows the emission load in kilogram per 1 kilometre from road II-11 of the Republican road network in the respective point.

TABLE 3.1-12: EXISTING EMISSION LOAD IN KILOGRAM PER 1 KILOMETRE FROM THE RESPECTIVE ROAD SECTION (KG/KM)

Year	Site	CO	NMVOC	NOx	N2O	NH3	Pb	PM2.5	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO2	SO2	benzene	tCO_2eq
2010	**ACP-205**	1.665	0.159	0.978	0.009	0.016	2.36E-06	0.036	6.38E-07	7.78E-07	9.50E-07	5.25E-07	301.87	0.00384	0.0048	**0.31**
	ACP -496	10.847	1.051	5.890	0.058	0.112	1.50E-05	0.193	4.12E-06	5.21E-06	6.24E-06	3.37E-06	1,985.80	0.02621	0.0315	**2.03**
2015	**ACP -205**	1.956	0.186	1.144	0.011	0.018	2.77E-06	0.042	7.49E-07	9.09E-07	1.11E-06	6.17E-07	354.28	0.00451	0.0056	**0.36**
	ACP -496	12.741	1.234	6.900	0.068	0.132	1.76E-05	0.226	4.84E-06	6.10E-06	7.31E-06	3.96E-06	2,330.78	0.03078	0.0370	**2.38**
2020	**ACP -205**	2.298	0.219	1.339	0.013	0.022	3.25E-06	0.050	8.79E-07	1.06E-06	1.30E-06	7.24E-07	415.85	0.00530	0.0066	**0.42**
	ACP -496	14.964	1.449	8.084	0.080	0.155	2.07E-05	0.266	5.68E-06	7.15E-06	8.57E-06	4.65E-06	2,735.84	0.03615	0.0435	**2.79**

TABLE 3.1-13: EXISTING EMISSION LOAD IN KILOGRAM PER 1 KILOMETRE FROM THE BUSES OF KOZLODUY NPP (KG/KM)

Year.	Buses [1] of Kozloduy NPP	CO	NMVOC	NOx	N2O	NH3	Pb	PM2.5	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO2	SO2	benzene	tCO_2eq
2013		2.177	0.209	0.471	0.010	0.026	2.11E-06	0.020	6.66E-07	3.16E-07	5.91E-07	5.73E-07	331.06	0.00533	0.0063	**0.34**

[1] These emissions are included in the emissions determined for 2015 and 2020 for ACP 205 and 496 because the counting, carried out in these points, includes the number of buses traveling to the NPP.

3.1.2.4 EMISSIONS FROM THE BUS TRAFFIC FROM AND TO KOZLODUY NPP

The bus traffic from and to Kozloduy NPP is considered because it has the greatest intensity and is a determining factor for the area of the IP – Radiana site. The emissions in kg/km (**Table 3.1-13**) from the Transport Scheme for transportation of workers[10] to the NPP have been assessed according to the **EMEP/EEA air pollutant emission inventory guidebook 2013** on main pollutants caused by interurban buses (**1.A.3.b.iii**) presented in section **Road Transportation**. There are 32 bus lines performing 688 runs per day.

Emissions are released directly into the ambient air from the exhaust-pipes of the buses. The total amount of greenhouse gases, expressed in tones of CO2 equivalent are 0.34 tons for 1 kilometre.

3.1.2.5 MEASURED CONCENTRATIONS

The National Environmental Monitoring System (NEMS), which performs the ambient air quality control on the territory of the country, does not have a fixed measurement station for the area of Kozloduy Municipality.

In 2011, in accordance with the approved operation schedule for the Mobile Automatic Stations (MAS), which perform additional measurements in areas where there are no stationary points or they are restricted in number, at the site of the Regional Fire and Emergency Safety Service (RSPAB) of the town of Kozloduy the Regional laboratory – Pleven carried out measurements for 52 24-hour periods by means of a mobile automatic station (MAS) for the control of the ambient air quality in the Northern/Danubian ROUKAV (regions for assessment and management of ambient air quality) [11].

The figures bellow (**Figure 3.1-9** to **Figure 3.1-15**) show the atmospheric conditions in the measurement periods. The Pasquill atmospheric stability classes - A = 1, B = 2, C = 3, D = 4, E = 5 and F = 6, have been determined according to the solar radiation, the wind speed and the time of the day. From these figures, it can be seen that the stable atmospheric conditions occurred in the evening and night hours – between 19:00 and 08:00[12].

The sunshine was stronger in July. The number of sunny hours was higher in September than it in March, which may be due to the greater cloudiness in the spring (this parameter was not recorded) and the larger precipitation amount, which is confirmed by the greater humidity registered in March compared to September when the average humidity for the measurement period was slightly over 41%.

[10] Letter from the Production Department of Kozloduy NPP EAD, № 586/28.05.2014

[11] Records of Regional Laboratory – Pleven, 2011

[12] The measurements for the period April 4 -10 are not reliable due to the unusual values of the solar radiation – high radiation amounts during the night hours.

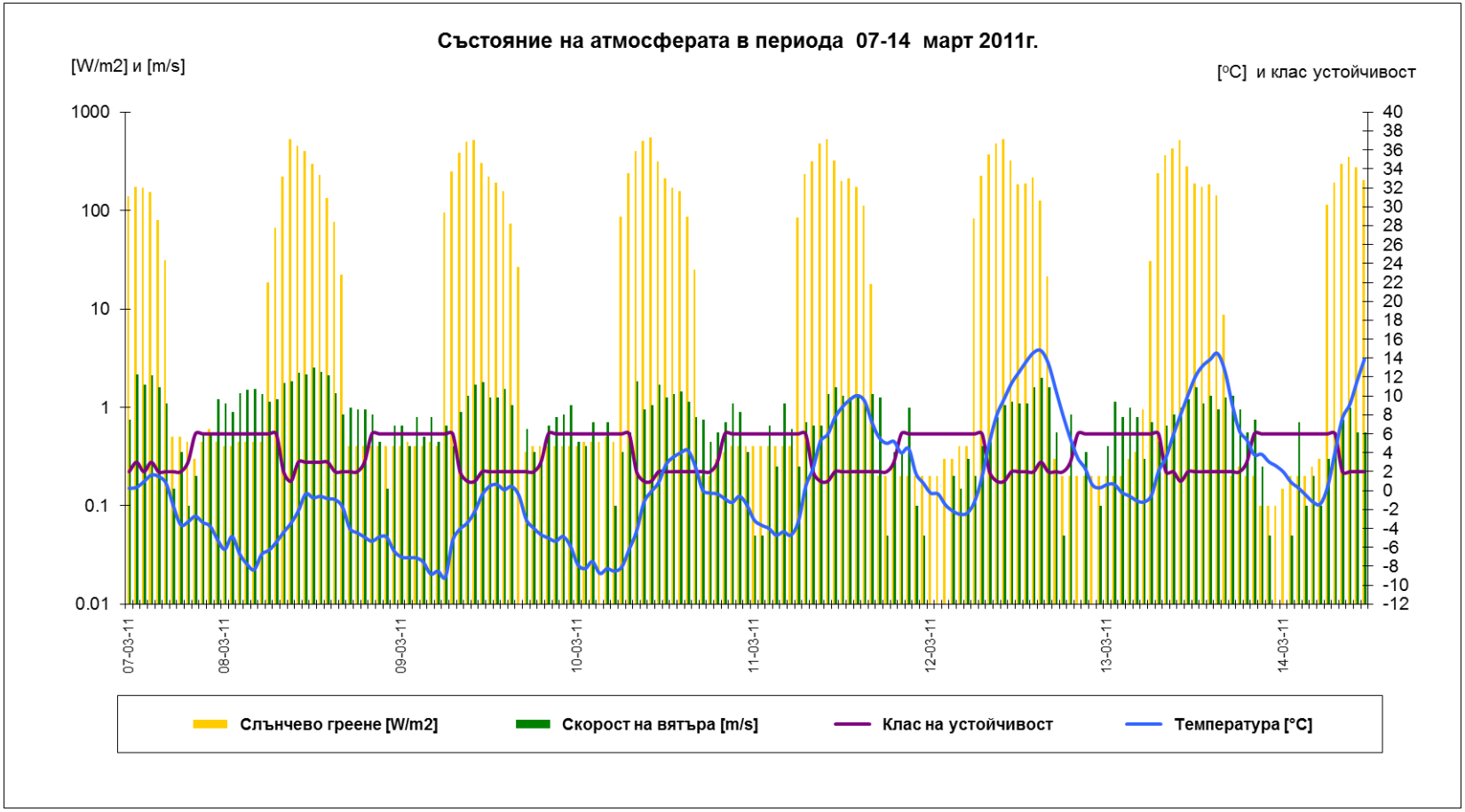


FIGURE 3.1-9 CONDITION OF THE ATMOSPHERE – MARCH 2011

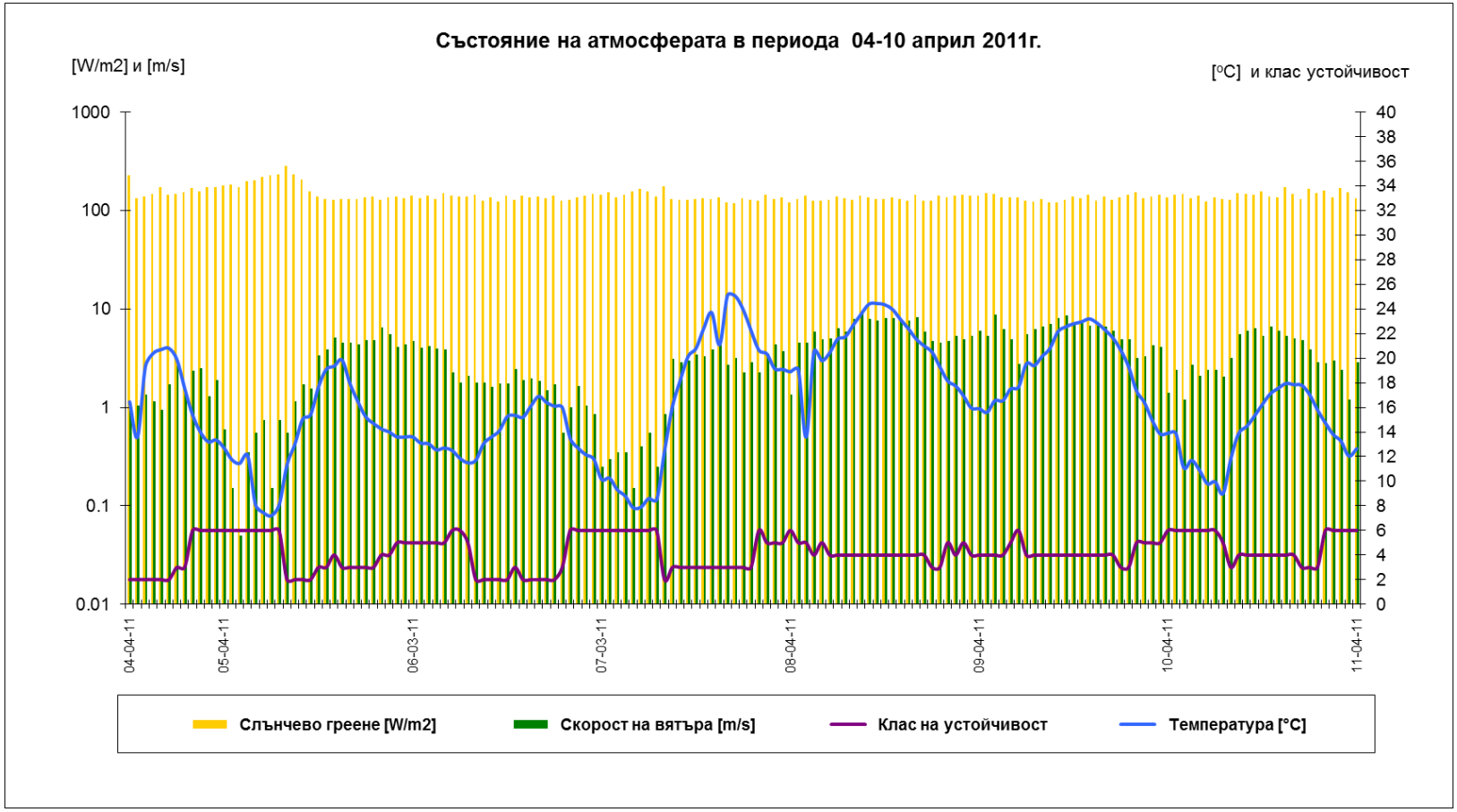


FIGURE 3.1-10 CONDITION OF THE ATMOSPHERE - APRIL 2011

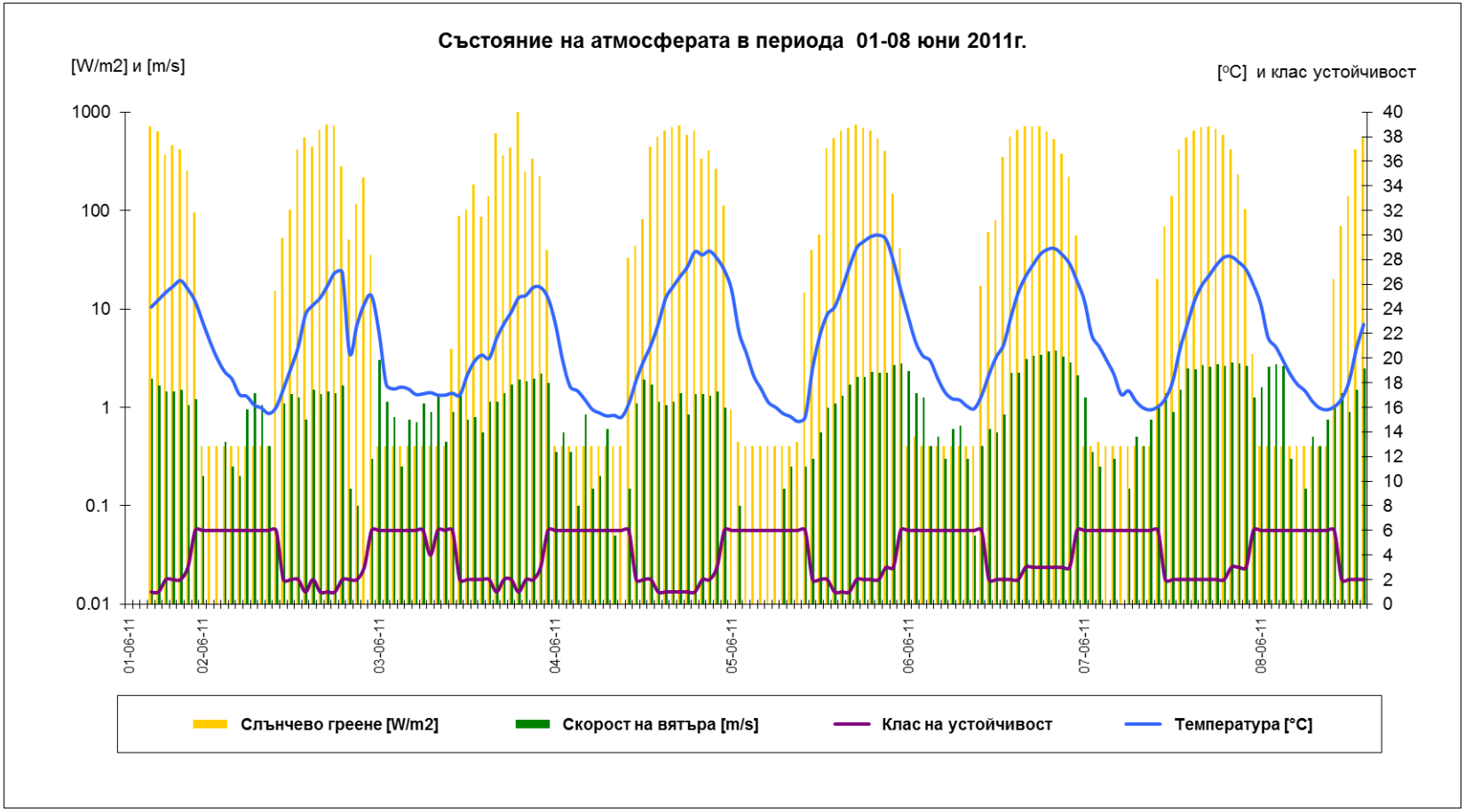


FIGURE 3.1-11 CONDITION OF THE ATMOSPHERE -JUNE 2011

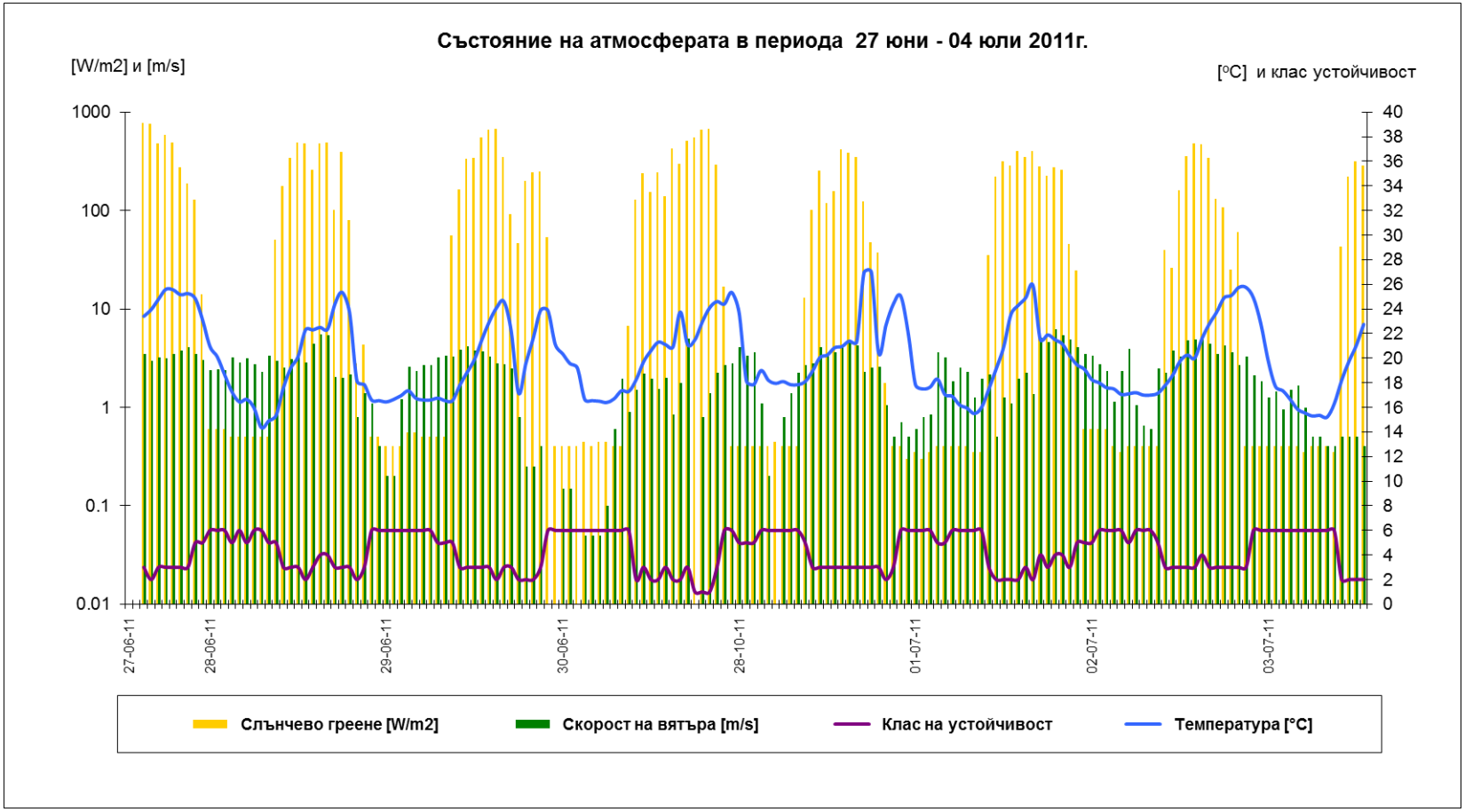


FIGURE 3.1-12 CONDITION OF THE ATMOSPHERE - JUNE/JULY 2011

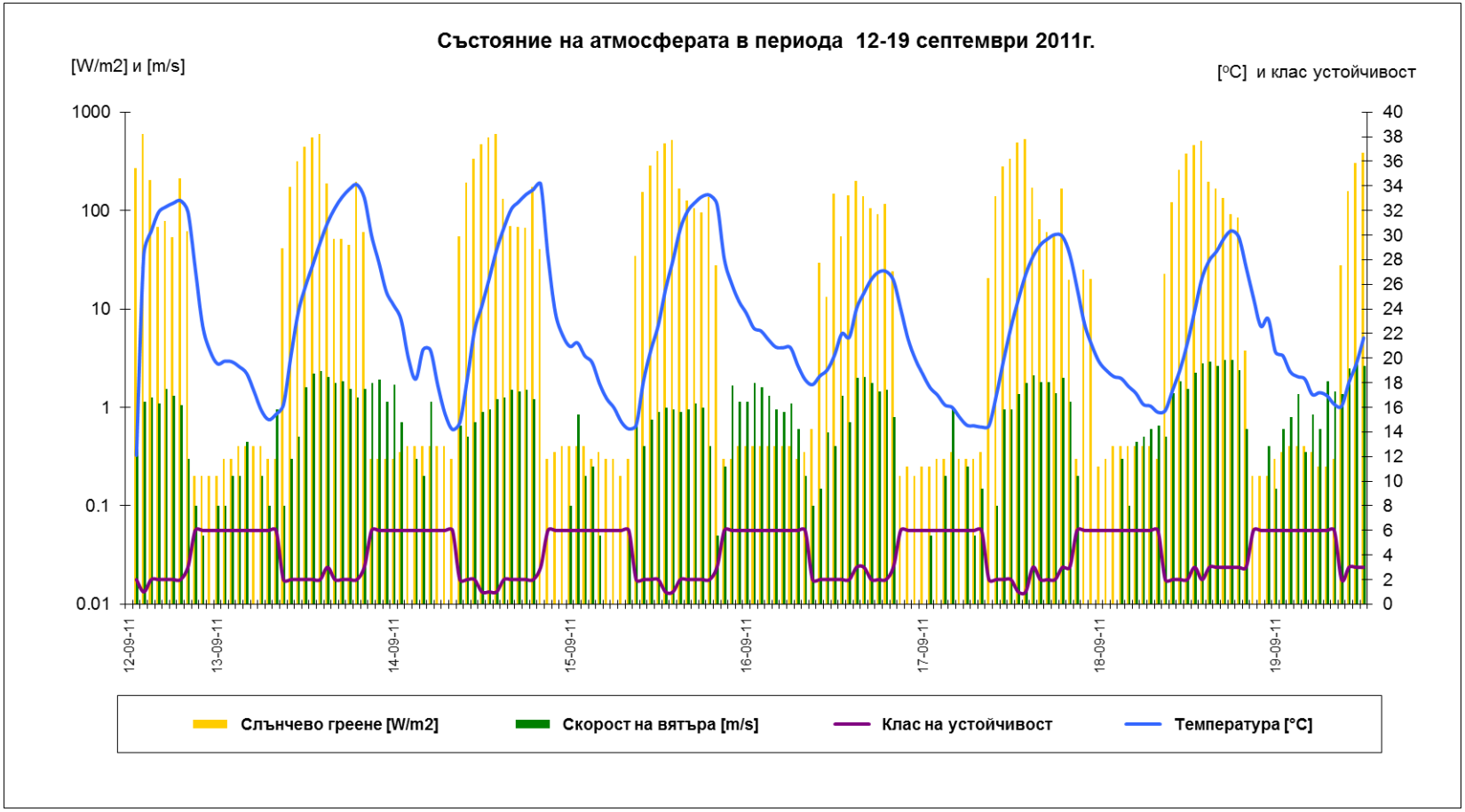


FIGURE 3.1-13 CONDITION OF THE ATMOSPHERE - SEPTEMBER 2011

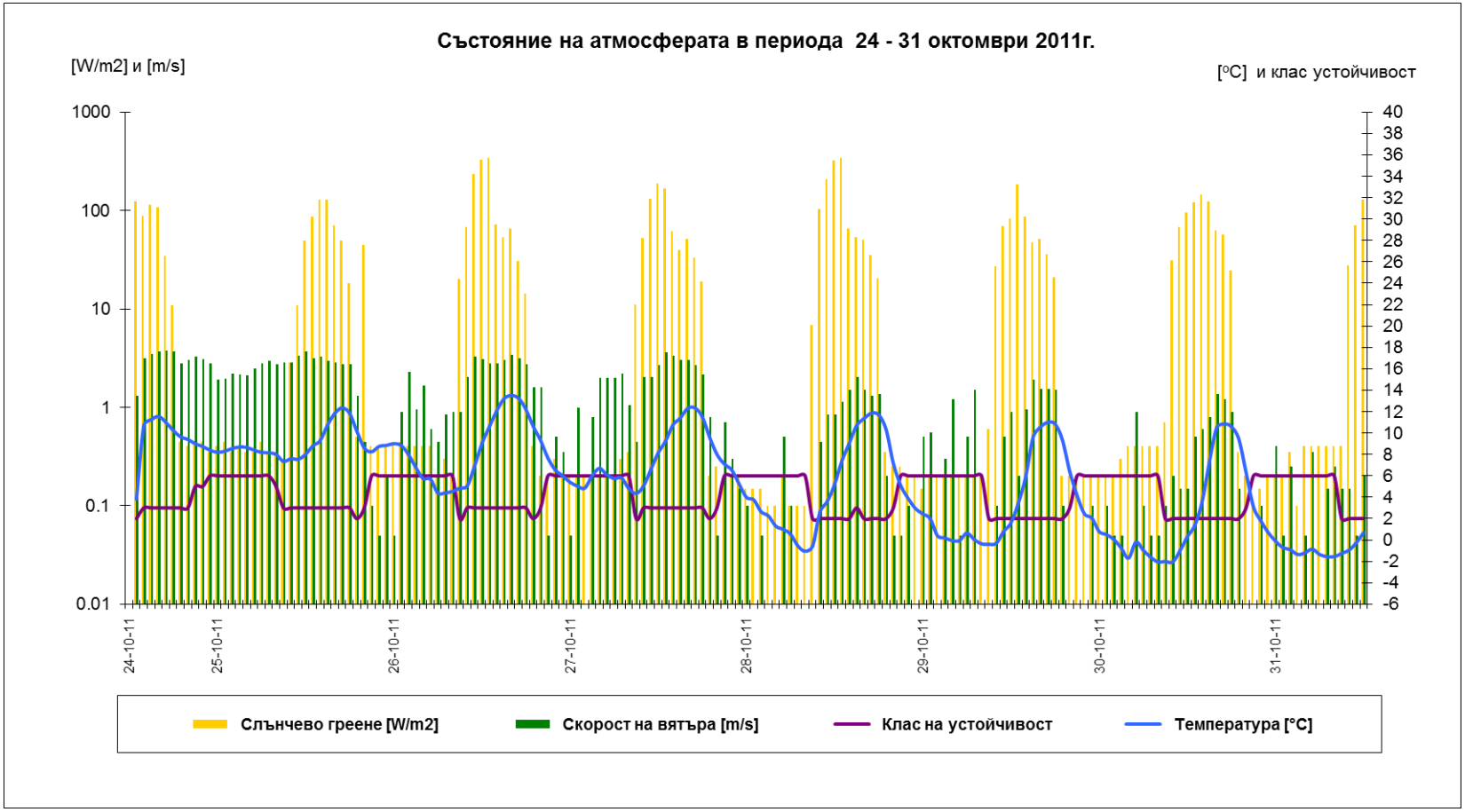


FIGURE 3.1-14 CONDITION OF THE ATMOSPHERE - OCTOBER 2011

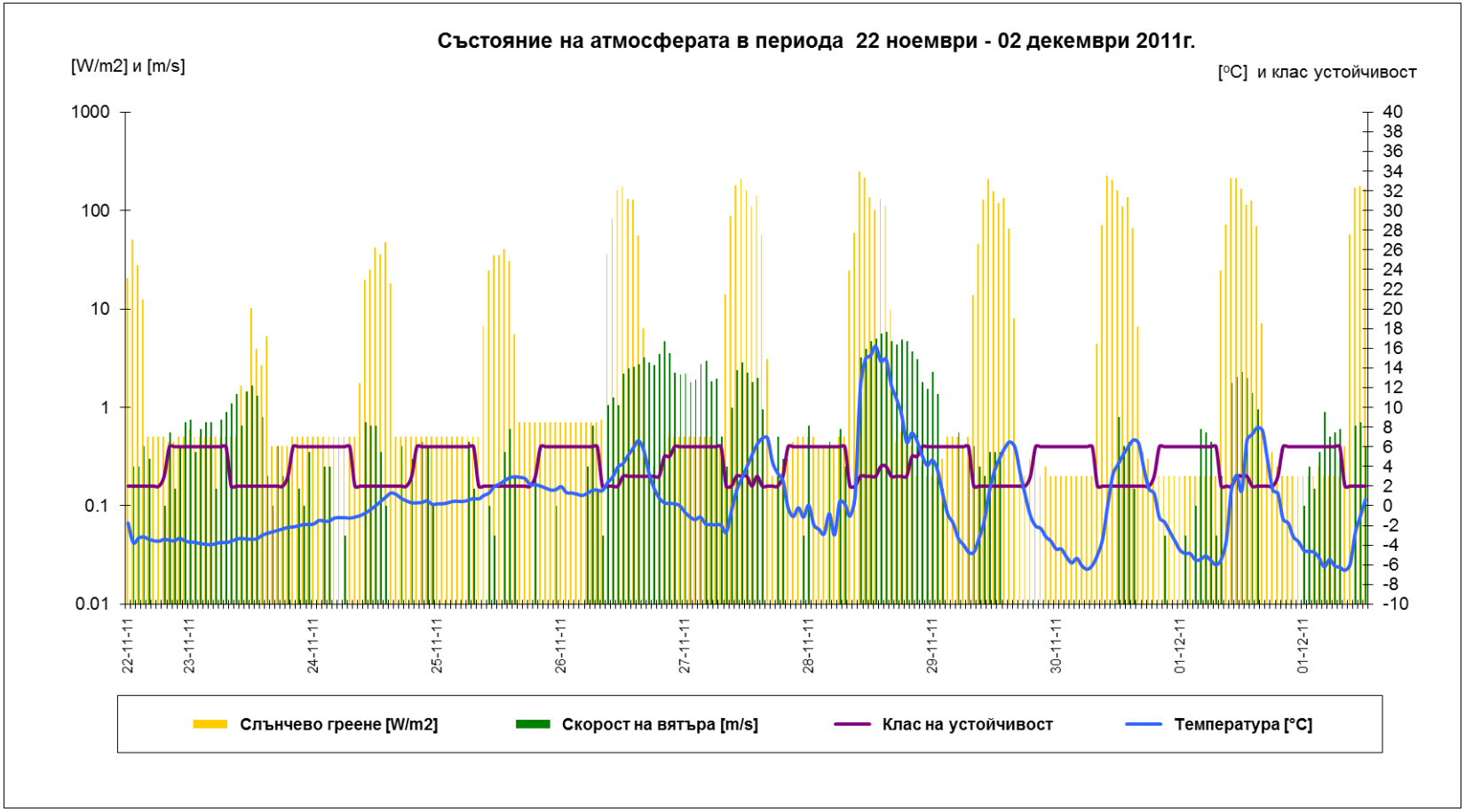
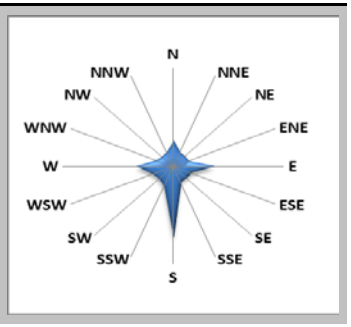
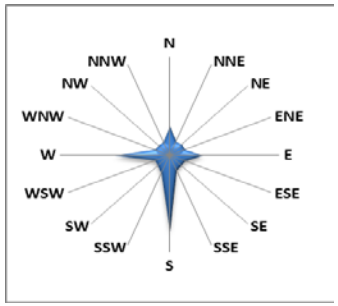
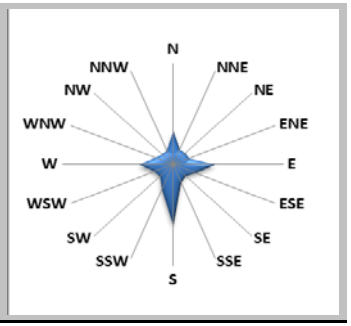


FIGURE 3.1-15 CONDITION OF THE ATMOSPHERE - NOVEMBER/DECEMBER 2011

TABLE 3.1-14: ANALYSIS OF THE RECORDS OF THE MEASURED CONCENTRATION AT THE RSPAB SITE, THE TOWN OF KOZLODUY

Parameters / Records		PM_{10}	SO_2	NO_2	NO	O_3	CO	Tempera-ture	Atmospheric pressure	Wind speed	Relative humidity	Wind rose of the period
mean daily norm ($\mu g/m^3$)		50	125	-	-	120	10	°C	hPa	m/s	%	
№ 123/124 March	07-03-11	31..7	16.2	6.7	1.3	25.9	2.1	-1.38	1,010.2	1.0	59.5	
	08-03-11	28.8	13.9	5.9	2.5	37.8	2.1	-4.26	1,012.5	1.3	63.9	
	09-03-11	17.8	17.6	6.7	1.5	43.6	1.6	-4.25	1,006.8	0.8	52.7	
	10-03-11	25.8	17.1	1.9	0.5	43.8	1.2	-2.32	1,002.0	0.8	44.2	
	11-03-11	29.8	16.8	8.6	3.4	42.0	2.4	2.75	1,001.3	0.7	47.6	
	12-03-11	30.2	15.1	14.3	8.3	35.1	0.8	5.22	1,003.7	0.6	58.1	
	13-03-11	21.3	14.5	13.5	4.7	35.1	0.9	5.32	1,002.5	0.8	68.5	
№ 180/181 April	04-04-11	67.5	24.7	9.8	4.6	32.5	2.3	17.1	986.2	1.6	41.3	
	05-04-11	41.4	12.1	7.8	4.2	19.2	1.2	13.7	996.1	2.7	70.2	
	06-03-11	39.5	13.7	6.5	4.3	21.8	1.5	13.8	1,002.1	2.2	70.8	
	07-03-11	29.8	13.6	10.7	8.5	25.5	1.2	16.7	996.9	2.2	54.2	
	08-04-11	59.9	11.0	9.1	9.2	26.9	1.3	20.7	986.9	6.1	30.3	
	09-04-11	26.6	12.1	8.8	5.9	31.3	1.4	19.3	988.2	5.9	23.2	
	10-04-11	20.4	14.6	9.2	6.9	32.1	1.3	14.0	991.3	3.6	25.4	
№ 396/397 June	01-06-11	27.9	8.3	6.4	5.3	34.3	2.9	24.1	1,081.3	1.0	51.4	
	02-06-11	24.9	11.9	7.3	5.9	27.8	1.9	20.6	1,089.9	0.9	70.0	
	03-06-11	11.3	15.5	7.8	6.0	28.9	1.8	20.3	1,090.9	1.1	75.4	
	04-06-11	8.4	15.3	7.3	8.2	32.4	1.7	21.8	1,090.8	0.8	60.4	
	05-06-11	15.7	17.5	8.9	8.1	35.3	1.0	22.4	1,090.1	1.2	59.1	
	06-06-11	32.1	16.3	10.3	4.9	39.3	1.5	22.4	1,088.3	1.5	56.7	
	07-06-11	23.9	17.4	7.0	11.4	23.6	1.2	21.9	1,085.0	1.6	53.4	

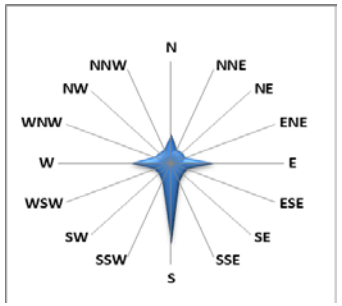
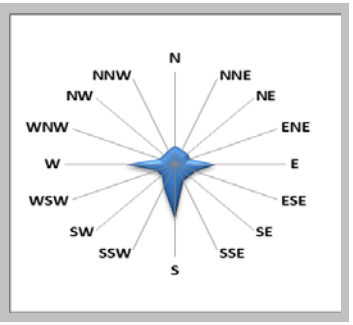
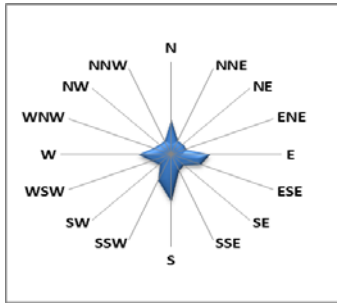
Parameters / Records		PM_{10}	SO_2	NO_2	NO	O_3	CO	Tempera-ture	Atmospheric pressure	Wind speed	Relative humidity	Wind rose of the period
mean daily norm ($\mu g/m^3$)		50	125	-	-	120	10	°C	hPa	m/s	%	
№ 490/491 June/July	27-06-11	28.3	51.6	12.5	4.3	40.5	3.1	23.9	1,087.0	3.2	12.3	
	28-06-11	29.1	15.2	17.8	4.3	34.8	1.5	18.8	1,079.3	2.5	45.1	
	29-06-11	36.5	16.0	16.8	4.5	30.3	1.3	19.7	1,074.9	2.1	59.3	
	30-06-11	15.4	15.0	10.8	6.5	22.6	0.9	20.3	1,077.2	1.6	66.2	
	01-07-11	12.5	13.0	12.3	6.4	26.0	1.0	20.5	1,077.8	2.1	71.9	
	02-07-11	16.3	10.3	14.8	8.1	29.7	1.0	19.6	1,080.1	2.8	56.7	
	03-07-11	14.2	9.4	12.5	9.2	25.8	1.1	20.4	1,092.4	2.8	71.0	
№ 09-0716/ 09-717 September	12-09-11	76.1	27.9	19.9	5.1	30.3	1.6	26.9	1,039.7	0.7	21.4	
	13-09-11	64.2	12.0	20.1	6.2	30.6	0.6	24.5	1,087.5	1.1	32.7	
	14-09-11	47.1	16.8	18.6	6.3	31.1	0.6	24.0	1,086.8	0.6	30.9	
	15-09-11	44.7	16.5	18.3	7.7	32.3	0.6	23.6	1,087.5	0.6	33.8	
	16-09-11	52.4	15.9	16.6	6.0	27.7	0.7	21.9	1,093.0	0.9	51.8	
	17-09-11	49.5	15.1	15.0	2.8	28.0	0.7	21.5	1,092.4	0.7	53.6	
	18-09-11	44.5	15.7	15.4	2.0	30.2	0.8	22.0	1,086.9	1.2	49.2	
№ 09-0878/ 09-879 October	24-10-11	37.8	12.4	9.2	3.8	18.9	2.1	9.3	1,032.4	3.0	64.6	
	25-10-11	43.7	12.0	9.6	4.3	22.0	1.2	9.0	1,080.5	2.2	59.9	
	26-10-11	59.7	15.3	8.9	4.4	18.8	1.3	8.1	1,080.1	1.7	67.2	
	27-10-11	42.8	14.9	10.0	5.0	19.1	1.0	7.4	1,085.6	1.6	65.1	
	28-10-11	51.4	13.6	11.8	5.1	15.6	0.4	4.8	1,092.6	0.5	68.0	
	29-10-11	35.1	11.0	10.3	4.9	14.6	0.4	3.4	1,091.7	0.6	81.4	
	30-10-11	41.4	13.4	8.8	4.5	14.8	0.4	2.2	1,086.8	0.3	80.1	

TABLE 3.1-14: CONTINUATION

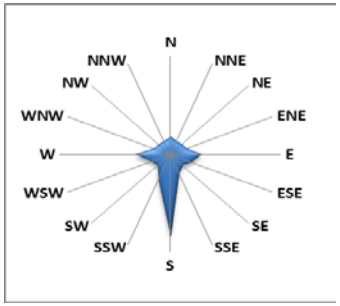
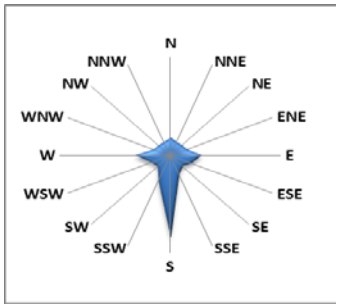
Parameters / Records		PM_{10}	SO_2	NO_2	NO	O_3	CO	Tempera-ture	Atmospheric pressure	Wind speed	Relative humidity	Wind rose of the period
mean daily norm (μg/m^3)		50	125	-	-	120	10	°C	hPa	m/s	%	
№ 09-1017/ 09-1053 November/ December	22-11-11	66.2	15.5	11.2	4.6	17.2	1.7	-2.7	1037.1	0.3	75.6	
	23-11-11	64.8	26.9	9.1	4.6	16.8	1.0	-3.1	1090.1	0.6	88.9	
	24-11-11	71.7	26.6	9.2	4.7	15.3	1.2	-0.3	1100.6	0.2	83.5	
	25-11-11	54.7	29.1	8.9	5.2	15.8	1.3	1.5	1094.1	0.1	78.5	
	26-11-11	43.8	30.7	7.2	4.9	21.4	1.1	2.3	1084.1	1.6	63.2	
	27-11-11	38.8	29.7	5.5	4.3	19.0	0.9	1.1	1084.5	1.3	63.4	
	28-11-11	49.3	30.9	7.8	5.4	19.9	0.9	5.8	1074.7	2.5	43.5	
	29-11-11	-	27.5	8.0	5.6	17.6	1.1	-0.8	1091.7	0.3	71.5	
	30-11-11	89.5	27.1	16.4	5.3	14.4	1.3	-3.4	1086.7	0.1	71.2	
	01-12-11	99.8	27.1	21.3	2.6	14.7	1.3	-3.4	1084.5	0.5	64.1	

TABLE 3.1-14: CONTINUATION

Parameters / Records		PM_{10}	SO_2	NO_2	NO	O_3	CO	Tempera-ture	Atmospheric pressure	Wind speed	Relative humidity	Wind rose of the period
mean daily norm (μg/m^3)		50	125	-	-	120	10	°C	hPa	m/s	%	
№ 09-1017/ 09-1053 November/ December	22-11-11	66.2	15.5	11.2	4.6	17.2	1.7	-2.7	1037.1	0.3	75.6	
	23-11-11	64.8	26.9	9.1	4.6	16.8	1.0	-3.1	1090.1	0.6	88.9	
	24-11-11	71.7	26.6	9.2	4.7	15.3	1.2	-0.3	1100.6	0.2	83.5	
	25-11-11	54.7	29.1	8.9	5.2	15.8	1.3	1.5	1094.1	0.1	78.5	
	26-11-11	43.8	30.7	7.2	4.9	21.4	1.1	2.3	1084.1	1.6	63.2	
	27-11-11	38.8	29.7	5.5	4.3	19.0	0.9	1.1	1084.5	1.3	63.4	
	28-11-11	49.3	30.9	7.8	5.4	19.9	0.9	5.8	1074.7	2.5	43.5	
	29-11-11	-	27.5	8.0	5.6	17.6	1.1	-0.8	1091.7	0.3	71.5	
	30-11-11	89.5	27.1	16.4	5.3	14.4	1.3	-3.4	1086.7	0.1	71.2	
	01-12-11	99.8	27.1	21.3	2.6	14.7	1.3	-3.4	1084.5	0.5	64.1	

The mean daily values of the measured climate elements and the respective pollutant concentrations, according to the measurements in 2011, are presented in **Table 3.1-14**. The wind roses for the different periods are presented in the last column. The south winds are prevailing due to the local specificity of the measurement site and not because of the prevailing transfer of air masses in the area of the town of Kozloduy.

The wind roses for the measurement periods show that the prevailing winds are coming from the south, which is a highly local effect, since prevailing for the area of Kozloduy Municipality is the zonal transfer of air masses – western-eastern winds.

It is visible from the table that in some of the measurement days the mean daily concentrations of particulate matter (PM_{10}) exceed the mean daily norm of 50 $\mu g/m^3$.

The high mean daily concentrations have occurred at wind speed of below 1 m/s - **Figure 3.1-16**. The explanation for this is that in the lack of wind, the area, where the mobile station was located, becomes quite dusty. In case of wind the dusty air is diluted and the particulate matter sensor registers lower concentrations. This is a local effect and it should be described in the records of the laboratory for air emission control as a condition of the surroundings during measurements.

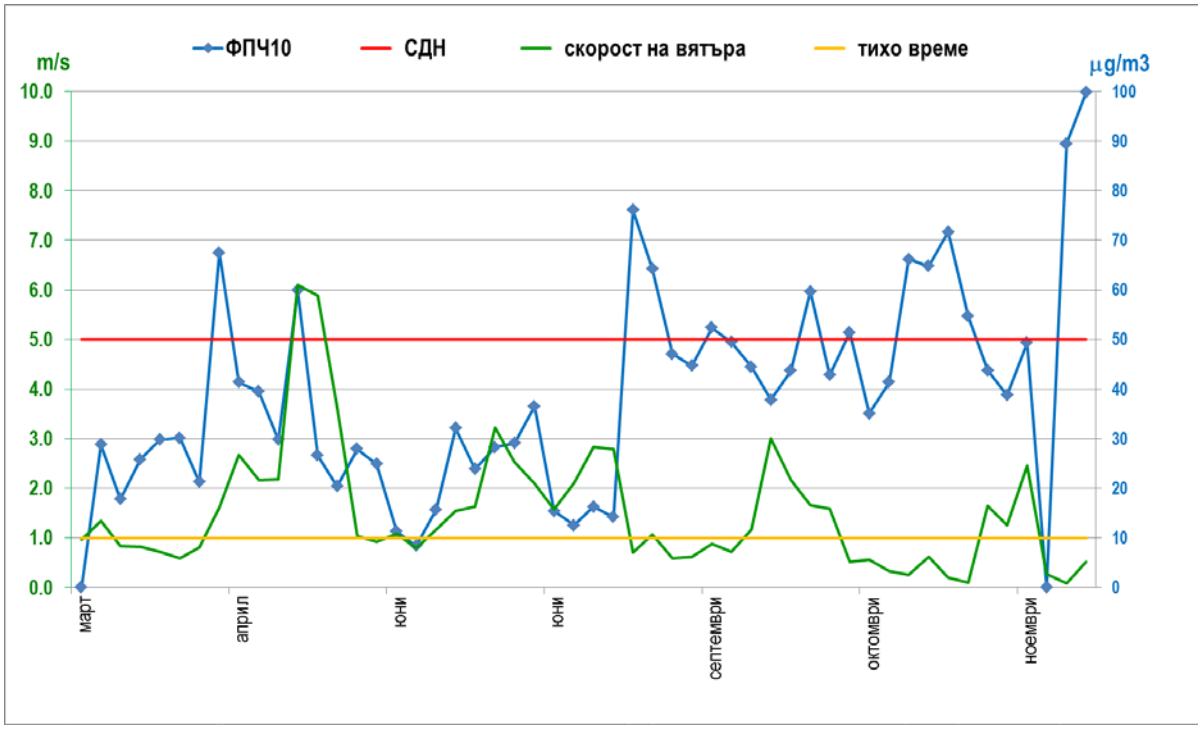


FIGURE 3.1-16: PM_{10} CONCENTRATIONS AND WIND SPEED

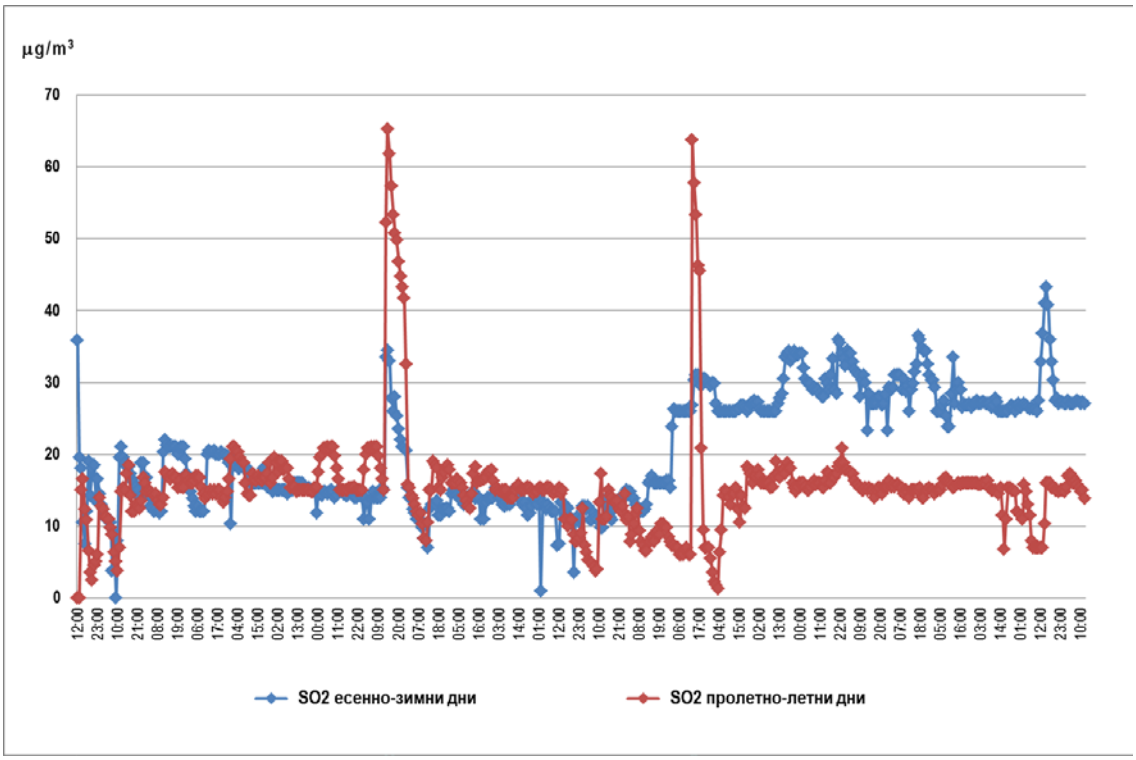


FIGURE 3.1-17: COMPARISON OF SULPHUR DIOXIDE CONCENTRATIONS

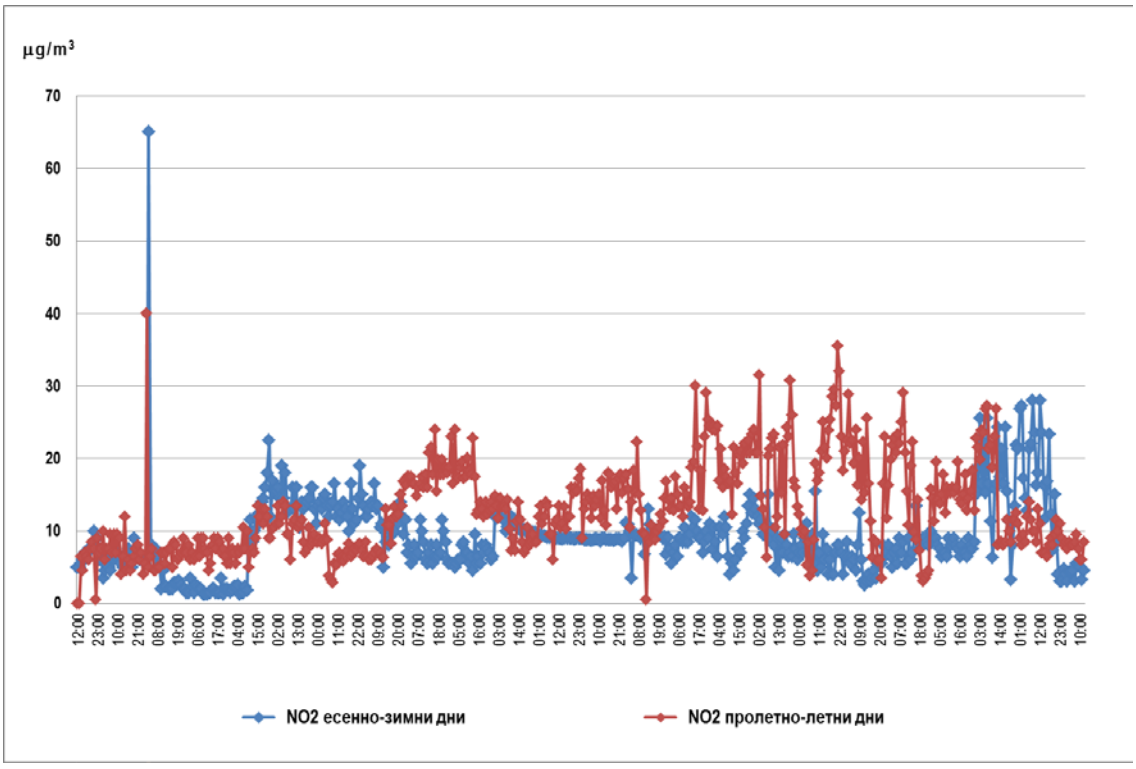


FIGURE 3.1-18: COMPARISON OF NITROGEN DIOXIDE CONCENTRATIONS

The comparison between the measured concentrations of sulphur and nitrogen dioxides (**Figure 3.1-17** and **Figure 3.1-18**) shows that the combustion of solid fuel in residential heating during the winter increases the sulphur dioxide pollution, while the waste gases caused by the road transport

during the summer increase the nitrogen dioxide pollution. The amount of the measured concentrations of both sulphur dioxide and nitrogen dioxide is way below the limit values, which are 350 μg/m^3 and 200 μg/m^3 respectively.

The rest of the pollutants show concentrations below the mean daily or the mean hourly standard.

Consequently, the ambient air quality in the area of the NDF is good.

3.1.3 ATMOSPHERIC RADIOACTIVITY

3.1.3.1 AEROSOLS

The ambient air radioactivity is examined regularly at 11 control points within the 30-km Surveillance Zone (SZ) and at benchmark points located at up to 100 km around the Kozloduy NPP and the site of the NDF respectively. A two-week sampling is carried out by means of high technological devices (model DH-60810EV.2) with large air flow rate for continuous aerosol sampling – digitally controlled devices with data storage. The new equipment put into service has reliable metrological control of the technical means for the measurement of the air inlet flow rate. The equipment is capable of measuring meteorological parameters – temperature and pressure, which contributes to the greater accuracy of the final sampling results and the measurement when standard conditions are provided. The filters used by the new system are of type LB-5211 (glass-fibre) with size of 8”x10” at flow rate of 80 m³/h. After exposure the filter must be removed and set aside for one week in order for the short-lived nuclides to decay and then it is compressed by a tablet press and subjected to gamma-spectrometric measurement. Depending on the specific conditions of sampling and analysis (air volume, dust loading, background rate of the equipment) the MDA can be altered and during measurements for ^{137}C at a time of 80,000 s it reaches an average of 2.3 μBq/m^3. Higher MDA levels are observed as a result of occasionally recorded lower volumes due to the power loss or icing of the filters during the winter months. The summarized data from the aerosol monitoring performed in the period 2009-2013 (Results from the radioecological monitoring of Kozloduy NPP, Annual Report 2013 - **Table 3.1-15**) show that the results are within normal limits **without variation of the background gamma radiation** and the gamma radiation activity.

TABLE 3.1-15 SUMMARIZED DATA ON THE AEROSOL MONITORING, 2009 – 2013

2009	✓ Collected samples: 231 samples with 231 gamma-spectrometric analyses performed as well as measurements of the total beta activity RESULTS: ✓ Within normal limits: gamma-spectrometric measurement with recorded background values for ^{137}Cs within the range 0.4÷9.1 μBq/m^3, an average of 2.0 μBq/m^3. ✓ Results for the total beta activity (up to April 2009) are within the range 0.14÷1.95 mBq/m^3, an average of 0.63 mBq/m^3.
2010	✓ Collected samples : 264 samples with 264 gamma-spectrometric analyses performed RESULTS: ✓ Within normal limits: gamma-spectrometric measurement with recorded background values for ^{137}Cs within the range 0.9÷10.3 μBq/m^3, an average of 2.8 μBq/ m^3.

2011	✓ Collected samples: 260 samples with 260 gamma-spectrometric analyses performed RESULTS: ✓ Within normal limits: gamma-spectrometric measurement with recorded background values for ^{137}Cs within the range 0.8÷10 μBq/m3, an average of 2.8 μBq/ m^3.
2012	✓ Collected samples : 259 samples with 259 gamma-spectrometric analyses performed RESULTS: ✓ Within normal limits: gamma-spectrometric measurement with recorded background values for ^{137}Cs within the range 0.8÷11 μBq/ m^3, an average of 2.3 μBq/ m^3.
2013	✓ Collected samples: 263 samples with 263 gamma-spectrometric analyses performed RESULTS: ✓ Within normal limits: gamma-spectrometric measurement with recorded background values for ^{137}Cs within the range 0.8÷10.4 μBq/ m^3, an average of 2.3 μBq/ m^3.

SUMMARY:

- **The operation of the existing nuclear facilities at the site of the Kozloduy NPP has not affected the radiation purity of the ambient air in the area of the NDF Radiana site and the 100-km zone of the existing nuclear facilities.**
- **The measured values are of typical background levels for this geographical region**
- **The technogenic activity is about 10^6 lower than the norm set in Regulation on Basic Norms of Radiation Protection (BNRP)-2012**

The results for ^{137}Cs from the gamma-spectrometric analyses of the aerosol samples in 2013 were close to and lower than the Minimum Detectable Activity MDA (0.8 to 10.4μBq/m^3), an average of 2.3μBq/m^3 . These are typical values for the surface air in the area. The results (**Figure 3.1-19**) give an actual assessment of the residual radiocaesium concentration in the atmosphere after Chernobyl and show the possibility to register even the smallest variations in the ambient air radioactivity. They have been compared to the corresponding MDA. The recorded ^{137}Cs volumetric activity in the ambient air is about 10^5÷10^6 times lower than the national norms (the limits on average annual volumetric activity –$LAAVA_{Air}$, for ^{137}Cs pursuant to BNRP-2012 is 3.2 Bq/m^3 – Annex 2 to Article 16, Table 4).

The measured concentrations of ^{137}Cs in aerosols from all of the control points in the 100-km zone of the Kozloduy NPP in 2013 as well as in previous years were negligibly low, with background concentrations. No impact or trends have been observed in the aerosol radioactivity from the facilities of the Kozloduy NPP site in the area of the NDF – Radiana site.

The conclusions on the background levels of the ambient air in the area are also confirmed by the data provided by Regional Laboratory – Varna under the EEA. The results from the examinations of the aerosol filters in 2013 show that the background concentrations of technogenic ^{137}Cs were within the MAD limits (from < 4 to 39 μBq/m^3). No significant adverse impacts are expected.

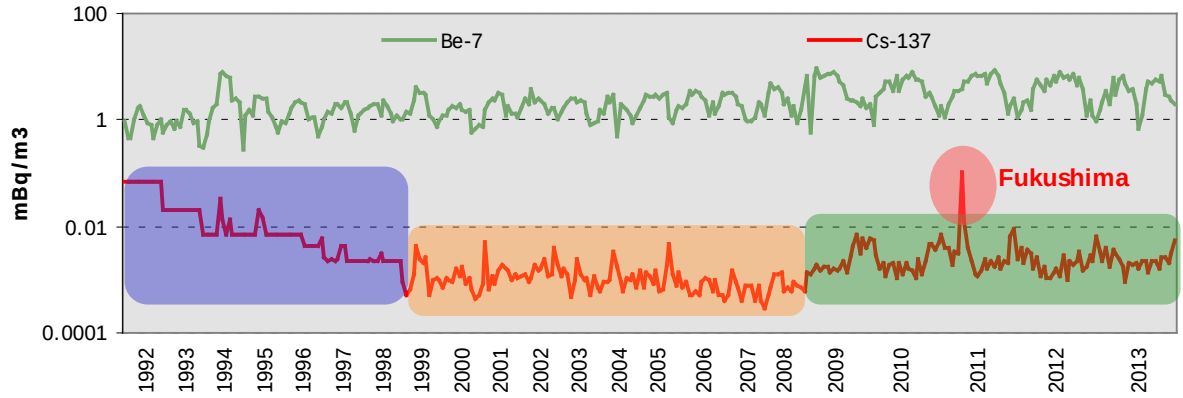


FIGURE 3.1-19 GAMA-SPECTROMETRIC ANALYSIS OF 137CS AND 7BE IN THE SURFACE AIR (MBQ/M^3) IN THE AREA OF KOZLODUY NPP, POINT-9 (THE VILLAGE OF HARLETS), 1992 – 2013

The total beta activity of the aerosol samples was examined up to April 2009, and then it was cancelled on the grounds of the amendment of the Monitoring Programme, coordinated with the NRA, and replaced by more frequent (two-week) gamma-spectrometric analyses of the samples by nuclide composition. For 2009, the average values of the beta activity in the long-lived aerosols for the individual points were within the range 0.50 ÷ 0.68 mBq/m^3. The results have been comparable in a narrow range for over different years. The long-term researches of this radiation parameter are presented in **Figure 3.1-20**. In previous years the average values of the total beta activity of the long-lived aerosols for the individual sites and years varied in a relatively narrow range – 0.45- 0.97 mBq/m^3 in 2006, from 0.29 to 0.99 mBq/m^3 in 2007 and from 0.35 to 0.95 mBq/m^3 in 2008. These are normal levels for this radiation parameter within the natural background values.

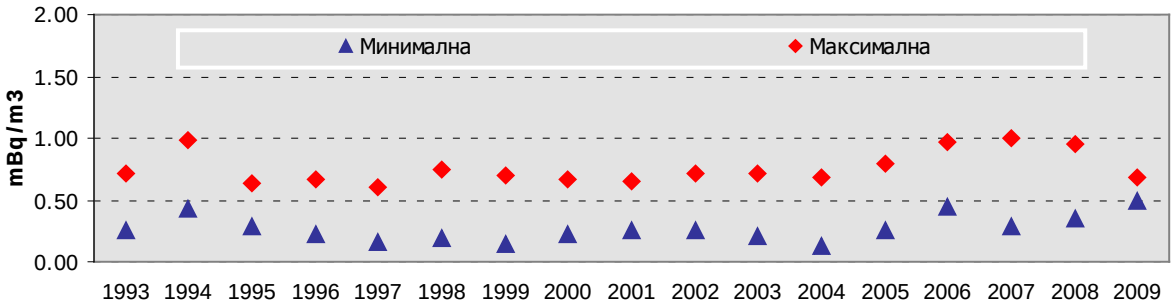


FIGURE 3.1-20 MEAN VALUES OF THE TOTAL LONG-LIVED BETA ACTIVITY (MBQ/M^3) IN AEROSOLS IN THE 100-KM ZONE OF THE KOZLODUY NPP, 1993-2009

The radiation control on the territory of RIEW – Vratsa is carried out by Regional Laboratory – the town of Vratsa under the EEA – Sofia.

In 2012 twenty five aerosol filters were collected from the stationary station in the town of Vratsa in order to monitor the presence of radionuclides in the ambient air (mBq/m^3). The results are presented in **Figure 3.1-21**.

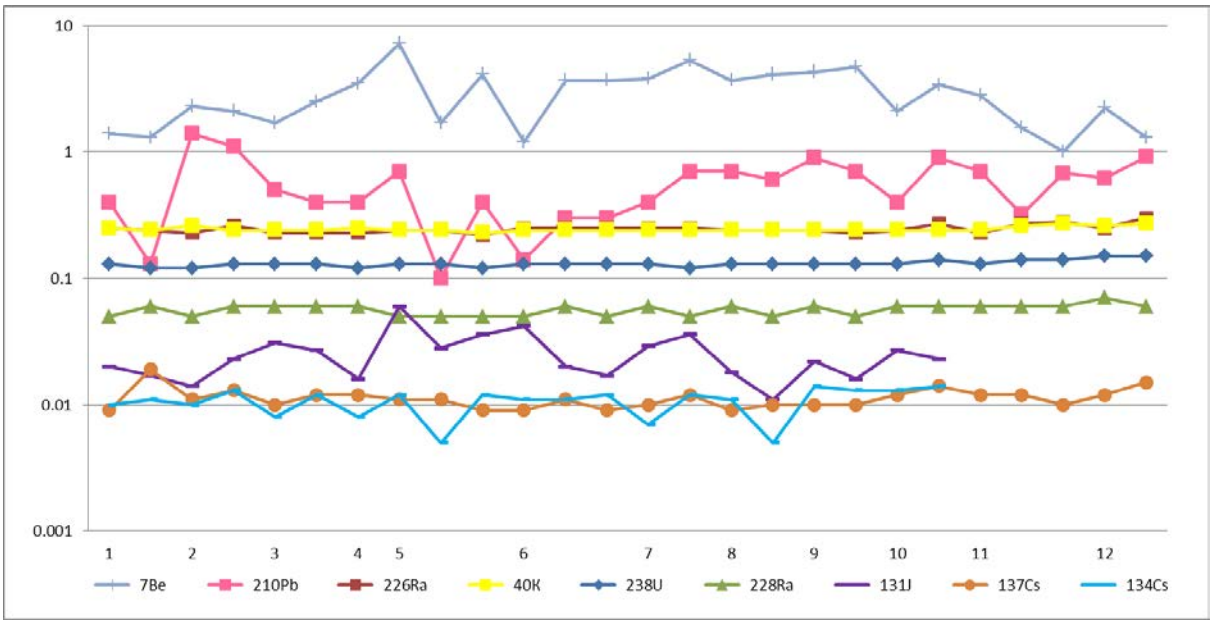


FIGURE 3.1-21: ATMOSPHERIC ACTIVITY IN MBQ/M^3 AT THE POINT LOCATED IN THE TOWN OF VRATSA, 2012

No increase in the specific activity of the natural and technogenic radionuclides in the ambient air has been recorded and the values did not differ from those of previous years.

The examination of the aerosol radioactivity by the regional laboratories (RL) in the system of the EEA showed background concentrations of technogenic Caesium-137 within the MDA limits (from < 0.004 to < 0.039 mBq/m^3) and Cosmogenic Beryllium-7 from 0.375 mBq/m^3 to 3.83 mBq/m^3 during the first trimester of 2013 for Montana and Buhovo respectively. The results obtained during the second trimester of 2013 showed background concentrations of technogenic Caesium-137 from < 0.005 mBq/m^3 (MDA) for Sofia – Nadezhda Quarter, and Cosmogenic Beryllium-7 in the range of 1.08 mBq/m^3 for Montana to 5.69 mBq/m^3 for Sofia – Nadezhda Quarter. During the third trimester of 2013 the obtained results showed background concentrations of technogenic Caesium-137 < 0.015 mBq/m^3 (MDA) for Montana and Cosmogenic Beryllium-7 within the range 0.99 ÷ 6.23 mBq/m^3 for Burgas and Svishtov respectively. The results from the analysed aerosol filters for the fourth trimester of 2013 also showed background concentrations of technogenic Caesium -137<0.019 mBq/m^3 (MDA) for Buhovo and Cosmogenic Beryllium-7 from 0.708 mBq/m^3 for Montana to 4.84 mBq/m^3 for Svishtov (information from the EEA bulletins).

The results, used for the purposes of the pre-operational aerosols monitoring at the Radiana site, are obtained from the aerosol filters of the devices located at point-1 (NPP) and point-13 (Kozloduy) according to the departmental radioecological monitoring programme of the Kozloduy NPP. These two control points, as part of the aerosol sampling network outside the NPP site, were selected because of their proximity to the NDF site. The results showed values of technogenic radioactivity within the limits of the MDA. Natural radioactivity within normal limits is measured only for the isotopes ^{7}Be and ^{40}K. All results were much below the norms. The data are presented in **Table 3.1-16**

TABLE 3.1-16 RESULTS FROM THE PRE-OPERATIONAL AEROSOL MONITORING AT THE RADIANA SITE OF THE NDF, MBQ/M^3

Aerosol filter	Activity, mBq/m^3	MDA	Results	Norm, Bq/m^3
			Value	BNRP-2012
point 1 (NPP) and point 13 (the town of Kozloduy, Radioecological Monitoring Department)	^{7}Be	0.014 ÷ 0.018	4.62 ÷ 5.44	< 1,900
	^{40}K	0.031 ÷ 0.044	0.079 ÷ 0.104	< 31
	^{54}Mn	0.0015 ÷0.0021	< MDA	< 72
	^{57}Co	0.00059 ÷ 0.0011	< MDA	< 110
	^{58}Co	0.0017 ÷ 0.0022	< MDA	< 53
	^{59}Fe	0.0041 ÷ 0.0057	< MDA	< 27
	^{60}Co	0.0017 ÷ 0.0023	< MDA	< 4
	^{65}Zn	0.0039 ÷ 0.0055	< MDA	< 47
	^{94}Nb	0.0012 ÷ 0.0017	< MDA	< 2.5
	^{95}Nb	0.0021 ÷ 0.0027	< MDA	< 62
	^{103}Ru	0.0016 ÷ 0.0020	< MDA	< 37
	^{106}Ru	0.011 ÷ 0.016	< MDA	< 1.9
	^{110m}Ag	0.0013 ÷ 0.0018	< MDA	< 9.1
	^{131}I	0.0068 ÷ 0.013	< MDA	< 7.3
	^{134}Cs	0.0011 ÷ 0.0017	< MDA	<6
	^{137}Cs	0.00083 ÷ 0.0019	< MDA	< 3.2
	^{226}Ra	0.026 ÷ 0.034	< MDA	< 0.013
	^{235}U	0.0016 ÷ 0.0021	< MDA	< 0.015
	^{238}U	0.038 ÷ 0.049	< MDA	< 0.015

The results from the aerosol monitoring performed in 2013 and in previous years showed lack of technogenic activity in the surface air. The values are within background levels typical of the natural background radiation.

The radiation purity of the air fully complies with the statutory requirements.

3.1.3.2 ATMOSPHERIC FALLOUT

The atmospheric fallout is monitored on a monthly basis at 33 control points within the 100-km surveillance zone around the NPP and the NDF site respectively. The samples are tested for total beta activity, gamma-spectrometric determination of technogenic radioactivity (^{137}Cs, ^{60}Co and etc.) and radiochemical isolation for the determination of the ^{90}Sr activity.

TABLE 3.1-17 SUMMARIZED DATA ON THE MONITORING OF ATMOSPHERIC FALLOUT MONITORING, 2009 – 2013

2009	✓ Collected samples: 396 samples with 806 analyses performed /*396 gamma-spectrometric analyses, 396 analyses of radiometry of total beta activity and 14 analyses with radiochemical isolation of strontium/* RESULTS: ✓ Within normal limits– values of total beta activity within the range 0.046 ÷ 2.39 Bq/(m^2.d), mean value – 0.42 Bq/(m^2.d)
2010	✓ Collected samples: 394 samples with 802 analyses performed /*394 gamma-spectrometric analyses, 394 analyses of radiometry of total beta activity and 14 analyses with radiochemical isolation of strontium* / RESULTS: ✓ Within normal limits – values of total beta activity within the range 0.043 ÷ 1.84 Bq/(m^2.d), mean value – 0.48 Bq/(m^2.d)
2011	✓ Collected samples: 396 samples with 820 analyses performed /*396 gamma-spectrometric analyses, 396 analyses of radiometry of total beta activity and 28 analyses with radiochemical isolation of strontium/* RESULTS: Within normal limits– values of total beta activity within the range 0.058 ÷ 1.96 Bq/(m^2.d), mean value – 0.43 Bq/(m^2.d)
2012	✓ Collected samples: 394 samples with 816 analyses performed /*394 gamma-spectrometric analyses, 394 analyses of radiometry of total beta activity and 28 analyses with radiochemical isolation of strontium/* RESULTS: Within normal limits– values of total beta activity within the range 0.066 ÷ 1.26 Bq/(m^2.d), mean value – 0.36 Bq/(m^2.d)
2013	✓ Collected samples: 394 samples with 816 analyses performed /*394 gamma-spectrometric analyses, 394 analyses of radiometry of total beta activity and 28 analyses with radiochemical isolation of strontium/* RESULTS: Within normal limits– values of total beta activity within the range 0.071 ÷ 3.02 Bq/(m^2.d), mean value – 0.43 Bq/(m^2.d)
SUMMARY: ➢ **The results are comparable to those from previous years.** ➢ **The total beta activity has natural values typical of the area.** **Overall, no technogenic activity has been detected except for the occasionally recorded traces of ^{137}Cs in some of the samples from the NPP industrial site.**	

The values of the registered total beta activity in the period 2009-2013 are presented by control points and in details in **Table 3.1-18**.

TABLE 3.1-18 TOTAL BETA ACTIVITY OF THE ATMOSPHERIC FALLOUT: MEAN AND MAXIMUM VALUES 2009 – 2013, BQ/(M^2.D)

Point	Year	Mean value	Maximum value
1÷4	2013	0.55	3.02
5÷8		0.38	0.82
9÷12		0.39	1.15
13÷20		0.40	0.89
21÷27		0.47	2.19
31÷33		0.39	0.67
34÷36		0.40	0.70
28–Lom		0.47	0.81
29–Pleven		0.42	0.63
30–Berkovitsa		0.43	0.69
points	**year**		
1÷36	2013	0.43	3.02
1÷36	2012	0.36	1.26
1÷36	2011	0.43	1.96
1÷36	2010	0.48	1.84
1÷36	2009	0.42	2.39

In 2013 the total beta activity of the atmospheric fallout varied within the range 0.071 ÷ 3.02 Bq/(m^2.d), at mean value of 0.43 Bq/(m^2.d). There is a slightly pronounced seasonal dependence with higher values during the spring-summer period. This fact is due to the intensive precipitation and the self-cleaning power of the atmosphere leading to decrease in the aerosol activity and, respectively, an increase in the activity of the atmospheric fallout. The measured activity is mainly due to the natural ^{40}K. The results from the analysis of the atmospheric fallout in 2013 are completely comparable to those of previous years and the data for the area before the commissioning of the NPP.

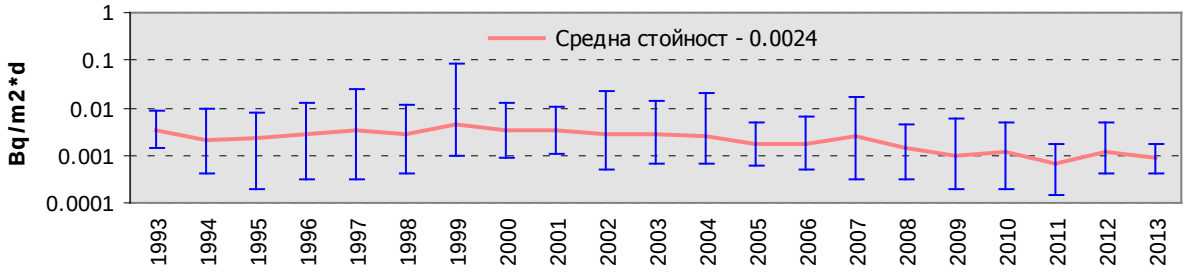


FIGURE 3.1-22 SUMMARIZED DATA ON ^{90}SR IN THE ATMOSPHERIC FALLOUT (BQ/M^2.D) FROM THE CONTROL POINTS AT THE SITE AND THE 100-KM ZONE, 1993 - 2013

The values measured during the analysis of ^{90}Sr in the atmospheric fallouts are within the range 0.6 ÷ 1.6 mBq/(m^2.d) at a mean value for all of the 33 points of 0.9 mBq/(m^2.d). In 2012 the respective values by radii and benchmark points in the 100-km zone were within 0.4 ÷ 4.7 mBq/(m^2.d), a mean of 1.2 mBq/(m^2.d). In 2011 the activity varied within the range 0.1 ÷ 1.8 mBq/(m^2.d), a mean of 0.7 mBq/(m^2.d), in 2010 – within the range 0.2 ÷ 5.0 mBq/(m^2.d), a mean of 1.2 mBq/(m^2.d) and in 2009 they were within the range 0.2 ÷ 5.8 mBq/(m^2.d), a mean of 1.0 mBq/(m^2.d). The results obtained during the last several years are among the lowest for the operational period - **Figure 3.1-22**.

The gamma-spectrometric analyses show that in the 2009-2013 period, similar to previous years, no other technogenic radionuclides (^{137}Cs, ^{60}Co etc.) were recorded at the control points within the 100-km zone of the Kozloduy NPP. Minimal traces of these nuclides were recorded at some of the points at the industrial site of the Kozloduy NPP. The values of ^{137}Cs from all of the 33 control points in the 100-km radius and at the NPP site varied up to 0.13Bq/(m^2.d), a mean of 0.014 Bq/(m^2.d), and maximum concentration measured in August 2013 at point-3 located at the site. These levels of activity are very low and within MDA levels.

Independent examinations of the radioactivity of the atmospheric fallout in the area have also been performed by the laboratories of NCRRP-MH. The technogenic activity of ^{137}Cs in the samples from the control point at the courtyard of the Radioecological Monitoring (RM) Department varied within the range 0.063 ÷ 0.069 Bq/(m^2.month). These data show background levels comparable to the rest of the results from the departmental monitoring.

Two control points (№4 and № 7) have been constructed at the Radiana site for the purposes of pre-operational monitoring of atmospheric fallout. As in the case of the other 33 control points within the 100-km radius around the site, the sampling device consists of a stainless steel vessel /cuvette/ with wall height of 10 cm and an area of 0.25 m². Filter paper pressed by a metal grid is placed on the bottom of the container. There is a tap installed in order to drain the accumulated precipitation water. The sampling device is placed at a height of 1.80 m and the samples are collected once a month. The filter paper, along with the water evaporated to dryness, is ashed in laboratory conditions and subjected to further analysis. At beta activity measurement time of 6,000 s, the MDA amounts to a mean of 0.012 Bq/(m^2.d). MDA of the ^{137}Cs (gamma-spectrometry) at measurement time of 10,000 s varies within the range of 0.0062 ÷ 0.027 Bq/(m^2.d), at mean value of 0.014 Bq/(m^2.d). The differences in the MDA values are determined by the specific conditions of the sampling and measurement. After the measurement of the beta activity and the gamma-spectrometry, the samples are combined by radii and every half year, after radiochemical isolation, they are measured for determination of ^{90}Sr by means of liquid scintillation spectrometer. At measurement time of 10,000 s, the MDA is within the range 0.2 ÷ 1.0 mBq/(m^2.d) with a mean of 0.6 mBq/(m^2.d) for the individual points.

The results from the performed pre-operational monitoring showed technogenic radioactivity values within the limits of the MDA. Natural radioactivity within normal limits has been measured for ^{7}Be and for total beta activity. The results are presented in **Error! Not a valid bookmark self-reference.**. The values for the Radiana site of the NDF, as well as for the entire area within the 30-km UPZ and the benchmark points within 100 km, are within normal background limits typical of the natural background radiation.

TABLE 3.1-19 RESULTS FROM THE PRE-OPERATIONAL MONITORING OF ATMOSPHERIC FALLOUT AT THE RADIANA SITE OF THE NDF, BQ/(M^2.D)

Atmospheric fallout	Activity, Bq/(m^2.d)	MDA	Results
			value
point-4 and point-7 NDF, (Radiana site)	**Total beta (Σβ)**	**0.0031 ÷ 0.018**	**0.13 ÷ 1.60**
	^{7}Be	0.062 ÷ 0.126	0.16 ÷ 4.01
	^{40}K	0.29 ÷ 0.30	< MDA
	^{54}Mn	0.010 ÷ 0.017	< MDA
	^{57}Co	0.0057 ÷ 0.0058	< MDA
	^{58}Co	0.017 ÷ 0.018	< MDA
	^{59}Fe	0.038 ÷ 0.044	< MDA
	^{60}Co	0.011 ÷ 0.020	< MDA
	^{65}Zn	0.042 ÷ 0.047	< MDA
	^{90}Sr	0.00036 ÷ 0.00042	0.00058 ÷ 0.00071

Atmospheric fallout	Activity, Bq/(m^2.d)	MDA	Results
			value
	^{94}Nb	0.013	< MDA
	^{95}Nb	0.019	< MDA
	^{103}Ru	0.014	< MDA
	^{106}Ru	0.11 ÷ 0.12	< MDA
	^{110m}Ag	0.013 ÷ 0.014	< MDA
	^{131}I	0.032 ÷ 0.033	< MDA
	^{134}Cs	0.010 ÷ 0.016	< MDA
	^{137}Cs	0.008 ÷ 0.018	< MDA
	^{226}Ra	0.018 ÷ 0.019	< MDA
	^{235}U	0.011	< MDA
	^{238}U	0.27	< MDA

Overall, the atmospheric fallout radioactivity in the area of the NDF site and the 100-km zone is considered within normal background limits.

No assessable technogenic impact has been recorded in terms of this radiation parameter.

3.1.3.3 BACKGROUND GAMMA RADIATION

3.1.3.3.1 WITHIN THE EMERGENCY PLANNING ZONES OF THE KOZLODUY NPP

In the area of the Radiana site, a regular monitoring of the background gamma radiation is performed for the emergency planning zones of the Kozloduy NPP. This includes a 2-km precautionary action zone (PAZ), 30-km Surveillance zone (SZ) and the 100-km zone, designated in relation to the NPP operation and not for the needs of the NDF. The fact that the Radiana site is located in the immediate vicinity of the Kozloduy NPP (it is within the borders of the surveillance zone – SZ, of the NPP) facilitates the environment condition assessment due to the large number of measurements and data available. The gamma radiation monitoring includes measurements at the control points and along the routes with portable dosimetric devices and permanently installed thermoluminescent dosimeters (TLD) within the borders of the 2-km UPZ, the 30-km SZ and the benchmark points in the 100-km zone. **Table 3.1-20** presents a summary of the results for the period 2009-2013.

TABLE 3.1-20 SUMMARIZED DATA FROM THE DOSIMETRIC ANALYSIS OF THE ENVIRONMENT, RM – 2009-2013

Period:	Monitoring Rγ	Measurements	Scope of control	Results
2009	Portable dosimetric devices	1,324	77 control points from the 100-km zone and the NPP site	0.05 ÷ 0.12 µSv/h 0.07 µSv/h
	TLD	246 .	22 control points up to 100 km	0.08 ÷ 0.14 µSv/h
			10 control points – NPP fence	0.11 µSv/h
			30 control points from the site (20 – specialized division for radioactive waste (SDRAW), 10 – spent fuel storage facility (SFSF))	0.08 ÷ 0.27 µSv/h 0.12 µSv/h
	Automatic system AISERM	On-line	8 control stations – 2-km PAZ	Mean: 0,096 µSv/h
	Total measurements, RM	**1,570 .**	Natural background radiation	0,05 – 0,15 µSv/h
2010	Portable	1,212 .	77 control points from the 100-km	0.05 ÷ 0.12 µSv/h

Period:	Monitoring Rγ	Measurements	Scope of control	Results
2011	dosimetric devices		zone and the NPP site	0.07 µSv/h
	TLD	245 .	22 control points up to 100 km	0.09 ÷ 0.16 µSv/h
			10 control points – NPP fence	0.11 µSv/h
			30 control points from the site (20 – SDRAW, 10 – SFSF)	0.09 ÷ 0.25 µSv/h 0.12 µSv/h
	Automatic system AISERM	On-line	2 base stations – site 8 control stations – 2-km PAZ	Mean: 0,094 µSv/h
	Total measurements, RM	**1,457**	Natural background radiation	0,05 – 0,15 µSv/h
	Portable dosimetric devices	1,299	77 control points from the 100-km zone and the NPP site	0.05 ÷ 0.11 µSv/h 0.07 µSv/h
	TLD	252 .	22 control points up to 100 km	0.07 ÷ 0.15 µSv/h 0.11 µSv/h
			10 control points – NPP fence	
			30 control points from the site (20 – SDRAW, 10 – SFSF)	0.07 ÷ 0.24 µSv/h 0.14 µSv/h
	Automatic system AISERM	On-line	2 base stations – site 8 control stations – 2-km PAZ	Mean: 0,094 µSv/h
2012	Total measurements, RM	**1,551 .**	Natural background radiation	0,05 ÷ 0,15 µSv/h
	Portable dosimetric devices	1,039 .	77 control points from the 100-km zone and the NPP site	0.05 ÷ 0.12 µSv/h 0.07 µSv/h
	TLD	276 .	22 control points up to 100 km	0.05 ÷ 0.14 µSv/h 0.09 µSv/h
			10 control points – NPP fence	
			37 control points from the site (20 – SDRAW, 10 – SFSF, 7 – SFDSF)	0.05 ÷ 0.22 µSv/h 0.14 µSv/h
	Automatic system AISERM	On-line	2 base stations – site 8 control stations – 2-km PAZ	Mean: 0,104 µSv/h
2013	Total measurements, RM	**1,315 .**	Natural background radiation	0,05 ÷ 0,15 µSv/h
	Portable dosimetric devices	1,023 .	77 control points from the 100-km zone and the NPP site	0.06 ÷ 0.11 µSv/h 0.08 µSv/h
	TLD	276 .	22 control points up to 100 km	0.06 ÷ 0.11 µSv/h 0.08 µSv/h
			10 control points – NPP fence	
			37 control points from the site (20 – SDRAW, 10 – SFSF, 7 – SFDSF)	0.05 ÷ 0.12 µSv/h 0.08 µSv/h
	Automatic system AISERM	On-line	2 base stations – the site 8 control stations – 2-km PAZ	Mean: 0,097 µSv/h
	Total measurements, RM	**1,299**	Natural background radiation	0,05 ÷ 0,15 µSv/h

In 2013, 1,023 measurements were performed by means of Portable dosimetric devices in a total of 77 control points from the 100-km zone. For the passive independent control of the background

gamma radiation, a total of 70 thermoluminescent dosimeters Panasonic UD-802AS have been used performing a total of 276 measurements. The summarized data and results for 2013, along with their comparison to the data for the period 2009-2013, indicate the following:

→ The results from the measurements by means of portable devices and TLDs are comparable in a narrow range. The background gamma radiation in several points at the NPP fence as well as in the control points and the settlements from the 100-km zone is completely comparable and within the range of the natural background radiation – 0.05÷0.15 μSv/h. The results from the *on-line* monitoring carried out by the automatic system AISRM in the 30-km SZ of the Kozloduy NPP are similar. **The background gamma radiation in the area of the town of Kozloduy is lower than a number of other areas in the country;**

→ The radiation conditions in the area are stable and have not been changed by the operation of the facilities in the Kozloduy NPP site. This is the situation existing prior to the construction of the NDF.

The graphical illustration of the above-mentioned is presented in **Figure 3.1-23** , **Table 3.1-19** and **Table 3.1-20** .

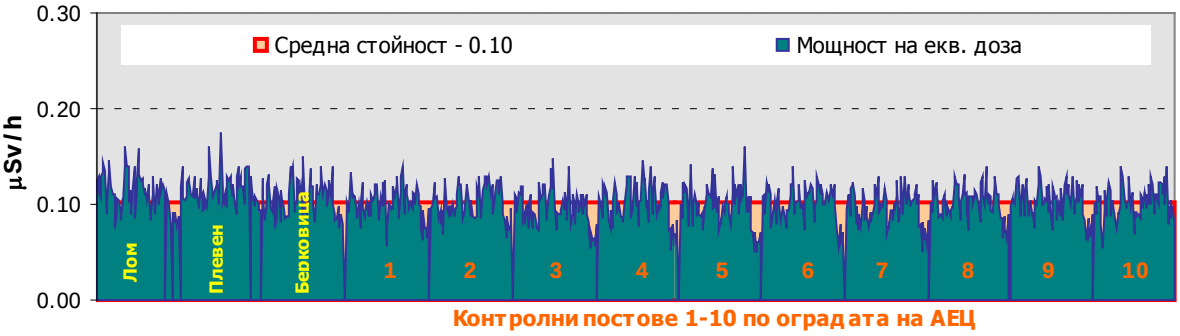


FIGURE 3.1-23 EQUIVALENT DOSE RATE (μSV/H) OF GAMMA RADIATION IN SETTLEMENTS WITHIN THE SZ AND THE NPP FENCE, TLD, 1996 – 2013

The data from the automated monitoring by means of the AISERM (**Table 3.1-21**) also indicate that the background gamma radiation in the 2-km zone shows no discrepancies from the natural background radiation values in the area.

TABLE 3.1-21 AUTOMATED MONITORING OF THE BACKGROUND GAMMA RADIATION IN THE 2-KM PAZ, 2013, μSV/H

Background gamma radiation recorded by AISERM in 2013, mean values, μSv/h							
KS-1	KS -2	KS -3	KS -4	KS -5	KS -6	KS -7	KS -8
0.097	0.104	0.093	0.103	0.104	0.094	0.086	0.096

The data from the automatic system for radiation monitoring (AISRM) of settlements closest to the site of the NDF – the Radiana site and the settlements of Kozloduy and Harlets[13], are shown graphically in **Figure 3.1-24** and **Figure 3.1-25** . Monthly reports of the data on the background

[13]AISRM, 2013

gamma radiation in the three adjacent municipalities – Kozloduy, Miziya and Oryahovo, are sent to the mayors every month in a bulletin on the radioecological monitoring.

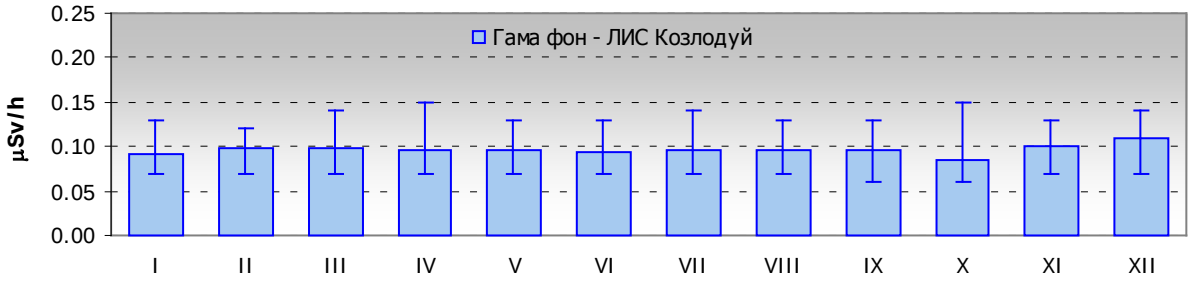


FIGURE 3.1-24 EQUIVALENT DOSE RATE (µSV/H) OF GAMMA RADIATION IN LOCAL MEASUREMENT STATION (LMS) KOZLODUY

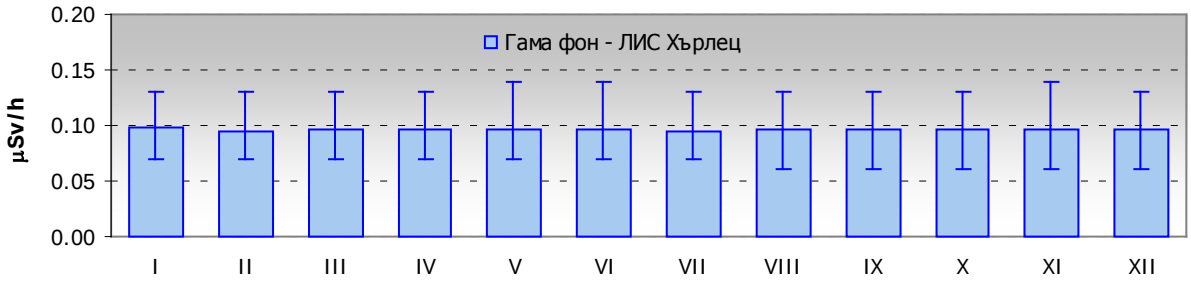


FIGURE 3.1-25 EQUIVALENT DOSE RATE (µSV/H) OF GAMMA RADIATION IN LMS HARLETS

3.1.3.3.2 ON THE TERRITORY OF THE REPUBLIC OF BULGARIA

In the Republic of Bulgaria, the Executive Environment Agency under the MoEW, which maintains the National Automatic System for Continuous Monitoring of Background Gamma Radiation (BULRaMo system - **Figure 3.1-26**), carries out the continuous monitoring of the background gamma radiation and presents the obtained data to the Joint Research Centre of the European Commission (DG JRC).

The mean values of the background gamma radiation for these stations on 06.10.2014 are presented in **Figure 3.1-27 .** The lowest value is observed in the village of Oresh (0.05758 µSv/h), while the highest is recorded on Mount Musala (0.15187 µSv/h). Although the figure shows only a momentary view of it, the already known fact that the background gamma radiation in Northern Bulgaria is always lower compared to that of Southern Bulgaria is clearly defined. This is a result of the different radioactivity of their geological structure: in Northern Bulgaria, it comprises mainly of sedimentary rocks, which, for the most part, are practically of low natural radioactivity; while in Southern Bulgaria, the geological structure consists, for the most part, of magmatic or metamorphic rocks, which are hosts of mineralization and are sources of natural radioactivity.

The highest value of background gamma radiation, recorded on Mount Musala, is due to the solar and cosmic radiation

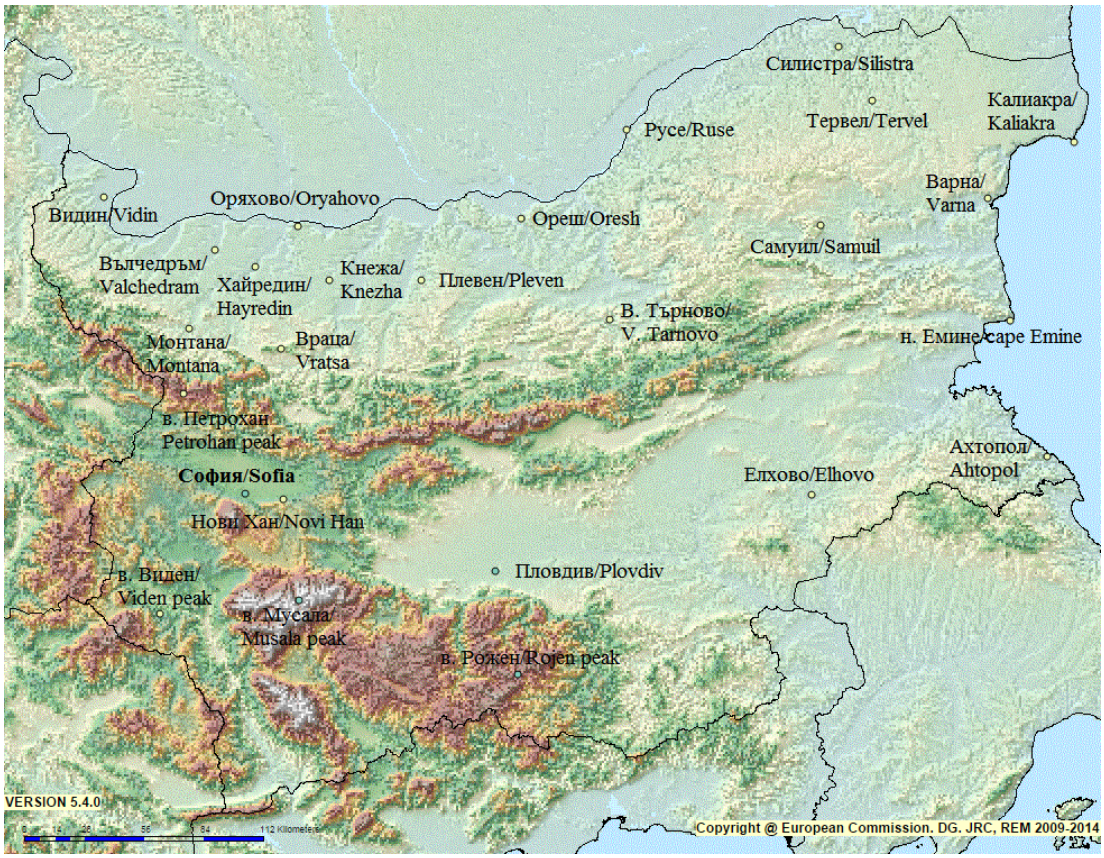


FIGURE 3.1-26 STATIONS OF THE BULRAMO SYSTEM, FOR WHICH MEASUREMENTS OF THE BACKGROUND GAMMA RADIATION FROM 06.10.2014 ARE AVAILABLE[14]

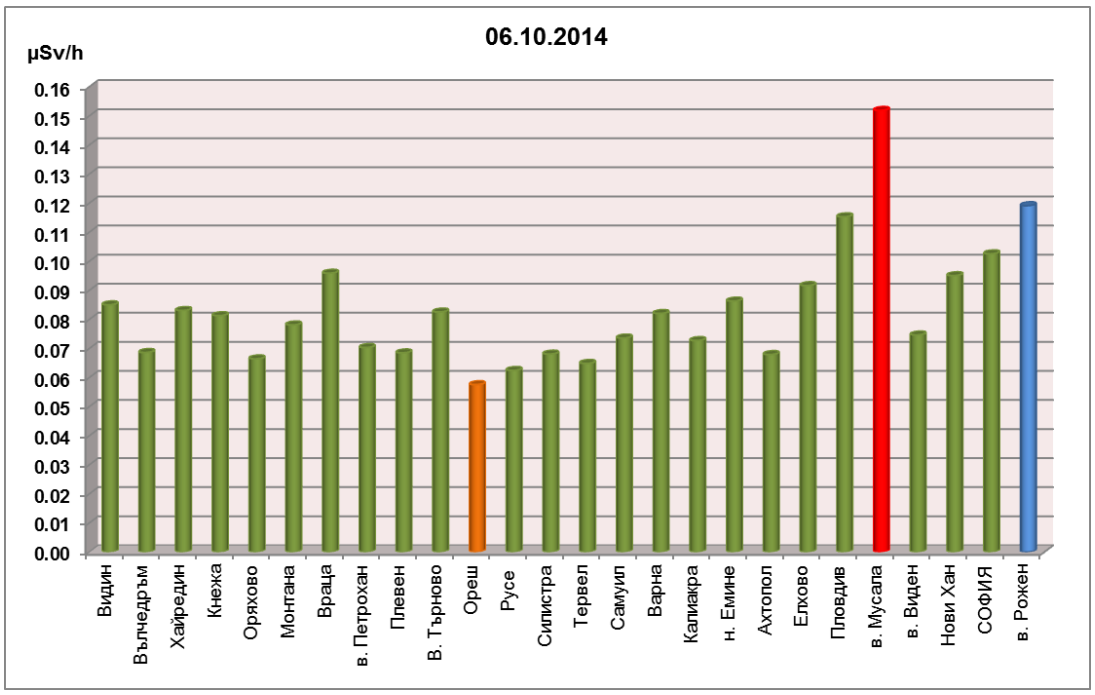


FIGURE 3.1-27 MEAN VALUES OF THE BACKGROUND GAMMA RADIATION ON 06.10.2014

The natural background gamma radiation on the territory of the Republic of Bulgaria is within the range of 0.06 to 0.40 μSv/h.

[14] http://eurdepweb.jrc.ec.europa.eu/EurdepMap/Default.aspx

The measurement results are further summarized on the internet site (http://www.bnsa.bas.bg/bg/emergency/radgamma_background) of the NRA:

- National Centre of Radiobiology and Radiation Protection under the MH – measurement is carried out at a single point;
- General Directorate "Fire Safety and Protection of the Population Service under the MoI – the background gamma radiation is measured at 335 points, located in the municipal administrations, and at 28 points located in the local administrations;
- Kozloduy NPP by means of the Automatic Information System for Radiation Monitoring (AISRM) – Katrin;
- Institute for Nuclear Research and Nuclear Energy (INRNE) under BAS (http://www.bnra.bg/bg/emergency/radgamma_background/inrne) – measurements are carried out at Mount Musala and at 7 points on the territory of the Institute and the research reactor.

The data on the mean values of background gamma radiation in the country for the same day – 06.10.2014, are presented in **Figure 3.1-28** .

станция	µSv/h
София	0.10
Варна	0.08
Пловдив	0.12
Плевен	0.07
Русе	0.06
Велико Търново	0.06
вр. Петрохан	0.07
н. Емине	0.08
Оряхово	0.07
Козлодуй	0.09
Нови хан	-
Банско*	0.18
Елин Пелин*	0.13
Лом*	0.14
Монтана*	-

FIGURE 3.1-28 SAMPLE OF THE MEAN VALUES OF THE BACKGROUND GAMMA RADIATION IN THE COUNTRY ON 06.10.2014

The data also show that the values of the background gamma radiation in Bulgaria are within the limits of the natural variations of this parameter and are typical for the respective areas.

3.1.3.3.3 ON THE TERRITORY OF THE REPUBLIC OF ROMANIA

The background gamma radiation at the nearest station, located on the Romanian coast and monitored by the competent authorities, varies around 0.1 µSv/h according to the EIAR for the dry storage facility for spent nuclear fuel at the Kozloduy NPP. The typical background gamma radiation values on Romanian territory are also confirmed by the current data. The stations of the Unified Automated Information System for Radiation Monitoring (UAISRM) under the MoEW are integrated with the control stations of the Automated Information System for External Radiation Monitoring (AISERM) within the 2-km PAZ of the Kozloduy NPP and are a part of the European Radiological Data Exchange Platform (EURDEP). This platform provides on-line access to the data

provided by all of the other European countries, including Romania and its data from the stations located within the 30-km SZ on Romanian territory. These stations have been constructed due to the proximity to the Kozloduy NPP, which provides additional information in the assessment of this radiological parameter for the needs of the EIAR of the NDF Radiana. The results are completely comparable within the range of the natural background radiation, which also indicates that the natural background radiation at the Radiana site of the NDF remains unchanged even on transboundary scale.

3.1.4 PRE-OPERATIONAL MONITORING OF THE BACKGROUND GAMMA RADIATION AT THE RADIANA SITE

The measurement of the gamma radiation equivalent dose rate is carried out by means of 18 thermoluminescent dosimeters (TLD) located at six control points – 3 TLDs (white, green and red) per point. The purpose of such organization of the measurements (the presence of three sets of TLDs at each point) is to accumulate statistically significant results and to minimize the uncertainty of the measurement.

TABLE 3.1-22 EQUIVALENT DOSE RATE OF GAMMA RADIATION AT THE RADIANA SITE

Point №	Equivalent dose rate of gamma radiation, µSv/h												
	2013						2014						Mean value
	07	08	09	10	11	12	01	02	03	04	05	06	
1	0.113	0.060	0.110	0.078	0.074	0.092	0.087	0.087	0.068	0.086	0.082	0.079	**0.085**
3	0.057	0.088	0.064	0.098	0.081	0.110	0.098	0.110	0.098	0.062	0.065	0.085	**0.085**
4	0.068	0.081	0.058	0.083	0.105	0.088	0.093	0.050	0.092	0.080	0.099	0.061	**0.082**
7	0.068	0.108	0.043	0.073	0.093	0.089	0.081	0.064	0.111	0.080	0.059	0.073	**0.079**
9	0.048	0.102	0.043	0.098	0.068	0.056	0.058	0.101	0.051	0.080	0.059	0.061	**0.069**
12	0.068	0.074	0.080	0.058	0.074	0.090	0.053	0.053	0.080	0.062	0.059	0.061	**0.068**

At this stage of the monitoring it can be said that the observed values are typical for the area and their levels are inherent to the natural background radiation in Northern Bulgaria.

3.2 WATER

3.2.1 SURFACE WATER

3.2.1.1 NON-RADIATION ASPECT

The NDF will be located on the Radiana Site, which is in the immediate vicinity of Kozloduy NPP, lying between two roads - one to the north controlled by Kozloduy NPP and considered as an inner plant road, and part of road No II-11 Kozloduy-Harlets-Miziya to the south. The site is situated at 3.3 km to the south-east of the regulation line of the town of Kozloduy, 4.3 km to the south-west of the construction limits of the village of Harlets and about 4.2 km to the south-west of the right bank of the Danube River. The area of the site is ca. 46 ha and its shape is almost rectangular. The site is situated on the slope between the first and the sixth loess terraces, with interval of ca. 55 m (from elevation +39 m to elevation +94 m) and lies between the second and the sixth non-flooded loess terraces on the right bank of the Danube River.

There are no natural water bodies on the territory of the Radiana site. The nearest rivers are the Danube, Ogosta, Skat and Tsibritsa.

10 km to 30 km to the south and south-east – the Ogosta river water body, code BG1OG100R014 and the Ogosta–Skat river water body, code BG1OG307R013;

10 to 30 km to the east and south – the Skat river water body, code BG1OG200R008;

20 km to 30 km to the west – the Tsibritsa river – two water bodies with codes BG1WO800R016 and BG1WO800R017;

The Danube River flows in close proximity, to the north of the NDF and is of great importance for the proposed development; name of the water body „the Danube River RWB01“, type R6[15] and code BG1DU000R001.

Applicable to these rivers are all requirements of the River Basin Management Plan (RBMP) and the measures therein, addressed in Programme 7.1.3, Programme 7.1.5, Programme 7.1.6, Programme 7.1.7, Programme 7.1.8, Programme 7.1.9 and in particular the requirements for: regulating the emissions through prohibition for discharge of point source pollution, prohibition for discharge of diffuse source pollution, prevention of water pollution by priority substances and prevention or reduction of the impact from accidental pollution and compliance with the protected area regimes. These requirements shall be observed in the course of realization of the investment proposal (IP) for NDF. In accordance with letter No 2915/05.06.2014 of the Danube Region River Basin Management Directorate (DRRBMD) the specific environmental objective for the Danube River surface water body, code BG1DU000R001, is as follows: "Prevention of the deterioration of the ecological potential and achievement of good status until 2021", "Prevention of the deterioration of the chemical status and achievement of good status until 2027". An exception has been introduced for this water body, in accordance with art. 4 of the EU Water Framework Directive 2000/60, for achievement of the environmental objectives (by 2015) by reason of the considerable anthropogenic impact.

The length of water body type BGTR7, code BG1OG100R014, Ogosta River is 3.175 km (part of water body Ogosta River). It is heavily modified and is defined in the RBMP as having good chemical status, moderate ecological potential, but is assessed as a water body "at risk" for achievement of the environmental objectives. During the construction of Kozloduy NPP the mouth of the Ogosta River has been modified in order to provide for the process water supply to the NPP form the Danube River. The river mouth has been shifted to the east, under the Riverbank Pumping Station (RPS).

Small dams have been built in the region, which are managed by the respective municipalities, as well as dams managed by Napoitelni Sistemi EAD (*Irrigation Systems Ltd.*). The Ogosta Dam is built near the city of Montana, on the Ogosta River; it is included in the list of large and complex dams in Bulgaria in Appendix No 1 of the Water Act. This dam has a significant impact on the river flow regime.

The artificial water bodies in the municipality of Kozloduy are Asparuhov Val Dam and Butan Dam. Their total area is 4,025 dca and in the past they had a well-developed system of irrigation channels. Shishmanov Val Dam (Asparuhov Val Dam) is located at ca. 10 km from the site and the NPP. The water reservoir was built for the purposes of the irrigation system of the same name. The reservoir is fed by the Danube River by means of a floating pumping station and has a volume of 7 mill. m^3. The dam is defined in the RBMP as an artificial water body, code BGW0900L017, and is registered with an area of 2 km^2.

The main irrigation channel M-1 passes through the Radiana Site. According to data from Irrigation Systems EAD, Vratsa Branch and the Danube Region Basin Directorate with headquarters in Pleven, MoEW, channel M-1 is part of the Shishmanov Val irrigation system is not considered a water body within the meaning of the Water Act and according to letter by the DRRBMD, ref. No

[15] Regulation No H-4/2012, State Gazette issue 22 of 05.03.2013 on characterization of surface water

2915/05.06.2014. According to information by Kozloduy NPP EAD, the M-1 channel is not used for emergency water supply of Kozloduy NPP.

Part of the existing irrigation channel is located within the Radiana Site. It is planned that the M-1 irrigation channel is shifted off the site designated for construction of the NDF. A project has been drawn for that purpose, commissioned by RAW SE.

According to the project, the new route of the channel will consist of a pressure pipeline with 800 mm diameter and an open channel with 2.50 m width. The pipeline will have a total length of 650 m and will be laid in the north-south direction; it will start at a distance of ca. 600 m from the Radiana Site. 520 m of its route will pass through the lands of the town of Kozloduy, Municipality of Kozloduy, and the remaining 130 m - through the lands of the village of Harlets, Municipality of Kozloduy. The newly designed open channel will be 2.50 m wide and 3,440 m long and its entire route will pass through the lands of the village of Harlets, Municipality of Kozloduy, at a distance of 2 km from the site, in the west-east direction. According to the project *the new route of the connection* will pass along part of the route of existing irrigation channels 3-S-6 and 3-G-24 in lands of the village of Harlets (Appendix, Infrastructure Plan).

Due to the nature of the Radiana Site (located on the northern slope of the second non-flooded terrace of the Danube River, with an average slope gradient of about 8º30'), the surface runoff is drained in the northern direction towards the area of Kozloduy NPP. Systems of drainage channels and facilities have been built in this area, which catch the surface runoff on the slopes. These systems provide protection of Kozloduy NPP area in case of heavy rains and prevent the plans form swamping. They have been dimensioned to drain the surface water from intensive rainfall with various duration and rainfall variability of 0.01% (once in 10,000 years). The drainage systems include three types of channels: drainage, collection and main channels. Water from the main channels is transferred to the Danube River over the embankments by means of pump stations (PSs). These drainage facilities are essential for the protection of the agricultural lands in the area and the existing and the planned infrastructure. The river is an important factor for the NDF and the other water consumers in the region, since it is used as a source of fresh water and a wastewater receiving body.

There is no risk of groundwater level rise at the Radiana Site of the NDF, since it is located at a non-flooded elevation, which is higher than that of the NPP site. This is evidenced by the long-term hydrological monitoring results. This conclusion is also confirmed by the analysis of the "stress tests" made in 2012 on the site of the nuclear power plant.

The total area of the international Danube basin is 817,000 km^2, and its total length is 2,857 km. The river is an international waterway transport corridor. In connection with the threat for the environmental status of the river waters assessed by the countries along its water course, due to the increased anthropogenic impact of human activities on the banks and the waterway traffic, as well as concerning the conservation of many protected areas and habitats, which are influenced by its waters, a decision was taken in 1992 to establish the International Commission for the Protection of the Danube River (ICPDR). The Republic of Bulgaria has ratified the Danube River Protection Convention. The Danube River and the whole Danube water management basin in Bulgaria have been designated as a sensitive area, the specific environmental objective of which is to reduce and/or to prevent further pollution of surface waters in that area by biogenic substances until 2015, on the grounds of Order No РД-970/28.07.2003 of the Minister of the MoEW, therefore the requirements for the users of water bodies are stricter. In the Republic of Bulgaria, the first management plan for the entire the international Danube basin is already in force, as well as the Danube Region River Basin Management Plan. In this plan, the river is categorized as a river named the Danube River RWB01, code BG1DU000R001. It has been defined as a heavily modified water body of moderate ecological potential and poor chemical status. An Action Programme aiming to achieve good chemical status and good ecological potential during the next planning periods until 2021 and 2027 has been prepared and is being implemented. These requirements will be applicable with respect to the ecological

commitments during the implementation of this IP. The river is subject to control physico-chemical monitoring and operative monitoring under a special National Monitoring Programme for major physico-chemical indicators, priority and specific pollutants, and hydro-morphological quality elements, according to the Programme of the ICPDR, which is included in the National System for Environmental Monitoring (NSEM) implemented by the Executive Environment Agency (ExEA) and the Regional Laboratories (RLs). Under the same Programme, control and operative hydro-biological monitoring is also performed. The implementation of the Danube River Monitoring Programme, as well as the monitoring of the Ogosta River status are regulated by Order No РД-715/26.02.2013 of the Minister of MoEW.

The hydrological regime of the Danube River can be generally characterized as follows:

→ The river has a **mixed snow and rain feed,** which is more pronounced in the upper and middle stream and less pronounced in the lower stream. Thus, the spring high water levels in the Lower Danube are observed between March and May ("cherry waters"), rarely in June. The summer low water levels occur shortly after that and are most pronounced in the period from August to October, rarely in November.

→ **High waters are characteristic of the spring flood-time** (April-May), and in individual years - in particularly cold winters, river icing, in conditions of flow blocking - disastrously high waters have been registered. Years with high spring waters were 1944, 1965, 1970, 1979, 1980, 1981, and years with winter maximums – 1942, 1954, 1974.

→ **During the months from July to November**, regardless of the general drop of the water levels, **separate tidal waves** of varying in intensity and size occur as a result of precipitation.

→ **The autumn low water levels are usually observed in the period October - November**, with most pronounced minimum in October. Low water levels have been registered also in the winter months (January - February), in periods of significant cold spells.

Figure 3.2-1 and **Figure 3.2-2** illustrate a comparison between the water quantities registered at the stations of Lom and Oryahovo for the period 2002-2012. It is evident that a clear tendency for a change cannot be identified. Rather, a cyclic recurrence can be observed, with alternation of low-water period in 2002 and 2003 a period of relatively wet years in the middle and again reducing water quantities in 2011 and 2012.

The monthly average water distribution at Water Monitoring Station (WMS) RPS1 of Kozloduy NPP shows that the highest average water levels are usually observed in the spring months, between April and June (**Figure 3.2-3)**.

The analysis of the monthly average water distribution shows that the highest average monthly water levels are usually observed in the spring months, between April and June.

FIGURE 3.2-1 ANNUAL DISTRIBUTION OF THE MONTHLY AVERAGE WATER QUANTITIES AT WMS RPS1 FOR THE PERIOD 2002-2012

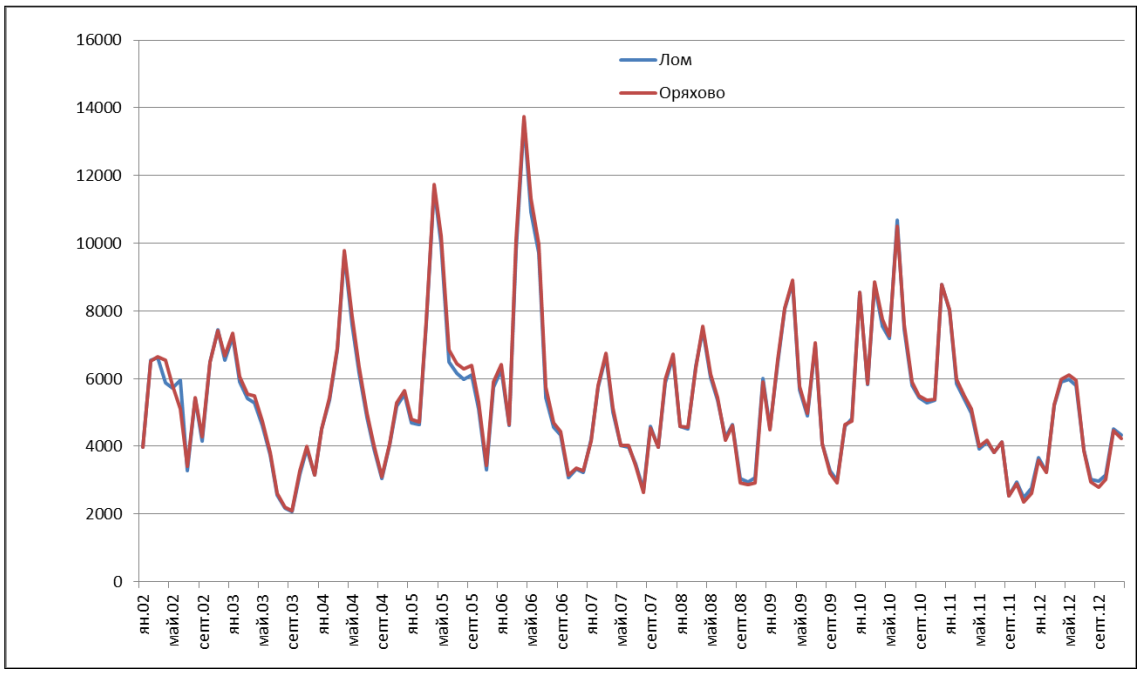


FIGURE 3.2-2 ANNUAL WATER QUANTITIES AT WMS LOM AND ORYAHOVO FOR THE PERIOD 2002-2012

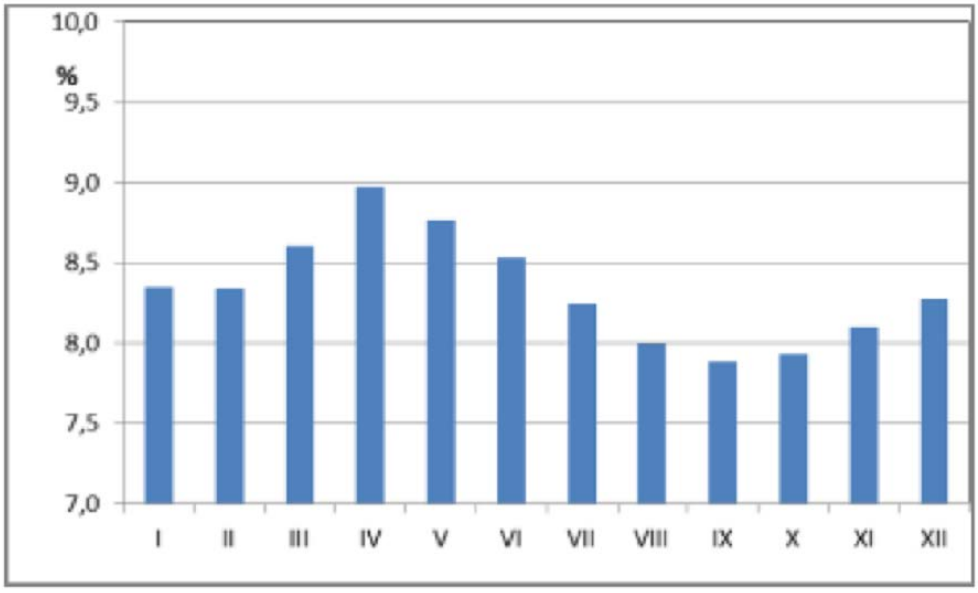


FIGURE 3.2-3 ANNUAL DISTRIBUTION OF THE MONTHLY AVERAGE WATER LEVELS AT WMS RPS1 FOR THE PERIOD 1980-2011

Information from the non-radiation monitoring carried out by the ExEA/RL Vratsa and RIEW Vratsa.

In 2009, in the waters of the Skat River downstream the town of Byala Slatina, the tendency for exceeding the maximum permissible concentration (MPC) of the nitrite nitrogen indicator prevalent in the preceding years remains. The exceeding levels of nitrite nitrogen in the Skat River downstream the town of Byala Slatina are mainly due to the discharge of untreated wastewater from the town sewerage of Byala Slatina. At the station of the Skat River, before it flows into Ogosta - the Skat River downstream the town of Miziya - values of nitrite nitrogen exceeding the MPC have also been registered. Generally, an improvement of the water quality of the Ogosta River is observed in the section passing through the territory of RIEW Vratsa, and it corresponds to the planned category.

The monitoring in the next years, until February 2013, has been carried out under the National Surface and Groundwater Monitoring Programme, introduced by order No РД-715/02.08.2010.

In 2010 the Ogosta River stations at the village of Sofronievo and at the Ogosta stream before it flows into the Danube have not registered values exceeding the MPS and all surveyed indicators correspond to the planned category of the receiving water body.

In 2011 the river stream of Ogosta on the territory of RIEW Vratsa has been controlled at the following stations of the National System for Environmental Monitoring (NSEM).

Quantitative monitoring of surface water:

- ✓ Ogosta River at the village of Hayredin
- ✓ Botunya River at the village of Golyamo Babino
- ✓ Varteshnitsa River at the town of Krivodol
- ✓ Barzina River upstream the village of Lipnitsa
- ✓ Skat River at the village of Malo Peshtene
- ✓ Skat River downstream the town of Byala Slatina

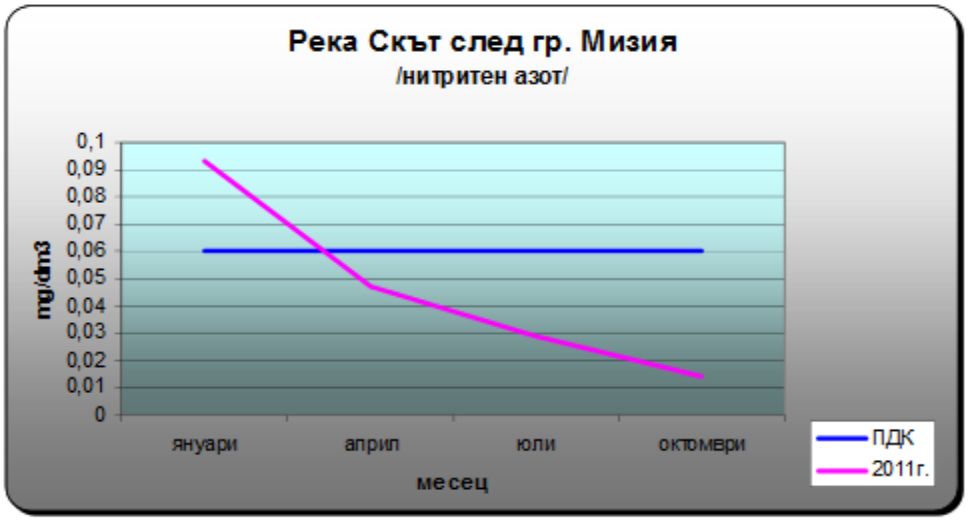
Operational monitoring of surface water:

- ✓ Skat River downstream the town of Miziya
- ✓ Skat River downstream the town of Byala Slatina
- ✓ Skat River at the village of Golyamo Peshtene

Control monitoring of surface water:

- ✓ Ogosta River at the town of Oryahovo, before it flows into the Danube River
- ✓ Botunya River at the village of Golyamo Babino before it flows into
- ✓ Varteshnitsa River
- ✓ Asparuhov Val Dam
- ✓ Barzina Dam
- ✓ Tri Kladentsi Dam

According to the control and operational monitoring carried out in 2011 at the NSEM monitoring stations, all surveyed surface water indicators correspond to the planned category, with the exception of the nitrite nitrogen indicator. With regard to the waters of the Skat River at the station downstream Byala Slatina, the tendency for exceeding the maximum permissible concentration (MPC) of the nitrite nitrogen indicator prevalent in the preceding years remains. The maximum value recorded was 0.199 mg/dm^3, and the norm for this indicator for a receiving water body of the third category, such as the Skat River, is 0.06 mg/dm^3. The excess levels of nitrite nitrogen in the Skat River downstream the town of Byala Slatina are mainly due to the discharge of untreated wastewater from the town sewerage of Byala Slatina. All other surveyed indicators of the river in this area are compliant with its planned category. A single case of nitrite nitrogen levels exceeding the MPC has been recorded once in January at the Skat River station downstream the town of Miziya. The registered value was 0.093 mg/dm^3, and the norm is 0.06 mg/dm^3.

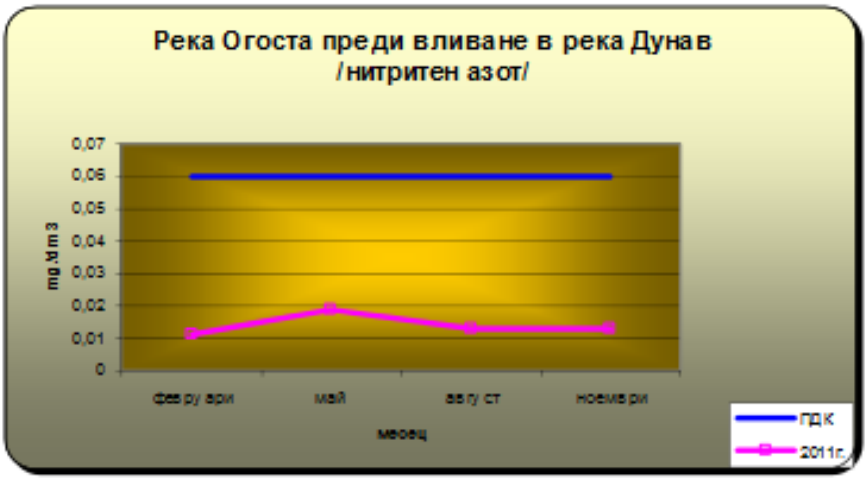


Source: Yearbook of RIEW Vratsa

FIGURE 3.2-4 DATA FROM THE MONITORING OF THE SKAT RIVER

None of the surveyed indicators has been registered with exceeding values at the Ogosta River station before it flows into the Danube, which has remained as a stable tendency.

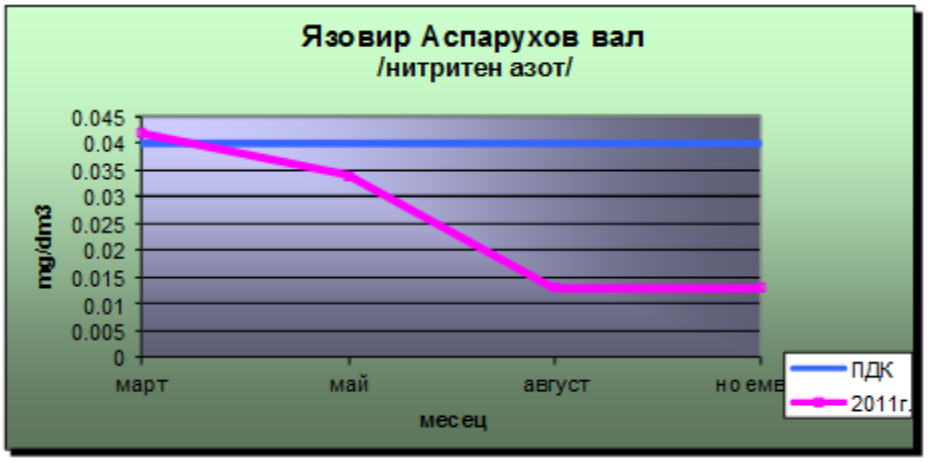
The laboratory control of the Danube River water is carried out every two months at the NSEM station, on the territory of RIEW Vratsa, and in the town of Oryahovo. The surveyed parameters are within the maximum permissible concentrations and the river is compliant with its planned category regarding all surveyed parameters.



Source: Yearbook RIEW Vratsa, 2011

FIGURE 3.2-5 DATA FROM THE MONITORING OF THE OGOSTA RIVER FOR 2011

The analysis of BOD5 and dissolved oxygen at the stations controlled by NSEM on the territory of the District of Vratsa, in the recent years shows a steady tendency towards improvement of the surface water quality; exceeding values of these indicators have not been recorded in 2011.



Source: Yearbook of RIEW Vratsa

FIGURE 3.2-6 DATA FROM THE MONITORING OF ASPARUHOV VAL (SHISHMANOV VAL) DAM FOR 2011

According to the control and operational monitoring carried out in 2012 at the NSEM monitoring stations, all surveyed surface water indicators correspond to the planned category, with the exception of the nitrite nitrogen indicator. With regard to the Skat River water at the station downstream Byala Slatina, the tendency for exceedance of the maximum permissible concentration (MPC) of the nitrite nitrogen indicator prevalent in the preceding years remains. The maximum value

was 0.410 mg/dm^3, recorded in July, and the norm for this indicator for a receiving water body of third category, such as the Skat River, is 0.06 mg/dm^3. The excess levels of nitrite nitrogen in the Skat River downstream the town of Byala Slatina are mainly due to the discharge of untreated wastewater from the town sewerage of Byala Slatina. All other surveyed indicators of the river in this area are compliant with its planned category. Exceeding MPC of the nitrite nitrogen indicator has not been recorded at the Skat River station downstream the town of Miziya.

All surveyed specific indicators are below the limit determined by the quantification method.

The control monitoring in 2012 at the Ogosta River mouth station has not registered indicators that do not correspond to the category of the water body. The recorded concentrations of a number of indicators correspond to a higher category.

Every second year, control monitoring was also carried out for Asparuhov Val Dam, Barzina Dam and Tri Kladenci Dam. Exceeding values of the surveyed indicators were not registered.

The laboratory control of the Danube River water is carried out every two months at the NSEM station, on the territory of RIEW Vratsa, and in the town of Oryahovo. The surveyed parameters are within the maximum permissible concentrations and the river is compliant with its planned category regarding all surveyed parameters.

There is a steady tendency for improvement of the surface water quality in the region, regarding the BOD_5 and dissolved oxygen indicators.

In 2013, the monitoring carried out under the National Surface and Groundwater Monitoring Programme was regulated by Order No РД-182/26.02.2013 of the Minister of Environment and Water.

In connection with the implementation of Directive 91/676, transposed in the Republic of Bulgaria with Regulation No 2/2000 on the protection of water against agricultural nitrate pollution, enforced by Order No РД-635/08.13.2013 of the Minister of Environment and Water, a programme for monitoring of nitrates in the surface and groundwater is also carried out.

The programme for control monitoring of surface water intended for municipal drinking water supply has also been updated.

According to the Annual report on the environmental status, prepared by RIEW Vratsa, the results and data for 2013 of the control monitoring of sites generating emissions of priority and priority hazardous substances, general and specific pollutants and discharging in water bodies have been entered in the Information System for water management permissions and monitoring.

The environmental component "water" within the territorial scope of RIEW Vratsa is in good ecological condition. Regarding the qualitative composition of the receiving water bodies in the area, there is a tendency for preservation and improvement of their condition.

The pollution of surface waters is more widespread in agricultural and urban areas and is characterized by complex pollution by biogenic substances (nitrogen and phosphorus), some heavy metals, organic pollutants and their degradation products.

The comparison between the operational monitoring carried out in 2013 and in 2012 at the NSEM station at the Skat River downstream the town of Byala Slatina reveals that with regard to the nitrite nitrogen indicator there was considerable improvement of the water quality of the river, which in this area is of the mature type.

Regarding the "dissolved oxygen" indicator, the status of the river in this area has deteriorated in comparison to 2012.

The monitoring carried out during that year at the National System for Environmental Monitoring station at the Skat River in the town of Miziya, shows that regarding the nitrite nitrogen indicator the ecological status of the river has preserved the tendency from the previous year.

In general, the ecological status of the rivers within the valley of the Ogosta River, on territory controlled by RIEW Vratsa, is moderate and good.

In 2013, the water quality of the Danube River in its Bulgarian section was surveyed at 5 monitoring stations. Three of the stations operate under two programmes - the National Water Monitoring Programme and the TNMN (the Danube Transnational Monitoring Network), and the other two stations - under the second, so called Danube Programme. At two of the stations - at Novo Selo and Silistra - the sampling and analysis are carried out on the same day at the Bulgarian bank, the thalweg and the Romanian bank.

In the Danube River, the values of the physico-chemical indicators, specific pollutants and priority substances, that correspond to good status in accordance with the requirements for type R7, have not been exceeded. The assessment of physico-chemical indicators compliant with BQE has been carried out on the basis of the requirements of Regulation H-4 on characterization of surface water, for type R7, i.e. large Danube tributaries. This is due to the fact that for large rivers type R6, to which the Lower Danube section belongs, the above-mentioned regulation does not specify reference values for very good, good and moderate status of the physico-chemical quality elements and for very good, good, moderate, poor and very bad of the BQE, which are yet to be determined[16].

3.2.1.1.1 MUNICIPAL DRINKING WATER SUPPLY

Water supply pipeline from the municipal water supply network passes though the Radiana Site. It supplies water to Kozloduy NPP and is owned by the ViK Vratsa OOD (*Water Supply and Sanitation Ltd.*). Drinking water is extracted from three wells, type Ranney, located on the terrace of the Danube River upstream the town of Kozloduy. They supply water also to the villages of Harlets and Glozhene. In compliance with the Water Act, the Municipality of Kozloduy has obtained from the DRRBMD a water abstraction permit for those water abstraction facilities. The water from the Kozloduy reservoirs reaches the pumping station through a gravity pipeline - length 11 km, diameter Ø500 mm and maximum water quantity 260 l/s. The pumping station pumps the water back to the plant reservoir at elevation 93.0 m (volume 2x2000 m^3) and from there it reaches the individual consumers through gravity pipelines. The length of the pressure pipeline from the pumping station to the reservoir is 0.5 km. The external water supply system to the first distribution shaft - wells, pumping stations, pipelines and other facilities - is supported by the ViK Vratsa OOD.

The system has sufficient capacity to ensure the municipal drinking water supply of the NPP, and to cover the needs of potable water during the construction, operation and decommissioning of the NDF. The water supply network section, which passes through the Radiana Site, will be shifted to the north, between the site fence and the existing internal road of the NPP. The capacity for supply to Kozloduy NPP will be preserved and a branch-off for supply to the NDF will be ensured. The use of this water will be in compliance with the regulatory requirements and based on contractual terms with ViK Vratsa OOD.

3.2.1.1.2 SANITATION SYSTEM

There is no built or existing sanitation network on the Radiana Site. According to the IP separate sewerage will be provided: for sanitary sewage from the administrative area, for surface runoff and for the internal drainage system from the repository cells, which will ensure the catchment and collection of the water that has penetrated (infiltrated) the conditioned RAW containers. The

[16] DRRBMD Pleven, Status of surface waters in 2013

internal drainage system will be built in a way which allows to determine exactly which buried radioactive waste cell has been penetrated by moisture and to establish the status of the containers. In accordance with the requirements of the nuclear legislation, since the water from the internal drainage system of the disposal modules is considered potentially radioactive contaminated wastewater, it will be discussed in the radiation aspect of the wastewater section.

The sanitary sewage will be discharged in the sanitary sewerage system of Kozloduy NPP, and the rainfall runoff will be discharged into the main drainage channel of the Blatoto drainage system, managed by Napoitelni Sistemi EAD - Miziya Branch[17]. The water from the Blatoto drainage system is transferred by a PS (pumping station) into the Danube River. At present, Kozloduy NPP, which discharges the water from its own sewage system in the main drainage channel, owns a Permit No 13750001/20.04.2007 with subsequent amendments, issued by the competent authority DRRBMD.

At a subsequent stage of the IP it will be decided whether the surface runoff from the NDF will be discharged directly into the main drainage channel or indirectly through the sewage system of Kozloduy NPP and will be determined whether the permit for discharge into a water body issued to Kozloduy NPP pursuant to the Water Act will be amended or a new permit will be issued to RAW SE. In both cases, the prohibition on new discharges of wastewater in irrigation and drainage systems will also be taken into account, art. 6, par. 1, 3, 4 of Regulation No 2 of 08.06.2011 (SG, issue 47 of 21.06.2011) on the issue of permits for discharge of wastewater into water bodies and setting individual emission limits for point sources of pollution.

The IP provides for building an obligatory rainfall water reservoir, which will be located near the road to Kozloduy NPP, in the lowest part of the site. The reservoir will collect only storm water from the site, clean water from the infiltration control reservoir, and clean water from the internal deep drainage network. The water quantities and the water drainage model will be clarified in the next design phase.

3.2.1.1.3 WASTEWATER - NOT CONTAMINATED WITH RADIATION

Potential source of contamination of the main water body in the region - the Danube - is Kozloduy NPP, which uses the river as a source of process water supply and as a water body receiving the process wastewater. It is planned that sanitary sewage and rainfall runoff from the NDF will be discharged in the main sewerage channel (MSC). Some information about the types of wastewater from the NPP in the non-radiation aspect is given below, along with their characteristics and the results of the monitoring undertaken in four main streams discharged into the main sewerage channel (MSC).

The non-radioactive wastewater streams from Kozloduy NPP are sanitary, process and rainfall waters. They are generated in administrative buildings, power generation buildings, sanitary and personnel buildings, specialized buildings, common auxiliary building, engineering and laboratory building, chemical water cleaning facility, fuel and oil facilities, diesel generator stations, rolling stock parks, etc.

The following main streams are generated:

- **Stream 1**: Mixed stream of sanitary (untreated), process and rainfall wastewater, drained in the MSC by means of trapezium-shaped open channel – Q_{max} = 30 l/s and Q_{min} = 10 l/s;
- **Stream 2**: Sanitary sewage from the so called "clean area" of EP-2, from RAW Kozloduy SE and AESP EAD, discharged (without treatment) into the MSC by means of a Ø300 mm collector during repair works, or in emergency situations – Q_{max} 30 l/s and Q_{min} =10 l/s;

17 Letter Reg. No 1011/06.06.2014 of Napoitelni Sistemi EAD - Mizia Branch

- **Stream 3:** Mixed stream of sanitary sewage from the controlled and the clean area treated at the Treatment Facility (TF) of EP-2, process wastewater, as well as rainfall runoff from EP-2 and from RAW Kozloduy SE, discharged into the MSC by means of a Ø1000 mm collector – Q_{max} = 90 l/s and Q_{min} = 30 l/s;
- **Stream 4:** Sanitary sewage and rainfall runoff, generated in the Open Switchgear Unit (OSU), discharged into the MSC by means of a 130/195 cm egg-shaped profile collector and an open lined channel.

For these wastewater streams a Permit No 13750001/20.04.2007 for wastewater discharge into a surface water body (discharge into MSC) was issued by the DRRBMD, which was extended until 20.04.2016 by means of Decision of the Director of DRRBMD No 216/25.02.2010.

In addition to above four streams, wastewater is discharged also into the Danube River by means of HC-1 and HC-2, for which a Permit for wastewater discharge into a surface water body has been issued by the DRRBMD.

The quantities of wastewater generated at the NPP site in 2007, 2008, 2009, 2010, 2011 and 2012, measured by Hydro-technical Facilities and Building Structures Department, compared to the permissible quantities, are given in **Table 3.2-1**.

TABLE 3.2-1 QUANTITIES OF WASTEWATER GENERATED BY THE NPP IN 2013[18]

Stream	Water origin	Permitted quantity in m^3	Generated quantity in m^3
Stream 1 TOC - MSC	Sanitary, rainfall and process wastewater from the NPP buildings and sites	1,300,000	835,934
Stream 2 Ø 300 - MSC	Rainfall and sanitary wastewater from the "clean area" of EP-3, RAW SE and AESP	48,672	3,940
Stream 3 Ø 1000 - MSC	Sanitary sewage from the "clean area" and "controlled area" of EP-2, treated water from RAW SE and AESP and treated water from the dirt and oil separator (DOS)	2,600,000	1,813,603
Stream 4 OSU - MSC	Sanitary wastewater from the OSU	1,095	1,095
Stream HC-1 - Danube River	1. Cooling and process water from NPP, Specialized Division for Decommissioning (SDD) 2. Sanitary wastewater from Kozloduy HPP	1,050,000,000	1,935,716,786
Stream HC-2 - Danube River	Cooling and process water from NPP	2,230,000,000	257,307,750

Sanitary sewage generated by the NDF operation personnel consisting of 64 people (< 22 PE) will be ca. 6-7 m^3/d and is minimal compared to the wastewater from the NPP. Their contribution to the total sanitary wastewater flow is negligible.

[18] Annual report on non-radiation monitoring of Kozloduy NPP in 2013.

FIGURE 3.2-7 MAP OF THE LOCATIONS OF KOZLODUY NPP MONITORING STATIONS

3.2.1.1.4 NON-RADIATION MONITORING CARRIED OUT BY KOZLODUY NPP

Kozloduy NPP EAD has arranged and carries out on a regular basis mandatory own non-radiation wastewater monitoring in compliance with the conditions given in the permits for discharge - at the separate sewage collectors and at the discharge points of the MSC, as well as at HC-1 and HC-2 discharge points in the Danube River. It carries out also additional internal monitoring and control at all discharge points and of the quality of wastewater discharged in the sewerage network by external users on the territory of the power plant, including also the specialized divisions of RAW SE - SDD of 1 to 4 unit and SD RAW Kozloduy.

The results of the plant's own monitoring show that the wastewater is characterized by ***Low organic contamination*** **(the registered values exceed the norms only in single cases). Measures have been taken related to the reduction of the quantity of discharged wastewater. All measurements in the recent years have registered that heavy metal concentration values are many times lower than the norms. The values in the recent years are similar.**

The monitoring is carried out on the grounds of an Annual non-radiation monitoring programmes and Annual monitoring reports.

The control monitoring at all points of wastewater discharge on the territory of the NPP is performed by the bodies of the MoEW/ExEA RL – Vratsa.

The data are compared to the Individual Emission Limits (IEL), which have been set by the DRRBMD, in accordance with Regulation No 6/09.11.2000 on the emission norms for permissible content of harmful and hazardous substances in wastewater discharged in water bodies at a moment when Regulation No 7 of 1986 on indicators and norms for assessment of the quality of flowing surface water was in force (SG, issue 96 of 1986)[19], pursuant to which the competent authority has defined in the permission document the MSC as a II category, and the Danube River as a III category receiving water body. Since 03.05.2013 in force is Regulation No H-4 of 09.14.2012 on characterization of surface waters (SG, issue 22 of March 5, 2013), which sets the procedure and methods for characterization, classification and reporting of the status/potential of surface water bodies, identification of the anthropogenic pressure on them by assessment of their ecological status/ecological potential through the monitoring system and classification of their chemical status by established quality standards for physico-chemical elements, specific pollutants, chemical and other substances, as a result of which the ecological status of each water body is determined in combination with biological and hydro-morphological quality elements.

The monitoring shows that there is no tendency for the increase of the values of the controlled indicators and significant exceedances of the permissible norms have not been registered. The values in the recent years are similar. The monitoring reports are sent periodically and annually in a summarized form to the DRRBMD, and the control over the observance of IEL is carried out by the RIEW Vratsa, in accordance with the requirements of the Water Act.

Pursuant to the provisions of the Water Act, regarding water abstraction and discharge in water bodies, the issued permits for discharge will be amended by decision of the competent authority and also in case that all parameters and conditions specified in the permits cannot be met during the construction and operation of the IP for NDF. The prohibition on new discharges of wastewater in irrigation and drainage systems will also be taken into account, art. 6, par. 1, 3, 4 of Regulation No 2 of 08.06.2011 (SG, issue 47 of 21.06.2011) on the issue of permits for discharge of wastewater into water bodies and setting individual emission limits for point sources of pollution.

The sampling locations are specified in the relevant permits for discharge of these streams, issued by the DRRBMD. The geographical coordinates of the monitoring stations are specified in the

19 Regulation No 7/1986 abrogated SG, issue 22 of 05.03.2013

respective permits, together with the control indicators, the set IEL and the quantity of wastewater, permitted for discharge.

Requirements for the future own monitoring of the NDF will be laid down by the competent authority, based on the IEL, and the proposed measures for improvement of the status of the water bodies, set out in the RBMP and in compliance with the regulations amendments.

3.2.1.1.5 GENERAL CONCLUSIONS REGARDING SURFACE WATER

- ✓ There is a technical possibility for connection of the NDF to the water mains by means of a branch-off at a suitable point of the existing water pipeline network supplying the NPP and the villages of Harlets and Glozhene and operated by ViK Vratsa OOD.
- ✓ The general condition of the existing sewerage network on the territory of Kozloduy NPP is good. Regular inspections of the separate sewerage branches are carried out. Accidents are rare and are quickly rectified. The receiver of the non-radiation municipal wastewater, rain and process water from the sewerage network is the MSC. From there the wastewater is transferred to the Danube River by means of a pumping station (PS).
- ✓ There is a technical possibility for discharge of non-radiation wastewater from the NDF in the sewerage network of Kozloduy NPP. According to letter No 2915/05.06.2014 of the DRRBMD Pleven, the permit for discharge of wastewater into the MSC No 13750001/20.04.2007 with subsequent amendments, issued to Kozloduy NPP EAD, is subject to amendment in order to include the repository wastewater, pursuant to Chapter IV, Section III of the Water Act. The NDF design does not allow for discharge of radioactive contaminated wastewater from the internal drainage system into the sewerage network of Kozloduy NPP. The technological solutions for management of surface and drainage water at the Radiana Site provide for the construction of physically separated systems for management of these water volumes justified by the possibility for their pollution. The waters caught in those areas of the Radiana Site, in which radioactive waste is not stored or buried, will be collected by gutters and drainage systems preventing them from penetration into the storage areas, and thereby eliminating the possibility for their pollution. All waters caught in areas were a potential risk of contamination exists will be collected in special watertight tanks, where they will be strictly controlled through direct measurement of their radiology status and in case their radionuclide contamination exceeds the reference levels, a technical solution is ensured for pumping them into specialized a vehicle, which will transfer them to the RAW processing plant where they will be treated in accordance with the regulatory requirements and the internal technological procedures of SD RAW - Kozloduy. Detailed analysis and assessment of potential impacts on atmospheric water and groundwater as a result of the implementation of the IP, as well as a detailed description of the drainage systems planned for the NDF is presented in Chapter 4, section 2 of the EIA Report.
- ✓ The existing treatment facilities and the Treatment Complex (Purification complex) for EP-2 can process the estimated municipal wastewater flow from the NDF, which will be negligible in quantity compared to the waters from the NPP.

Kozloduy NPP EAD has implemented and successfully performs its own non-radiation monitoring, radio-ecological monitoring and internal environmental control monitoring. The purpose of the non-radiation monitoring is to maintain the compliance with regulatory requirements and the conditions set in the permits issued by the MoEW, ExEA, DRRBMD and RIEW Vratsa. According to the developed and approved Programme for internal non-radiation monitoring, 20 indicators for the quality of wastewater discharged from the plant are monitored for compliance with the IEL set in the permits issued by the Basin Directorate. The results indicate that there is no tendency for exceeding values of the controlled indicators and significant exceedances of the permissible norms have not been registered..

3.2.1.2 RADIATION ASPECT

According to the results of the radio-ecological monitoring of Kozloduy NPP[20], the technogenic radioactivity of the surface water bodies in the area is within the normal limits, i.e. the values are typical for natural water basins and many times lower than the established norms.

Surveyed is the radioactivity of water along the Danube River stream and in inland rivers and reservoirs in the vicinity of the nuclear power plant – the Ogosta River, the Tsibritsa River and the Kozloduy Dam. Particular attention is paid to the Danube River, since it receives the liquid discharges from the NPP and is a border river.

Samples are taken at 7 control points. Danube River samples have been taken at four locations (1 upstream and 3 downstream the NPP), these are the Radetski Port (704 km), the discharge channel at RPS (687 km), the Batatovets area upstream the town of Oryahovo (682 km) and the Oryahovo Port (678 km).

The results for 2013 (**Figure 3.2-8)** show that the total beta activity is within the the normal range: from <0.018 to 0.088 Bq/l (Tsibritsa River), which is up to 18% of the norm (0.5 Bq/l as per Regulation No H-4/14.09.2012). The maximum value measured in the Danube River water is 0.079 Bq/l. These values are typical for the natural water bodies and are comparable to the data from previous years. There is no considerable difference between the data at the control points upstream and downstream of Kozloduy NPP, which proves the absence of significant impact regarding this indicator of the discharged imbalanced water.

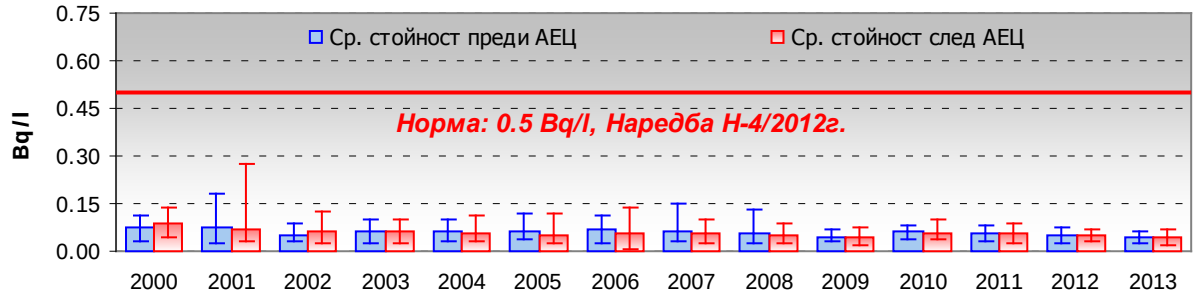


FIGURE 3.2-8 SUMMARIZED RESULTS FOR THE TOTAL BETA ACTIVITY (BQ/L) OF THE WATER IN THE DANUBE RIVER, 2000–2013

In 2013 sporadic tritium activity was registered only in the water at Water Station 1 - up to 11.5 Bq/l and at the discharge channel of the NPP - up to 84.7 Bq/l. The tritium levels registered at the other control points is slightly over the MPA (the average value of the MPA is 6.3 Bq/l). The tritium activity measured at the discharge channel shows minimum impact of the imbalanced water discharged by the NPP in the channel. The results for the activity of ^{90}Sr in 2013 vary between 2.0÷4.3 mBq/l. The gamma-spectrometric analyses show that in 2013, the activity of ^{137}Cs was very low and varied within the MPA range < 0.2 to <0.9 mBq/l for the water in the Danube River. The radiation status of the water is stable and within the normal range. The radioactivity values of the water in the inland rivers Ogosta, Tsibritsa and Kozloduy Dam are typical for natural water bodies. The total beta activity is within the range of < 0.023 ÷ 0.088 Bq/l, and the tritium content is under the MPA (Bq/l < 2.2).

In 2013, the values of ^{137}Cs (4.83 ÷ 67.74 Bq/kg a.d.w.) and ^{90}Sr (0.13 ÷ 2.08 Bq/kg a.d.w) measured in bottom sediments are comparable with the results of previous years. The activity accumulated in the sediments (silts) is an indicator of the radionuclide accumulation in water

[20]Kozloduy NPP EAD. Results from the environmental radiation monitoring of Kozloduy NPP in 2009, 2010, 2011, 2012 and 2013

basins. Data for the region show that the natural water bodies in the area are not affected by the operation of the plant. The results for the radio-ecological status of the Danube River are confirmed by the independent monitoring carried out by the Executive Environment Agency (ExEA) at the MoEW.

Increased values of specific activities of the natural and technogenic radionuclides were not observed in samples of bottom sediment from the water basins in the 30-km area of Kozloduy NPP for the period 2009-2013. According to Regulation No H-4/d 14.09.2012 on the characterization of surface water, the common beta radioactivity surveyed in the surface waters in the vicinity of Kozloduy NPP is far below the norms for the 5-year period of 2009-2013.

The results of the internal radio-ecological monitoring of the surface-flowing natural waters for the period of 2009-2013 are presented in **Table 3.2-2** .

TABLE 3.2-2 SUMMARIZED DATA FROM THE MONITORING OF NATURAL WATER, 2009 – 2013

2009	✓ There have been taken: 41 samples and a total of 134 analyses carried out (*38 gamma spectrometric, 41 radiometric for total beta activity and 14 with strontium radio-chemistry, 41 liquid-scintillation of tritium)* RESULTS: ✓ Within the normal range, characteristic for natural water bodies ▪total beta activity < 0.018 ÷ 0.14 Bq/l, average annual – 0.047 Bq/l ▪ activity of ^{90}Sr – 1.5 ÷ 3.4 mBq/l, average annual – 2.5 mBq/l ▪ activity of ^{3}H - < 4.1 ÷ 15.7 Bq/l, average annual – 5.8 Bq/l ▪ activity of ^{137}Cs - < 0.3 ÷ 2.0 mBq/l, average annual – 0.9 mBq/l
2010	✓ There have been taken: 46 samples and a total of 149 analyses were carried out (43 gamma spectrometric, 46 radiometric for total beta activity and 14 with strontium radio-chemistry, 46 liquid-scintillation of tritium) **RESULTS:** ✓ **Within the normal range, characteristic for natural water bodies** ▪ total beta activity < 0.025 ÷ 0.15 Bq/l, average annual – 0.059 Bq/l ▪ activity of 90Sr – 1.6 ÷ 6.4 mBq/l, average annual – 3.0 mBq/l ▪ activity of 3H - < 4.6 ÷ 53.8 Bq/l, average annual – 7.7 Bq/l ▪ activity of 137Cs - < 0.3 ÷ 1.0 mBq/l, average annual – 0.6 mBq/l
2011	✓ There have been taken: 53 samples and a total of 179 analyses were carried out (50 gamma spectrometric, 53 radiometric for total beta activity and 26 with strontium radio-chemistry, 53 liquid-scintillation of tritium) **RESULTS:** ✓ **Within the normal range, characteristic for natural water bodies** ▪ total beta activity < 0.012 ÷ 0.15 Bq/l, average annual – 0.056 Bq/l ▪ activity of 90Sr – 0.9 ÷ 3.9 mBq/l, average annual – 1.8 mBq/l ▪ activity of 3H - < 4.0 ÷ 22.3 Bq/l, average annual – 7.2 Bq/l ▪ activity of 137Cs - < 0.3 ÷ 1.1 mBq/l, average annual – 0.6 mBq/l

2012	✓ There have been taken: 50 samples and a total of 176 analyses were carried out (50 gamma spectrometric, 50 radiometric for total beta activity and 26 with strontium radio-chemistry, 50 liquid-scintillation of tritium) **RESULTS:** ✓ **Within the normal range, characteristic for natural water bodies** ▪ total beta activity < 0.018 ÷ 0.084 Bq/l, average annual – 0.043 Bq/l ▪ activity of 90Sr – 0.9 ÷ 8.4 mBq/l, average annual – 2.3 mBq/l ▪ activity of 3H - < 3.3 ÷ 33.0 Bq/l, average annual – 9.0 Bq/l ▪ activity of 137Cs - < 0.2 ÷0.9 mBq/l, average annual – 0.6 mBq/l
2013	✓ There have been taken: 53 samples and a total of 185 analyses were carried out (50 gamma spectrometric, 53 radiometric for total beta activity and 29 with strontium radio-chemistry, 53 liquid-scintillation of tritium) **RESULTS:** ✓ **Within the normal range, characteristic for natural water bodies** ▪ total beta activity 0.018 ÷ 0.088 Bq/l, average annual – 0.046 Bq/l ▪ activity of 90Sr – 2.0 ÷ 4.3 mBq/l, average annual – 2.8 mBq/l ▪ activity of 3H - < 2.2 ÷ 84.7 Bq/l, average annual – 6.3 Bq/l ▪ activity of 137Cs - < 0.2 ÷< 0.9 mBq/l, average annual – < 0.6 mBq/l
SUMMARY: The results are similar to those of previous years. There is no registered impact from the NPP on the water ecosystem in the region.	

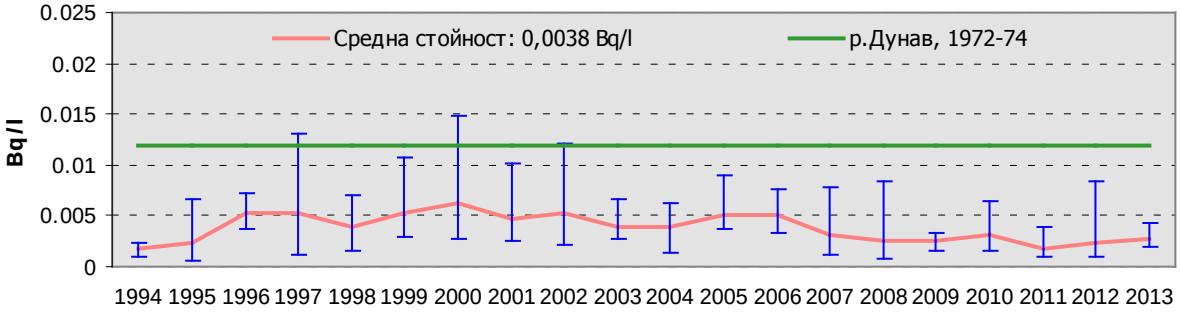


FIGURE 3.2-9 SUMMARIZED DATA FOR ^{90}SR (BQ/L) IN THE DANUBE RIVER IN THE AREA OF KOZLODUY NPP, 1994 – 2013

The figure illustrates the similarity of the data for the studied period, where the activity in the last years is lower than that in the years before commissioning of the NPP, 1972-1974. The technogenic activity of ^{90}Sr is a result of the global pollution and the levels are typical for the natural water bodies. The values vary depending on the river flow intensity, and respectively on the suspended organic and inorganic matter containing radioactivity. According to data of the National Centre of Radiobiology and Radiation Protection (NCRRP), the values of the technogenic activity in Kozloduy NPP pre-commissioning period - 1972-1974 - were 12.0 ± 2.0 mBq/l for ^{90}Sr and 4.0 ± 1.2 mBq/l for ^{137}Cs.

Summarized results of the ^{137}Cs activity in the NPP discharge water channel for the recent years are given in **Figure 3.2-10**. The radiation status of the water is stable and within the normal range. Over the past 14 years the activity of ^{137}Cs varies below levels of the pre-commissioning period 1972-1974.

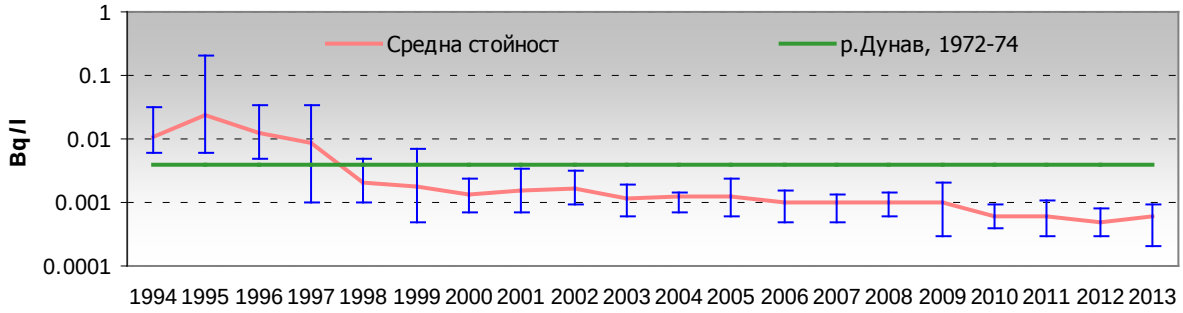


FIGURE 3.2-10 ACTIVITY OF ^{137}CS (BQ/L) IN THE WATER OF THE NPP DISCHARGE CHANNEL, 1994 – 2013

CONCLUSION

The measured values of radioactivity are close to the background radioactivity. Activities of ^{137}Cs and other characteristic nuclides, which are above the background values, have not been registered. This confirms the absence of technogenic impact of the nuclear power plant and the other facilities on the site.

The radio-ecological status of the water in the Danube River and the other water bodies in the area of the potential NDF site - Radiana has not been influenced over the years. The results are within the normal range for natural water bodies and are many times below the established norms.

3.2.2 GROUNDWATER HYDROGEOLOGY

3.2.2.1 HYDROGEOLOGICAL CONDITIONS

Radiana Site is located on the territory of the Danube Region River Basin Management Directorate, with headwaters in Pleven (DRRBMD). According to its location it falls within the Lom artesian basin in the western part of the Moesian hydrogeological region.

The hydrogeological conditions of the *Lom Artesian Basin* are characterised by layered lithostratigraphic units with varying degrees of water permeability.

According to data from 4000÷5000 m deep drills for prospecting and exploration of oil and gas and many other exploration works and researches, the following zones are differentiated according to the intensity of water circulation, from bottom upwards:

- ✓ **lower zone** with practically no water exchange containing water with high mineralization and high temperature;
- ✓ **middle zone** with slow water exchange in confined aquifers and complexes, containing water with higher mineralization and temperature;
- ✓ **upper zone** with active water exchange of confined and unconfined water bodies, containing fresh ground water.

Major regionally-distributed aquifers revealed in the lower and middle zone are the Triassic aquifer of limestone and dolomites with streaks of argillites, siltstones and sandstones at depths below 3500÷4000 m and the Middle Jurassic-Lower Cretaceous aquifer of limestones and dolomites at a depth below 2100÷3200 m. They are followed by Upper Cretaceous-Paleogene aquifer of limestone at a depth below 800÷1000 m with upper confining bed of Paleogene clays and marls and Sarmatian clays with thickness of 400÷500 m, above which lies a Meotian-Pontian aquifer complex with thickness of 200÷250 m consisting of clays predominant in the upper part of the section and with thin sandy streaks of the Smirnenski Formation.

The underground water in deeply deposited aquifers consists mainly of mineral water and brines with mineralization of 5÷10 to 130 g/l and temperature of 25÷100 ^{0}C, predominantly sodium-chloride brines, which in some places have an increased content of sulphates and hydrogen sulphide and considerable quantities of micro-elements (iodine, bromine, boronic acid, fluoride, strontium, lithium, etc. (P. Petrov, et al., 1970[21]). These have actually not been studied. For that reason, and because the drills in which they have been found were demolished, they are not included in the list of mineral waters, which are exclusive state property (Annex No 2 to art. 14 pt. 2 of the Water Act). They do not appear in the DRRBMD register of mineral water facilities, which are public municipal property.

Those regionally-distributed large and impermeable horizons (mainly the clays of the Smirnenski Formation) prevent the hydraulic connection between underground water bodies in the upper near-surface zone of the earth crust and the described deep aquifers. Therefore they act as a natural barrier against infiltration of non-radiation contaminants and radionuclides possibly generated on the site designated for construction of the NDF**.**

The upper near-surface zone of the earth at and around the Radiana Site in the Lom Artesian Basin includes parts of the following groundwater bodies: Neogene Pore Water - Lom-Pleven Depression, code BG1G00000N2034, and Quaternary Pore Water - Rivers Between Lom and Iskar, code BG1G0000Qrl023. To the north-east of the site lies the groundwater body (GWB) Quaternary Pore Water - Kozloduy Plain, code BG1G0000Qal005; Kozloduy NPP is located in its south-western periphery.

Groundwater body BG1G00000N2034 consists of two layers - upper and lower. Part of this water body, lying around the Radiana Site, is illustrated in **Figure 3.2-11**.

FIGURE 3.2-11 GROUNDWATER BODY NEOGENE PORE WATER - LOM-PLEVEN DEPRESSION, CODE BG1G00000N2034

[21]P. Petrov, S. Martinov, K. Limonadov, J. Straka, 1970. Hydrological studies of mineral waters in Bulgaria, Tehnika Publ.

The upper layer consists of a laminar aquifer of unconfined and confided nature, of Pliocene age, formed in the Brusartsi Formation, built of sandy layers, streaks and lenses among grey to greenish sandy clays and lignite at the bottom of the profile, which are widely spread within the Lom Coal Basin. In the literature it is described as *Dacian-Romanian aquifer*. It is recharged by infiltration of rainfall and surface water, and is drained in the rivers and ravines, the gravel and sandy formations of the Kozloduy Plain and the Ogosta River, and also through water abstraction facilities. Its regional hydrogeological parameters are characterized by following values: thickness of 70 m, hydraulic conductivity 140 m^2/d, transmission coefficient of 2.0 m/d, groundwater flow rate 0.8 l/s.km^2. The protective effect of the overlying layers is distributed as follows: 0% favourable, 10% average and 90% poor. The infiltration properties of the Radiana Site are low. The transmission coefficients are: for the sandy varieties - C = 0.1÷1.0 m/d and for the clays - C = 0.001-0.01 m/d. The average conductivity is assessed at 3÷4 m^2/d.

The lower layer, described in the literature as *Upper Pontian Aquifer,* is composed of small- to medium-grain, and at some places coarse-grain sands with thin clayey streaks of the Archar Formation. Its top boundary within the scope of the Radiana Site is found at elevation +4,7 m to elevation -8.4 m. The overall thickness of Archar Foundation is not exceeded in the area of the site. It is supposed to be in the range of 40÷50 m. The layer is recharged by infiltration of precipitation, irrigation waters and by the Rivers Lom, Nechinska Bara, Tsibritsa, etc., where the sands and gravels are revealed on the surface and/or overlap eolian formations in a strip with width of 1÷10 km. In this vast area of outcrops and river terraces the groundwater is unconfined. To the north, towards the Danube River, the lower layer of the groundwater body sinks under the Dacian-Romanian sediments and becomes confined. Between the villages Archar, Dobri Dol and Slivata to the north and between the town of Kozloduy and the village of Harlets to the east, the Upper Pontian aquifer crosses the Danube River beneath the alluvial formations of the Archar-Orsoya and Kozloduy Plains. In this strip, the aquifer is drained into the Danube River through a direct hydraulic connection with groundwater body Quaternary Pore Water - Archar-Orsoya Plain, code BG1G0000Qal003 - to the west and groundwater body Quaternary Pore Water - Kozloduy Plain, code BG1G0000Qal005 - to the east. The lower layer of the groundwater body in the region is characterized by medium hydrogeological parameters: thickness 100 m, hydraulic conductivity 2500 m^2/d and transmission coefficient 25 m/d. The protective effect of the overlying layers is distributed as follows: 95% favourable, 5% average and 0% poor. The infiltration properties of the upper Archar Formation, composed of fine-grained and clayey sands within the Radiana Site, are low. The transmission coefficient is C = 0.1÷3.0 m/d.

The area of the groundwater body BG1G00000N2034 is 3065 km^2, and its recharge area - 677 km^2. Based on art. 7, pt. 1 of Directive 2000/60/EC and art. 119 of the Water Act, it is designated as a drinking water protected area with code BG1DGW00000N2034, from which water intended for human consumption is extracted with an average daily flow rate of 10 m^3/d or is used for water supply to more than 50 people. Its chemical status is poor, showing deviations in the nitrate indicator, which are a result of pollution from diffuse sources (it overlaps partially with the nitrate vulnerable zone designated by Order No 930/25.10.2010 of the Minister of Environment and Water), while the chemical status of the protected zone is good. The quantitative status of the water body is good.

Groundwater body Quaternary Pore Water - Rivers Between Lom and Iskar, code BG1G0000Qrl023 is located in the basis of the eolian formations in the lands between the rivers Lom and Tsibritsa, Tsibritsa and Ogosta, Ogosta and Iskar **Figure 3.2-12**.

FIGURE 3.2-12 GROUNDWATER BODY QUATERNARY PORE WATER - RIVERS BETWEEN LOM AND ISKAR, CODE BG1G0000QRL023

The water body consists of unconfined underground streams, the flow direction of which is defined by the river-ravine network. The groundwater body is recharged by precipitation through the vadose zone and is drained by gravity springs, which form almost all ravines in the Zlatiyata plateau, as well as by water abstraction facilities (mainly shaft and tube wells) for the needs of the population. Regionally, the groundwater body is characterized by medium hydrogeological parameters: thickness 25 m, hydraulic conductivity 13 m^2/d, transmission coefficient 2.0 m/d, groundwater flow rate 1.1 l/s.km^2. The infiltration properties of the Radiana Site are represented by average values of the transmission coefficient of 0,025 m/d for the clayey loess and the sandy clays, 0,25 m/d for the silty collapsible loess and 7,6 m/d for the gravel with clayey and sandy filling (RAW SE). The protective effect of the overlying layers is distributed as follows: 30% favourable, 70% average and 0% poor. The area of the GWB is 2890 km^2, and the exposed area, excluding urbanized areas - 2807 km^2. The groundwater body is designated as a drinking water protected area with code BG1DGW0000Qal023. The quantitative and chemical status of the GWB is good. The chemical status of the protected area is good.

Groundwater body Quaternary Pore Water - Kozloduy Plain, code *BG1G0000Qal005*, has formed in the alluvial formations of the floodplain and non-flooded terraces of the Danube River, in the Kozloduy Plain. These formations are mixed with the alluvium of the mouth area of the Ogosta River in the eastern part of the plain. The length of the GWB along the Danube bank is 14 km, its width is 1.0 to 3.5 km and its area - 39 km^2. The exposed area of the GWB, excluding urbanized areas, is 37 km^2 (**Figure 3.2-12**). The floodplain river terrace has a two-layer structure with a total thickness of 15÷16 m. Its upper layer consists of sandy and silty clays with an average thickness of 6÷7 m. The average thickness of the lower gravelly-sandy layer is 7.0 m. The western part of the terrace base consists of clayey materials of the Brusartsi Formation, and the central and eastern parts of the terrace lie over the sands of the Archar Formation. The non-flooded terrace also consists of two layers. The first (upper) layer is composed of loess material. Its thickness is in the range of 11÷15 m. The second (lower) layer consists of gravelly-sandy formations. Its thickness varies from 1÷2 m to 10÷11 m, with an average of 6÷7 m. According to the hydraulic conditions, the top boundary of the groundwater body is distinguished as an unconfined to semi-confined bed. It is recharged by surface rainfall infiltration, by high water levels of the Danube River, to the south - by surface water streaming down the slope and by the groundwater in the under-loess gravel (GWB BG1G0000Qrl023), in depth - by GWB BG1G0000N2034 at contact areas with the sandy layers of the Brusartsi and Archar Formations. It is drained through the runoff in the drainage canals and towards the Danube River in the periods of low water levels, as well as through water acquisition facilities (tube and shaft wells).

Regionally, the groundwater body is characterized by medium hydrogeological parameters: thickness 13 m, hydraulic conductivity 1155 m^2/d, transmission coefficient 89 m/d, average groundwater flow rate 4.0 l/s.km^2. The protective effect of the overlying layers is distributed as follows: 0% favourable, 10% average and 90% poor.

The groundwater body is designated as a drinking water protected area with code BG1DGW0000Qal005. Currently, the quantitative status of the GWB is poor; its chemical status is good and that of the protected area - poor.

The quantitative status of the GWB is monitored by measuring the water levels in three points (**Figure 1.5-6 in Section 1 of the EIA Report**). According to the results obtained for the period 2011÷2013, the water level is set at the following depths:

→ - at point BG1G0000alMP024 - Kozloduy Tube Well (TW) (located at about 1,300 m to the south-west of the Danube River and at 5,000 m to the east-northeast of the Radiana Site) - from 0.49 m in May 2012 to 1.93 m in September 2012;

→ - at point BG1G0000alMP025 - Kozloduy TW (located at about 500 m to the south-west of the Danube River and at 5,800 m to the east-northeast of the Radiana Site) - from 0.28 m in February 2011 to 2.32 m in September 2012;

→ - at point BG1G0000alMP026 - Kozloduy TW (located at about 900 m to the south-west of the Danube River and at 5,300 m to the east-northeast of the Radiana Site) - from 0.49 m in April 2012 to 1.93 m in September 2012;

Groundwater body BG1G0000Qal005 is not present in hydrogeological profile of the Radiana Site, but due to its hydraulic connection with GWB BG1G0000N2034 it is a potential receiver of any contaminants (non-radiation and radiation) generated on-site.

Since the three groundwater bodies described within the territory and around the Radiana Site are hydraulically connected, they form a common underground infiltration flow directed from south-southwest to north-northeast towards the non-flooded and the floodplain terrace of the Danube River, which is illustrated in **Figure 1.5.7 of Section 1 of the EIA Report**. The groundwater is recharged in the area located to the south of the site and uphill (through infiltration within its boundaries) It is drained out through the water abstraction facilities (shaft and tube wells) and into the main discharge channel, through which all water collecting within the Kozloduy Plain, i.e. within the lower floodplain terrace of the Danube, are drained (by means of pumps) into the Danube River. According to the hydrodynamic map, the groundwater level within the site is established in the altitude range of 50÷30 m, with a gradient of 0.036 within Terrace T_6 and to the south of it to a gradient of 0.017 at the base of the slope in the north-eastern part of Terrace T_2, the average being estimated at 0.028 (**Figure 3.2-13**)[22].

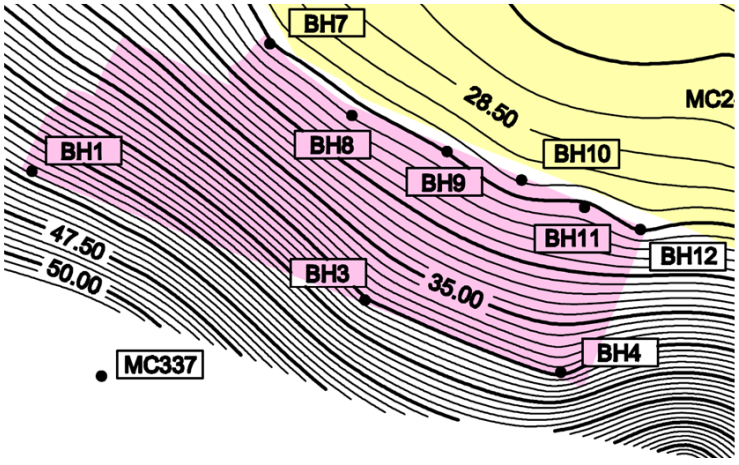


FIGURE 3.2-13 HYDRODYNAMIC MAP OF THE RADIANA SITE /GERGINOV, 2014/

[22]Gerginov, P., 2014. Hydrodynamic map of the Radiana Site area

To the north-east, towards the Danube River, the water level is set at a depth of 0.5÷5.0 m in the floodplain terrace, and up to 8÷12 m in the non-flooded terrace, at an altitude of 24.4 m to 26 m, with a gradient in the range of 0.001÷0.007.

Key factors affecting the groundwater regime are the Danube River and the hydro-technical and irrigation facilities built in the Kozloduy Plain. The change of water level follows the change of the river water level. This influence is most significant near the river (within about 500 m to the south of it). By moving away from the river (to about 2.0 km), its influence gradually decreases. The rate of aquifer level change follows the river water level, but is smoother and has much smaller amplitude.

The geological profile of the Radiana Site reveals a clearly distinguished unsaturated (vadose) zone and a saturated zone, which includes the upper and lower layer of groundwater body Neogene Pore Water - Lom-Pleven Depression, code BG1G00000N2034.

The clays of the Smirnenski Formation form the regional confining bed. This formation is not reached in the area of the site. It consists of solid, impermeable clays, which form the lower confining bed of the aquifer sediments belonging to the Archar Formation. The top boundary of the formation is at a depth of about 150÷220 m.

The results of the study of the chemical composition of water from the saturated zone in the sandy layers of Brusartsi Formation are illustrated in **Table 3.2-3**, and those of the study of the radiological composition - in **Table 3.2-4**.

TABLE 3.2-3 CHEMICAL COMPOSITION OF GROUNDWATER IN THE RADIANA SITE

No	Indicator	Unit	Results of the study		Quality standard As per Reg. No 1/2007
			Sample from MS 1	Sample from MS 9	
1	Act. reaction	pH	7.6	7.3	6.5÷9.5
2	Electrical conductivity	mS/cm	1.35	1.12	2,000
3	Oxidizability	mg O_2 /l	2.76	1.32	5.0
4	Ammonium ion	mg/l	0.04	0.03	0.50
5	Nitrites	mg/l	0.20	0.03	0.50
6	Nitrates	mg/l	0.18	7.53	50
7	Chlorides	mg/l	73.0	117.0	250
8	Sulphates	mg/l	123.0	74.5	250
9	Hydrocarbonates	mg/l	659.1	448.6	-
10	Carbonates	mg/l	9.03	-	-
11	Calcium	mg/l	23.76	83.53	150
12	Magnesium	mg/l	46.92	4.98	80
13	Sodium	mg/l	235.4	72.01	200
14	Dry residue	mg/l	874	-	-
15	Fluorides	mg/l	0.30	< 0.10	1.5
16	Natural uranium	mg/l	0.0186	0.020	0.06
17	Total beta activity	Bq/l	0.056	0.114	1.00
18	Total alpha activity	Bq/l	0.066	0.061	0.5

TABLE 3.2-4 SPECIFIC ACTIVITY OF NATURAL RADIONUCLIDES IN THE GROUNDWATER OF THE RADIANA SITE

No	Radiological parameters and radionuclides	Unit	Results of the study		
			Sample from MS 1	Sample from MS 9	Sample from MS 10
1	Potassium-40	Bq/l	0.30	0.33	0.39
2	Manganese-54	Bq/l	< 0.05	< 0.05	< 0.05
3	Cadmium-109	Bq/l	< 0.05	< 0.05	< 0.05
4	Caesium-137	Bq/l	< 0.05	< 0.05	< 0.05
5	Lanthanum-140	Bq/l	< 0.05	< 0.05	< 0.05
6	Bismuth-214	Bq/l	0.305	0.335	0.301
7	Lead -214	Bq/l	0.292	0.332	0.277
8	Radium-226	Bq/l	0.055	0.060	0.051
9	Thorium-232	Bq/l	0.042	0.042	0.040
10	Uranium-238	Bq/l	0.102	0.118	0.090
11	Uranium-235	Bq/l	< 0.05	< 0.05	< 0.05

On the grounds of these results, the following conclusions can be made regarding the groundwater in the saturated zone of the Radiana Site:

→ the concentration of the studied indicators is under the groundwater control levels pursuant to Ordinance No 1/2007;

→ the specific activity of the tested radionuclides is lower than the limit values for drinking water (dose of 0.1 mSv/a) as per the Regulation on the basic norms of radiation protection - 2012.

Regarding the geomorphology of the site, there are two options for location of the NDF:

→ Construction of a repository of the trench or tunnel type within Terrace T_6 - slope area;

→ Construction of a repository of the trench type storage in the lower, flat part of the site within Terrace T_2 - flat area.

In the slope area of Terrace T_6 The geotechnical profile includes contemporary soil, Layer 1 - collapsible loess 2nd type; Layer 2 - non-collapsible loess; Layer 3 - alluvial sandy clay; Layer 5 - Pliocene silty clay (Brusartsi Formation); Layer 6 - Pliocene sand (Brusartsi Formation); Layer 7 - Miocene clayey sand (Archar Formation); and Layer 8 - Miocene silty clay (Archar Formation).

In the variant of a trench-type repository the trench slopes will be formed in Layers 1, 2, 3 and 4. The lithological structure under the trench bottom, at an elevation of 50 m, includes:

→ under the repository modules: Pliocene silty clay (Layer 5) with thickness up to 32 m in two-thirds of the area and Pliocene sand (Layer 6) with thickness of 5.5÷7.5 m in the eastern one-third of the site area;

→ under the auxiliary buildings: Layer 5 and Layer 3 in the north-western half of the site; and Layer 2 with thickness of 5.5÷8.0 m and Layer 1 with thickness of 7.5 m in the north-eastern half.

In the variant of a trench-type repository, two hydrogeological units are distinguished under the modules: unsaturated (vadose) zone and saturated zone.

The unsaturated (vadose) zone has a total thickness of 11÷16 m in the southern part and up to 13÷17 m in the northern part of the ground base. This zone includes only clayey-sandy sediments of the Brusartsi Formation (Layer 5 and Layer 6).

The saturated zone includes the groundwater in Layers 2a and 3 and in the upper layer (Brusartsi Formation) and the lower layer (Archar Formation) within the composition of the groundwater body

Neogene Pore Water - Lom-Pleven Depression, code BG1G00000N2034. The water level is set at an altitude of 40÷45 m in the south-western part, to 32÷38 m in the north-eastern part of the area.

In the variant of a tunnel-type repository, the mine works can be made in the boundary of Layer 5 and Layers 1 and 2. In this case the unsaturated zone under the repository will include a small part of the loess formations (Layers 1 and 2), the alluvial formations (Layers 3 and 4) and the clays of the Brusartsi Formation (Layer 5).

In the flat area of Terrace T_2, the geotechnical profile includes: contemporary soil, Layer 1a - collapsible loess 1st type; Layer 2a - non-collapsible (compactible) loess; Layer 3 - alluvial sandy clay; Layer 5 - Pliocene silty clay (Brusartsi Formation); Layer 6 - Pliocene sand (Brusartsi Formation); Layer 7 - Miocene clayey sand (Archar Formation); and Layer 8 - Miocene silty clay (Archar Formation).

In the variant of a trench-type repository, two hydrogeological units are distinguished under modules: unsaturated (vadose) zone and saturated zone.

The unsaturated (vadose) zone has a total thickness of 5÷6 m. This zone includes only Quaternary eolian formations (Layer 1a and Layer 2a).

The saturated zone includes groundwater in the upper layer (Brusartsi Formation) and the lower layer (Archar Formation) within the composition of the groundwater body Neogene Pore Water - Lom-Pleven Depression, code BG1G00000N2034. The water level is set at an altitude range of 30÷38 m.

3.2.2.2 GROUNDWATER ABSTRACTION FACILITIES. SANITARY PROTECTION ZONES AROUND WATER SOURCES AND FACILITIES FOR MUNICIPAL DRINKING WATER SUPPLY

According to the information available from the DRRBMD, within the scope of the Radiana Site there are no groundwater sources, water supply facilities and sanitary protection zones of such facilities.

A number of underground water systems and facilities have been built for municipal and process water supply to Kozloduy NPP and for monitoring (non-radiation and radiation) of groundwater, as well as for municipal drinking water supply to the settlements in the area around the Radiana Site.

The municipal drinking water supply of the town of Kozloduy, Kozloduy NPP and the villages Harlets and Glozhene is provided by ViK Vratsa EOOD (*Water Supply and Sanitation Utility*). Water is abstracted on the basis of a Permit for water abstraction No 11510229/05.01.2009 issued by the DRRBMD for the Kozloduy water abstraction system, comprising three Raney-type shaft wells (SW) with radial screens. The wells are constructed in groundwater body BG1G0000Qal005, at about 250 m to the south of the Danube River banks, at the north-western vicinities of the town of Kozloduy. They are located at about 10 km to the north-west of the Radiana Site. The information available about the Kozloduy water abstraction system and the permitted water quantities (DRRBMD, 2014[23]), are given in **Table 3.2-5.**

TABLE 3.2-5 INFORMATION ABOUT THE KOZLODUY WATER ABSTRACTION SYSTEM AND THE PERMITTED WATER QUANTITIES

No	Water abstraction facility	Well depth	Static water level	Permissible drop-down S_D	Permitted flow rate, l/s	
					24-hour average	Maximum
		m			$Q_{average}$	Q_{max}
1	SW R1	38.4	7.85	9.51	35.3	150
2	SW R2	36.4	4.85	10.45	49.1	150
3	SW R3	44.3	1.53	13.51	26.9	150

[23]DRRBMD, 2014. Register of the issued underground water permits.

	∑	**111.3**	**450**

The water from the shaft wells enters a double reservoir with V = 2*2,000 m³, where it is distributed to the town of Kozloduy and to Kozloduy NPP. The drinking water is disinfected in the chlorination station. The water from the reservoirs of the town of Kozloduy is fed by gravity via two water supply pipelines to a pumping station to the east of the Radiana Site. From there, by means of a the distribution shaft, it is headed in two directions - westwards to the village of Harlets and eastwards to the plant reservoir at an elevation of 93 m, from where the water reaches the individual consumers by gravity. The water supply pipelines are currently passing through the Radiana Site, and for that reason it is planned that they are shifted to the north of the future site fence. In view of the considerable capacity given in the table, it is possible to ensure the drinking water supply to the NDF on the Radiana Site from the Kozloduy water abstraction system by means of a branch-off from the shifted pipelines made of a high-density polyethylene water pipe (HDPE) with a diameter of Ø110 mm and volumetric flow rate of 27,74 m^3/h (about 7.7 l/s).

Besides the Kozloduy water abstraction system to east and south of the Radiana Site, in order to ensure the municipal drinking water supply to the settlements around Kozloduy NPP and the Radiana Site, ViK Vratsa EOOD and the municipalities operate other water abstraction systems and facilities, the location of which is shown in **Figure 3.2-14**. Among these, permits for water abstraction from groundwater body Quaternary Pore Water - Ogosta River, code BG1G0000Qal015, held by the Municipality Kozloduy are issued for the water abstraction facilities Kriva Bara PS - TW 6 and TW 6-1 (Permit for water abstraction No 100248/21.01.2004) and Grudov Kladenets No 1 and No 2 - village of Sofronievo (Permit No 81/13.11.2000). Sanitary protection zones are established only around two water abstraction systems - Kozloduy and Kriva Bara PS - TW 6 and TW 6-1, shown in the figure.

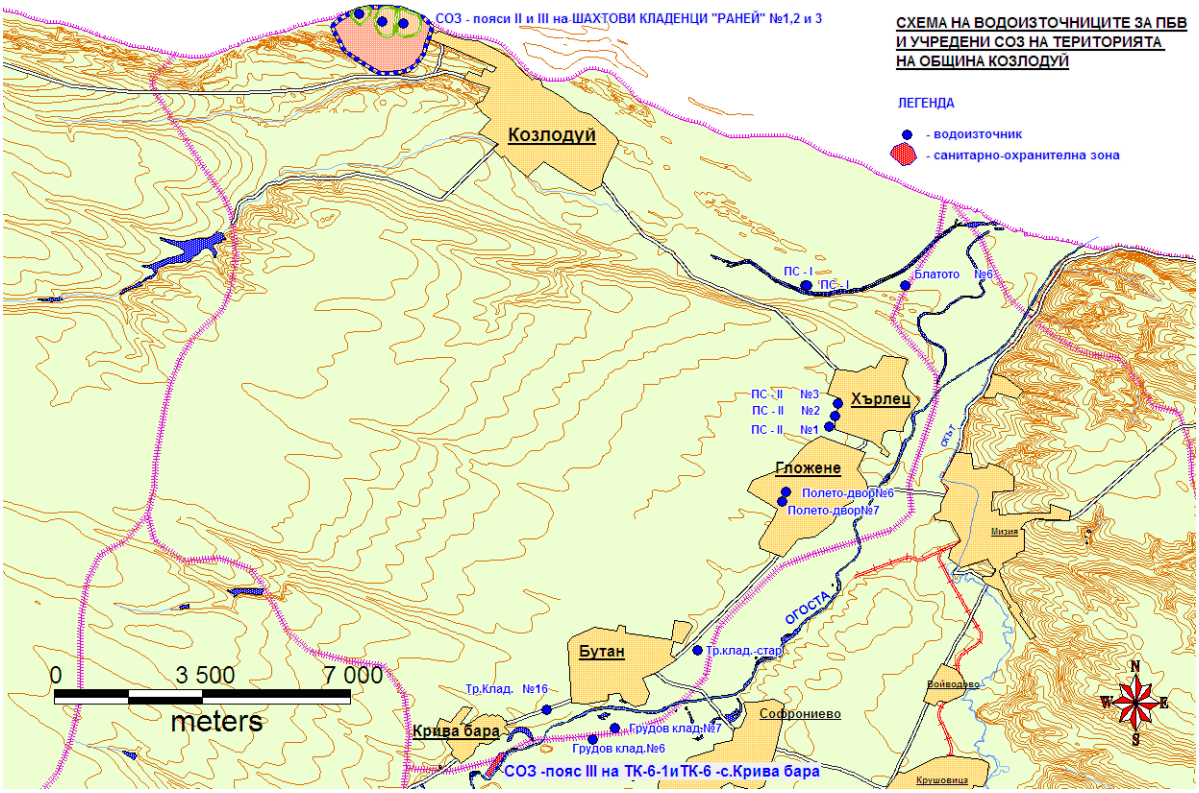


FIGURE 3.2-14 MAP OF THE WATER ABSTRACTION FACILITIES FOR MUNICIPAL DRINKING WATER SUPPLY AND THE ESTABLISHED SANITARY PROTECTION ZONES IN THE MUNICIPALITY OF KOZLODUY

Abstraction of process water for Kozloduy NPP is carried out in compliance with the conditions specified in the permits for water abstraction issued by the DRRBMD, as follows:

→ Permit for water abstraction No 11530127/30.05.2008 for six shaft wells (Shaft Pumping Stations (SPS) 1÷6) for industrial and other purposes - backup (emergency) process water supply of Unit 5 and Unit 6 and spray cooling ponds. The wells are built in GWB BG1G0000Qal005, alongside the Danube River, at about 3.8 km to the north of the Radiana Site. The depth of the wells is 26.8 m to 28.5 m, the static water level is at a depth of 2.4÷2.7 m, the permissible drop-down - 4,5÷6,0 m, the permitted average annual amount - 7,884,000 m3/y (250 l/s);

→ Permit for water abstraction No 11530128/30.05.2008 from Raney-5 Well. For process and fire-fighting purposes. The well is built in GWB BG1G0000Qal005, alongside the Danube River, at about 7.0 km to the north-east of the Radiana Site. The depth of the well is 32.6 m, the static water level is at a depth of 17.5 m, the permissible drop-down is 4.0 m, the permitted average annual amount is 1,600,000 m3/y (50.74 l/s), and the maximum flow rate is 116 l/s;

→ Permit for water abstraction No 11590203/30.05.2008 from Valyata SW for other purposes (drinking and sanitary water supply for units 1 to 4 of Kozloduy NPP). The well is built in GWB BG1G0000Qal005, at about 3.0 km to the east of the Radiana Site. The depth of the well is 25.9 m, the static water level is at a depth of 12.0 m, the permissible drop-down is 6.95 m, and the permitted average annual amount is 788,400 m3/y (25.0 l/s).

3.2.2.3 MONITORING OF GROUNDWATER IN THE AREA OF THE IP

3.2.2.3.1 NON-RADIATION MONITORING

The groundwater bodies BG1G00000N2034, BG1G0000Qal023 and BG1G0000Qal005, which in the area of the Radiana Site and the Kozloduy NPP form a common underground infiltration stream, are subject to monitoring **under the National Monitoring Programme**, carried out on the grounds of Order No РД-182/26.02.2013 of the Minister of Environment and Water. According to the results obtained (DRRBMD, 2014)[24]:

- **For water body with code BG1G00000N2034**:
  - at monitoring point (MP) BG1G0000N2MR189 TW in Septemvriytsi, Municipality of Valchedram, District of Montana, the monitored nitrate concentrations are above the threshold values since 2012 - **Figure 3.2-15**;
  - at point BG1G00000N2MR190 TW2 at Podem PS in Byala Slatina, Municipality of Byala Slatina, District of Vratsa, the annual average values for the nitrate concentrations are at the upper limit of the threshold value **Figure 3.2-15**. According to the remaining indicators the water is in good chemical status, as evident by the results of the monitoring obtained by the Regional Laboratories of Vratsa and Montana for the period 2011-2013, which are given in **Table 3.2-6**.

[24] DRRBMD, 2014. Groundwater status within the Danube Basin Management Region in 2013.

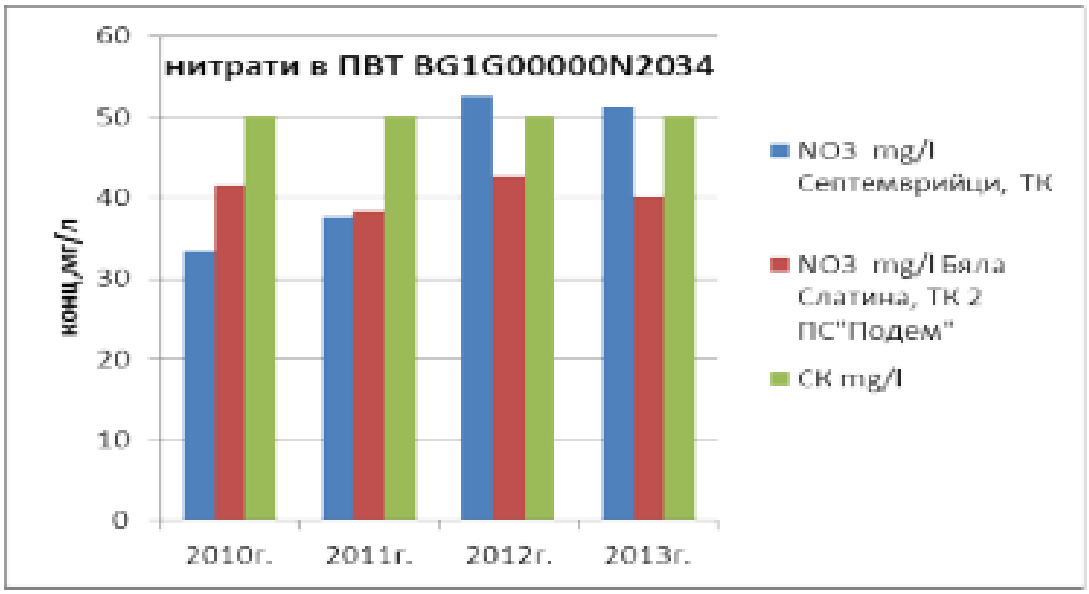


FIGURE 3.2-15 NITRATE CONTENT IN GWB NEOGENE PORE WATER - LOM-PLEVEN DEPRESSION, CODE BG1G00000N2034

TABLE 3.2-6 RESULTS OF THE GROUNDWATER CHEMICAL STATUS MONITORING IN THE PERIOD 2011÷2013

No	Indicator	Unit	Monitoring results				Quality Standard (QS) Reg. No 1 of 2007
			GWB BG1G00000N2034		GWB BG1G0000 Qal023	GWB BG1G0000 Qal005	
			MP BG1G0000N2MP189 TW Septemvriytsi	MP BG1G00000N2MP190 TW2 Podem PS Byala Slatina	MP BG1G0000QalMP122 SW Gabrovnitsa PS	MP BG1G0000QalMP027 SW-R2 Kozloduy WAS	
1	Act. reaction	pH	7.08-7.74	6.89-7.67	7.05-7.75	7.29-8.16	6.5-9.5
2	Ammonium ion	mg/l	0.02-0.434	0.01-0.426	0.02-0.254	1.96-3.7	0.5
3	Electrical conductivity	µS/cm	325-985	815-1,045	69-980	279-791	2,000
4	Potassium	mg/l	0.562-1.9	0.91-2.95	1.4-3.88	1.96-2.93	-
5	Calcium	mg/l	77-108.2	57.8-108	72.1-128	52.5-95.4	150
6	Magnesium	mg/l	14.1-57	46.6-79.2	4.9-25.5	14.3-32.2	80
7	Sodium	mg/l	57.3-69	27.6-67.9	12-23	12.4-49.4	200
8	Chlorides	mg/l	6-12.2	9.54-26.2	9.4-31	5.8-21.8	250
9	Sulphates	mg/l	15.38-29	17.1-56.7	12.66-124.28	23.1-58.2	250
10	Hydrocarbonates	mg/l	275-616	445-634	220-583	213-457	-
11	Carbonates	mg/l	2-30	0.4-0.5	12-20	0.4-12.4	-
12	Nitrates	mg/l	19.41-21.6	3.67-56.4	10-53	5.3-26.3	50
13	Oxidizability	mg O_2 /l	1.1-3.2	0.43-1.47	1.1-2.3	0.55-1.37	5
14	Dry residue	mg/l	565-652	557-834	418-668	199-583	-
15	Total solids	mg/l	mg∑qv/l	7-11.2	5.4-7.4	3.8-7.4	12
16	Temperature	^{0}C	9.8-14.6	12.5-15.8	8.2-20.6	10.8-21.8	-

- **For water body with code BG1G0000Qpl023:**
  - at point BG1G0000QalMP122 SW Gabrovnitsa PS, in the village of Gabrovnitsa, Municipality of Montana, District of Montana. The water quality meets the quality standards for good chemical status (**Table 3.2-6**).
- **For water body with code BG1DGW0000Qal005:**
  - at point BG1G0000QalMP027 SW-R2 Kozloduy WAS, Municipality of Kozloduy, District of Vratsa, the quality meets the quality standards for good chemical status (**Table 3.2-6**).

Within the programme for internal monitoring carried out by Kozloduy NPP[25] subject to control are the amount and the quality of withdrawn underground water and the underground water in the area of the plant. The internal non-radiation monitoring of groundwater at the site of Kozloduy NPP is carried out by means of 17 drilled wells, 14 of which are in the protected area and three outside the protected area of the plant. Measured are the water levels in the wells and the quality indicators of chemical status according to the regulations.

The monitoring of the chemical status of withdrawn groundwater includes annual survey of the water indicators specified by the permits as mandatory: active reaction, electrical conductivity, dissolved oxygen concentration, ammonium ions, nitrates, chlorides and sulphates. These are tested by the Vratsa Regional Laboratory, ExEA (accreditation certificate No 95 ЛИ/19.02.2009) on the basis of the respective contract. Every three years the plant carries out an internal control of the abstracted groundwater quality standard indicators (Appendix No 1 to Regulation No 1/2007 on the study, use and protection of groundwater [26]). Such studies are carried out by the Testing and Calibration Laboratory at the Chemical Engineering Division Kozloduy NPP (accredited according to BDS EN ISO/IEC 17025:2006, reg. No 122 ЛИ/06.01.2014, and accreditation order No A04/01.06.2014):

→ of the following indicators in 2011: pH, iron, cadmium, manganese, copper, nickel, lead, zinc, chromium, aluminium, mercury, antimony, arsenic, selenium, calcium, magnesium, sodium, boron, dissolved oxygen, electrical conductivity, chlorides, sulphates, ammonium ions, nitrites , nitrates, phosphates, permanganate oxidation, cyanides, natural uranium, organochlorine pesticides (α-HCH, β-HCH, γ-HCH /lindane/, δ-HCH, ε-HCH, HCB, heptachlor, aldrin, dieldrin, eldrin, metoxichlorine , o,p DDE, p,p DDE, p,q DDD, p,p DDT), nitrogen and phosphorus containing pesticides (atrazine, propazine, simazine), polycyclic aromatic hydrocarbons (benzo-/b+k/ fluoroethane, benzo-/a/ pyrene, indeno-/1,2,2-c,d/ pyrene), volatile organic compounds (benzene, 1,2-dichloroethane, trichloroethane, tetrachloroethane);

→ of the following indicators in 2013: iron, cadmium, manganese, copper, nickel, lead, zinc, chromium, aluminium, mercury, antimony, arsenic, selenium, calcium, magnesium, sodium and boron.

The results of the chemical status monitoring of the extracted groundwater during the period 2009÷2013 show:

→ exceedances of the standard values for the indicators:

- nitrates in SPS-1 in 2009 (54.5 mg/l, where the standard value is 50 mg/l);
- iron in Ranney 5 SW (258.60 μg/l in 2011 and 419.36 μg/l in 2013, where the standard value is 200 μg/l);
- manganese in SPS 1, 2, 3 and 6 (58.05÷171.92 μg/l in 2011) and in Ranney 5 SW (663.36 μg/l in 2011, where the standard value is 50 μg/l);

[25] Annual reports on the results of the internal non-radiation environmental monitoring in the area of Kozloduy NPP in 2009, 2010, 2011, 2012 and 2013.

[26] MoEW, MRDPW, MH, ME. Regulation No 1/10.10.2007 on the study, use and protection of groundwater (Prom. SG, issue 87/2007, last amendments SG, issue 28/2013)

- sodium SPS 1, 2, 3, 4 and 6 (212.1÷424.7 μg/l in 2011, where the standard value is 200 μg/l), in Valyata SW (2360.9 μg/l in 2011, where the standard value is 200 μg/l) and in Raney 5 SW (315.5 μg/l in 2011, where the standard value is 200 μg/l);
- selenium in SPS 1 - 18.04 μg/l in 2011, where the standard value is 10 μg/l).

→ the concentration of other surveyed indicators is below their standard value pursuant to Appendix No 1 to Regulation No 1/2007.

3.2.2.3.2 RADIATION MONITORING

The internal radiation monitoring of groundwater is an integral part of the long-term environmental radiation monitoring programme of Kozloduy NPP[27]. The programme is based on the industry legal requirements - art. 130 of the Regulation on ensuring the safety of nuclear power plants, prom. SG, issue 66 of 30.07.2004, art. 118 of the Regulation for radiation protection during activities with sources of ionizing radiation, prom. SG, issue 74 of 24.08.2004, art. 14, par. 1, pt. 3 of the Regulation on the conditions and procedure for establishing special-statutory areas around nuclear facilities and facilities with sources of ionizing radiation, prom. SG, issue 69 of 06.08.2004, as well as the good international practice and operational experience of the Radiation Monitoring Department.

The practical experience shows that the values measured as a result of the radiation monitoring are significantly lower than those prescribed by the regulations. For that reason, the current results are generally compared to results obtained in previous years of operation and before commissioning of the nuclear power plant. The available data on the water radioactivity in the environment of Kozloduy NPP in the pre-commissioning period 1972÷1974 show the following concentrations: Caesium (^{137}Cs) - 10.0±6.0 mBq/l, strontium (^{90}Sr) - 7.0±6.0 mBq/l, Total β-activity - 420±170 mBq/l.

3.2.2.3.2.1 Drinking water

The drinking water supplied to the town of Kozloduy, the village of Harlets, and the town of Oryahovo is tested for total β-activity and tritium (^{3}H) on a monthly basis. Strontium (^{90}Sr) and caesium (^{137}Cs) content in the water abstraction wells of Kozloduy NPP, the NPP 2nd pumping station and at Harlets are tested twice a year, and the content in Oryahovo water supply network is tested four times a year. The summarized results for the period 2009÷2013 are given in **Table 3.2-7** (Kozloduy NPP[28]).

TABLE 3.2-7 SUMMARIZED RESULTS OF THE DRINKING WATER RADIATION MONITORING

2009	Taken were: 59 samples and a total of 142 analyses were carried out (12 gamma spectrometric, 59 radiometric for total beta activity and 59 with strontium radio-chemistry, 12 liquid-scintillation of tritium) RESULTS: Within the normal limits for drinking water: - total beta activity - < 0.024÷0.088 Bq / l, average annual - 0.051 Bq/l; - activity of ^{90}Sr - 0.8÷2.3 mBq/l, average annual - 1.4 mBq/l; - activity of ^{3}H - < 4.0÷8.3 mBq/l, average annual - 5.7 mBq/l; - activity of ^{137}Cs - < 0.4÷ 1.1 mBq/l, average annual - 0.6 mBq/l.

[27] Environmental radiation monitoring programme during the operation of Kozloduy NPP, ref. No УБ.МОС.ПМ.262/02

[28] Kozloduy NPP EAD. Results from the environmental radiation monitoring of Kozloduy NPP in 2009, 2010, 2011, 2012 and 2013

2010	There have been taken: 59 samples and a total of 142 analyses were carried out (12 gamma spectrometric, 59 radiometric for total beta activity and 60 with strontium radio-chemistry, 12 liquid-scintillation of tritium) RESULTS: Within the normal limits for drinking water: - total beta activity - < 0.024÷0.088 Bq/l, average annual- 0.051 Bq/l; - activity of 90Sr - 0.8÷2.3 mBq/l, average annual - 1.4 mBq/l; - activity of 3H - < 4.0÷8.3 mBq/l, average annual - 5.7 mBq/l; - activity of 137Cs - < 0.4÷ 1.1 mBq/l, average annual - 0.6 mBq/l.
2011	There have been taken: 60 samples and a total of 144 analyses were carried out (12 gamma spectrometric, 60 radiometric for total beta activity and 60 with strontium radio-chemistry, 12 liquid-scintillation of tritium) RESULTS: Within the normal limits for drinking water: - total beta activity - < 0.024÷0.088 Bq/l, average annual - 0.051 Bq/l; - activity of 90Sr - 0.8÷2.3 mBq/l, average annual - 1.4 mBq/l; - activity of 3H - < 4.0÷8.3 mBq/l, average annual - 5.7 mBq/l; - activity of 137Cs - < 0.4÷ 1.1 mBq/l, average annual - 0.6 mBq/l.
2012	There have been taken: 59 samples and a total of 140 analyses were carried out (11 gamma spectrometric, 59 radiometric for total beta activity and 60 with strontium radio-chemistry, 11 liquid-scintillation of tritium) RESULTS: Within the normal limits for drinking water: - total beta activity - < 0.031÷0.075 Bq/l, average annual - 0.048 Bq/l; - activity of 90Sr - 0.8÷2.6 mBq/l, average annual - 1.4 mBq/l; - activity of 3H - < 3.9÷6.4 mBq/l, average annual - 4.8 mBq/l; - activity of 137Cs - < 0.4÷ 0.8 mBq/l, average annual - 0.6 mBq/l.
2013	There have been taken: 60 samples and a total of 144 analyses were carried out (12 gamma spectrometric, 60 radiometric for total beta activity and 60 with strontium radio-chemistry, 12 liquid-scintillation of tritium) RESULTS: Within the normal limits for drinking water: - total beta activity - < 0.024÷0.084 Bq/l, average annual - 0.046 Bq/l; - activity of 90Sr - 0.5÷2.4 mBq/l, average annual - 1.4 mBq/l; - activity of 3H - < 2.2÷7.6mBq/l, average annual - 3.6 mBq/l; - activity of 137Cs - < 0.9÷ 1.4 mBq/l, average annual - 0.9 mBq/l.

CONCLUSION

The analysis of the results for the period 2009÷2013 shows that the values are similar and comparable to those of previous years. The conclusion can be made that the radiation status of drinking water in the area around the IP site is not influenced by the operation of Kozloduy NPP

and is in full compliance with the sanitary norms pursuant to Regulation No 9/2001 [29] and the Regulation on the basic norms for radiation protection - 2012 [30].

3.2.2.3.2.2 Groundwater at the site of Kozloduy NPP

186 drilled wells (piezometers) are installed on the site of Kozloduy NPP. Of these, 76 are located in the area of units 1÷4, 52 in the area of EP-2 and 58 around the SFS, the RAW Storage Facility and the Lime Plant. Since the commissioning of the RAW Processing Plant (RAWPP) in 2001, 26 newly installed piezometers have been included in the monitoring, and since 2012 - five new piezometers have been added on the west side of the DSF Storage Facility.

In 2013, samples for study of the groundwater radioactivity were taken from a total of 121 drilled wells. Of these, 26 were in the area of units 1-4, 30 in the area of EP-2, 26 in the area of SFS and RAWPP and RAW Storage Facility, 31 in the area of SFS, DSF Storage facility, RAW Storage Facility, the Lime Plant and site for temporary open storage of solid RAW, and 5 at the landfill. Sampling and analysis at benchmarking (comparative) drilled wells in the vicinity of the industrial site has been started in August 2004.

Water samples from the drilled wells are analysed four times a year for total beta activity and tritium content.

The drilled wells, which have showed total beta activity higher than 1.0 Bq/l, are subjected to additional gamma-spectrometric analysis. The measurements are made without radiochemical processing with regard to geometry (Marinelli-2l). The minimum detectable activity for a spectrometry period of 20,000 seconds varies within the range of 0.041÷0.49 Bq/l for ^{134}Cs, 0.075 ÷ 0.36 Bq/l for ^{137}Cs and 0.096÷0.34 Bq/l for ^{60}Co.

Summarized results of the groundwater radiation monitoring in the period 2009÷2013 are shown in **Table 3.2-8**.

TABLE 3.2-8 SUMMARIZED RESULTS OF THE RADIATION MONITORING OF GROUNDWATER ON THE SITE OF KOZLODUY NPP

2009	Taken were: 611 samples from 116 wells, and a total of 1,298 analyses were carried out (76 gamma spectrometric, 611 radiometric for total beta activity and 611 liquid-scintillation of tritium) RESULTS: - total beta activity - < 0.051÷2.10 Bq/l, average annual - 0.047 Bq/l; - activity of 3H - < 4.1÷14.2 κBq/l, average annual - 311.0 Bq/l; - activity of 137Cs - < 0.08÷ 0.79 Bq/l, average annual - 0.21 Bq/l.
2010	Taken were: 611 samples from 116 wells, and a total of 1,301 analyses were carried out (761 gamma spectrometric, 615 radiometric for total beta activity and 615 liquid-scintillation of tritium) RESULTS: - total beta activity - < 0.041÷2.52 Bq/l, average annual - 0.181 Bq/l; - activity of 3H - < 4.15÷10.6 κBq/l, average annual - 267.5 Bq/l; - activity of 137Cs - < 0.11÷ 0.50 Bq/l, average annual - 0.23 Bq/l
2011	Taken were: 692 samples from 115 wells, and a total of 1,308 analyses were carried out (76 gamma spectrometric, 616 radiometric for total beta activity and 616 liquid-scintillation of tritium)

[29] MH, MRDPW, MoEW. Regulation No 9/16.03.2001 1 on the quality of water intended for human consumption (prom. SG, issue 7/21)

[30] Regulation on the basic norms for radiation protection (Prom. SG, issue 76/05.11.2012)

	- RESULTS: - total beta activity - < 0.051÷3.02 Bq/l, average annual - 0.193 Bq/l; - activity of 3H - < 4.15÷10.6 κBq/l, average annual - 317.6 Bq/l; - activity of 137Cs - < 0.17÷ 0.52 Bq/l, average annual - 0.22 Bq/l
2012	Taken were: 6,926 samples from 120 wells, and a total of 1,312 analyses were carried out (80 gamma spectrometric, 616 radiometric for total beta activity and 616 liquid-scintillation of tritium) RESULTS: - total beta activity - < 0.032÷2.95 Bq/l, average annual - 0.206 Bq/l; - activity of 3H - < 3.8÷50.6 κBq/l, average annual - 607.4 Bq/l; - activity of 137Cs - < 0.07÷ 0.59 Bq/l, average annual - 0.19 Bq/l
2013	Taken were: 717 samples from 121 wells, and a total of 1,331 analyses were carried out (103 gamma spectrometric, 614 radiometric for total beta activity and 614 liquid-scintillation of tritium) RESULTS: - total beta activity - < 0.028÷2.71 Bq/l, average annual - 0.208 Bq/l; - activity of 3H - < 5.2÷13.7 κBq/l, average annual - 263.6 Bq/l; - activity of 137Cs - < 0.10÷ 0.50 Bq/l, average annual - 0.22 Bq/l

CONCLUSION

The radiation status of the groundwater in the area of Kozloduy NPP is influenced only in small local areas adjacent to the facilities of radioactive potential. Technogenic impact has not been registered outside the plant borders. This is evidenced by the results obtained by surveying the reference wells, which are within the normal background levels.

The technogenic activity of groundwater at the NDF Radiana Site is within normal background levels, typical for this environmental component.

3.2.2.4 PRE-COMMISSIONING GROUNDWATER MONITORING AT THE RADIANA SITE

The pre-commissioning groundwater monitoring at the Radiana Site is intended to provide additional and more detailed and reliable information about:

→ the hydrogeological conditions, including geochemical characteristics of the pore water in the unsaturated zone and in the saturated zone;

→ hydrodynamic characteristics and mass-transfer parameters of the aquifer;

→ partition coefficients for key radionuclides of the main lithological variations;

→ radiological condition of the site prior to the commissioning of the NDF;

→ development of a programme for hydrological and radiation monitoring during the operation and after the closure of the NDF;

→ realistic assessments of the radiation exposure of the population living in the vicinity of the repository during its operation.

For the realization of these fundamental goals, the RAW SE, NDF SD has prepared and approved on 04.01.2013 the following programmes:

→ Programme for pre-commissioning hydrogeological monitoring of the National Repository for Radioactive Waste, ref. No HX-PEM-MP -002/01;

→ Programme for pre-commissioning radiation monitoring of the National Repository for Radioactive Waste, ref. No HX-PEM-MP -001/01.

3.2.2.4.1 PROGRAMME FOR PRE-COMMISSIONING HYDROGEOLOGICAL MONITORING

The Programme for pre-commissioning hydrogeological monitoring includes:

→ design and construction of a system for hydrological monitoring and geochemical analyses on the NDF site;

→ identification and provision of additional and more detailed information about the hydrogeological conditions of the site, the geochemical characteristics of pore water (in the vadose zone), the groundwater and the soil types;

→ specification of the distribution coefficients of key radionuclides (the values of C_d) in the main soil types;

→ indicative mass-transfer field tests for specification of some hydrodynamic characteristics and mass-transfer parameters of the aquifer.

Based on the results of the long-term monitoring, further mathematical modelling will be made of the seepage flow in the vadose zone and in the aquifer, and of the hydrodynamic conditions in the subsoil area and a programme for hydrological monitoring during the operation of the NDF will be developed.

The activities connected with the pre-commissioning hydrological monitoring and geochemical analyses are planned to last 36 months in total, of which six months are planned for the development of the monitoring project, building of the monitoring system, including also the monitoring wells and summarizing the results at the end of the 30-month monitoring period. Interim analysis of the monitoring results will be made every 6 months.

During the implementation of this programme under the NN Commercial Project[31],[32] 12 monitoring points (piezometers BH1÷BH12) and two tracers (markers BHT1 and BHT2) for indicative mass transfer field trials were installed in 2013. Their location is illustrated in **Figure 3.2-16** and the depth, coordinates and altitude are given in **Table 3.2-9**[33].

[31] NN Commercial, 2013. Deliverable D 4: Design of the Overall Monitoring System Including Vadose Zone and Saturated Zone (Aquifer) Monitoring

[32] NN Commercial, 2013. Deliverable D 6: Construction of Vadose Zone Monitoring Systems

[33] NN Commercial, 2013. Deliverable D 12: Construction of the Saturated Zone (Aquifer) Monitoring Systems

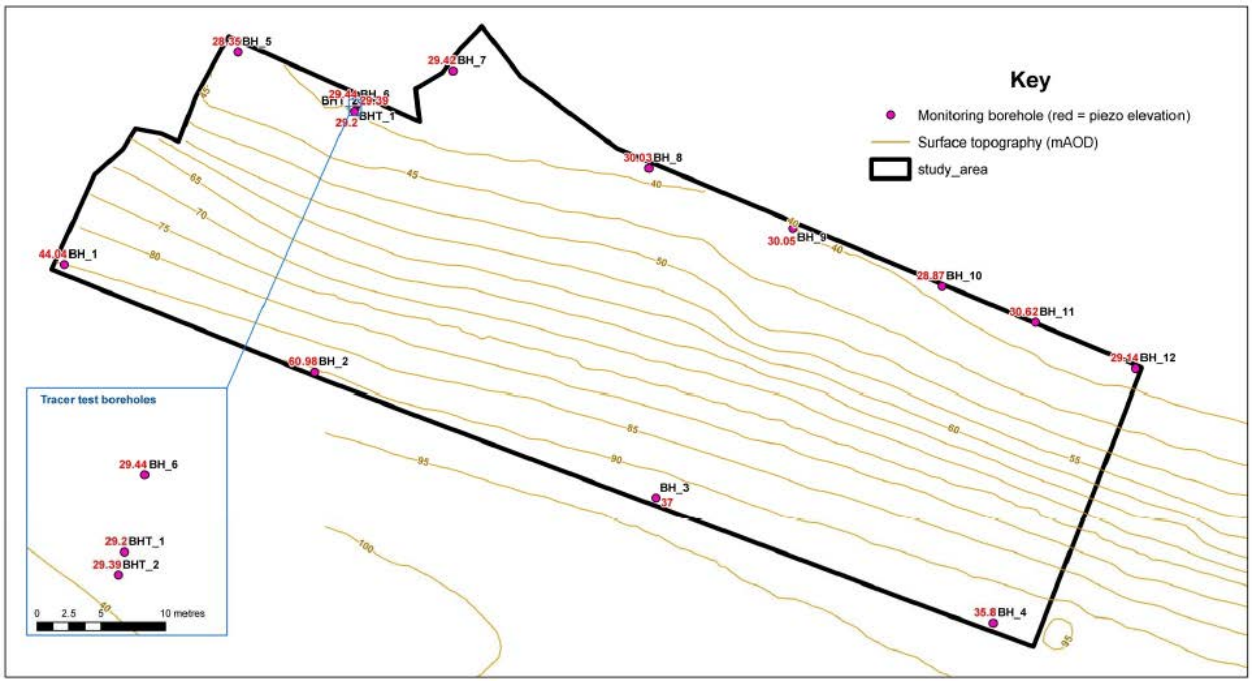


FIGURE 3.2-16 LOCATION OF MONITORING POINTS FOR PRE-COMMISSIONING MONITORING OF GROUNDWATER

3.2.2.4.2 PROGRAMME FOR PRE-COMMISSIONING RADIATION MONITORING

With regard to groundwater, subject to the pre-commissioning radiation monitoring are:

→ the drinking water - one monitoring point at the water supply network of the town of Kozloduy;

→ the groundwater in the existing piezometers and in those planned for installation in the near future.

RAW SE has assigned the activities under the programme to the Tita-Consult OOD and to Radio-Environmental Monitoring - Kozloduy NPP EAD, based on contract No 2012049/09.07.2012. After the expiry of the contract, the programme activities will be assigned to appropriately trained personnel of the RAW SE. Tita-Consult OOD has developed a Programme for pre-commissioning radiological monitoring of the Radiana Site (ref. No ТК.Д-142-D3/2012), in compliance with the approved programme and as part of the assigned contract.

TABLE 3.2-9 DEPTH AND COORDINATES OF THE POINTS FOR PRE-COMMISSIONING GROUNDWATER MONITORING

Monitoring point (piezometer)	Depth m	Geodetic coordinates		Altitude at the mouth, m
		X	Y	
BH1	60.00	8,542,478.34	4,755,805.64	86.10
BH2	39.00	8,542,794.16	4,755,680.44	90.87
BH3	107.00	8,543,192.32	4,755,529.30	93.52
BH4	79.00	8,543,611.90	4,755,374.77	93.85
BH5	24.47	8,542,683.62	4,756,069.57	40.74
BH6	15.14	8,542,851.68	4,755,995.13	40.38
BH7	35.00	8,542,988.16	4,756,078.59	37.64
BH8	46.11	8,543,164.12	4,755,925.20	39.39
BH9	15.98	8,543,368.27	4,755,847.37	41.13

Monitoring point (piezometer)	Depth m	Geodetic coordinates		Altitude at the mouth, m
		X	Y	
BH10	25.68	8,543,528.44	4,755,786.46	40.06
BH11	36.07	8,543,662.66	4,755,727.81	38.53
BH12	47.00	8,543,783.35	4,755,680.44	37.91
BHT1	12.62	4,755,693.54	8,543,495.40	40.10
BHT2	15.10	4,755,685.58	8,543,493.88	40.31

TABLE 3.2-10 RESULTS OF THE PRE-COMMISSIONING GROUNDWATER MONITORING AT THE RADIANA SITE

Радиоактивност на подземни води от площадка "Радиана" - НХРАО

Предексплоатационен мониторинг - "Тита Консулт" ООД - ЛИ-РМ на АЕЦ "Козлодуй", 2013-2014 г.

Обща бета активност, Bq/l									*контролно ниво <1 Bq/l, (Наредба №1/10.10.2007г.)*			
	Сондажен кладенец №											
Дата	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9	BH-10	BH-11	BH-12
03.10.2013	< 0.059	0.103 ± 18 %	0.071 ± 28 %	0.095 ± 25 %	< 0.074	< 0.095	< 0.076	< 0.058	< 0.087	< 0.061	< 0.084	0.071 ± 20%
05.11.2013	0.077 ± 25 %	0.108 ± 18 %	0.097 ± 29 %	0.132 ± 19 %	< 0.066	0.109 ± 28 %	0.070 ± 31 %	< 0.059				
09.12.2013	0.084 ± 29 %		< 0.077	0.18 ± 14 %					0.099 ± 27 %	< 0.075	< 0.065	0.095 ± 18 %
07.01.2014	< 0.026	0.045 ± 19 %	< 0.031	0.030 ± 29 %	0.038 ± 22 %	0.031 ± 26 %	< 0.031	< 0.027				
11.02.2014	< 0.073	< 0.084	< 0.071	0.101 ± 22 %					< 0.011	0.055 ± 29 %	0.087 ± 23 %	0.084 ± 15 %
03.04.2014	< 0.059		< 0.064	0.11 ± 26 %					< 0.095	0.11 ± 16 %	0.073 ± 23 %	0.240 ± 11 %
08.05.2014	< 0.056	< 0.093	< 0.064	< 0.046	< 0.074	< 0.094	0.072 ± 24 %	< 0.047				
06.06.2014	0.048 ± 13 %		< 0.070	0.090 ± 23%					< 0.092	< 0.045	< 0.062	0.103 ± 20%

Обща алфа активност, Bq/l									*контролно ниво <0.5 Bq/l, (Наредба №1/10.10.2007г.)*			
	Сондажен кладенец №											
Дата	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9	BH-10	BH-11	BH-12
03.10.2013	0.085 ± 11 %	0.081 ± 11 %	0.069 ± 10 %	0.113 ± 11 %	0.137 ± 10 %	0.062 ± 10 %	0.047 ± 11 %	0.069 ± 10 %	0.077 ±10 %	0.076 ±11 %	0.045 ±11 %	0.046 ±11 %
05.11.2013	0.062 ± 11 %	0.113 ± 11 %	0.063 ± 11 %	0.076 ± 11 %	0.069 ±10 %	0.160 ±10 %	0.032 ± 9 %	0.035 ±11 %				
09.12.2013	0.119 ± 11 %		0.124 ± 11 %	0.036 ± 11 %					0.051 ± 12 %	0.090 ± 11 %	0.033 ±12 %	0.016 ± 13 %
07.01.2014	0.082 ± 11 %	0.149 ± 11 %	0.059 ± 10 %	0.106 ± 10 %	0.063 ± 11 %	0.151 ±11 %	0.031 ± 13 %	0.030 ± 13 %				
11.02.2014	0.173 ± 10 %	0.137 ± 11 %	0.166 ± 10 %	0.050 ± 12 %					0.148 ± 10 %	0.188 ±10 %	0.188 ±10 %	0.053 ± 11 %
03.04.2014	0.106 ± 10 %		0.185 ± 10 %	0.052 ± 12 %					0.092 ± 11 %	0.152 ± 11 %	0.127 ±11 %	0.112 ± 11 %
08.05.2014	0.125 ± 11 %	0.133 ± 11 %	0.104 ± 11 %	0.040 ± 13 %	0.171 ± 11 %	0.281 ± 10 %	0.055 ± 11 %	0.048 ± 13 %				
06.06.2014	0.028 ± 11%		0.079 ± 10%	0.012 ± 17%					0.021 ± 14%	0.032 ± 13%	0.025 ± 12%	0.046 ± 11%

НАРЕДБА № 1 от 10.10.2007 г. за проучване, ползване и опазване на подземните води

Активност на Тритий (^{3}H), Bq/l									*контролно ниво <100 Bq/l, (Наредба №9/16.03.2001г.)*			
	Сондажен кладенец №											
Дата	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9	BH-10	BH-11	BH-12
03.10.2013	< 2.2	5.5 ± 14.2%	< 2.2	4.0 ± 18.9%	< 2.2	< 2.2	< 2.3	< 2.4	< 2.3	< 2.5	< 2.4	< 2.3
05.11.2013	< 6.3	< 6.4	< 6.2	< 6.4	< 6.3	< 6.4	< 6.3	< 6.3				
09.12.2013	< 6.7		< 6.6	< 6.6					< 6.7	< 6.6	< 6.6	< 6.6
07.01.2014	< 6.3	< 6.4	< 6.5	< 6.4	< 6.4	< 6.4	< 6.3	< 6.5				
11.02.2014	< 6.3	< 6.4	< 6.4	< 6.4					< 6.4	< 6.3	< 6.4	< 6.4
11.03.2014	< 6.9	< 7.0	< 7.1	< 7.3	< 7.3	< 7.4	< 7.3	< 7.3				
03.04.2014	< 6.5		< 6.8	< 6.5					7.8 ± 27 %	< 6.5	< 7.1	
08.05.2014	< 6.5	< 6.6	< 6.6	< 6.6	< 6.6	< 6.6	< 6.6	< 6.3				
06.06.2014	< 6.7		< 6.7	< 6.6					< 6.6	< 6.6	< 6.7	< 6.6

НАРЕДБА № 9 от 16.03.2001 г. за качеството на водата, предназначена за питейно-битови цели

The personnel of Tita-Consult OOD organize and take samples at the control points designated by the programme.

The personnel of Radio-Environmental Monitoring - Kozloduy NPP EAD will carry out the preparation and analysis of data in compliance with the established methodology and will draw the sample test protocols.

For the purpose of the radio-ecological groundwater monitoring, the following parameters are surveyed, with a sampling frequency, as follows:

→ total alpha activity and total beta (+alpha) activity - twice a year in the drinking water of the town of Kozloduy and every month of the groundwater in drilled wells at and around the Radiana Site;

→ concentration of key radionuclides in samples:

→ ^{3}H - twice a year in the drinking water of the town of Kozloduy and every month of the groundwater in drilled wells at and around the Radiana Site;

→ γ-nuclides - monthly in the groundwater;

→ ^{63}Ni, ^{99}Tc and ^{129}I - once a year in the groundwater.

At the end of the first year after the programme commencement the sampling frequency and the surveyed parameters will be updated.

The results of the pre-commissioning groundwater monitoring of the Radiana Site to date are summarized in **Table 3.2-10**.

The gamma-spectrometric analyses have not registered technogenic and other natural radioactivity in samples. The results for the respective radionuclides are under the MPA, average values of which are shown in **Table 3.2-11**.

TABLE 3.2-11 AVERAGE VALUES OF RADIOLOGICAL INDICATORS IN THE GROUNDWATER OF THE RADIANA SITE

Piezometer used for sampling	Radionuclide	Average value of the activity in Bq/l < MPA
Drilled wells BH 1÷2	^{7}Be	< 1.77
	^{40}K	< 1.97
	^{54}Mn	< 0.19
	^{57}Co	< 0.18
	^{58}Co	< 0.19
	^{59}Fe	< 0.38
	^{60}Co	< 0.18
	^{65}Zn	< 0.48
	^{94}Nb	< 0.17
	^{95}Nb	< 0.24
	^{103}Ru	< 0.22
	^{10}Ru	< 1.72
	^{110}Ag	< 0.19
	^{131}I	< 0.54
	^{34}Cs	< 0.19
	^{137}Cs	< 0.20
	^{26}Ra	< 4.32
	^{235}U	< 0.27
	^{238}U	< 16.7

The results presented in the table show that at the Radiana Site of the NDF radioactive impact on groundwater has not been not registered. The values of all surveyed radionuclides, determined in the radionuclide list of Programme for pre-commissioning monitoring, are under the MPA. These are typical background levels characteristic for this geographical area.

3.3 SUBSURFACE. GEOLOGICAL SETTING, NATURAL RESOURCES AND SEISMIC ACTIVITY

3.3.1 GEOMORPHOLOGICAL SETTING

Regionally, the area of the Radiana Site is located in the western part of the Danube hilly plane - a morphostructural area, the modern topography of which is to a great extent the product of geological and lithological composition and the tectonic development of the Moesian platform.

The Danube plain is mainly flat and its predominant altitude is 100÷250 m. Its topographic surface is slightly inclined to the north-east. The valleys of the rivers Lom, Tsibritsa and Ogosta have cut into the flat plain, thus altering its initial topography. The right slopes of the river valleys in the riparian part of the plane and along the Danube River reveal the upper layers of the Dacian-Romanian Formation, represented by colourful clays. The valleys of Lom, Tsibritsa, Ogosta and

Skat break the plane into flat asymmetric ridges extending from the south-west to the north-east. Across the entire area these watershed divide plateaus consist of a thick loess layer. At many places the ridges end up in steep slopes descending to the Danube River, and their lower sections are terraced by landslides - a result of gravitational processes and phenomena. They are manifested in the Quaternary loess formations and the underlying clayey and sandy deposits of the Neogene Brusartsi Formation. The inter-valley ridges are asymmetrical, with long and low-grade eastern slopes and short, steeply descending western slopes. The watershed divide usually passes along their western parts. The eastern slopes of the ridges have gentle and wavy surface, which makes an almost imperceptible transition to the river terraces of the neighbouring valleys, while to the west they end up with steep slopes, at places cut by deep ravines and gullies. This marked asymmetry of the river valley network is due to the gradual shifting and sinking of the rivers to the east. Vast alluvial lowlands have formed along the Danube, where the high main bank retreats into the plain. Slightly indented 160÷180 m high loess plateaus are distinguished along the riparian area. The Zlatiyata Plateau, between the rivers Tsibritsa and Augusta, is flat and low, divided by dry gullies, some of which are up to 40 m deep and up to 10 km long.

The presence of a fairly thick loess cover, the geotechnical properties of the loess formations and the climatic conditions have contributed to the formation of specific loess forms, such as greda ridges, "steppe dishes" and loess walls.

Greda ridges are oblong, rounded sand hills with length up to 2.0 km and are formed only on the floodplain Danube river terrace in the Kozloduy Plain.

Steppe dishes - inherited land depressions of destructive origin, filled with fluviogenous deposits, are the most typical land forms on the Zlatiyata Plateau.

Loess walls are observed along the river banks, developed mainly in areas with thick loess layers. The largest are those near Harlets - 30 m high, near Kozloduy – 20÷30 m high. Their formation is associated with one of the most characteristic loess properties – the vertical cleavage.

Loess yields to quick development of gullies and ravines. River-bank edges feature "loess funnels" - vertical-wall fissures of erosion and anthropogenic nature.

The main stages in the development of the Danube Plain topography are determined by the Pliocene and Quaternary neo-tectonic movements. The form, the nature and the pace of the neo-tectonic movements have influenced the denudation and accumulation processes and have delineated several plantation stages, which outline the general evolution of the topography.

In the Pliocene the Radiana Site area was included into the Lom Bay of the Dacian Lacustrine Basin. 2.59 Ma ago there was a climate cooling and a land uplift, accompanied by intense coastal erosion processes. Sediments of the basal gravelly-sand bed are deposited over the Lower Romanian clays. They form the basis of the so-called "old abrasion-accretion level" (OAAL).

The quaternary stage began with renewal of the differential epeirogenic movements. Simultaneously, global climate changes occurred as a result of freezing. The cumulative effect of these endogenous and exogenous processes led to significant changes in the landscape and outlined the beginning of a new cycle of sediment accretion of the so called "covering gravelly-clay bed", which was subsequently covered by loess.

The activity of endogenous and exogenous processes during the Quaternary period is clearly manifested in the landscape of modern river valleys. The stages in this evolution are most distinctly marked in the river terraces of the Danube.

The Danube bank can be divided into two parts. Larger part of it is steep, with predominant landslide and slump processes, forming typical morphological forms. The smaller part of it comprises the two riparian lowlands – Kozloduy and Dolni Tsibar plains.

The Kozloduy Plain features a well-developed floodplain and a non-flooded terrace of the Danube River. The floodplain terrace rises at 3÷6 m above the river. Its surface is slightly undulated by long and low ridges (the so called greda ridges), with a height of 7÷10 m. In the past, this terrace was swamped. Consequently the area was drained and dikes were built along the Danube, Ogosta and Skat. The non-flooded terrace lies at 10÷20 m above the Danube River.

Radiana Site is located on the slope along the south-western periphery of the Kozloduy Plain. The area around it includes part of the Zlatiyata loess plateau between the rivers Tsibritsa and Ogosta, indented by relatively small tributary valleys, two of which are tributaries of the Danube River, and the rest - flow into the Ogosta River, to the south of the village of Glozhene, near the villages Butan, Kriva Bara, Bazovets, Septemvriytsi, etc.

The tributary valleys were formed in the Pleistocene. They feature accreted pre-deposited loess, in a layer thinner than that of the plateau.

The terrain of the loess plateau is flat and is genetically linked to OAAL. This level is incised in the Pliocene (Lower Romanian) clays. Its profile is revealed in the higher right bank of the Tsibritsa River, near the villages Zlatya, Valchedram and Madan. The eroded Lower Romanian clays are covered by fluvial-lacustrine sediments, represented by basal gravelly-sand bed and covering gravelly-clay bed. The top boundary of the alluvium has an absolute elevation of 125÷130 m and slopes towards the Danube River. They are covered by the loess group, represented by six loess layers, separated by buried soils. To the south, beyond the boundary of the studied area, the OAAL borders on the Pliocene denudation surface. A range of river terraces (T_6 to T_0, depending on number of loess horizons), formed in the Glacial Pleistocene and the Holocene, are featured from the plateau to the modern river beds of the Tsibritsa, Ogosta and Danube.

A large number of steppe dishes, dells and gullies are featured in the loess plateau and the high river terraces around Kozloduy NPP. All of them have been imprinted in modern topography by older depressions, which have been flooded during the eolian loess accretion and therefore are lined with more or less altered and clayey loess.

The present topography of area around the Radiana Site has formed under the influence of the abrasion-accretion activity of Dacian Fluvial-Lacustrine Basin, and later by the erosion-accretion activity of the Paleo-Danube and Paleo-Ogosta rivers. The old abrasion-accretion level is featured in the western and the southern part of the area. To the east, a considerable area is occupied by a gentle slope, formed in the OAAL sediments, and to the north-east lie the river terraces. The Radiana Site and the terrain lying to the south are part of a slope stretching from elevation of 38÷39 m to an approximate elevation of 120 m. It features the following geomorphological forms:

→ Gentle slope between OAAL and Terrace T_6 in the altitude range of 98÷120 m, as well as between Terraces T_6 and T_2 with width of 60÷100 m and elevation from 58 m to 46 m. The slope cuts into the Lower Romanian clays and sands of the Brusartsi Formation. The loess cover has a maximum thickness of up to 47 m in the upper part of the slope and reduces to 7÷8 m between Terraces T_6 and T_2;

→ Terrace T_6 - width of 270÷380 m, elevation from 98 m to 58 m. The central and western footing of the terrace in the area of Kozloduy NPP cuts into Lower Romanian clays (Brusartsi Formation) at an elevation of 51÷54 m. The eastern footing is at height of about 50 m, and buried in sands of the Brusartsi Formation. The alluvium top boundary has elevations in the range of 52÷57 m. The overlying loess cover consists of five buried soil layers, separated by loess layers;

→ Terrace T_2 - width of 70÷120 m, elevation from 46 m to 38÷39 m. Its footing cuts into Lower Romanian clays and sands at an elevation of 23÷25 m, while at the rear part of the terrace the elevation is up to 27 m. The alluvium top boundary is at an elevation of 26÷27 m and up to 30 m in the rear part of the terrace. The loess cover consists of two loess layers separated by buried soil.

The inclination of the slope is to the north-east. It varies in the range of $4.8 \div 5.7^0$ at Terrace T_2, $9.5 \div 10^0$ along the gentle slope between Terraces T_6 and T_2 and $9.3 \div 9.8^0$ within Terrace T_6. The average inclination within the area of Terrace T_2 to Terrace T_6 is $8.4 \div 8.6^0$.

Terraces T_1 and T_0 lie between Terrace T_2 and the right bank of the Danube River.

Terrace T_1 is a plane with an altitude of 38÷28 m. Kozloduy NPP is situated on this terrace. Its width to the north of the plant ranges from 900 m to 1200 m. To the north-west, within the town of Kozloduy, it widens up to 1300 m. To the east it narrows to 300 m. It has been studied by means of more than 100 boreholes made by MEG Energoproekt, 1967; NIPPIES Energoproekt," 1978; IPP Vodproekt, 1961; Geotehnika ABS; the Geological Institute, 2009; etc. The footing of the terrace cuts into the clays of the Brusartsi Formation. In the vicinity of Terrace T_2 the footing is at an elevation of 15÷16 m, thereafter it rises to an elevation of 17÷18 m and at the front of the terrace it lowers to 13÷14 m. The alluvium top boundary is at an average elevation of 22÷24 m, featuring certain undulations with elevations of 21 and 25 m. The loess cover over alluvium consists of one loess layer, which is more clayey below the water level.

Terrace T_0 extends within the Kozloduy Plain at an altitude of 28 m to 26 m. Its topography features shallow depressions with marshes and swamps. At some places the terrace features small hills rising to an elevation of 30 m and forming a broken range,; they extend from the north-west to the north-east (the so called "eolian greda ridges").

The footing of the terrace has formed in the clays of the Brusartsi Formation at an elevation of 13 m to 15 m. Towards the Danube River the footing elevation lowers to 12÷13 m. At some places the terrace bed falls to an elevation of 10 m. In the riparian western part of the terrace the footing has a lower elevation - from 7 m to 10 m, while in the eastern part the elevation is 12÷13 m. In the easternmost part the footing consists of sands of the Brusartsi and Archar Formations.

Terraces T_5 and $T_{4,3}$ do not exist in the area of Kozloduy NPP and the Radiana Site, because they have been washed eroded by the Danube River after their formation.

The location of the described morphological forms is given in **Figure 3.3-1** .

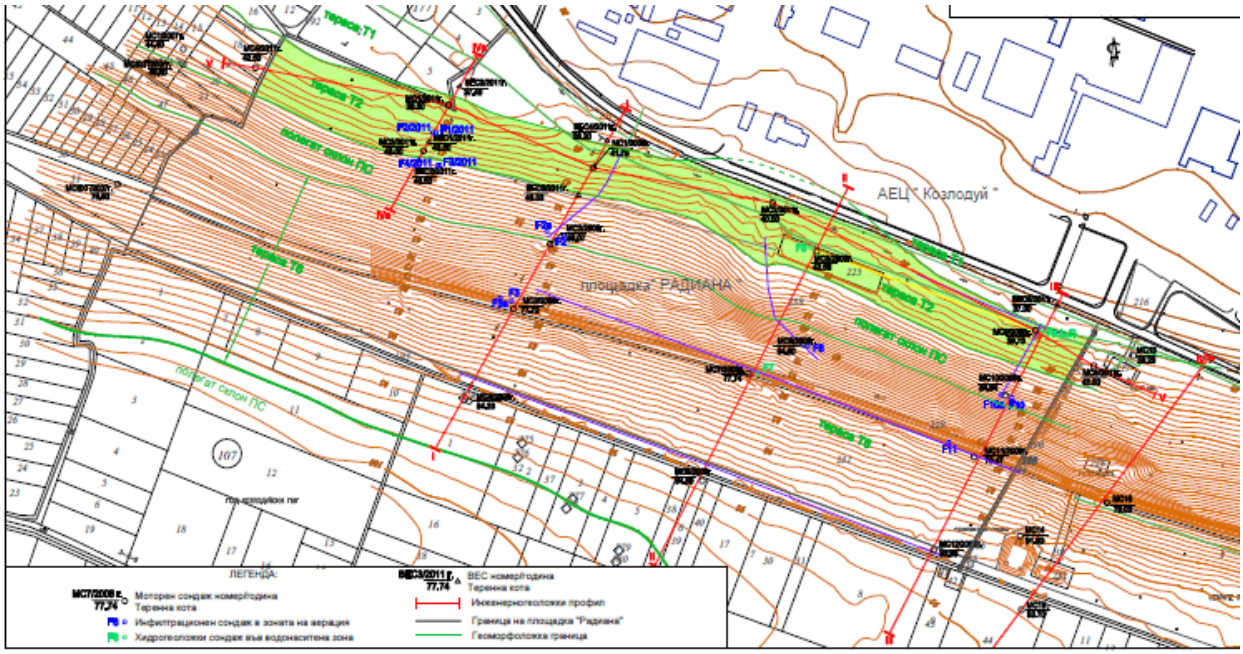


FIGURE 3.3-1 GEOMORPHOLOGICAL MAP OF THE RADIANA SITE

3.3.2 GEOLOGICAL SETTING

3.3.2.1 LITHOSTRATIGRAPHY

Regionally, the Radiana Site is located in the Lom Depression, in the north-eastern part of the Moesian Platform. Quaternary formations and Neogene sediments are revealed on surface around the site. The deep geological profile below them features Paleogene and Mesozoic deposits, discovered by deep structural drilling, illustrated in **Figure 3.3-2**.

The *Mesozoic* is represented by the Triassic, Jurassic and Cretaceous as follows:

- → *Triassic* - comprises the Petrohan Group (red sandstone rock formation /$1T_1$/, siltstones and sandstones of the Alexandrovo Formation /aT_1^{sp}/), Iskar carbonate group (Doyrentsi Formation /doT_1^{sp}/, Mitrovo Formation /$T_2^1 - T_3^k$/, Rusinov Del Formation /rdT_3^k/ and Preslav Formation /prT_3^k/ with a Pisarevo Member) and the Moesian Group, comprising the sandstones, claystones, limestones and dolomites of the Kozloduy Formation /kzT_3^{k-r}/;
- → *Jurassic* – comprises three lithostratigraphic units: Yavorets /$jJ_2^c - J_3^o$/ and Ginska /gJ_3^{o-k}/ Formations, consisting of limestones, and Pleven Formation /$plJ_2^c - J_3^t$/, including aphanitic limestones dolomitized limestones and dolomites;
- → *Upper Jurassic - Lower Cretaceous* – comprises the Glozhene Formation /$glJ_3^t - K_1^{bs}$/ (aphanitic limestones) and Kaspichan Formation /$kJ_3^t - K_1^h$/ (limestones, dolomitized limestones and dolomites);
- → *Lower Cretaceous* – comprises the Salash Formation /sK_1^{ls-b}/ (limestones and marls), the Hayredin Formation /hK_1^{b-ap}/ (claystones and marls) and Trambesh Formation /tK_1^{ap-al}/ (marls, siltstones and clayey limestones);
- → *Upper Cretaceous* – includes the Sanadinovo Formation /sK_2^{cm-t}/ (marls and clayey limestones), Belo Bardo Formation /bbK_2^{cn-st}/ (marls and silty limestone), Knezha Formation /knK_2^{cp}/ (marls and clayey limestones), Mezdra Formation /mzK_2^{cp-m}/ (sandy and clayey limestones) and Kaylaka Formation /kK_2^m/ (limestones and biogenic limestones).

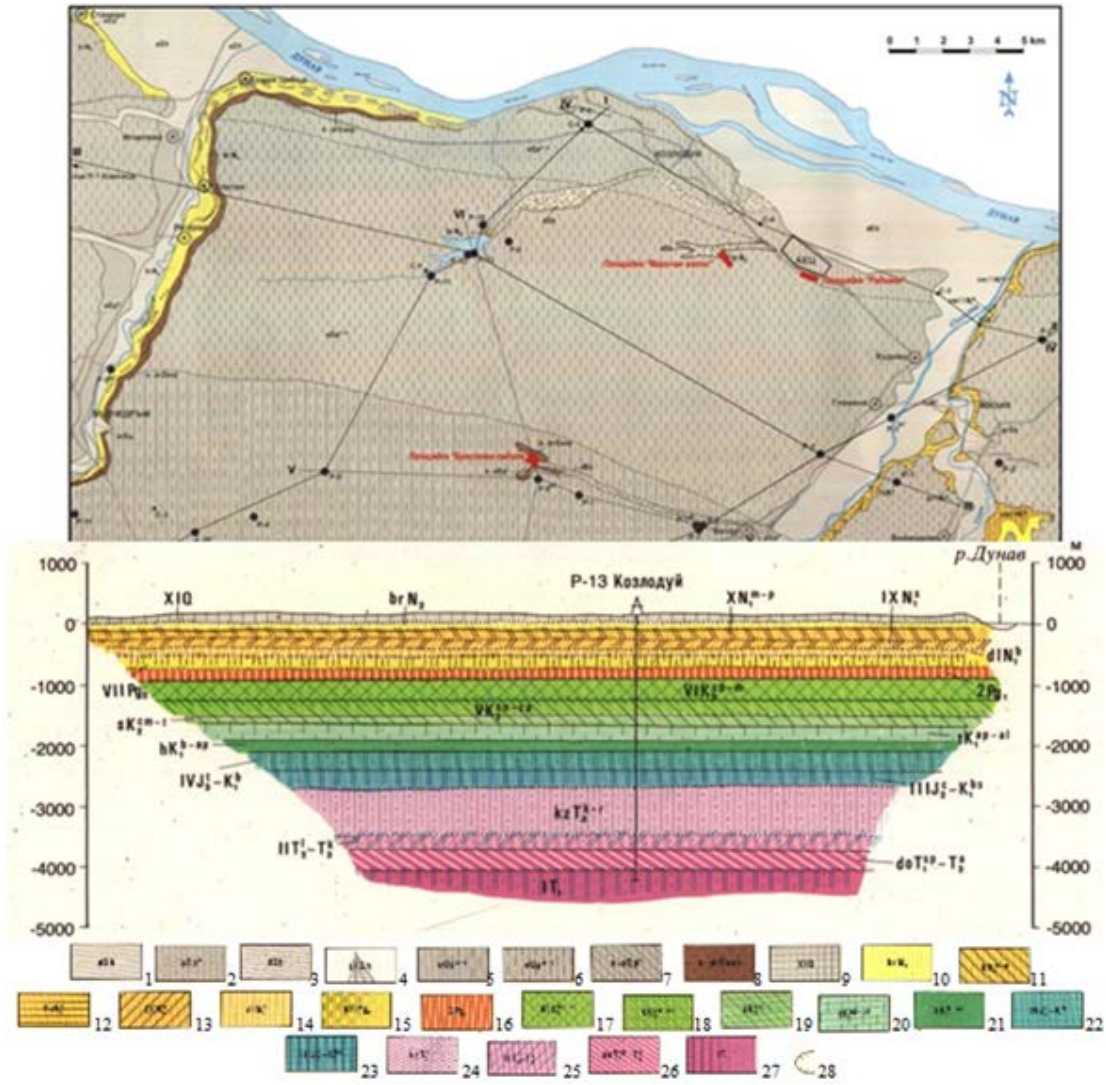


FIGURE 3.3-2 FRAGMENT OF A GEOLOGICAL MAP OF BULGARIA SHOWING THE AREA OF THE RADIANA SITE /FILIPOV, L. ET AL, 1989/

QUATERNARY: 1, 2 - Alluvial formations: gravels, sands, clays, pre-deposited loess; 3 - Deluvial formations: clayey-sand and loess-like materials; 4 - Proluvial cone sediments: sandy clays and loess-like materials; 5, 6 - Eolian-eluvial formations: loess and loess-like clays; 7, 8 - Fluvial-lacustrine formations: basal gravels and sands, red sandy clays; 9 - Undetermined Quaternary formations; NEOGENE: 10 - Brusartsi Formation (Pliocene): clays with sand streaks; 11 - Archar Formation (Pontian): sands with clay streaks and Smirnenski Formation (Meotian): clays with steaks of sandstone and marl; 12 - Furen Formation (Sarmatian): clays, marls and clayey limestones; 13 - Krivodol and Florentin Formation (Sarmatian): clays, marls and clayey limestone;14 - Deleyna Formation (Badenian): clays with layers of gypsum or anhydrite; PALEOGENE: 15 - Marl-limestone and clayey-marl rock formation (Eocene); 16 - Limestone rock formation (Paleocene); CRETACEOUS: 17 - Mezdra and Kaylaka Formation (Campanian-Maastrichtian): sandy, clayey and biogenic limestones; 18 – Belo Bardo and Knezha Formation (Coniacian-Campanian): marl and clayey limestones; 19 - Sanadinovo Formation (Cenomanian-Turonian): marls with clayey limestone streaks; 20 - Trambesh Formation (Aptian-Albian): marls, limestones and clayey limestones; 21 - Hayredin Formation (Barremian-Aptian); JURASSIC-CRETACEOUS: 22 - Kaspichan and Salash Formation (Tithonian-Barremian): limestones, dolomites and marls; 23 - Yavorets, Ginska, Pleven and Glozhene Formations (Callovian-Berriasian): limestones and dolomites; TRIASSIC: 24 - Kozloduy Formation (Carnian-Rhaetian): sandstones, claystones, limestones and dolomites; 25 - Mirovo, Rusinov Del and Preslav Formation (Ladinian-Carnian): claystones, siltstones, sandstones, limestones, dolomites, anhydrites; 26 - Doyrentsi Formation (Spathian-Anisian): limestones, dolomites and claystones; 27- Red sandstone rock formation and Alexandrovo Formation (lower Triassic): sandstones, claystones and siltstones; 28 - Landslides.

The Paleogene includes three rock formations: limestone $/2Pg_1/$, marl-limestone $/3Pg_2^{1-2}/$ and clay-marl $/4Pg_2^3/$.

Deleyna , Krivodol, Furen, Florentin, Smirnenski and Archar Formation of Miocene age, as well as Brusartsi Formation of Pliocene age, are differentiated in the Neogene profile.

The Deleyna Formation (dlN_1^b) is represented by bluish-grey clays - thin-layered, calcareous, silty. Single streaks of clayey limestones, siltstones and sandstones emerge among them. A member of light-grey and light-yellow gypsum and less often layers of anhydrite have developed in the middle of the profile across the entire Lom Depression. The total thickness of the Deleyna Formation usually ranges from 200 to 440 m.

The Krivodol Formation (krN_1^s) is composed of grey and bluish-grey, layered, silty and calcareous clays. Streaks of marls and compact clay limestones are often featured among them. The thickness of the Krivodol Formation in the area of Kozloduy is 120÷140 m.

The Florentin Formation (flN_1^s) includes streaked clays with thickness of 20÷30 m.

The Furen Fomation (fuN_1^s) is about 50 m thick and composed of limestones with clayey-sand streaks.

The Deleyna, Krivodol, Furen and Florerntin Formaitons lie at a depth of more than 300÷400 m.

The Smirnenski Formation (smN_1^{m-p}) consists mainly of grey and grey-greenish, slightly calcareous and silty clays, with streaks of clayey limestones, marls and sandstones in the lower part of the profile, which is 5÷10 m thick. The thickness of the formation is 200-250 m.

The Archar Formation (arN_1^p) is composed of yellowish to rusty-brown or greenish, small- to large-grain oligomictic sands, often featuring oblique layers. The lower sand layers are streaked by dark-grey, slightly calcareous, thin-layered clays. Its lower border with Smirnenski Formation is regular. It is covered by the Brusartsi Formation through a regular border or by Quaternary deposits through erosional surface. The 40÷50 m thickness of the Archar Formation in the area of Kozloduy extends to over 100 m towards the village of Septemvriytsi.

The Brusartsi Formation (brN_2) is part of the Pre-Quaternary plate. The geologic profile is dominated by clays, which are unevenly layered by irregularly shaped, often lenticular streaks of small- to medium-grained and clayey sands. The thickness of the streaks ranges from 1.0÷2.0 m to 8.0÷10.0 m, and that of the Formation is 50÷60 m.

The Quaternary is presented by the fluvial-lacustrine, eluvial, eolian-eluvial formations that are genetically associated with certain geomorphological forms.

The *fluvial-lacustrine formations* include basal gravels and sands with thickness up to 10 m and covering gravels with thickness 2÷3 m.

The eluvial formations are uncovered in the southern parts of the area, where they lie over the so called Pliocene denudation surface, above which there are pieces of indigenous rocks and red "Terra Rosa" clays with thickness of 1÷5 m.

The *alluvial formations* include the river terraces, composed of gravels, sands and clays covered with buried soil. Differentiated are six non-flooded and two floodplain terraces.

The *eolian-eluvial* formations relate to the loess complex, represented by silty loess and loess-like silty-sandy clay, layered by buried soils.

3.3.2.2 TECTONICS

The area of the Radiana Site is situated in the eastern periphery of the Lom depression, which is the deepest part of the Moesian platform - a primary tectonic unit on the Bulgarian and Romanian territory (**Figure 3.3-3**).

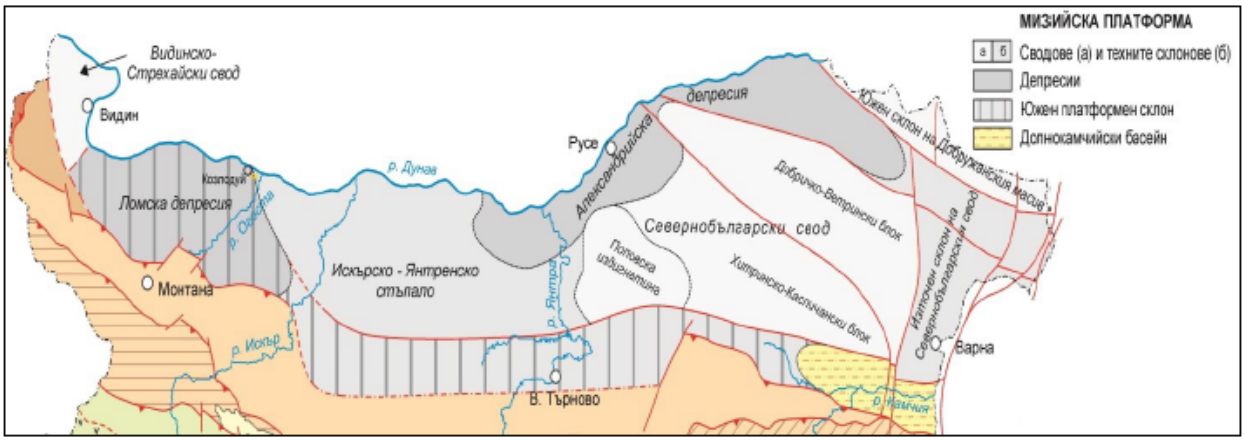


FIGURE 3.3-3 TECTONIC MAP OF THE BULGARIAN PART OF THE MOESIAN PLATFORM (DABOVSKI, ZAGORCHEV, 2009[34])

The foundation of the Moesian Platform in Bulgaria is composed of slightly folded Palaeozoic rocks. Its cover comprises sub-layer Mesozoic and Cenozoic sediments with total thickness of up to 7÷8 km.

The profile of the sediment cover of the platform features regional displacements at the base layers of the Triassic, Jurassic, upper Cretaceous and Eocene, which correspond to the major tectonic events in the Alpine orogeny. From the point of view of tectonics, most significant is the angular displacement between the Triassic and Jurassic (about 200 million years ago), which marks the end of the intensive tectonic activity. The Paleogene and Neogene-Quaternary rocks lying over this displacement are virtually horizontal, with a gradient from 1^0 to $3–4^0$. These geological facts, documented in numerous boreholes and natural outcrops, are essential for the long-term forecasts and prospects for tectonic stability of the geological plate in the area of the Radiana Site.

The tectonic development of the area has undergone numerous stages that can be combined into three groups: *Pre-Paleogene, Paleogene-Neogene and Quaternary.*

The *Pre-Paleogene* tectonic development includes the formation of the slightly folded foundation of the Moesian Platform to the middle Palaeozoic and stretches to the end of the intensive tectonic activity at the end of the Triassic.

According to the existing data form numerous boreholes in the area, movement of old faults has not been proven *in the Paleocene-Neogene structural level*. No facts have been found proving the presence of faults with impact on modern topography and no folded structures have been documented in both Miocene and Pliocene sediments.

The lack of significant tectonic events and faulting at the *Quaternary structural level* is evidenced by the comparison of the base plate and the top alluvium border of the OAAL in the Lom Bay and the Ruse-Silistra Bay. It shows that the elevation in both areas is almost the same – around 125÷133 m, hence they have been subjected to similar positive movements. (Evlogiev, 2006[35]).

The neo-tectonic development is characterized by an absence of sharp gradients in the gravity, geomagnetic and geothermal fields, as well as local anomalies of these fields. Established are tendencies for relative subsidence within the range of (-1) to (-2) mm/y. There is no accumulation of tectonic stress on the regional scale. Over the past 23.5 million years only slight oscillations have

[34] Zagorchev, I., H. Dabovski, T. Nikolov (ed.), 2009. Geology of Bulgaria. Volume II. Mesozoic Geology, BAS, 13-37.

[35] Y. Evlogiev, 2006. Pleistocene and Holocene in the Danube Plain, PhD Dissertation.

occurred. In the 30 km area around the Radiana Site there are no topography defining active faults, including Neogene and Pre-Quaternary.

On the grounds of the above, the following conclusions can be made:

→ The active tectonic processes in the area were most intensive up to the Triassic period and with its end they gradually came to a stop. After that, during the Cretaceous, Paleogene and Neogene, the tectonic activity subsided and came down to predominantly slow oscillatory movements;

→ At the end of the Pliocene and during the Quaternary, the movements were positive and led to the formation of flat planes and river terraces. Since the Radiana Site is situated in the most stable inner part of the Moesian Platform, there is no reason to expect sharp changes in the velocity and orientation of the contemporary positive vertical movements.

→ From the point of view of the neo-tectonic development, it can be surmised that in the next 2÷3 million years (Ma) there is no probability that substantial changes will occur in the present geodynamics of the area.

3.3.3 GEOTECHNICAL SETTING

The immediate geological setting of the Radiana Site and the terrain to the north, from top downwards, consists of Quaternary formations and Neogene sediments of the Brusartsi and Archar Formations, in which the following geotechnical layers can be differentiated (**Figure 3.3-4**):

Contemporary soil, dark-grey in colour, with thickness of 0.5÷1.0 m;

Layer 1 - collapsible loess of the 2nd type (silty loess - light-yellow, micro-porous, with crumbly structure, developing into dark-brown macro-porous clay towards the plate). It forms the near-surface part of Terrace T_6, with thickness of 6.0 m to 16 m;

Layer 1a - collapsible loess of the 1st type (silty to silty-sandy loess - macro-porous, light-yellow, with a crumbly structure, at some places streaked by clayey loess). It forms the near-surface part of Terraces T_2 and T_1, with thickness of 5÷11 m;

Layer 2 - non-collapsible loess of the high Danube terrace (silty loess, without macro-pores, streaked by loess-like clay - buried soils). Underlies layer 1, with thickness of 30÷33 m to the south of Terrace T_6, up to 32 m within Terrace T_6 and up to 1.0 m - within Terrace T_2;

Layer 2a - non-collapsible (compactible) loess (clayey loess, without macro-pores, with a compacted structure, wet to water saturated). Established within Terraces T_2 and T_1, with thickness of 2÷4 m to 8.0 m;

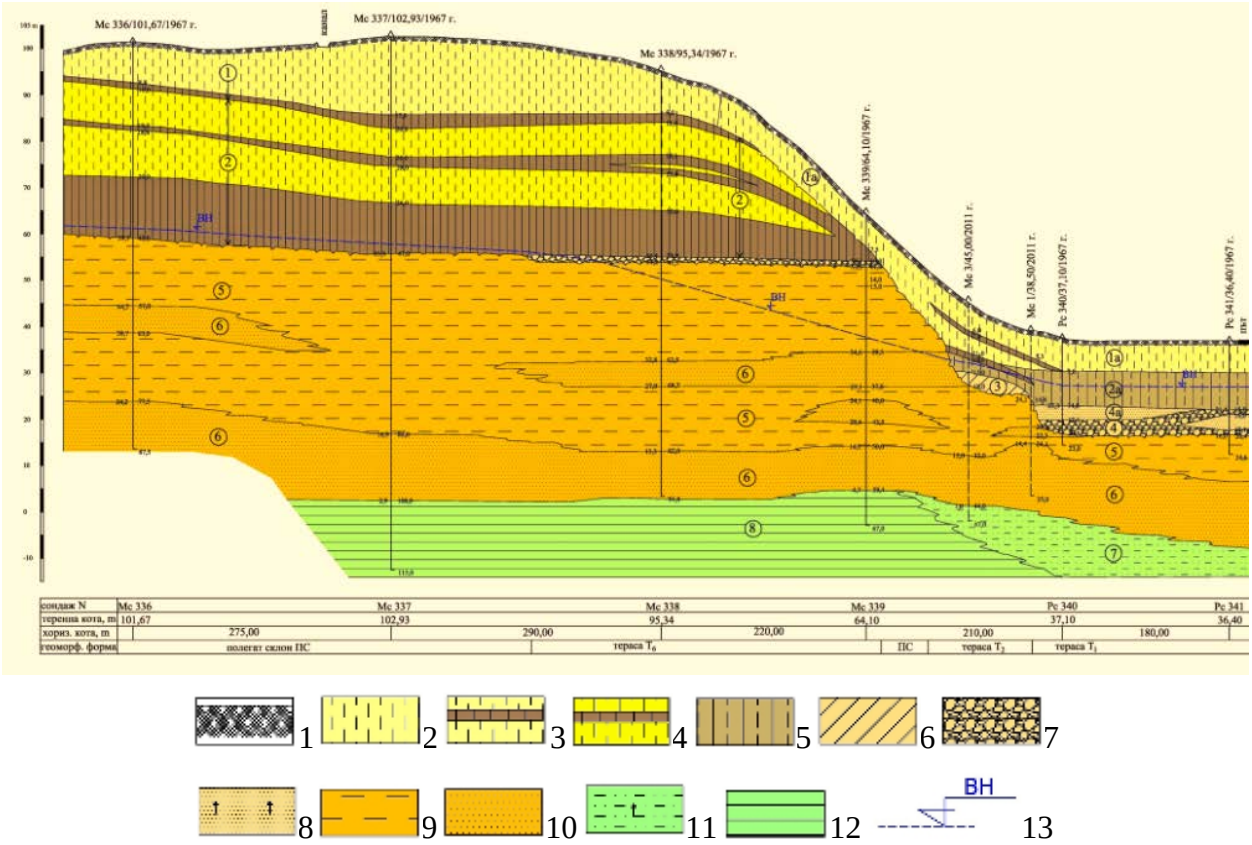


FIGURE 3.3-4 GEOTECHNICAL PROFILE (EVLOGIEV, Y., 2013)

1. Contemporary soil; 2. Layer 1 - collapsible loess 2nd type; 3. Layer 1a - collapsible loess 1st type; 4. Layer 2 - non-collapsible loess; 5. Layer 2a - non-collapsible (compactible) loess; 6. Layer 3 - alluvial sandy clay; 7. Layer 4 - alluvial gravel; 8. Layer 4a - alluvial sand; 9. Layer 5 - Pliocene silty clay, (Brusartsi Formation); 10. Layer 6 - Pliocene sand (Brusartsi Formation); 11. Layer 7 - Miocene clayey sand (Archar Formation); 12. Layer 8 - Miocene silty clay (Archar Formation); 13. water level

Layer 3 - alluvial sandy clay (sandy clay, beige-brown, mixed at some places with gravel pieces). Established in the alluvium top boundary with thickness up to 2.0÷5.5 m in Terraces T_6 and T_2, and thickness of 2÷8 m in Terrace T_0;

Layer 4 - alluvial gravel (gravel or gravelly-sand and clayey-sand (Terrace T_6) and sand filling (Terraces T_1 and T_0). Within Terrace T_6 it usually has a thickness of 1.0÷4.3 m. Its thickness in Terraces T_1 and T_0 varies from 2÷5 m to 8÷13 m;

Layer 4a - alluvial sand (fine- to medium-grain sand, clayey at some places). Established in the lower Terraces T_1 and T_0 with thickness of 1.0 m to 3.3 m in the form of lenses and streaks in Layer 4;

Layer 5 - Pliocene silty clay (Brusartsi Formation) - silty clay, compact, yellow-rusty, motley to grey in depth, with single carbonate gravel pieces. Builds the footing of the terraces and the greater part of the formation profile. Its top boundary is at elevations of 48÷54 m within Terrace T_6; 24÷27 m - Terrace T_2; 13÷19 m - Terrace T_1; and 11÷17 m - Terrace T_0. The thickness of Layer 5, together with the included sand layers and streaks (Layer 6), is 48÷52 m thick in Terrace T_6; 25÷26 m - Terrace T_2 and 20÷25 m - Terrace T_1;

Layer 6 - Pliocene sand (Brusartsi Formation) - fine- to medium-grained or clayey sand, beige to grey. Forms streaks among the clays of the Brusartsi Formation (Layer 5) with thickness of 0.5÷1.0 m to 12 m;

Layer 7 - Miocene clayey sand (Archar Formation) - fine-grained clayey sand, sage-green, aquifer, thixotropic. Established under an altitude of +4.7 to -8.6 m;

Layer 8 - Miocene silty clay (Archar Formation) - silty clay, compact, bluish-grey, developing into clayey marl.

The average values of the physico-mechanical characteristics of the described layers are shown in **Table 3.3-1**. Data about layer 8 is not given due to absence of relevant studies.

Regarding the geomorphology of the site, there are two options for location of the NDF:

Construction of a repository of the trench or tunnel type within Terrace T_6 - slope area;

Construction of a repository of the trench type storage in the lower, flat part of the site within Terrace T_2 - flat area.

In the slope area of Terrace T_6 The geotechnical profile includes contemporary soil, Layer 1 - collapsible loess 2nd type; Layer 2 - non-collapsible loess; Layer 3 - alluvial sandy clay; Layer 5 - Pliocene silty clay (Brusartsi Formation); Layer 6 - Pliocene sand (Brusartsi Formation); Layer 7 - Miocene clayey sand (Archar Formation); and Layer 8 - Miocene silty clay (Archar Formation).

In the variant of a trench-type repository the trench slopes will be formed in Layers 1, 2, 3 and 4. The lithological structure under the trench bottom, at an elevation of 50 m, includes:

under the repository modules: Pliocene silty clay (Layer 5) with thickness up to 32 m in two-thirds of the area and Pliocene sand (Layer 6) with thickness of 5.5÷7.5 m in the eastern third of the site area;

under the auxiliary buildings: Layer 5 and Layer 3 in the north-western half of the site; and Layer 2 with thickness of 5.5÷8.0 m and Layer 1 with thickness of 7.5 m in the north-eastern half.

In the variant of a trench-type repository, two hydrogeological units are distinguished under the modules: an unsaturated (vadose) zone and a saturated zone.

The unsaturated (vadose) zone has a total thickness of 11÷16 m in the southern part and up to 13÷17 m in the northern part of the ground base. This zone includes only clayey and sandy sediments of the Brusartsi Formation (Layer 5 and Layer 6).

The saturated zone includes the groundwater in Layers 2a and 3 and in the upper layer (Brusartsi Formation) and the lower layer (Archar Formation) within the composition of the groundwater body Neogene Pore Water - Lom-Pleven Depression, code BG1G00000N2034. The water level is set at an altitude of 40÷45 m in the south-western part, to 32÷38 m at the north-eastern part of the area.

In the variant of a tunnel-type repository, the mine works can be made at the top boundary of Layer 5 and Layers 1 and 2. In this case the unsaturated zone under the repository will include a small part of the loess formations (Layers 1 and 2), the alluvial formations (Layers 3 and 4) and partially the clays of the Brusartsi Formation (Layer 5).

Due to the relatively non-homogeneous geotechnical conditions at Radiana Site, there are a number of lithological types that are related to the radionuclide migration and therefore the geochemical parameters of the six types are analysed. Their main geochemical characteristics are presented in **Table 3.3-2** .

In the flat area of terrace T_2 the geotechnical profile includes: contemporary soil, Layer 1a - collapsible loess 1st type; Layer 2a - non-collapsible (compactible) loess; Layer 3 - alluvial sandy clay; Layer 5 - Pliocene silty clay (Brusartsi Formation); Layer 6 - Pliocene sand (Brusartsi Formation); Layer 7 - Miocene clayey sand (Archar Formation); and Layer 8 - Miocene silty clay (Archar Formation).

The geochemical characteristics are similar to those of the slope area.

Table 3.3-3 gives the distribution coefficient C_d of predicted radionuclides for the respective lithological types in the slope area, and **Table 3.3-4** gives the distribution coefficient C_d of the predicted radionuclides for the respective lithological types in the flat area.

TABLE 3.3-1 SUMMARY OF THE AVERAGE VALUES OF THE PHYSICO-MECHANICAL INDICATORS OF THE LITHOLOGICAL TYPES IN THE RADIANA SITE

No	Indicator	Unit	Lithological type									
			Layer 1	Layer 2	Layer 1a	Layer 2a	Layer 3	Layer 4	Layer 4a	Layer 5	Layer 6	Layer 7
1	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	Dry 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	Void ratio e	-	0.90	0.80	0.97	0.75	0.60	0.50	0.64	0.60	0.50	0.58
5	Plasticity index I_p	%	11.7	22.2	7.0	13.0	38.7	28.5	-	34.4	8.4	1.6
6	Consistency index I_c	-	> 1	> 1	> 1	-	> 1	0.84	-	> 1	> 1	-
7	Degree of saturation S_r	-	0.294	0.567	0.39	0.77	0.693	0.708	-	0.896	0.815	1.00
8	Macroporosity $n_{mp0.4}$	%	7.1	4.1	2.39	-	-	-	-	-	-	-
9	Initial collapse load P_{in}	κPa	92	135			-	-	-	-		-
10	Angle of internal friction 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 modulus $M_{0.3}$	MPa	5.9	9.2	6.3	7.9	10.6	-	-	10.3	12.2	-
13	Modulus of deformation E_0	MPa	14	14	12.6	16	18	18	8-9	45	50	50

TABLE 3.3-2 GEOCHEMICAL CHARACTERISTICS OF THE RADIANA SITE

Geochemical indicator	Unit	Lithological type					
		Silty loess	Loess-like clay	Sandy clay	Gravelly sandy clay	Silty clay	Fine-grain clayey sand
Clay fraction content	%	6.9	14.5	10.1	9.0	42.1	6.0
Clay mineral content	%	58	59	81	75	81	73
Smectite content	%	36	33	42	41	25	32
Cation 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 extract	-	9	9	8.5	8.5	8.5	8.5
Content of:							
Ca^{2+}	mg/dm^3	15.8	8..	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 3.3-3 DISTRIBUTION COEFFICIENTS OF THE PREDICTED RADIONUCLIDES IN THE SLOPE AREA OF THE RADIANA SITE

Lithological type	Distribution coefficient C_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
Unsaturated layer 1	0	2E-2	1	0.3	0.07	0.16	1E-4	1E-3	0.20	0.11	10
Unsaturated layer 2	0	3.5E-3	5.5E-1	0.65	0.12	0.55	1E-3	1E-3	0.25	0.21	20
Unsaturated layer 3	0	3.5E-3	6E-2	0.65	0.14	0.55	1E-4	1E-3	0.23	0.16	20
Unsaturated layer 4	0	5E-3	0.5	0.40	0.075	0.16	1E-4	1E-3	0.14	0.15	20
Unsaturated layer 5	0	1E-3	5.5E-1	0.65	0.2	0.55	1E-3	1E-3	0.4	0.56	30
Unsaturated 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

TABLE 3.3-4 DISTRIBUTION COEFFICIENTS OF THE PREDICTED RADIONUCLIDES IN THE FLAT AREA OF THE RADIANA SITE

Lithological type	Distribution coefficient C_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
Unsaturated layer 1	0	2E-2	1	0.3	0.02	0.16	1E-4	1E-3	0.20	0.11	10
Unsaturated layer 2	0	2E-2	1	0.5	0.07	0.55	1E-4	1E-3	0.25	0.21	20
Aquifer	0	5E-3	1	0.65	0.2	0.9	1E-4	1E-3	0.4	0.56	30

3.3.4 SUBSURFACE NATURAL RESOURCES

According to information in letter No 92-00-79/1505-2014 of the Ministry of Economy and Energy:

On the sites Radiana, Varbitsa and Marichin Valog there are no deposits, which are accounted for in the National Balance of Reserves and Resources and there are no granted rights for mining and issued operating permits for prospecting and/or exploration of mineral resources;

The territory of the Brestova Padina site is within the scope of an enforced permit for prospecting and exploration for Oil and Gas - Block 1-10 Botevo, holder MOEZIYA OIL AND GAS PLC, granted by Decision of the Council of Ministers No 791 of 24.09.2012.

According to data from the long-term municipal program[36], in the Municipality of Kozloduy there are no aggregate quarries along the Ogosta River near the village of Butan, and in the bed of the Danube River near Kozloduy. At about 1.0 km from the village of Kriva Bara, there are deposits of Quaternary clays suitable for production of bricks.

According to the specialised maps under the Subsurface Resources Act (SRA), the following underground natural resources within the 30 km zone around the Kozloduy NPP are accounted for in the National Balance of Reserves and Resources (NBRR):

Bhutan gas field, Municipality of Kozloduy, District of Vratsa, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Bhutan-South gas and condensate field, Municipality of Kozloduy, District of Vratsa, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Oryahovo condensate field, Municipality of Oryahovo, District of Vratsa, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Selanovtsi gas and oil field, Municipality of Oryahovo, District of Vratsa, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Bardarski Geran gas and oil field, Municipality of Knezha, District of Pleven, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Marinov Geran gas and condensate field, Municipality of Knezha, District of Pleven, concession granted to Exploration and Production of Oil and Gas JSC, Sofia;

Tarnava brick clay deposit, Municipality of Byala Slatina, District of Vratsa;

Monastirishte - Beli Brod cladding limestone deposit, Municipality of Hayredin, District of Vratsa;

Monastirishte - Vlashko Selishte limestone deposit, Municipality of Hayredin, District of Vratsa;

Monastirishte - Central cladding limestone deposit, concession granted to Monolit AD;

Obroka cladding limestone deposit, Municipality of Hayredin, District of Vratsa;

Lom Coal Basin - South-east lignite deposit, Municipality of Lom, District of Montana.

Coarse aggregate and sand are some of the building materials, which will be used in all main stages of the NDF construction - from preparation of the site, through building the underground and surface communications, to the surface construction of buildings and facilities on the selected site, until repositry decommissioning. The building qualities of the materials, depending on the specificity of the facility and the respective construction works, will be specified in the respective technical designs, related to the realisation of the IP.

According to the information in letter No IV-512/14.05.2014 of the competent authority Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR), Ruse, 32 licenses have been issued for extraction of alluvial deposits (sand and gravel) from the Danube River. Among them, closest to the Radiana Site are the river sections: from $^{km}693 \div ^{km}689$ - town of Kozloduy, $^{km}770 \div ^{km}759$ - village of Archar, $^{km}676.6 \div ^{km}675.4$ - village of Leskovets, $^{km}662.5 \div ^{km}660$ - village of Ostrov, etc.

[36] Long-term municipal program for promotion of renewable energy sources and biofuels in the Municipality of Kozloduy 2013 - 2023

The extraction of coarse aggregate and sand is permitted also at the Ogosta Dam. This activity however is subject to the license regime of the MoEW. There are small aggregate extraction plants along the rivers Ogosta and Iskar as well, which are subject to the license regime of the DRRBMD.

The supply of the construction site with the necessary quantities of river aggregate and sand will be carried out by aggregate extraction plants within or outside the investment proposal area, which are licensed pursuant to the Water Act. These activities are regulated by the Water Act. The licensing regime for extraction of alluvium deposits from the Danube River is governed by the EAEMDR Ruse, for extraction from dams pursuant to Annex 1 of the Water Act - by the MoEW, and for ballast aggregate extraction plants along the inland rivers - by the DRRBMD.

3.3.5 SEISMIC ACTIVITY

The seismicity of the region has been researched by the Geophysical Institute of the Bulgarian Academy of Sciences in 1990-1992.

A catalogue of earthquakes was used, which comprises the period from 375 AD to 1990. The parameters of the earthquakes researched have been unified and standardised, and the intensity assessments have been made according to the MSK scale. The majority of studied seismic events have been linked with the seismic zones: Sofia, Maritsa, Gorna Oryahovitsa, Shabla, Provadiya, Kresna, Negotin-Krajna and Campulung-Vrancea (shallow and medium depth) and local. The spatial, time and energy characteristics of these zones have been studied in detail. The Sofia seismic zone is located at a closest distance to Kozloduy NPP and respectively - to the Radiana Site. The maximum epicentre intensity documented in this zone was IX degree (MSK), magnitude M = 6.6 in the earthquake of 30.09.1958. Similar magnitude had the earthquake of 1641. Many other earthquakes of smaller magnitude have been registered, among which was the earthquake of 18.10.1917, with magnitude M = 5.5. The maximum macroseismic effect on the site of Kozloduy NPP caused by earthquakes in the Sofia zone is I_{koz} = 3 (MSK).

Earthquakes, within a region of 150 km around Kozloduy NPP and Radiana Site, are generated in the earth crust at a depth of up to 50 km. The maximum density of the earthquake hypocentres is observed in a layer with depth between 5 km and 25 km. Powerful medium-focus earthquakes, with considerable macroseismic impacts (long-distance effects) are generated at depths from 90 km to 230 km in the seismic zone of Vrancea in Romania, which is at a distance of more than 240 km from the Radiana Site.

The zone that has greatest impact on the earthquake hazard of the Radiana Site and Kozloduy NPP is the Vrancea zone in the neighbouring Romania, which has generated events with magnitude M > 7, at depth of 80÷120 km. The maximum macroseismic impact on the site (I_{koz} = 6÷7) has been recorded as a result of the earthquake of 1977, with M = 7.2 and I_0 = 8.0 (MSK). The impacts are due to the specifics of the source processes (isoseismal lines extremely elongated to south-west).

Major earthquakes outside the specified zones are: the event in North Greece in 1828 with M = 7.5 and I_0 = 10 (MSK) and the earthquake in the area of Dulovo in 1882 with M = 7.3 and I_0 = 7.8, which caused macroseismic impact on the site of Kozloduy NPP – I_{koz} = 5÷6 (MSK).

According to the seismic hazard maps drawn for periods of 1,000 and 10,000 years (**Figure 3.3-5**), the investment proposal is located in a zone with intensity of expected earthquake impacts of the VII degree according to the MSK-64 scale, in which the buildings and structures shall be secured by a seismic coefficient C_c = 0.10[37].

[37]Regulation No РД-02-20-2/27.01.2012 on the design of buildings and structures in earthquake zones

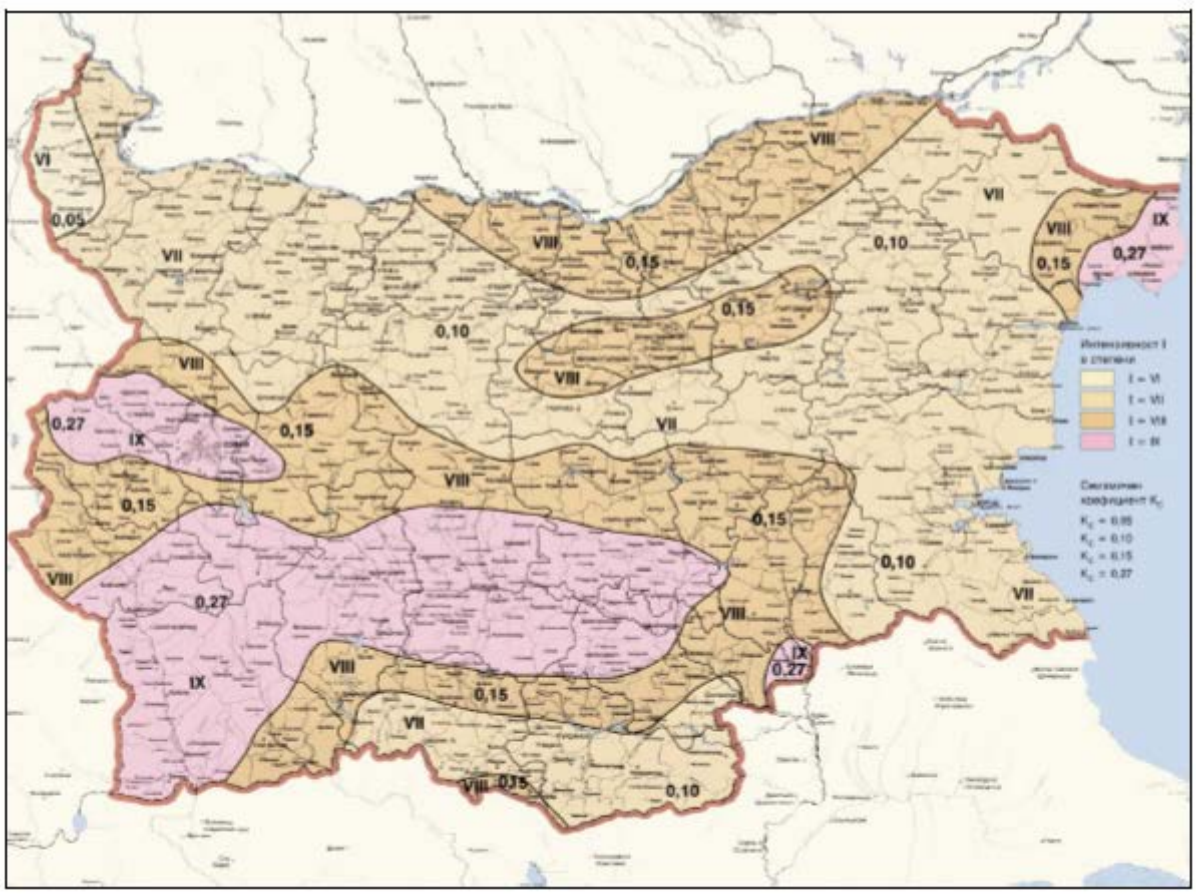


FIGURE 3.3-5 SEISMIC ZONING MAP OF BULGARIA FOR A PERIOD OF 1,000 YEARS

Radiana Site is located in the stable part of the Moesian platform, which predetermines a low-level seismic activity within the sub-region. The maximum earthquake magnitude in the sub-region is $M_{max} = 5.0$.

The documented earthquakes from local seismic sources are with M < 4 and are referred to the category of background seismicity.

The researches of the BAS Geophysical Institute related to the seismic safety of the site of Kozloduy NPP, adopted by missions of IAEA in 1992, arrived to the conclusion that a potential earthquake with an acceleration of 0.1 g can be expected once in 100 years, and a maximum of 0.2 g acceleration – once in 10,000 years. This conclusion is valid also for the Radiana Site, since it is in the immediate vicinity of the nuclear power plant.

The recent researches of the National Institute of Geophysics, Geodesy and Geography at the Bulgarian Academy of Sciences, carried out in connection with the new seismic regional division of the territory of Bulgaria, definitely supported the principal conclusion for maximum acceleration of a potential earthquake, obtained as a result of specialised seismic safety studies of Kozloduy NPP in the 90's of the last century.

According to Seismic Zoning of the Republic of Bulgaria, consistent with the provisions of Eurocode 8 (GPI-BAS, 2009[38]) and the new seismic zoning maps, the Radiana Site in located in an area with a maximum reference acceleration of 0.07 g for a period of 95 years (**Figure 3.3-6**[39]).

[38]GPI-BAS, 2009. Final contract report: Seismic zoning of the Republic of Bulgaria, consistent with the provisions of Eurocode 8 and seismic zoning maps indicating the seismic hazard on the territory of the country

[39]BDS EN 1998-1/NA. Eurocode 8. Seismic Design of Buildings

This fact confirms the main conclusion of the specialised researches on the seismic safety of the site for a maximum potential earthquake acceleration of 0.1 g (for a period of 100 years).

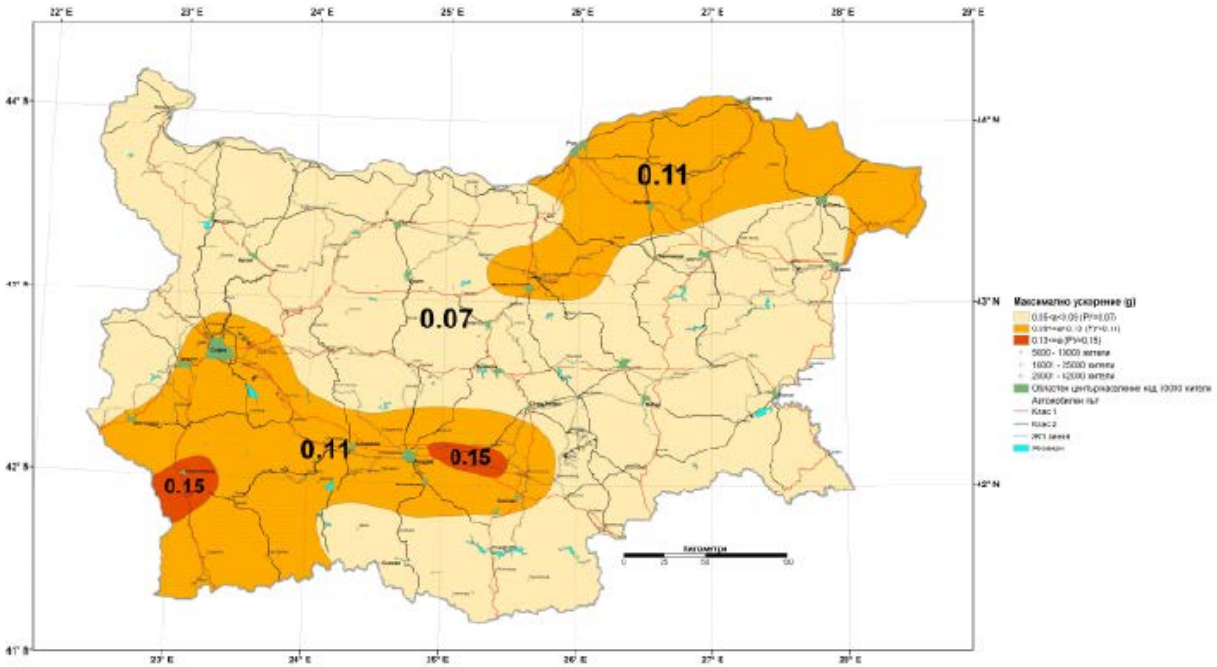


FIGURE 3.3-6 MAP OF THE REFERENCE ACCELERATION FOR A PERIOD OF 95 YEARS

The picture of the spatial distribution of earthquakes with a magnitude above 4.0 in the area of Kozloduy NPP, used for assessment of the seismic hazard in the new seismic zoning, is presented in **Figure 3.3-7**.

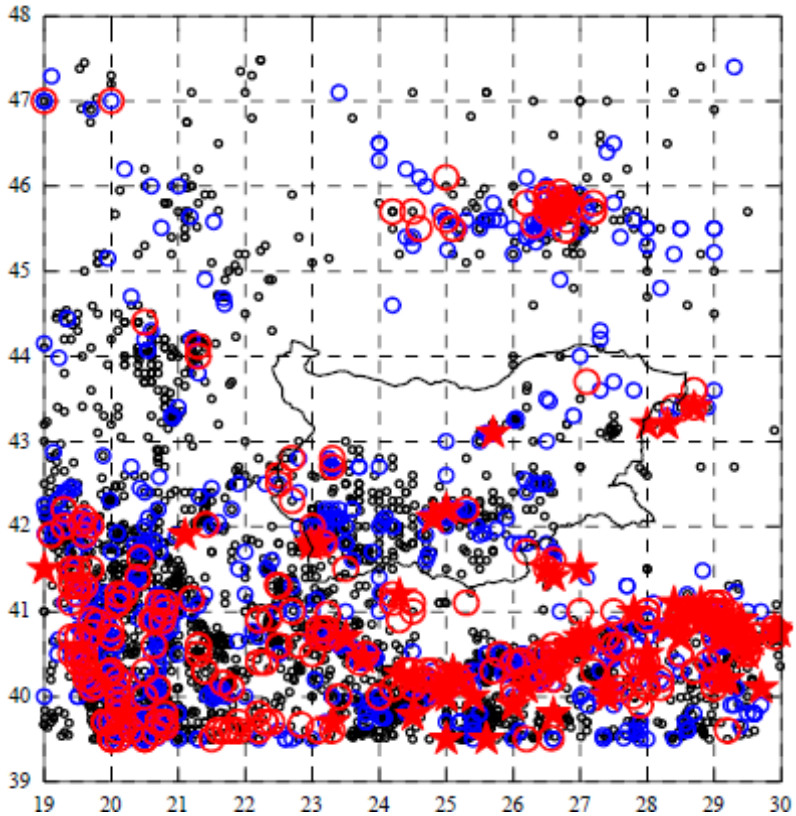


FIGURE 3.3-7 MAP OF THE LOCAL SEISMICITY (M≥4,0) AND THE SEISMIC ZONES

An aseismic area is clearly outlined in the figure, in the central part of which Kozloduy NPP and the Radiana Site are located. Therefore, the results from the seismic hazard research, carried out for the purpose of the new seismic zoning, can be considered as one more confirmation of the conclusion already made, that from a seismic point of view the local 30-km and the sub-regional 50-km area around the site of the investment proposal pertain to the calmest areas of the central Balkan territory.

3.3.5.1 SEISMIC MONITORING

Currently, seismic monitoring is carried out at the site of Kozloduy NPP and seismic pre-commissioning monitoring is foreseen for the Radiana Site – the site designated for construction of the NDF.

3.3.5.1.1 SEISMIC MONITORING OF THE SITE OF KOZLODUY NPP

Kozloduy NPP site seismic monitoring is performed by the following independent systems[40]:

- → Seismic monitoring and control system, which registers and records seismic events above certain threshold (0.01g). The system sensors are installed on Unit 6, and the information panels for registered events are connected with the Unit Control Rooms (UCR) 5 and 6;
- → An accelerograph system for seismic monitoring of equipment and structures, consisting of 10 accelerographs installed separately in the free field and at designated places on the civil structures. The system registers and records seismic events above a given threshold (0.01g);
- → Equipment for industrial seismic protection intended to cause automatic reactor shutdown in case of a registered seismic acceleration movement of the base plate exceeding 0.05g;
- → Local seismological network (LSN), consisting of three peripheral seismic stations situated around Kozloduy NPP site (the village of Malko Peshtene, the town of Valchedram and the town of Oryahovo), which perform real-time seismic monitoring of the plant surroundings. The LSN provides reliable registration and localization of seismic events on the territory of the country and the surrounding regions that may affect the safe operation of Kozloduy NPP.

Written procedures have been developed for each action, in compliance with the quality assurance system. The actions are performed by qualified personnel.

An Emergency Response Procedure has been developed for the actions to be performed by unit shift operator in case of an earthquake and a plan for the actions of the staff during and after an earthquake. An Earthquake Event Emergency Procedure has been developed.

3.3.5.1.2 PRE-COMMISSIONING SEISMIC MONITORING OF THE NATIONAL REPOSITORY FOR RADIOACTIVE WASTE

The purpose of the pre-commissioning seismic monitoring is to provide real-time seismic information, including also about small-scale earthquakes (micro-earthquakes) with magnitude M < 3 in the area of the planned national repository prior to commissioning of the disposal facilities. For this purpose a Programme for pre-commissioning seismic monitoring of the National Repository for Radioactive Waste has been prepared, ref. No НХ-ПЕМ-ПМ-003/01, approved on 01.04.2013. The main activities within the pre-commissioning seismic monitoring and the expected results are as follows:

Design and construction of a local monitoring system for collection of instrumental seismic information, including about small-scale earthquakes (micro-earthquakes) with a magnitude of less than 3.

[40]Nuclear Regulatory Agency, 2014. National Action Plan following the Stress Tests of Kozloduy NPP.

The system design shall provide for complete integration with the existing seismic monitoring network of Kozloduy NPP, intended for registration of low-scale seismic events, including micro-earthquakes in the area with a radius of 30 km. For that reason, all basic elements of the local seismic monitoring system at the NDF site – seismometers (ultra-low-noise and broadband sensors), accelerometers (highly sensitive, three-component, suitable for "free field" installation), a digital system for registration and initial processing of the seismic impact, synchronization and encoding equipment, power-supply devices, etc., shall be compatible with the respective components of the NPP seismic network.

Recording and analysis of all seismic events and impacts, including micro-earthquakes and aftershocks in the area of NDF.

The real-time seismic information will provide basis for additional conclusions about the seismicity of the region, the location of seismogenic structures and the characteristics of earthquake zones, for identification of earthquakes, which are not connected with known structures (disperse seismicity), for updating the level of historic seismic activity, assessing the parameters of ground motion attenuation characteristic for site and obtaining important information for future analysis and evaluation of the seismic behaviour of the combined ground-structure system.

Forecasting the possible future development of adverse geodynamic processes in the ground base and assessment of their impact on the long-term stability of the disposal facilities as a function of the measured seismic parameters at the NDF site.

The data collected shall serve as grounds for evaluation of possible future development of adverse geodynamic processes in the ground base and assessment of their impact on the long-term stability of the disposal facilities as a function of registered seismic parameters at the NDF site.

Development of a programme for operational seismic monitoring.

The results collected via the local seismic monitoring network shall serve as basis for development of a programme for seismic monitoring during the operation of the NDF, including expansion of the local network with appropriate sensors (accelerometers and others instruments) for seismic monitoring of the structure.

3.3.6 PHYSICO-GEOLOGICAL PROCESSES AND PHENOMENA (GEOLOGICAL AND GEOMORPHOLOGICAL RISK)

The physico-geological processes and phenomena developed in the studied region are erosion and deposition, gravitational processes and phenomena, ground subsidence, swamping and liquefaction of sands.

The erosion and deposition processes and phenomena are determined by the hydrological and hydraulic properties of the surface runoff and the results of their impact on the topography. These processes include river and surface erosion, as well as transfer and accretion of the washed-out material. They have contributed to the formation of the ancient and contemporary geomorphological landscape of the IP area, consisting of the river-ravine system of the asymmetric valleys of the rivers Lom, Tsibritsa, Ogosta and others, featuring steep right banks and gentle left slopes, as well as numerous gullets (dry valleys), ravines and gullies, high accumulation terraces of the Danube River, wide flat slopes, etc.

The past active *river erosion and deposition* in the area of the Radiana Site, Kozloduy NPP and the town of Kozloduy is reflected in the topology, which features river terraces gradually lowering towards the Danube - T_6, T_5, $T_{4,3}$, T_2, T_1, T_0. All of them were formed by the Paleo-Danube, which has emerged 800 thousand years ago. The location of the terraces one above the other on Bulgarian Danube bank is an indication of its uniform uplift in the Pleistocene. In the area of the Radiana Site only Terraces T_6, T_2, T_1 and T_0 have survived. The other terraces have eroded in the distant geological past. The river terraces cut into the Pliocene sediments of the Brusartsi Formation. Each

of them has the following lithological and stratigraphic features: the terrace footing is formed by an erosion surface at a certain relative height, followed by alluvial (underwater) accumulation of partial or complete sedimentation cycle (gravels, sands, clays, soil formations), with top border at a certain relative height, followed by a layered loess bed (from six layers in T_6 to one - in T_1), separated by buried soils.

Figure 3.3-8 illustrates time span of the past erosion-accumulation processes and phenomena in the area of the Radiana Site.

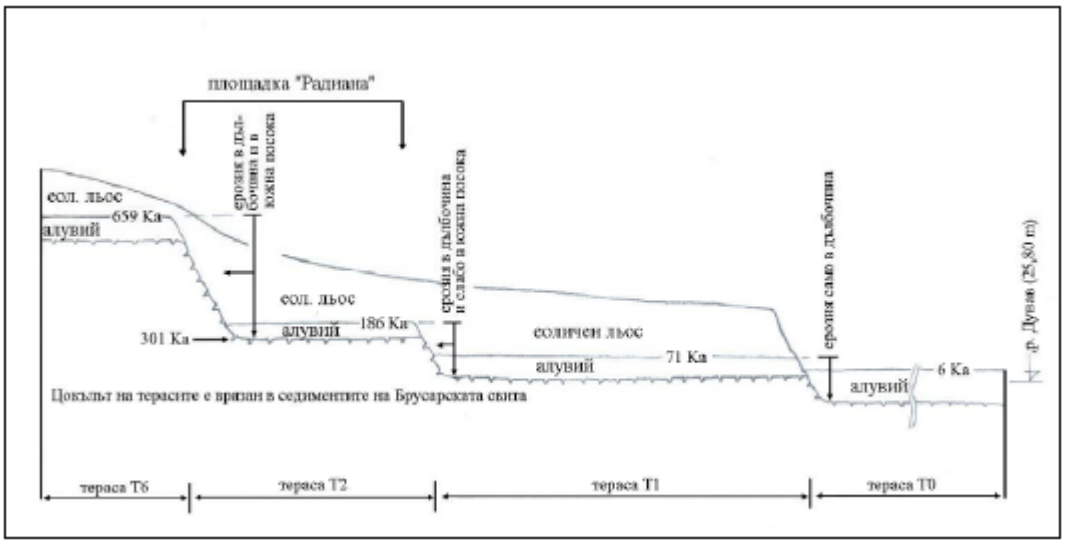


FIGURE 3.3-8 GEOLOGICAL AND GEOMORPHOLOGICAL PROFILE OF THE RADIANA SITE WITH DATA ABOUT THE DANUBE EROSION IN THE GEOLOGICAL PAST (EVSTATIEV, EVLOGIEV, 2011)

The contemporary bed of the Danube River has formed about 6,000 years ago. Since then, the river erosion processes on the south bank have subsided, which is evidenced by the great width of the low floodplain Terrace T_0. At present, however, the riverbed is subject to constant reversible and irreversible changes associated with cyclical fluctuations of the liquid and solid sediment flow - coming from the surface of the catchment area. Reversible deformations are determined by the natural laws - the river flow maintains consistency between the amount of transit sediments, the transport capacity of the flow and the particle size of the sediments. When the water flow is insufficiently saturated with sediments in relation to its transportation capacity, it causes divergence of the river bed (erosion). When the water flow is saturated with sediments in relation to its transportation capacity, the sediments carried by it are deposited. This leads to a reduced cross section, increased speed, increased transport capacity, as a result of which the deposition stops.

The surface erosion is a product of the temporary surface flows, which have variable regime, determined by the regional climatic conditions. It is well manifested on slopes steeper than 30^0. When slopes are steeper than $7 \div 8^0$, the deep and lateral erosion of the temporary streams form shallow gullies, which gradually evolve into ravines. Most affected by gulley formation are the Danube bank and the steep right banks of the rivers Lom, Tsibritsa, Ogosta and others. Gullies are mainly formed in the loess, and partly in the Neogene clays, sands and Quaternary delluvial materials, as well as in landslides. The gullies on the steep right slopes are typically short, but deeply incised - 5÷8 m. Often, towards the bottom, the gullies grow into ravines, which are up to 10÷15 m deep and up to 30 m wide. Well-formed gullies are observed in the Zlatiyata plateau, between the rivers Tsibritsa and Ogosta, some of which are 40 m deep and 10 km long. Surface erosion on the Radiana Site is considerably limited due to the fact that the terrain is currently planted with low vegetation. Therefore, it takes the form of shallow furrows and gullies.

The gravitational processes and phenomena, among which most significant are the landslides, have occurred on the Bulgarian Danube bank along most of its length, and on some of the slopes of its right tributaries. According to their age and dynamics, the landslides are deep ancient and shallow contemporary.

The deep landslides on the right bank of the Danube River, including also the landslides which are closest to the IP site - near the village of Gorni Tsibar and within the bounds of the town Oryahovo, have developed in Quaternary formations and Neogene sediments of the Brusartsi Formation. Their location is marked by numerous visible surface damages and characteristic geomorphological forms - landslide slopes to a height of 30÷40 m with raised blocks and permanently or temporarily swamped lower areas alternating down the slope, swelling on the slope footing, etc. Some of the deepest landslides have been stabilized, others are in a state close to the limit equilibrium, slowly crawling over the most deep-seated slip surface and are periodically activated under the influence of destabilizing factors - erosion, rainfall, water level fluctuations in rivers, change in the groundwater regime, technogenic impact caused by excavation, backfilling or aggregate extraction works that are not consistent with the stability conditions and so on.

Contemporary landslides are often underlain by ancient landslide deposits. Their depth range is usually up to 5÷10 m, but sometimes reaches to more than 15÷20 m. They are widely spread and are activated under the influence of precipitation, erosion and technogenic activity. By type they are mainly rotational.

Collapse occurs when eolian formations in a strained condition, caused by external load and/or by their own weight, subside (sink) in wet conditions. This property refers them to the problematic (structurally unstable) soils. Pursuant to art. 94 of the Norms for Design of Flat Foundations, the ground base is divided into two types according to the collapsibility of the soil under its own weight: Type 1 – when the collapse does not exceed 5 cm and Type 2 – when the collapse is greater than 5 cm. Deformations from soil subsidence are not recorded when macroporosity is less than 1%.

The geological-lithological profile of the Radiana Site includes soils of the 2nd type: **Layer 1 -** silty loess, light-yellow, micro-porous, with crumbly structure, forming the surface of Terrace T_6 and with thickness of 6.0 m to 16 m; and of the 1st type: **Layer 1a** - silty to silty-sandy loess - macro-porous, light-yellow, with a crumbly structure, at some places streaked by clayey loess.

Therefore, the design and construction of a trench-type NDF will possibly require the inclusion of measures for removal or reduction of the collapsibility properties, in accordance with Section I of Chapter Six of the Norms for Design of Flat Foundations:

- → in the slope area of the terrain - only for part of the auxiliary buildings and facilities, where the foundation depth partially penetrates into Layer 1;
- → in the flat area of the slope - for the repository modules and the auxiliary buildings and facilities, which are partially located in layer 1a.

Water logging. Waterlogged areas are observed on Terrace T_0, to the north-east of the Radiana Site. Their area and depth vary depending on the Danube water level. Organic soil depositions of thickness up to 1÷2 m are found in these areas. They refer to the category of the weak water-saturated soils with degree of saturation $Sr > 0.9$ and modulus of deformation $E_0 < 5.0$ MPa.

Liquefaction of sands. The absence of earthquake induced liquefaction risk in the medium-compacted and compacted (according to SPT tests) alluvial sands in T_1 is proven by studies made in connection with the operational safety of Kozloduy NPP. No evidence for this phenomenon have been found in the non-flooded terrace and on the higher terraces of the Danube River after the Vratsa earthquake of 1977.

Liquefaction induced by seismic impact can possibly occur, also in other Danubian lowlands, in the Holocene sands of the floodplain terrace (Geological Hazard Map of Bulgaria, 1994).

On the grounds of the above, a conclusion can be made that within the Radiana Site and the surrounding area hazardous physico-geological processes and phenomena have not been observed. Nevertheless, the fact that the site is situated on a slope with a height of about 50 m and an inclination in the range of $5 \div 10^0$, composed of relatively weak loess and clayey-sandy soil varieties, is a potential premise for activation and development of landslides and ground subsidence as a result of natural and anthropogenic factors.

In connection with that, the Slope software of the Canadian company Geoslope Ltd. was used *in the natural slope stability assessment* to generate multi-variant stability predictions for a basic combination of loads and for a specific combination of loads (taking into account seismic impact of different intensities from VII to IX degree). The following stability coefficients C_{ST} were obtained (UMG, 2007[41]):

→ for a basic combination of loads (no earthquake) - $C_{ST} = 2.41$;

→ for a specific combination of loads: for an earthquake of VII degree - $C_{ST} = 1.86$; earthquake of VIII degree - $C_{ST} = 1.66$ and earthquake of IX degree - $C_{ST} = 1.32$.

The location of the most hazardous slip surfaces is illustrated in **Figure 3.3-9** .

For the assessment of the feasibility of the chosen alternative for construction of a trench-type NDF on the Radiana Site, analysis of the slope stability and deformation analysis were carried out [42].

3.3.6.1 SLOPE STABILITY ANALYSIS

This assessment includes a significant number of calculations of the overall stability of the two south-western slope profiles of the trench for deposition of repository modules and of the auxiliary buildings and facilities. Conventional widely-applied methods were used for calculation of the limit equilibrium (Morgenstern-Price) of a slope with height of about 38 m and a gradient of about 20.5^0 for the two variants under the following conditions:

→ Variant 1 - the slope consists only of collapsible loess;

→ Variant 2 - the slope consists of collapsible loess, non-collapsible loess with thickness of 5 m and alluvial clay with thickness of 5 m at the base of the slope.

→ The pseudo-static analysis for soil type C adopted in Eurocode 8 was used for identification of the seismic forces. Soil type C includes the soil varieties at the Radiana Site in the area of the repository;

→ The calculations were made for three different equivalent seismic accelerations: $a_h = 0.2$ g, $a_h = 0.15$ g and $a_h = 0.1$ g.

The calculation pattern for Variant 1 is illustrated in **Figure 3.3-10**, and for Variant 2 – in **Figure 3.3-11**. The results of the slope stability analysis are summarised in **Table 3.3-5**.

[41] St. Ivan Rilski University of Mining and Geology, 2007. Assignment Report: Analysis of the conditions for surface disposal of RAW.

[42] Westinghouse, DBEtec, Enresa, EQE Bulgaria AD 2013. Technical project. Part: Geomechanical assessment and analysis.

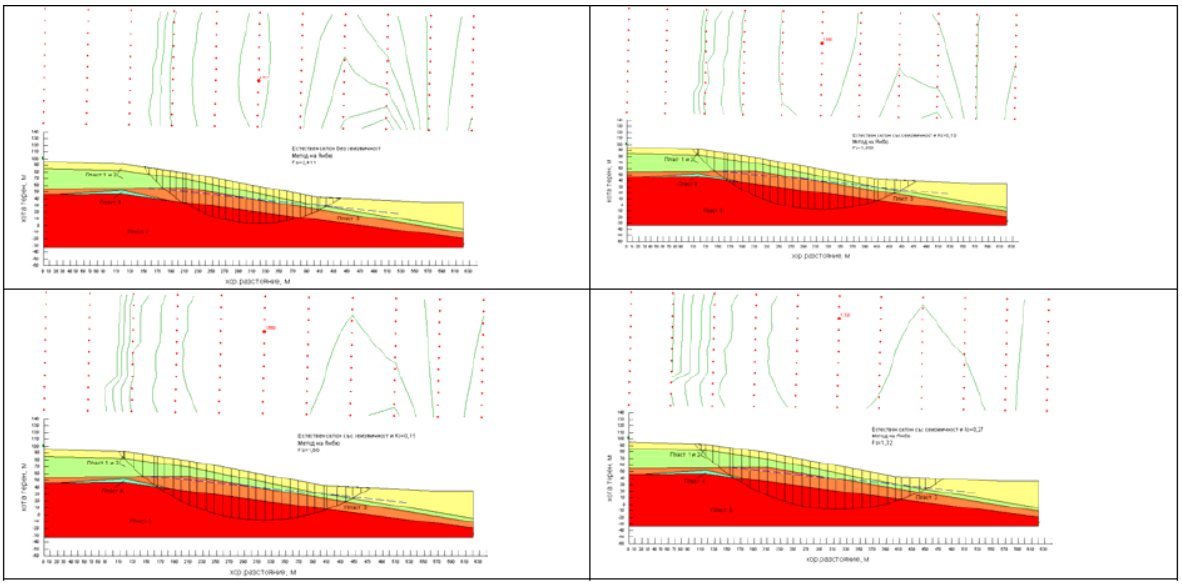


FIGURE 3.3-9 CALCULATION PROFILE OF THE NATURAL SLOPE STABILITY FORECAST FOR A BASIC COMBINATION AND A SPECIFIC COMBINATION OF THE LOADS (TAKING INTO ACCOUNT SEISMIC IMPACT OF VARIOUS INTENSITIES (VII÷IX DEGREE))

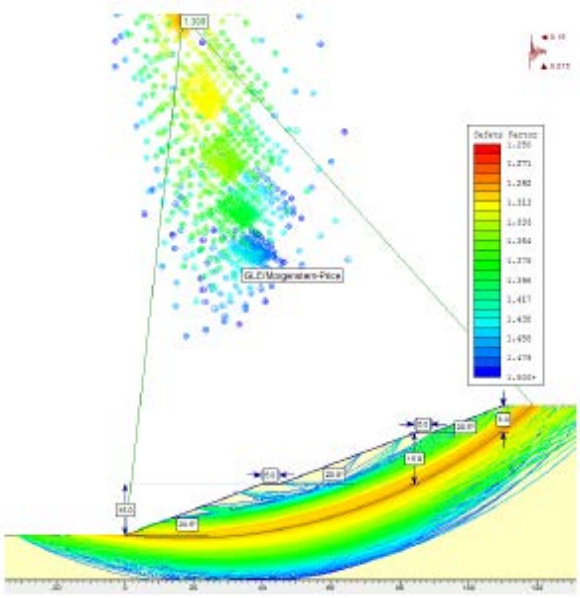


FIGURE 3.3-10 CALCULATION PATTERN OF THE BASIC SLOPE STABILITY FOR VARIANT 1 WITH SEISMIC IMPACT (0.15G)

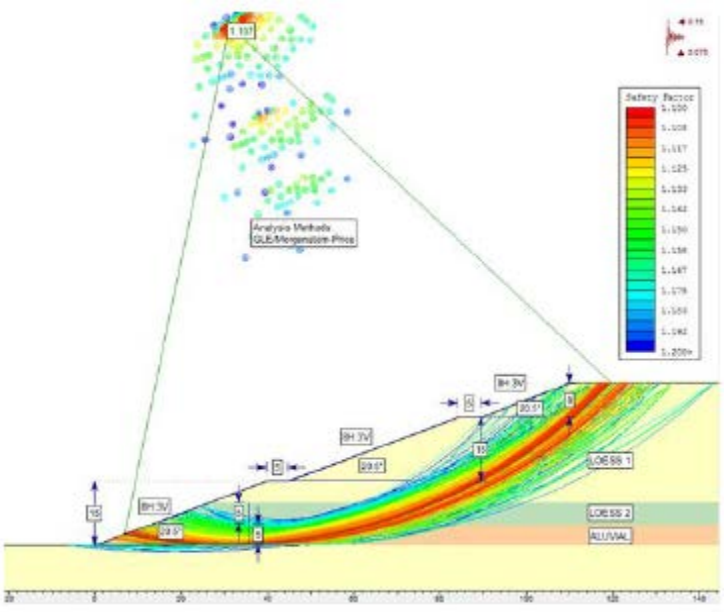


FIGURE 3.3-11 CALCULATION PATTERN OF THE BASIC SLOPE STABILITY FOR VARIANT 2 WITH SEISMIC IMPACT (0.15G)

TABLE 3.3-5 RESULTS OF THE SLOPE STABILITY ANALYSIS

Variant	Loads	Calculated safety factor		
		a_h = 0.20 g	a_h = 0.15 g	a_h = 0.10g
Homogeneous collapsible loess slope	Basic load combination	1.98	1.98	1.98
	Specific load combination (earthquake)	1.14	1.30	1.48
Slope of collapsible loess, non-collapsible loess and alluvial clay	Basic load combination	1.71	1.71	1.71
	Specific load combination (earthquake)	0.98	1.11	1.27

The results obtained show that the calculated safety factors are certainly higher than the standard ones for the basic load combination ($FS_{sta} \geq 1.50$), and for the specific load combination ($FS_{dyn} \geq 1.10$) with the design equivalent seismic accelerations a_h = 0.15 g and a_h = 0.10 g.

3.3.6.2 DEFORMATION ANALYSIS

Two hypotheses were analysed in order to assess the deformation behaviour of soils and their general stability: in the first hypothesis, the Pliocene clay is set as "soil with increasing stiffness" with an initial modulus of deformation of 45 MPa and modulus of deformation under unloading-loading 135 MPa, and in the second hypothesis, it is described as a soil of the Mohr-Coulomb model with modulus of deformation of 135 MPa. The second hypothesis is calculated by taking into account the results of the supporting analysis of the subsidence of Units 5 and 6 of Kozloduy NPP, in which it is assumed that existing Pliocene materials under the level of the studied stresses will move only following an elastic pattern of unloading-loading. The calculation profile is shown in **Figure 3.3-12 .**

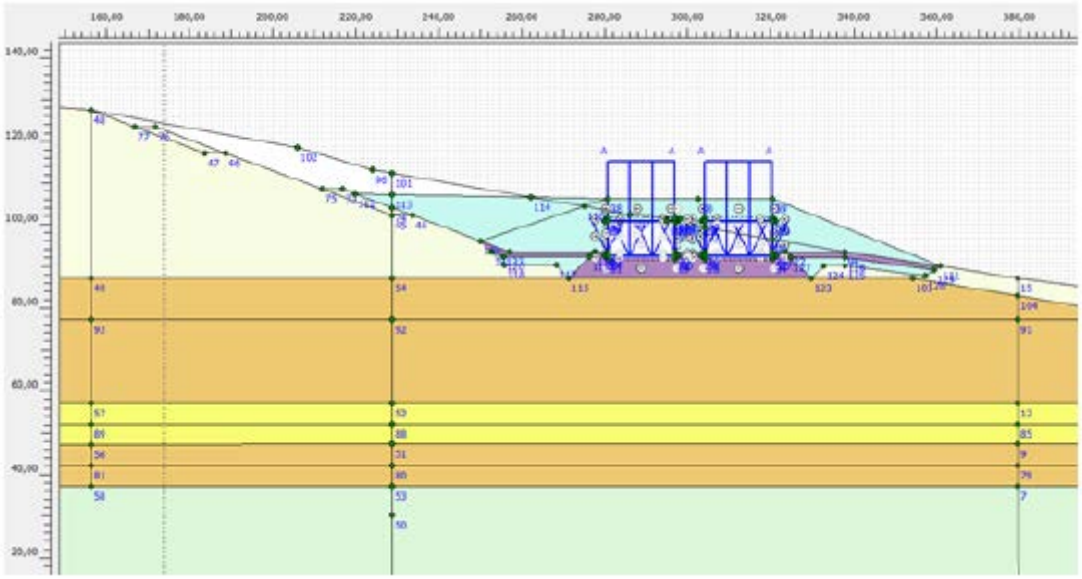


FIGURE 3.3-12 CALCULATION PROFILE FOR DEFORMATION ANALYSIS

The deformation analysis was performed with Plaxis software by applying the finite element method. Seven stages of repository construction were considered: slope excavation (Stage 1), laying the loess-cement cushion (Stage 2), construction of the facility (Stage 3), storage of radioactive waste (Stage 4), partial covering of the cells (Stage 5), final covering of the cells (Stage 6) and seismic analysis of the final stage (Stage 7). Further analysis was made of the conditions for construction of the foundation and the auxiliary buildings.

The results of the calculations, illustrated in **Figure 3.3-13**, clearly indicate that the selected alternative for construction of the NDF will result in small subsidence in the range of 9 to 12 cm, similar to that observed in blocks 5 and 6 of Kozloduy NPP. In fact, since there are differences between the vertical loads acting on the NPP and those envisaged in the NDF, it is quite possible that the actual subsidence of the NDF will be significantly lower than the calculated (estimated) one. In addition to that, the demonstrated general slope stability under seismic impact after the final layer is applied, is expressed by the calculated safety factor FS_{din} = 1.35.

Regarding the foundations of the auxiliary buildings, the option for construction on the slope is also suitable and feasible. Suitable conditions for the building foundations can be achieved by leaving the natural gravel as a ground base of the buildings or improving the alluvial clays or the collapsible loess layers by depositing a compacted 1.3 m gravel layer over them.

In conclusion, the selected alternative for construction of the NDF is considered appropriate from the geotechnical point of view. Nevertheless, it is advisable that suitable supervision and further investigation is provided for before and during the construction phase, if necessary.

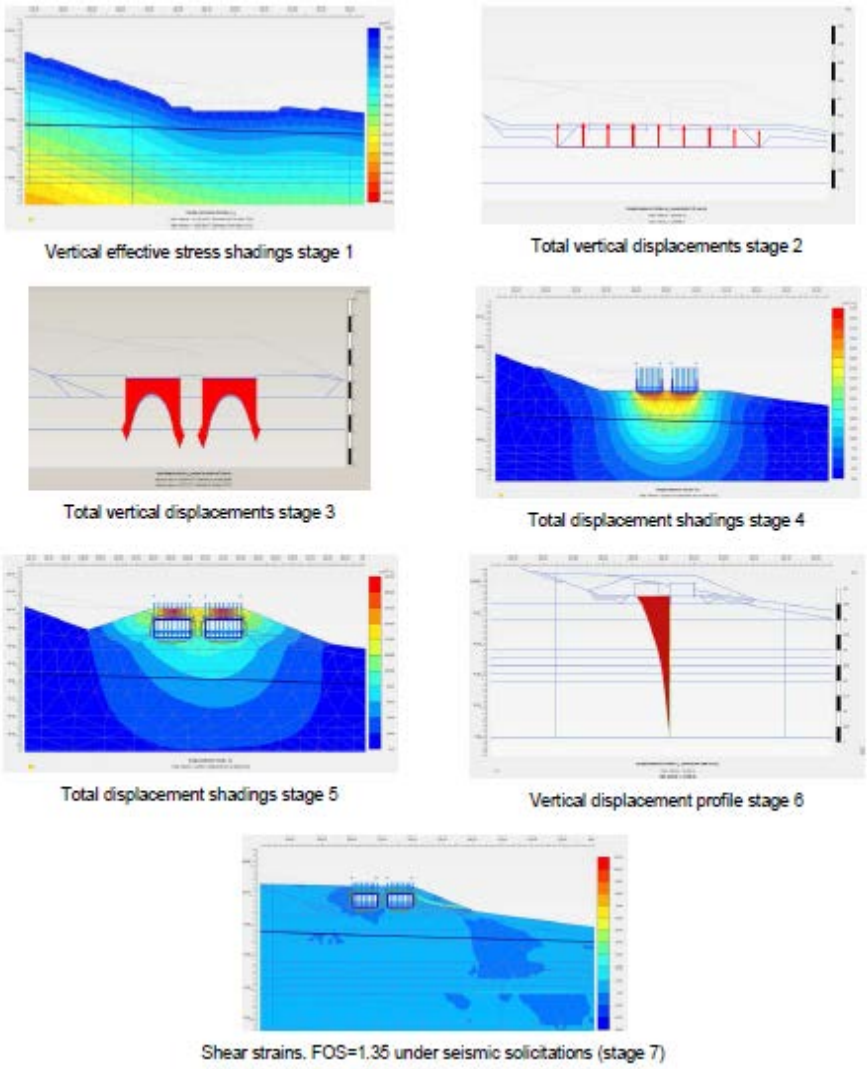


FIGURE 3.3-13 ILLUSTRATION OF THE RESULTS OF THE MODEL CALCULATIONS IN THE SEPARATE STAGES OF CONSTRUCTION OF THE NDF

3.3.7 GEODETIC MONITORING

During their lifetime, the technical facilities undergo certain changes under the influence of factors and forces of different origin and nature. The result of this complex impact on the equipment are transient or permanent geometric changes, which are generally referred to as deformations. Depending on the nature and severity of the deformation processes, certain parts and elements of the building structures can turn into potential source of hazard to the stability and quality of the facilities, as well as to cause environmental impact. In order to ensure maximum safety, operational suitability and proper use of the facilities' technological resources, it is necessary to plan and implement activities for monitoring, assessment and management of conditions, processes and phenomena occurring in their structure. These activities can be summarized with the term monitoring of movements and deformations.

The surveying of movements and deformations is important for studying the behaviour, functional and operational suitability of building structures and facilities throughout their life cycle, as well as that of the ground base on which they are built. Another important objective of the monitoring of movements and deformations is to provide a realistic impact assessment of the set of factors influencing the surveyed structures. Such studies provide data that can be used in the decision-making process regarding the intervention on existing problematic facilities, in connection with re-

assessment of building technologies and in projects for future construction or verification of scientific hypotheses and models of the studied objects. Particular attention in this regard shall be paid in the process of construction and long-term operation of sites, such as nuclear power plants and radioactive waste storage facilities.

3.3.7.1 GEODETIC MONITORING OF KOZLODUY NPP

The geodetic network built on the territory of Kozloduy NPP is designed to monitor the horizontal and vertical displacement of the ground base. Since 1998, five monitoring campaigns have been carried out, including surveying and evaluation of local geodynamics. The results show that near the Radiana Site:

→ the expected average vertical displacement is approximately less than 10 mm;

→ the displacement of monitoring pillars 116 and 120 measured by means of a forced centering device were Δh = - 0.0046 m and Δh = - 0.0006m. For the same period, the horizontal displacements of these pillars were 0.0139 m and 0.0296 m;

→ the vertical displacements were of a magnitude lower than the corresponding horizontal ones, but the measurement accuracy of the horizontal displacement was of a lower grade.

The conclusion that follows from the analysis of these results is that there were no significant vertical and horizontal displacements in the area of the Radiana Site[43].

3.3.7.2 PRE-COMMISSIONING GEODETIC MONITORING OF THE NDF

The need for geodetic monitoring is particularly relevant for the NDF, since the planned buildings and facilities on the Radiana Site will be located on a slope, which in the case of a trench-type repository will require large-scale excavation works in relatively complex geological conditions. In connection with that, in 2013 RAW SE prepared terms of reference for a Project for pre-commissioning geodetic monitoring of the Radiana Site. The objective of the project is to develop a basic network for geodetic monitoring of the site and to provide updated geodetic information prior to construction and operation of the NDF. The following steps are planned for achievement of this objective:

→ Design and construction of a network for geodetic monitoring of the NDF site, which should indicate the geometric changes (e.g. coordinates of points) of the site topography by measuring multiple geometric elements;

→ Assessment based on appropriate geodesic measurements of earth movements and site deformations during the pre-commissioning phase as an important input for the deformation analysis during the construction and operation of the NDF;

→ Providing data about the long-term natural slope stability in order to confirm the design assumptions and to ensure the long-term stability of the NDF;

→ Development of a geodetic monitoring programme for the operational period of the NDF;

→ Training of the NDF staff for the geodetic monitoring implementation.

3.4 LANDS AND SOILS

3.4.1 LANDS

The lands in the area of the Radiana site are predominantly state-owned. The land is not used for agricultural purposes. The terrain is overgrown with low-stemmed forests, mainly acacias and shrubs.

[43] Westinghouse, DBEtec, Enresa, EQE Bulgaria AD, 2013. Technical project. Part: Geodesy

The site is located on the land belonging to the village of Harlets, Kozloduy Municipality, Vratsa District about 200 km along a road north of the capital Sofia and only 5 km east of the town of Kozloduy. The Radiana site covers an area of approximately 46 ha and is almost rectangular in shape with maximum dimensions of 470 m x 1250 m. It is situated in the immediate vicinity of Kozloduy NPP between two roads, a service road, managed by the NPP, connecting the town of Kozloduy and the NPP to the north and a secondary road, connecting the village of Harlets and the town of Kozloduy to the south. The repository is located outside the restricted access zone and the security fence of Kozloduy NPP, but lies within the outer security perimeter of Kozloduy NPP, as described in the technical design[44].

In terms of geography, the site is located between the second and sixth loess terraces in the non-flooded site to the right of the Danube. The lower terrace, T_2, is relatively horizontal, with elevations between 39 and 45 m and occupies the northern and northeastern part of the site. The upper terrace, T_6, with elevations between 65 and 93 m, takes up the southern part of the sloping part of the site. The latter is almost flat having a slope of about 3% and a sloping area between the zones corresponding to T_2 and T_6, with a slope of 12%. According to the "stress tests"[45] conducted by the EU, the maximum elevation that can be flooded once for a period of 10,000 years (probability p = 0.01%) is 33.50 m for the zone – i.e. well below the elevation of the site.

Over the past four decades, the Radiana site has been studied in detail; at first as part of the research for determining the location of Kozloduy NPP and recently, between 2007 and 2011, extensive analyses were carried out for selecting the NDF site. In 2011, the Geological Institute of the Bulgarian Academy of Sciences carried out a study named Forecast for possible change of the hydrogeological conditions of the flat part of the Radiana site under the most unfavourable hydrological, hydraulic and climatic conditions and together with erosion and flood risk assessment.[46]. The conclusion of this study is that the Radiana site is not threatened by flood or erosion caused by the Danube and the maximum rise of the water level is projected to be 0.9 m.

It is clear from the provided plans of the plots and ADC with the same numbers (Appendix 8-III.1 and Appendix 8-III.2) that:

→ Property 000254, with UCATTU 77548, Kozloduy Municipality, formed by property № 000238 on the land belonging to the village of Harlets, is located in the Starite Lozya area with the following borders and neighbours:

№ 000316	Deciduous forest	of MAF- DA/DDS
№ 000218	Electric line	of Kozloduy NPP EAD
№ 000141	Field road	of Kozloduy Municiplity Land border
№ 000229	Irrigation channel	of MAF-HMS
№ 000225	Sports’ area	of Kozloduy Municiplity

The property includes a building intended for laboratory owned by RAW SE. There are restrictions on part of the property due to the wires passing through it and easements around them having a width of 7.5 and 5.00 m on one side and 2.5 m on the other.

[44] © WESTINGHOUSE ELECTRIC SPAIN, DBE TECHNOLOGY GMBH, ENRESA AND EQE. ALL RIGHTS RESERVED. Project signture EQEB-11207-TD-GEN-R01(2)_BG / PAGES 55/60

[45] Technical Design: General Explanatory Note Part. Explanatory Note. EQEB-11207-TD-GEN-R01

[46] Report on the review and selection of potential NDF sites; Annex to the General Report; Development of a conception for disposal of radioactive waste and for review and selection of potential NDF sites; 2004; GI,GphI – BAS.

→ Property № 000355, with UCATTU 77549, Kozloduy Municipality, formed by property № 000231 on the land belonging to the village of Harlets, is located in the Starite Lozya area with the following borders and neighbours:

№ 000385	Deciduous forest	of MAF- DA/DDS
№ 000005	Field road	of Kozloduy Municiplity Land border
№ 000223	Secondary road	State-owned

The studies for determining the site for construction of NDF continued many years during which a number of institutions were assigned to conduct in-depth studies concerning all aspects of impacts: geological, hydrogeological, seismic, soil, land use, etc.

The status of the land, falling within the site and in its area, based on relevant information of the Agriculture and Forestry Municipal Office and the Cadastre, Geodesy and Cartography Agency is presented in **Table 3.4-1**.

TABLE 3.4-1 STATUS OF THE PROPERTIES LOCATED ON THE RADIANA SITE AND ITS AREA.

№ of property	Owner	Designated use	Type of property	Area, daa[47]
000254	RAW SE	Other settlement area	Public state	309633
000238	SLF	Forest in agricultural lands	Private state	100215
000232	Kozloduy Municipality	Water facility	Private municipal	1569
000355	RAW SE	Other settlement area	Public state	129871
000231	SLF	Forest in agricultural lands	Private state	79228
000229	MAF-HMS	Irrigation channel	Private state	32904
000228	Kozloduy Municipality	Water facility	Private municipal	0603
000227	Kozloduy Municipality	Water facility	Private municipal	1017
000225	Kozloduy Municipality	Sports' area	Private municipal	426
000038	Kozloduy Municipality	Field road	Public municipal	1091
000005	Kozloduy Municipality	Field road	Public municipal	10532

The table shows that the land on the Radiana site is public state property. The land around the site is also predominantly state, with small plots which are private municipal property and public municipal property.

The state of agriculture in the area of the Radiana site is determined on the basis of data on the structure of the soil cover and the land productivity as well as on the manner of sustainable use of agricultural lands.

Figure 3.4-1 presents the reference plan of the Radiana site against the adjacent lands.

The access to the site is possible by following the road from Kozloduy NPP (northern road) and from secondary road II-11 from the national road network after making a deviation.

It is envisaged that the power and water supply will be provided by the operating companies CEZ Electro Bulgaria AD and ViK Vratsa. The sewerage will be ensured by means of connection to the

[47]International abbreviation of **decare** - *deka*(**da**) + *are*(**a**) = **daa**– equal to 10 are or 1000 m^2

wastewater system of Kozloduy NPP. The connection points will be equipped with appropriate measuring equipment.[48]

As the site of the IP is in close proximity to the nuclear plant, the analysis of the distribution of arable land in the areas around Kozloduy NPP[49] is also applicable to the Radiana site.

TABLE 3.4-2 LAND DISTRIBUTION (DECARES /DAA) IN THE AREAS AROUND KOZLODUY NPP.

Zones around Kozloduy NPP	10 km	20 km	30 km	110 km
Total area, including:	174,000	710,000	1,587,000	21,368,000
Arable land area	100,000	406,000	908,000	12,280,000
- - areas under crops	84,000	346,000	774,000	10,468,000
- - perennial fruit trees	4,000	15,000	33,000	446,000
- - natural meadows	7,000	30,000	67,000	906,000
- - pastures	5,000	15,000	34,000	460,000
Forests, bushes, rocky areas, rivers and water basins	14,000	304,000	679,000	9,088,000

According to the Ecological Assessment of the Specialised Detailed Development Plan (SDDP), the zone with a radius of 2 km around Kozloduy NPP, intended for preventive protection measures, covers 9,554 daa, of which 3,012 are occupied by the electricity generation site of Kozloduy NPP, the site for storage and processing of the radioactive waste belonging to the Kozloduy RAW Specialised Division and the site of Units 1 to 4, which are to be decommissioned by the Specialised Division for Decommissioning of Units 1 to 4. The remaining lands are arable areas, planted each year with various agricultural crops.

The summarising conclusion, which can be made, is that plant growing in the area is oriented towards grain production, however, technical crops and perennial plants are also of great significance. Stock-breeding is poorly developed and animals are being bred are for personal use in private farms.

[48]EQEL-11207-CD-GTC-R01(1)_BG (2013 -11-01) Preliminary Design Alternative 1: Geotechnics and Geomechanics Part. Geomechanical and geotechnical conditions and ground.

[49]EIAR of IP for Construction of a New Nuclear Unit of the Latest Generation at Kozloduy NPP Site Version 03, items 3.2 and 4.3., August 2013. page: 1199

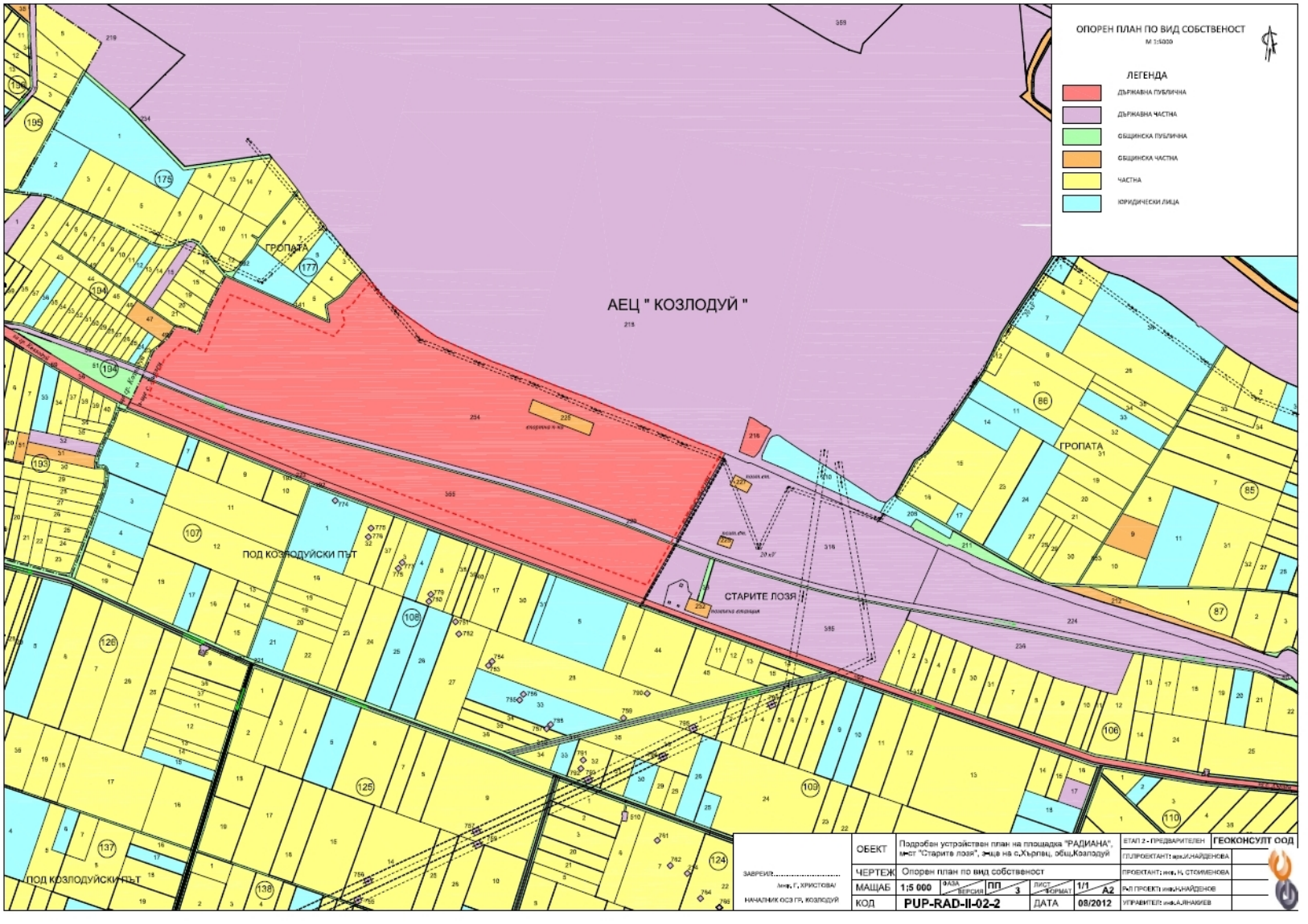


FIGURE 3.4-1 REFERENCE PLAN BY TYPE OF OWNERSHIP

Data on the reinstated property, the type of land use and ownership of the lands belonging to the town of Kozloduy and the village of Harlets are given **Table 3.4-3**. The land of the town of Kozloduy covers a total area[50] of 1,111.781 daa and the one belonging to the village of Harlets is equal to 4,877.916 daa.

Data on the reinstated property, the type of land use and ownership of the lands belonging to the town of Kozloduy and the village of Harlets are given. The distribution of the sites is presented as a structure, manner of permanent usage and type of property (**Table 3.3-3).**

As regards the area of the town of Kozloduy, the terrain includes watercourses and water areas as drainage channels, of which 16.107 daa are private state property, 1.829 daa are municipal private property and other type of channel, which occupies the greatest area of 530.265 daa on the land of various public organisations. The channels cover a total area of 548.194 daa.

The field roads, traced for agricultural purposes lie on public municipal property and comprise 42.125 daa of the territory. The pastures and grasslands comprise 3 plots with an area of only 12.614 daa.

The share of the fields amount to 426.848 daa, of which 355.512 daa are private property, 26.901 daa belong to public organisations, 25.187 daa are private state property and 19.250 daa are fields lying on private municipal property.

The vineyards have a total area of 82.001 daa, the share of the private property being 46.440 daa, some 27.065 daa of vineyards are managed by the Municipality. Four plots of vineyards with a total area of 8.496 daa are owned by public organisations.

TABLE 3.4-3 DATA ON THE REINSTATED PROPERTY AND THE TYPE OF LAND USE FOR THE LANDS BELONGING TO THE TOWN OF KOZLODUY AND THE VILLAGE OF HARLETS

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
Kozloduy	37798.0.2	Watercourses and water areas	Other type of channel	Public organisations	530,265
Kozloduy	37798.0.196	Watercourses and water areas	Drainage channel	Private state	15,160
Kozloduy	37798.0.618	Watercourses and water areas	Drainage channel	Private state	0,940
Kozloduy	37798.0.197	Watercourses and water areas	Drainage channel	Private municipal	1,829
					548,194
Kozloduy	37798.0.418	For agricultural purposes	Field road	Public municipal	11,026
Kozloduy	37798.0.428	For agricultural purposes	Field road	Public municipal	8,727
Kozloduy	37798.0.434	For agricultural purposes	Field road	Public municipal	1,989
Kozloduy	37798.0.446	For agricultural purposes	Field road	Public municipal	1,945
Kozloduy	37798.0.614	For agricultural purposes	Field road	Public municipal	2,783
Kozloduy	37798.0.615	For agricultural purposes	Field road	Public municipal	1,416
Kozloduy	37798.0.616	For agricultural purposes	Field road	Public municipal	1,732
Kozloduy	37798.0.617	For agricultural purposes	Field road	Public municipal	8,466
Kozloduy	37798.0.554	For agricultural purposes	Field road	Public municipal	4,041

[50]EIAR of IP for Construction of a New Nuclear Unit of the Latest Generation at Kozloduy NPP Site, 2013 .

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
42,125					
Kozloduy	37798.0.447	For agricultural purposes	Pasture, grassland	Public municipal	2,421
Kozloduy	37798.0.499	For agricultural purposes	Pasture, grassland	Public municipal	0,940
Kozloduy	37798.0.761	For agricultural purposes	Pasture, grassland	Public municipal	9,253
					12,614
Kozloduy	37798.209.1	For agricultural purposes	Field	Private	1,001
Kozloduy	37798.209.2	For agricultural purposes	Field	Private	2,476
Kozloduy	37798.209.4	For agricultural purposes	Field	Private	4,055
Kozloduy	37798.209.7	For agricultural purposes	Field	Private	2,702
Kozloduy	37798.209.8	For agricultural purposes	Field	Private	5,495
Kozloduy	37798.209.9	For agricultural purposes	Field	Private	8,111
Kozloduy	37798.209.10	For agricultural purposes	Field	Private	14,346
Kozloduy	37798.209.11	For agricultural purposes	Field	Private	11,260
Kozloduy	37798.209.13	For agricultural purposes	Field	Private	15,586
Kozloduy	37798.209.17	For agricultural purposes	Field	Private	46,736
Kozloduy	37798.209.18	For agricultural purposes	Field	Private	2,701
Kozloduy	37798.210.4	For agricultural purposes	Field	Private	1,804
Kozloduy	37798.210.5	For agricultural purposes	Field	Private	2,795
Kozloduy	37798.210.6	For agricultural purposes	Field	Private	4,507
Kozloduy	37798.210.9	For agricultural purposes	Field	Private	3,750
Kozloduy	37798.210.13	For agricultural purposes	Field	Private	4,508
Kozloduy	37798.210.14	For agricultural purposes	Field	Private	4,325
Kozloduy	37798.210.17	For agricultural purposes	Field	Private	4,508
Kozloduy	37798.210.18	For agricultural purposes	Field	Private	4,507
Kozloduy	37798.210.21	For agricultural purposes	Field	Private	8,112
Kozloduy	37798.210.28	For agricultural purposes	Field	Private	15,311
Kozloduy	37798.244.45	For agricultural purposes	Field	Private	3,602
Kozloduy	37798.244.46	For agricultural purposes	Field	Private	3,594
Kozloduy	37798.244.49	For agricultural purposes	Field	Private	4,502
Kozloduy	37798.244.50	For agricultural purposes	Field	Private	4,047
Kozloduy	37798.244.51	For agricultural purposes	Field	Private	4,684

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
Kozloduy	37798.244.56	For agricultural purposes	Field	Private	4,232
Kozloduy	37798.244.57	For agricultural purposes	Field	Private	4,352
Kozloduy	37798.244.58	For agricultural purposes	Field	Private	3,577
Kozloduy	37798.244.59	For agricultural purposes	Field	Private	3,279
Kozloduy	37798.244.60	For agricultural purposes	Field	Private	4,324
Kozloduy	37798.244.61	For agricultural purposes	Field	Private	2,699
Kozloduy	37798.245.2	For agricultural purposes	Field	Private	18,888
Kozloduy	37798.245.3	For agricultural purposes	Field	Private	16,384
Kozloduy	37798.245.5	For agricultural purposes	Field	Private	6,413
Kozloduy	37798.245.6	For agricultural purposes	Field	Private	29,327
Kozloduy	37798.246.1	For agricultural purposes	Field	Private	4,053
Kozloduy	37798.246.2	For agricultural purposes	Field	Private	16,872
Kozloduy	37798.246.3	For agricultural purposes	Field	Private	18,847
Kozloduy	37798.302.5	For agricultural purposes	Field	Private	15,585
Kozloduy	37798.302.8	For agricultural purposes	Field	Private	3,244
Kozloduy	37798.302.10	For agricultural purposes	Field	Private	3,602
Kozloduy	37798.302.11	For agricultural purposes	Field	Private	5,405
Kozloduy	37798.302.12	For agricultural purposes	Field	Private	5,404
					355,512
Kozloduy	37798.302.14	For agricultural purposes	Field	Public organisations	5,045
Kozloduy	37798.302.9	For agricultural purposes	Field	Public organisations	2,692
Kozloduy	37798.245.4	For agricultural purposes	Field	Public organisations	6,756
Kozloduy	37798.210.10	For agricultural purposes	Field	Public organisations	5,589
Kozloduy	37798.209.12	For agricultural purposes	Field	Public organisations	3,216
Kozloduy	37798.209.5	For agricultural purposes	Field	Public organisations	3,603
					26,901
Kozloduy	37798.209.6	For agricultural purposes	Field	Private municipal	3,603
Kozloduy	37798.245.7	For agricultural purposes	Field	Private municipal	13,380
Kozloduy	37798.302.13	For agricultural purposes	Field	Private municipal	2,268
Kozloduy	37798.245.1	For agricultural purposes	Field	Private state	14,467
Kozloduy	37798.302.16	For agricultural purposes	Field	Private state	10,720

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
					44,438
Kozloduy	37798.630.63	For agricultural purposes	Vineyard	Private	1,557
Kozloduy	37798.630.65	For agricultural purposes	Vineyard	Private	2,649
Kozloduy	37798.630.67	For agricultural purposes	Vineyard	Private	1,350
Kozloduy	37798.630.71	For agricultural purposes	Vineyard	Private	1,254
Kozloduy	37798.630.73	For agricultural purposes	Vineyard	Private	2,026
Kozloduy	37798.630.74	For agricultural purposes	Vineyard	Private	1,861
Kozloduy	37798.630.75	For agricultural purposes	Vineyard	Private	1,732
Kozloduy	37798.630.76	For agricultural purposes	Vineyard	Private	1,607
Kozloduy	37798.630.77	For agricultural purposes	Vineyard	Private	1,977
Kozloduy	37798.630.78	For agricultural purposes	Vineyard	Private	2,503
Kozloduy	37798.630.79	For agricultural purposes	Vineyard	Private	0,283
Kozloduy	37798.630.81	For agricultural purposes	Vineyard	Private	0,954
Kozloduy	37798.630.82	For agricultural purposes	Vineyard	Private	1,870
Kozloduy	37798.630.85	For agricultural purposes	Vineyard	Private	1,045
Kozloduy	37798.630.86	For agricultural purposes	Vineyard	Private	3,306
Kozloduy	37798.633.4	For agricultural purposes	Vineyard	Private	1,872
Kozloduy	37798.633.5	For agricultural purposes	Vineyard	Private	5,318
Kozloduy	37798.633.8	For agricultural purposes	Vineyard	Private	2,068
Kozloduy	37798.633.9	For agricultural purposes	Vineyard	Private	1,966
Kozloduy	37798.633.10	For agricultural purposes	Vineyard	Private	2,275
Kozloduy	37798.633.12	For agricultural purposes	Vineyard	Private	2,592
Kozloduy	37798.633.14	For agricultural purposes	Vineyard	Private	1,759
Kozloduy	37798.633.15	For agricultural purposes	Vineyard	Private	2,616
					46,440
Kozloduy	37798.630.62	For agricultural purposes	Vineyard	Managed by the municipality	2,358
Kozloduy	37798.630.64	For agricultural purposes	Vineyard	Managed by the municipality	0,782
Kozloduy	37798.630.66	For agricultural purposes	Vineyard	Managed by the municipality	2,766
Kozloduy	37798.630.68	For agricultural purposes	Vineyard	Managed by the municipality	2,123
Kozloduy	37798.630.72	For agricultural purposes	Vineyard	Managed by the municipality	1,336
Kozloduy	37798.630.80	For agricultural purposes	Vineyard	Managed by the municipality	1,246

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
Kozloduy	37798.630.84	For agricultural purposes	Vineyard	Managed by the municipality	0,780
Kozloduy	37798.633.1	For agricultural purposes	Vineyard	Managed by the municipality	2,039
Kozloduy	37798.633.2	For agricultural purposes	Vineyard	Managed by the municipality	3,172
Kozloduy	37798.633.3	For agricultural purposes	Vineyard	Managed by the municipality	3,408
Kozloduy	37798.633.6	For agricultural purposes	Vineyard	Managed by the municipality	2,032
Kozloduy	37798.633.7	For agricultural purposes	Vineyard	Managed by the municipality	2,464
Kozloduy	37798.633.11	For agricultural purposes	Vineyard	Managed by the municipality	2,559
					27,065
Kozloduy	37798.630.69	For agricultural purposes	Vineyard	Public organisations	1,302
Kozloduy	37798.630.70	For agricultural purposes	Vineyard	Public organisations	1,395
Kozloduy	37798.630.83	For agricultural purposes	Vineyard	Public organisations	2,411
Kozloduy	37798.633.13	For agricultural purposes	Vineyard	Public organisations	3,386
8,494					
Harlets	77548.0.384	Watercourses and water areas	Drainage channel	Private state	1,170
Harlets	77548.0.64	Watercourses and water areas	Drainage channel	Private state	26,109
					27,279
Harlets	77548.0.71	Watercourses and water areas	Drainage channel	Private municipal	26,479
Harlets	77548.0.111	For agricultural purposes	Field road	Public municipal	5,128
Harlets	77548.0.113	For agricultural purposes	Field road	Public municipal	4,552
Harlets	77548.0.155	For agricultural purposes	Field road	Public municipal	1,860
Harlets	77548.0.158	For agricultural purposes	Field road	Public municipal	5,859
Harlets	77548.0.201	For agricultural purposes	Field road	Public municipal	12,390
Harlets	77548.0.645	For agricultural purposes	Field road	Public municipal	5,242
Harlets	77548.0.344	For agricultural purposes	Field road	Public municipal	2,714
Harlets	77548.0.538	For agricultural purposes	Local road	Public municipal	0,128
					64,352
Harlets	77548.53.9	For agricultural purposes	Field	Private	37,931
Harlets	77548.54.12	For agricultural purposes	Field	Private	12,510
Harlets	77548.54.13	For agricultural purposes	Field	Private	27,720
Harlets	77548.56.5	For agricultural purposes	Field	Private	32,076
Harlets	77548.54.15	For agricultural purposes	Field	Private	2,603
Harlets	77548.56.9	For agricultural	Field	Private	11,009

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
		purposes			
Harlets	77548.56.10	For agricultural purposes	Field	Private	11,009
Harlets	77548.56.11	For agricultural purposes	Field	Private	11,009
Harlets	77548.56.12	For agricultural purposes	Field	Private	12,310
Harlets	77548.86.2	For agricultural purposes	Field	Private	5,625
Harlets	77548.86.6	For agricultural purposes	Field	Private	5,004
Harlets	77548.86.9	For agricultural purposes	Field	Private	10,004
Harlets	77548.86.10	For agricultural purposes	Field	Private	19,940
Harlets	77548.86.12	For agricultural purposes	Field	Private	2,052
Harlets	77548.86.15	For agricultural purposes	Field	Private	23,770
Harlets	77548.86.16	For agricultural purposes	Field	Private	7,006
Harlets	77548.86.19	For agricultural purposes	Field	Private	7,507
Harlets	77548.86.20	For agricultural purposes	Field	Private	9,062
Harlets	77548.86.23	For agricultural purposes	Field	Private	16,013
Harlets	77548.86.26	For agricultural purposes	Field	Private	23,020
Harlets	77548.86.27	For agricultural purposes	Field	Private	6,005
Harlets	77548.86.28	For agricultural purposes	Field	Private	3,002
Harlets	77548.86.30	For agricultural purposes	Field	Private	10,018
Harlets	77548.86.31	For agricultural purposes	Field	Private	15,313
Harlets	77548.86.32	For agricultural purposes	Field	Private	8,307
Harlets	77548.86.34	For agricultural purposes	Field	Private	4,153
Harlets	77548.86.35	For agricultural purposes	Field	Private	4,153
					338,131
Harlets	77548.0.208	For agricultural purposes	Abandoned perennial plants	Public organisations	4,925
Harlets	77548.0.210	For agricultural purposes	Abandoned perennial plants	Public organisations	12,822
					17,747
Harlets	77548.86.17	For agricultural purposes	Field	Public organisations	2,002
Harlets	77548.86.21	For agricultural purposes	Field	Public organisations	5,425
Harlets	77548.86.24	For agricultural purposes	Field	Public organisations	17,795
Harlets	77548.86.29	For agricultural purposes	Field	Public organisations	3,003
Harlets	77548.86.33	For agricultural purposes	Field	Public organisations	8,307

Land of	Cadastre Identifier	VT_STR	Land use	Type of property	Area, daa
Harlets	77548.86.36	For agricultural purposes	Field	Public organisations	43,147
Harlets	77548.86.11	For agricultural purposes	Field	Public organisations	10,288
Harlets	77548.54.14	For agricultural purposes	Field	Public organisations	12,151
Harlets	77548.55.35	For agricultural purposes	Field	Public organisations	142,711
Harlets	77548.56.3	For agricultural purposes	Field	Public organisations	22,718
Harlets	77548.86.7	For agricultural purposes	Field	Public organisations	12,990
Harlets	77548.86.1	For agricultural purposes	Field	Public organisations	4,007
Harlets	77548.86.14	For agricultural purposes	Field	Public organisations	8,667
					293,211
Harlets	77548.56.4	For agricultural purposes	Field	Private state	30,551
Harlets	77548.56.8	For agricultural purposes	Field	Private state	11,009
Harlets	77548.56.1	For agricultural purposes	Field	Private state	132,085
Harlets	77548.54.16	For agricultural purposes	Field	Private state	31,535
Harlets	77548.53.10	For agricultural purposes	Field	Private state	73,685
					27,8865
Harlets	77548.0.980	For agricultural purposes	Destroyed field – industrial	Private state	22,106
Harlets	77548.0.981	For agricultural purposes	Destroyed field – industrial	Private state	6,868
					28,974
Harlets	77548.0.211	For agricultural purposes	Pasture, grassland	Public municipal	**6,199**
Harlets	77548.0.212	For agricultural purposes	Abandoned perennial plants	Private municipal	**6,443**
Harlets	77548.0.218	Settlements	Electric lines	Public organisations	**3,714,745**
Harlets	77548.0.358	For agricultural purposes	Industrial site	Private state	**101,712**
Harlets	77548.0.537	For agricultural purposes	Other settlement area	Public organisations	**0,255**
					5,989,697
				Kozloduy area	**1,111,781**
				Harlets area	**4,877,916**

The area of the lands belonging to the village of Harlets is considerably greater (over 4 times more than those in Kozloduy). Three drainage channels are built on it, covering an area of 53.728 daa. Two of the drainage channels are built on private state property with an area of 27.279 daa and one is built on private municipal land of 26.479 daa.

The field roads take up 37.872 daa being only public municipal property. The fields with a total area of 910.208 daa have various owners. The private fields cover 338.131 daa. Public organisations own 293.211 daa, while the share of the private state property is 278.866 daa. According to the information provided, some 28.974 daa have been specified as destroyed fields on private state property. Other 17.747 daa have been reported as abandoned orchards and vineyards owned by

public organisations and 6.443 daa are private municipal property. The area of a pasture, grassland of 6.199 daa, is public municipal property.

The types of land use are more various on the territory of the village of Harlets. Part of the territory is taken up by electricity transmission facilities, that part has the biggest share amounting to 3,714.745 daa and is owned by public organisations. There is a terrain of 101.712 daa stated to be production area intended for agriculture purposes on private state property and public organisations own some 0.255 daa again for agricultural purposes in other settlement territory. The total area of the village of Harlets in the area of the sites is equal to 4,877.916 and the total area of the lands of the two settlements comes to 5,989.697 daa.

3.4.2 SOILS

3.4.2.1 NON-RADIATION ASPECT

3.4.2.1.1 CHARACTERISTICS OF THE GENETIC SOILS IN THE AREA OF THE INVESTMENT PROPOSAL

According to the soil geographic regioning of Bulgaria[51], the Municipality of Kozloduy is located in the soil geographic region of the Chernozem (black earth) Danubean subarea, Middle Danubean province and the agro-ecologic area is also the region of Chernozem soils[52],[53]. In terms of erosion, it belongs to the plain and hilly regions with non-erosion soils. The soils of the Municipality of Kozloduy are mainly deep soils, which are clayey-sandy and sandy-clayey soils, mostly calcareous chernozems and alluvial (deluvial) meadow soil[54]. The main soil formation rocks on which they lie are predominantly calcareous materials, conglomerates and sandstones and in the lowerings and the river terraces - alluvial and deluvial sediments. Vegetation cover is primarily represented by coppice forests of rare hornbeam, flowering ash, oak, acacia, sometimes mixed with conifer plants. The most common bushes found are hawthorn, raspberry, sloe, Christ’s thorn, briar, blackberry, etc.

In terms of climate, the area falls within the moderate-continental climatic sub-region of the European continental climatic region, characterised by cold winters and hot summers - with absolute maximum temperature of 43.50 °C , absolute minimum of - 35.50 °C. During the year 60-70 days have temperature lower than 0°C; the amount of summer rainfalls is more than 30% higher than winter rainfalls; the snow cover is stable and with greater thickness; there are frequent and strong winds.

The soils of the project sites are within the agro-ecological region of the chernozems [55]

The main soil types are calcareous, typical and meadow chernozems and alluvial (deluvial) – meadow soils. In relation to the mechanical composition and density, the chernozems are characterised as slightly sandy-clayey to heavily sandy – clayey with texture coefficient of 2 to 1.3. The alluvial soils are sandy and sandy-clayey depending on the character of the sediment material.

As to the land rating grouping, soils are referred to the first (soils rating grade of 80 and more) and second rating group (good land with rating of 60-80 grade).

These are the main soil formation factors which have contributed to the formation of the genetic soil types found in the region: calcareous chernozems - in a wide strip around the Danube, typical chernozems - south of the calcareous ones close to the middle courses of the rivers of Ogosta and

[51] Ninov N. (1982): Soil-geographic regions, pp. 399-400. Geography of Bulgaria, BAS edition

[52]Penkov, M. 1995. Evaluation of agricultural lands in Bulgaria – University of Architecture, Civil Engineering and Geodesy

[53]Kabakchiev, Iv. (1982): Rating of agricultural lands by agroproduction groups. Georgraphy of Bulgaria, BAS edition

[54] Kabakchiev, Iv. (1982): Azonal soils: Georgraphy of Bulgaria, BAS edition

[55] Yolevski, M., A. Hadzhiyanakiev, Iv. Kabakchiev. 1982.: Agroproduction grouping of soils. Georgraphy of Bulgaria, BAS edition

Skat, leached chernozems - in the higher parts of the territory south of the typical and calcareous, grey forest (usually above 500-800 m) alluvial (deluvial)-meadow soils – around the rivers of Tsibritsa, Ogosta and Skat as well as their tributaries and a small part of the eastern part of the terrain is taken up by meadow-swamp soils. The variety of grey forest soils as a result of the influence of bedrock and the elementary soil processes is complemented by various degrees of soil erosion and mechanical composition[56],[57].

Calcareous chernozems are distributed in the form of a strip along the Danube. They contain carbonates of 50 cm to the surface of the soil profile and the latter can be described as Ak-ASA-Bcc. The total capacity of the humus-accumulative horizon ranges between 40 and 80 cm, but the capacity of the entire profile reaches up to 80-150 cm. They are formed on a loess base. Throughout the whole profile soils are loose and active biological activity is observed – roots, passages of insects and other burrowing animals. The mechanical composition is slightly sandy-clayey. Within the soil profile, the mechanical composition is almost homogeneous. The primary minerals are represented mainly by quartz, feldspars and micas. In clayey soil fraction contains kaolinite and montmorillonite. The chemical composition is characterized by free alkaline earth carbonates throughout the whole profile. In the upper horizons, the carbonates are little and slightly increase with the depth. They decrease in the soil formation loess. The humus content in arable soils reaches between 2.5% to 4.5% in the fallow land and the overall storage reserves are high, ranging between 80 to 100 t/ha. Humus is very rich in nitrogen. The content of nitrogen in the fallow land is 3-5 t / ha, but its absorbable forms are few. The content of phosphorus is also high, but it has little absorbable forms. The content of total potassium is also high, varying from 1.5 to 2.5%, but these soils are characterised by favourable potassium regime. There are considerable quantities of trace elements in these soils, but due to the higher amount of carbonates , their absorbable forms are few[58].

Calcareous chernozems have good general physical properties and structure, they do not have great plasticity and are easy to process. The water regime of these soils is not very good because of the continuous droughts during the summer and the considerable unproductive moisture evaporation.

In terms of productivity of these soils, it could be noted that they possess favourable qualities that outline relatively good fertility. The latter can be enhanced by applying a set of melioration measures - mineral and organo-mineral fertilization, irrigation, appropriate operation and proper management in terms of crops used.

They are highly resistant to pollution because of the high content of carbonates and the comparatively high content of humus[59].

Typical chernozems are relatively less in the region and are located south of the calcareous chernozems and due to the hilly relief, part of them have eroded. For that reason, the capacity of the humus horizon and the soil profile are quite diverse, 50-60 cm and 90-110 cm, respectively in non-eroded and slightly eroded soils and 10-20 cm and 20-50 cm, respectively in moderately and heavily eroded soils. The transition between the separate horizons is gradual. Carbonates are found at 40-50 cm depth, but the eroded ones could be observed even on the surface.

As regards the mechanical composition, the first ones are moderate and heavily sandy-clayey containing between 35 and 55% physical clay (particles smaller than 0,01 mm) and the second ones are slightly to moderately sandy- clayey containing 25 - 45% clay.

[56]Yolevski, M., A. Hadzhiyanakiev, Iv. Kabakchiev. 1982: Agroproduction grouping of soils. Georgraphy of Bulgaria, BAS edition

[57] Kabakchiev, Iv. (1982): Rating of agricultural lands by agroproduction groups. Georgraphy of Bulgaria, BAS edition

[58] Donov, V.1993. Forest soil pedology. Ed. Martilen. page 222

[59]Bulletin № 27 of MAF 1994, Instructions for determining the type and degree of contamination of agricultural lands by areas and their use

The storage of humus, total nitrogen and total phosphorus is low and moderate, while the storage of potassium is higher. Soil reaction is neutral and alkaline.

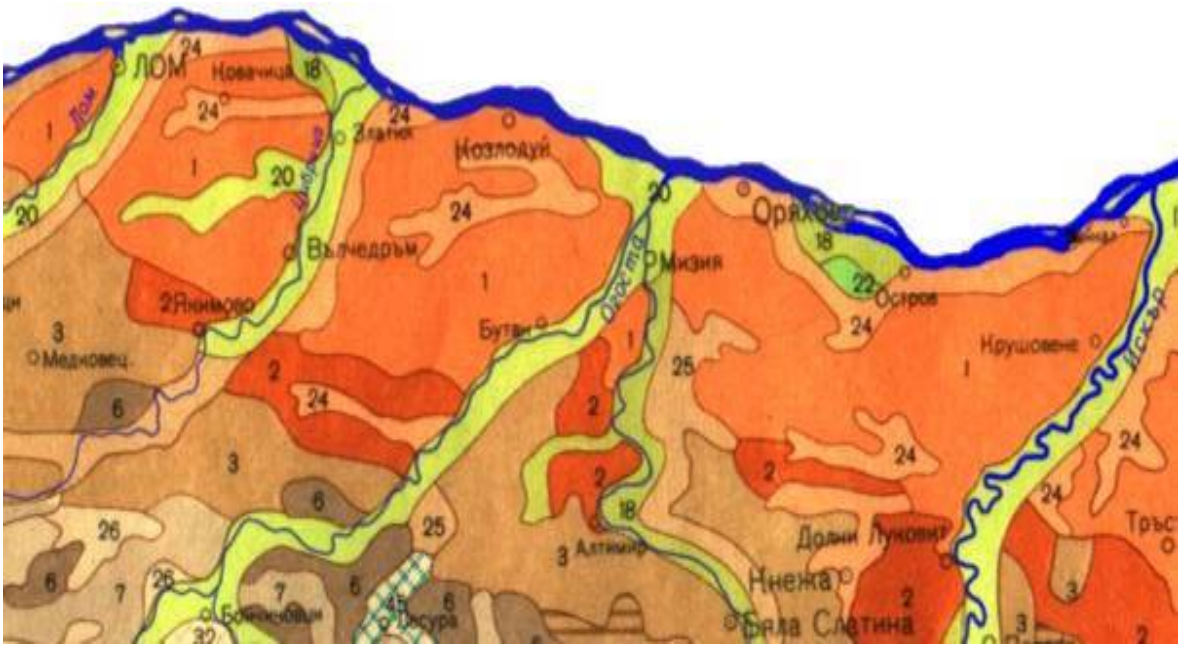


FIGURE 3.4-2 TYPICAL SOILS IN THE AREA OF THE RADIANA SITE" (SOIL RESOURCES AGENCY)[60]

Legend:

1 – Calcareous chernozems
2 – Typical chernozems
3 – Leached chernozems
6 – Dark grey forest
7 – Grey forested
18 – Meadow chernozems
20 – Alluvial and alluvial -meadow
22 – Meadow and peat-swampy
24 – Eroded calcareous and typical chernozems
25 – Eroded leached chernozems
26 – Eroded grey forest
32 – Grey forest

Leached chernozems are formed mainly on loess, and clayish loess and loess sandy clays. Unlike the preceding types, they are better shaped and have more powerful humus horizon and soil profile. Their capacity is respectively 50 to 90 and 80 to 150 cm. Carbonates and other easily soluble salts are washed at a depth of 80-120 cm, i.e. at the bottom of the transitional horizon. The soil profile is sealed and the transition between horizons is clear.

The total amount of salts (dry residue) stays within normal limits - 0.06 to 0.10 %.

As regards the resistance of these soils to chemical pollution, due to their neutral to slightly alkaline reaction, they could be referred to second and third class.[61].

Alluvial and alluvial-meadow soils are located in the floodplain and non-flooded terraces of the rivers of Danube, Tsibritsa, Ogosta, Skut, flowing into it and their tributaries. They are formed over alluvial sediments under the influence of meadow vegetation and nearby groundwater in the winter-spring period. They have a loose and well-aerated profile and a diversely humusified horizon (average 1-3%), whose capacity usually varies between 10 and 40 cm. There are layers of deposits

[60] http://www.soils-bg.org/soilmap/bul_soils/att/SMUTMBG_2793.html

[61] Bulletin № 27 of MAF 1994, Instructions for determining the type and degree of contamination of agricultural lands by areas and their use

underneath, some of which are influenced by soil formation process, but subsequently flooded and buried. The mechanical composition is extremely diverse, but mostly sandy and clayey-sandy. Soil reaction in almost all cases is neutral to slightly alkaline.

Alluvial (-deluvial)-meadow soils in the region have a moderately powerful humus horizon (30-40 cm) and not a very deep soil profile (up to about 60-70 cm), except for those around the Danube. They are loose, almost structureless or having a poorly-shaped and unsound crumb-grain structure in the surface horizon. Non-calcareous or calcareous sand, gravels and sandy clays are next to be found in depth.

The mechanical composition is light and usually clayey-sandy, containing 11.4 to 19.0% physical clay in the vague humus horizon.

These are soils poor in humus and containing low levels of total nitrogen. Their values are below 1% and 0.100%, respectively. Soil reaction in the surface horizon is neutral - pH (H2O) 6.90 and pH (KCI) 5.95. In the following horizons and layers down, the soil reaction is slightly alkaline.

As regards the resistance of these soils to chemical pollution, due to their neutral to slightly alkaline reaction, they could be referred to third class.[62]

Meadow-swampy soils, located near the site described, are hydromorphic soils produced under the influence of the meadow formation process and in the presence of high groundwater[63]. Typically, water is found at a depth of 50-100 cm and depending on the humidity of the year, it could go deeper or higher. Their carbonates are most frequently start from the surface and increase in depth. Their mechanical composition is heavy and gley mottles can be observed on the their profile. In virgin soils, the humus content is above 5% and in arable soils about 3-4%. The total content of essential nutrients is high. Soil reaction is neutral to slightly alkaline. The sorption capacity of these soils is high and saturation with bases is also high. The physico-mechanical properties of the soils are good, but their filtration capacity is low. These soils are naturally found in the Blatoto area (the Marsh), where the main drainage channel and the collection channels contribute to maintaining their swamping and contamination.

Due to the alkaline reaction of these soils and their heavy mechanical composition, they may be referred to third class of resistance to chemical pollution[64].

Anthropogenic soils. They are found on the territory of Kozloduy NPP and within the 30-km zone. They have been formed at Kozloduy NPP site because of the construction works related to the building of the plant. The soils on the selected sites in one way or another are anthropogenised, irrespective of the fact that their genetic origin is clear.

3.4.2.1.2 DEGRADED LANDS AND SOILS AND SUCH WITH A CERTAIN DEGREE OF DEGRADATION

- **Eroded soils**

In terms of erosion, the lands and soils within the 30-km monitoring zone around Kozloduy NPP fall into the groups of non-eroded, slightly eroded and moderately eroded soils. Due to the openness of the terrain and the characteristic north-eastern and north-western winds, the soils in the region, mainly agricultural soils used for annual crops, are subject to deflation, particularly in winter, when they have no vegetation cover. The soil in the project site is largely covered with trees and shrubs, which protect it from wind erosion. In this regard, the water erosion is not a significant issue when there are more

[62] Donov, V.1993. Forest soil pedology. Ed. Martilen. page 222; Penkov, M. 1988. Soil pedology, Zemiizdat, S.; Penkov, M. 1995. Evaluation of agricultural lands in Bulgaria – University of Architecture, Civil Engineering and Geodesy; Nonov, N. (1982): Soil-geographic regions, p. 399-400. Geography of Bulgaria, BAS edition

[63] Kabakchiev, Iv. (1982): Azonal soils. Geography of Bulgaria, BAS edition

[64] CONSORTIUM DICON-ACCIONA ING. 2013. EIAR of IP for Construction of a New Nuclear Unit of the Latest Generation at Kozloduy NPP Site Version 03, August 2013. page: 2799

intensive precipitations. Quite often there are hailstorms in some parts of the region.[65] If the vegetation cover in the open areas of the site is restored after the construction of the NDF, the erosion processes will not have any negative effect both on the site and the adjacent areas.[66]

- **Acidic, overhumidified and swampy soils**

In the area of the presumed impact of the sites, there are no acidic soils as the genetic soil types feature natural alkaline, slightly alkaline or neutral reaction.

No overhumidification or swamping of the genetic soil types is observed due to their good filtration capacity. No noticeable densification is exercised on them, which could cause deterioration of their density or filtration properties. A small part of the soils outside the Radiana site – in the northern part of Kozloduy NPP and near the Danube are overhumidified and swampy, polluted by construction waste. The swamping here is caused by processes of natural influence of the Danube and its tributaries, since the area is located in the lowest part of the lands in the floodplain section of the river. Due to the swamping, the soil fertility is lower.

3.4.2.1.3 POLLUTED LANDS AND SOILS

The summary of the data from the studies related to the preparation of the EIA of Kozloduy NPP in 1999 (which is very detailed in terms of soil data) and the subsequent EIARs for Decommissioning of Units 1 to 4, Plasma Melting Facility and a New Nuclear Unit in 2013, as well as data from other administrative and research institutions[67], indicate that the soils in the area are relatively slightly polluted and do not differ much from the ones in the other regions in the country.

The samples analysed in connection with the Ecological model of Kozloduy Municipality show a relatively good picture of the status of municipal pollution by various industrial activities, including by the Kozloduy NPP. The following sources of pollution were identified, other than the Nuclear Power Plant: the concrete plant, the construction company, the asphalt centre and the ceramic factory, the gas field and the industrial companies in the town of Miziya, which due to the wind characteristics, have direct effect on the territory under consideration.

- **Lands polluted with heavy metals**

Studies concerning soil contamination with heavy metals in the area have been conducted by the control authorities as well as in the form of self-monitoring of various investors, but mostly in connection with the activities of Kozloduy NPP.

The registered amounts of some heavy metals like copper, lead, etc. are not considered to be related to the operation of Kozloduy NPP. The registered higher amounts of copper in some agricultural regions of Vratsa District is most probably connected with the use of copper-containing preparations for spraying the vineyards and other agricultural crops (out of a total of 31 agricultural lands covered with perennial plants, 23 have been found to contain higher concentrations of copper and zinc). Generally, the data indicate that:

→ Soils polluted with lead are found around the villages of Glozhene, Harlets, Butan (farmyard and gas field), the territory of the town of Kozloduy, the Ogosta River valley and the southern boundary of Kozloduy Municipality;

[65] Environment Impact Assessment Report (EIAR) for Construction of a National Repository for Disposal of Low and Intermediate Level Radioactive Waste - NDF. CONTRACTING AUTHORITY – RAW SE, 2010

[66] Environment Impact Assessment Report (EIAR) for Construction of a National Repository for Disposal of Low and Intermediate Level Radioactive Waste - NDF. CONTRACTING AUTHORITY - RAW SE, 2010; RAW SE, Version 03, August 2013 page: 2799 CONSORTIUM DICON-ACCIONA ING. 2013.

[67] EIAR of IP for Construction of a New Nuclear Unit of the Latest Generation at Kozloduy NPP Site Version 03, August 2013. page: 27/99 CONSORTIUM DICON-ACCIONA ING. 2013.

→ The soils at MTS – Glozhene contain lead, copper and zinc above the standard. This is due to the motor vehicles – tractors, trucks and agricultural equipment. The case is isolated and not typical (not representative) of the region;

→ The content of manganese in the analysed soil samples is within the limits of Clark's concentration of 850 mg/kg, however, deviations 4 times above the background content have been registered near Glozhene and Sofronievo, in the Ogosta River valley and at the motor depot of Kozloduy NPP.

The data in **Table 3.4-4** show the concrete pollution with heavy metals in the area of the IP and Kozloduy NPP site,[68, 69].

3.4.2.1.4 LANDS POLLUTED WITH OIL PRODUCTS

The data from the research of the team, which studied the soils in the area of Kozloduy NPP in relation to the EIAR of the Nuclear Power Plant indicate that the pollution with oil products does not differ from the one seen one way or another around any other industrial company at any industrial site, which is controlled by monitoring of its own and by the state control authorities.

The authors of the EIAR of Kozloduy NPP in 1999 have studied also the salt content of soils. They found by chemical analysis that their electrical conductivity is not more than 4.0 mS/cm, which shows that the soils fall into the zero class of salinity (from 0 to 4 dS/m). In general, soil pollution with oil products in the area of Kozloduy NPP is minimal (below MPC) and does not differ from the pollution of any other industrial site, which is controlled by monitoring of its own or by the state control authorities (**Table 3.4-5**) [70]. There is local spillage of oil products at the black oil and oil storage station of Kozloduy NPP site, while slight pollutions with oils, oil products, etc. are found at the gas field in the village of Butan, the landfills of the villages of Harlets and Kriva Bara, near former agricultural sites.

[68] Environmental Protection Programme of Kozloduy Municipality for the period 2004 to 2010.

[69] Tourism Development Programme of Kozloduy Municipality for the period 2008 to 2011.

[70] According to the EIAR of Kozloduy NPP, 1999

TABLE 3.4-4 SOIL POLLUTION ON THE LAND OF KOZLODUY MUNICIPALITY (WITH PH 7.5- 8.5)[71]

Element	Number of samples	Average [mg/kg]	Sample No	Amount mg/kg	MPC, mg/kg	Content in times MPC	Approximate location of the soil sample taken
Sandy-clayey calcareous chernozems							
Pb	123	5177	41	114.0	above 80	143	Village of Butan – next to a sheep-breeding farm
			61	398.4		4.98	before the petrol station
			62	91.5		114	Village of Butan – next to the farmyard
			63	251.8		3.15	Village of Butan – next to MTS, before the gas field
			69	390.0		488	Village of Butan – after the petrol station after the border with the village fo Kriva Bara
Oils and Oil products	29	180	62	51	300 with 1% humus	below MPC	Village of Butan – next to MPS, before the gas field
Oil products		131		37	300 with 1% humus	below MPC	Village of Butan - next to MTS, before the gas field
Medium and heavy sandy-clayey meadow chernozems							
Pb	17	3516	40	1090	below 80	136	Kozloduy stock-breeding farm
Cu	17	8106	41	3170	270-280	1.17-1.13	Village of Butan, next to the sheep-breeding farm, before the petrol station
Oils and oil products	3		2	1400	300 with 1% humus	below MPC	At the submersible pumping station
Oil products			2	800	“	below MPC	At the submersible pump
			40	6800		2.27	Kozloduy stock-breeding farm below the channel
			80	700		below MPC	
Sandy and sandy-clayey alluvial and alluvial-meadow soils							
Pb	29	6457	18	2750	below 80	344	Village of Glozhene – next to MTS
			24	1825		228	Ogosta River – under the bridge
			46	1495		187	Village of Harlets – next to the dump site
			49	1308		164	Village of Butan- next to the gas field
			106	2515		314	Village of Glozhene - next to MTS
Cu	29	5726	18	3475	270-280	1.29-1.24	Village of Glozhene – next to MTS
Zn	23	1375	18	7750	360-370	2.15-2.09	
Mn	23	8896	24	34500	850	406	Ogosta River – under the bridge
			57	10120		119	Village of Glozhene – next to the dump site
			106	38750		456	Village of Butan - next to the gas field
As	5	1970	24	„	25		Ogosta River - under the bridge
			106	„	25	788	

[71] According to Environment Impact Assessment Report for Decommissioning of Units 1 to 4 at Kozloduy NPP. Chapter 3. Rev: 02. Date: 2013-04-12. Ref:P16D09Rev02_EIAR. Status: Final

Oils and oil products	8	'	72	2060	300 with 1% humus	687	The village of Kriva Bara - next to the dump site
Oil products		'		880		293	

TABLE 3.4-5 HEAVY METALS AND METALLOIDS CONTENT IN SOIL SAMPLES (MG/KG) WITHIN THE 30-KM AREA OF KOZLODUY NPP[72]

Sample No	pH	Cu		Pb		Zn		Ni		Hg		As		Cd		Cr		Mn	Co	Fe	B
		Result	MPC	Result	MPC	Result	MPC	Result	MPC	Result	MPC	Result	MPC	Result	MPC	Result	MPC	Result	Result	Result	Result
1	69	28950	260	20408	80	60513	340	27765	70	-	-	-		traces	30	-	-	320123	7831	745610	-
2	72	21244	270	18070	80	32695	360	28814	70	-	-	-	-	traces	-30	-	-	293270	6837	760402	-
4	7.0	18929	260	23481	80	44566	340	32Л07	70	-	-	-	-	traces	30	-	-	298304	7188	751390	-
5	7.0	20747	260	21850	80	37080	340	26927	70	0232	1	86	29-55	traces	30	-	-	278317	7504	689503	-
6	7.0	17705	260	18548	80	30773	340	24871	70	-	-	598	25	traces	30	233	200	265366	6323	660990	367
7-	7.0	18031	260	21930	80	41910	340	26072	70	-	-	-	-	traces	30	-	-	280458	7066	156189	356
8	7.0	18689	260	20678	80	32607	340	25052	70	-	-	02	25	traces	30	-	-	259066	7158	624304	-
9	68	35413	260	47217	80	57515	340	26874	70	-	-	-	-	traces	30	-	-	322986	8037	787121	395
10	7.3	20583	270	19142	<8()	36226	360	31286	70	0412	1	10.3	25	traces	30	-	-	279722	8645	645892	-
11	75	22533	270	21347	80	39611	360	30123	70	-	-	-	-	traces	30	340	200	312381	8776	744307	520
12	7.3	17735	270	32711	80	53992	360	23252	70	-	-	-	-	0197	30	-	-	262868	5518	609285	-
13	7.0	22001	260	22719	80	38741	340	28219	70	-	-	-	-	traces	30	-	-	306103	8370	749474	-
H	7.0	16858	260	21639	80	36987	340	22142	70	-	-	-	-	traces	30	-	-	256894	5787	772192	-
15	80	17200	280	10500	80	43700	360	21000	70	1350	1	44	25	0440	30	236	200	335000	2800	-	371
14	-	--	-	-	-	-	-	-	-	1040	1	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	0810	1	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	0602	1	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	•	-	-	-	-	0050	1	-	-	-	-	-	•	-	-	-	-

Note: *The samples marked with asterik (*) №: 2. 4. 5 and 7 fall into the NPP site and are assessed as representative of non-agricultural lands, i.e. as lands characterised by old pollutions in industrial companies.*

[72] According to the Environment Impact Assessment Report of Kozloduy NPP, 1999

3.4.2.2 RADIATION ASPECT

The area of the Radiana site predominantly includes calcareous chernozems, I and II rating group.

The radiation status of soils in the area has been studied under the internal radiation monitoring of Kozloduy NPP and an independent institutional monitoring by the authorities of the MoEW and NCRRP. Pre-commissioning soil monitoring has also been carried out in the area of the NDF site. The content of natural radionuclides ^{238}U, ^{226}Ra, ^{232}Th is within the range, natural for the soils in the area and the content of technogenic ^{90}Sr and ^{137}Cs in the surface soil layer (0-30 cm) is within the standard and does not significantly differ from their content across North Bulgaria, being due to residual contamination from Chernobyl. According to data revealing the results of the radio-ecological monitoring of Kozloduy NPP, their permanent content is evidence of the lack of additional local fallout from the operation of Kozloduy NPP.

The radioactivity of soils in the area of Kozloduy NPP, where the NDF will be located, has been subject to detailed and systematic studies starting from the commissioning of the plant in 1974 until now. The interest in the radiation status of soils is determined by the fact that they resemble "an ecological seal of time" and provide valuable information about the history and origin of radioactive contamination. Within a 100-km zone, soil sampling and analysis is carried out from 36 monitoring points and 1 point at the Non-radioactive Household and Industrial Waste Landfill. The soil sampling has been conducted in close proximity to the monitoring points, preferably from non-arable lands. A sampling device with a diameter of 8 cm have been used to takes samples from the 5-cm surface layer. Each sample is composed of six sub-samples taken in a straight line. The main subject of interest is the content of long-lived technogenic radionuclides with marked radiotoxicity, typical of the Water-Water Energetic Reactors (VVER) - ^{90}Sr, ^{134}Cs, ^{137}Cs and others. The results are annually verified by studies under parallel programmes of the ExEA/ MoEW and NCRRP/MH.

After drying to constant weight, soils are finely ground using a ball mill, processed through a sieve having 2 mm wide openings, which are homogenized. Samples are quartered and some of them are used for gamma-spectrometric analysis and determination of ^{90}Sr content. Gamma-spectrometric measurements are directly performed for duration of 60000 s, without further processing of the samples. For defining ^{90}Sr, the radiochemical methods established in practice are employed based on isolation of radiostrontium in soil, separation of Ca using sodium hydroxide and liquid scintillation spectrometry and measurement for 10000 s of the daughter isotope ^{90}Y (in "Cherenkov counting" mode) after establishing radioactive equilibrium.

The minimum detectable activity /MDA / of ^{137}Cs, which can be determined using the methods and conditions of measurement ranges within 0.32 ÷ 0.56 Bq/kg a.d.w. MDA value in determining the content of ^{90}Sr amounts to an average of 0.14 Bq/kg a.d.w.

The results of the internal radio-ecological monitoring of the NPP for 2013 show that the activity of ^{90}Sr in the analysed soils ranges between 0.29 ÷ 3.71 Bq/kg a.d.w. and the average yearly content for all 36 monitoring points is 1.18 Bq/kg. These results are within the normal limits for this geographical area, characterising the global fallout on the ground due to nuclear tests in the atmosphere and the accident at the Chernobyl NPP. The values are close to the ones measured in previous years, with a slight tendency towards self-cleaning of the topsoil layer. According to the results of radiological monitoring of Kozloduy NPP, the content of ^{37}Cs in the analysed soils ranges between 1.32 and 38.8 Bq / kg with an average value for 2013 equal to 10.4 Bq / kg within the 100-km zone around the plant. In general, the content of ^{90}Sr and ^{137}Cs in the soils of the area of Kozloduy is lower than that measured in other regions of the country.

The results of the internal radio-ecological monitoring of soils within the 30-km zone for the period 2009-2013 are presented in **Table 3.4-6**. Sampling is conducted twice a year from a total of 36 monitoring points in the 100-km zone and the Non-radioactive Household and Industrial Waste Landfill.

TABLE 3.4-6 SUMMARY DATA ON SOIL MONITORING, 2009-2013 .

2009	Sampling is carried out twice a year in a total of 36 monitoring points within a 100-km zone and 1 point at the Non-Radioactive Household and Industrial Waste Landfill There have been taken: 72 samples with 86 analyses conducted /72 gamma-spectrometric and 14 including radiochemical isolation of strontium / RESULTS: ✓ Activity of ^{137}Cs within the range of 1.75 ÷ 47.4 Bq/kg a.d.w. ✓ Activity of ^{90}Sr within the range of 0.40 ÷ 1.49 Bq/kg a.d.w.
2010	There have been taken: 72 samples with 86 analyses conducted /72 gamma-spectrometric and 14 including radiochemical isolation of strontium / RESULTS: ✓ Activity of 137Cs within the range of 1.78 ÷ 54.4 Bq/kg a.d.w. ✓ Activity of 90Sr within the range of 0.22 ÷ 1.92 Bq/kg a.d.w.
2011	There have been taken: 72 samples with 86 analyses conducted /72 gamma-spectrometric and 14 including radiochemical isolation of strontium / RESULTS: ✓ Activity of 137Cs within the range of 1.55 ÷ 45.4 Bq/kg a.d.w. ✓ Activity of 90Sr within the range of 0.22 ÷ 3.97 Bq/kg a.d.w.
2012	There have been taken: 74 samples with 88 analyses conducted /74 gamma-spectrometric and 14 including radiochemical isolation of strontium/ RESULTS: ✓ Activity of 137Cs within the range of < 0.42 ÷ 48.1 Bq/kg a.d.w. ✓ Activity of 90Sr within the range of 0.33 ÷ 3.84 Bq/kg a.d.w.
2013	There have been taken: 74 samples with 88 analyses conducted /74 gamma-spectrometric and 14 including radiochemical isolation of strontium / RESULTS: ✓ Activity of 137Cs within the range of 1.32 ÷ 38.8 Bq/kg a.d.w. ✓ Activity of 90Sr within the range of 0.29 ÷ 3.71 Bq/kg a.d.w.
CONCLUSION: **The results are comparable with those from previous years.** **The technogenic activity in the points within the 100-km area is due to transboundary transmission / Chernobyl / as well as to nuclear weapons tests.** **The facilities on the NPP site have not been registered to have any impact on the soils in the area.**	

The results concerning the technogenic radioactivity of ^{90}Sr and ^{137}Cs in soils of the area for a long-term period are graphically presented in **Figure 3.4-3** to **Figure 3.4-5**.

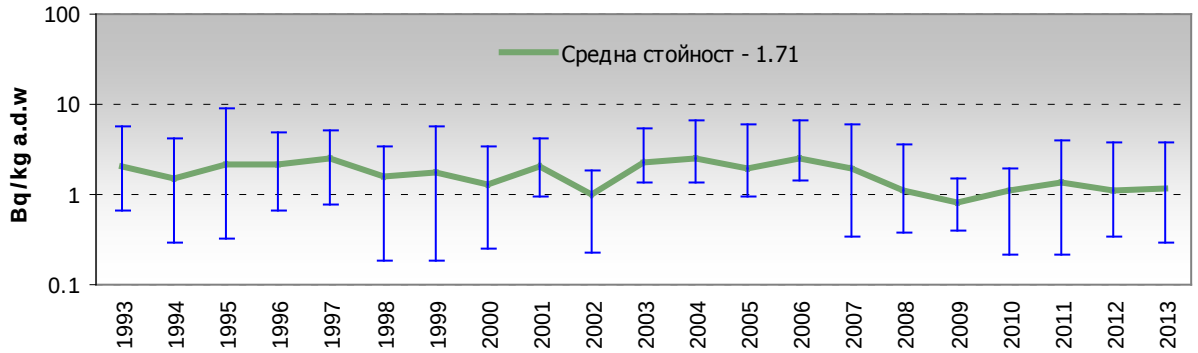


FIGURE 3.4-3 SUMMARY DATA ON ACTIVITY OF ^{90}SR (BQ/KG A.D.W.) IN SOILS OF THE MONITORING POINTS WITHIN THE 100-KM ZONE, 1993 - 2013.

The typical content of ^{90}Sr in Bulgarian soils as well as in the soils of most European countries ranges between 2 ÷ 6 Bq/kg a.d.w. This content is primarily determined by the global fallout, where the "contribution" of Chernobyl in terms of soil contamination with radiostrontium is negligible. In previous years, the activity was generally within the same range, with a maximum of 114 Bq/kg a.d.w in point-27 (Town of Oryahovo) in 1996.

Despite the high sensitivity of the analyses, due the shorter half-decay of ^{134}Cs (2.06 years), it is no longer possible to register Chernobyl traces of this radionuclide in the soils under the particular conditions. In 2013 and in recent years ^{134}Cs, as MDA, measured in the samples is averagely equal to 0.95 Bq / kg.

The activities of radiocaesium (^{134}Cs and ^{137}Cs) and their ratios, measured in previous years, definitively proved its transboundary origin in the soils of the 100-km zone - mainly the transmission from the nuclear accident at the Chernobyl NPP in 1986.

In general, the content of ^{90}Sr and ^{137}Cs in the soils belonging to the area of Kozloduy is lower than that measured in other regions of the country. The reason for the slight contamination of Northwestern Bulgaria is due to the inconsiderable rainfalls in this area in May 1986, respectively the lower amount of deposited technogenic radionuclides.

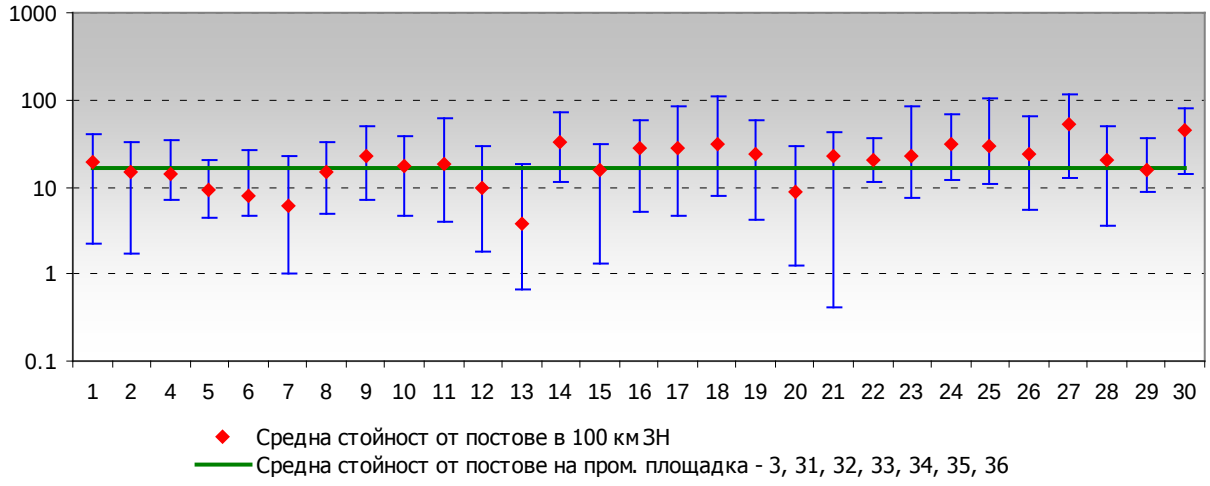


FIGURE 3.4-4 ACTIVITY OF 137CS IN SOILS (BQ/KG A.D.W.) OF THE MONITORING POINTS WITHIN THE 100-KM ZONE, 1995 – 2013.

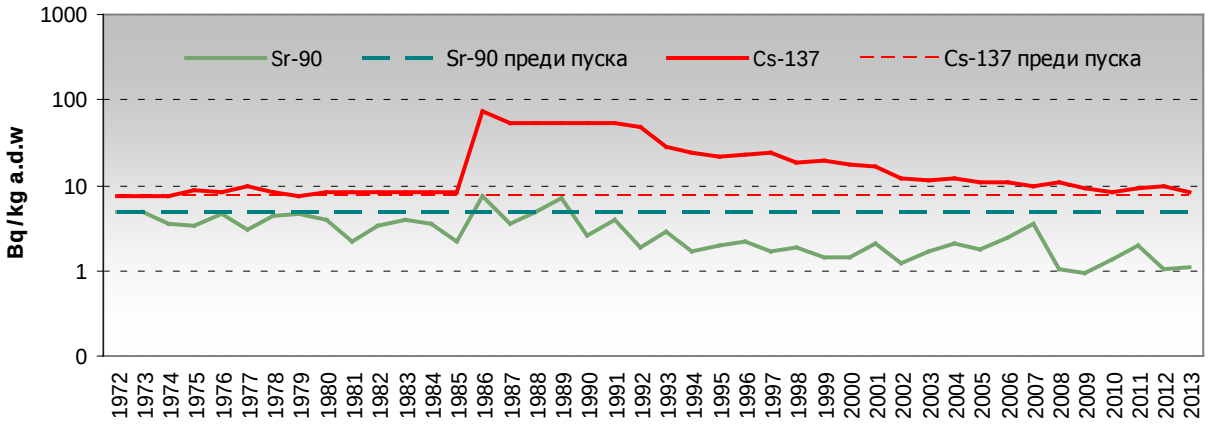


FIGURE 3.4-5 SOIL RADIOACTIVITY (BQ/KG A.D.W) WITHIN 3 KM AROUND KOZLODUY NPP, 1972 – 2013

The results of the pre-commissioning monitoring of the soils from the Radiana site show levels typical of the region. 8 monitoring samples were initially analysed (zero measurements) and then soils from two monitoring points on the site were regularly analysed. The results are: ^{54}Mn: <0.22÷<0.40 Bq/kg, ^{60}Co: <0.40÷<0.70 Bq/kg, ^{134}Cs: <0.45÷<1.09 Bq/kg, ^{137}Cs: 2.98÷ 43.82 Bq/kg, ^{90}Sr: 0.95÷1.55 Bq/kg, ^{238}Pu: < 0.0079÷0.013 Bq/kg, $^{239+240}$Pu: 0.056÷0.17 Bq/kg, ^{241}Am: 0.033÷0.083 Bq/kg, ^{242}Cm: < 0.006÷< 0.0071 Bq/kg and $^{243+244}$Cm: < 0.0061÷< 0.0066 Bq/kg. These activities are typical of the soils in the area, with minimum residual technogenic impact of the transboundary transmission of the nuclear accident at the Chernobyl NPP and deposits of the global transmission due to nuclear tests in the last century.

The Radiana site includes two monitoring points intended to keep track of the radiation status of soils - Point № 4 and Point № 7. Samples are taken every six months.

TABLE 3.4-7 SOIL RADIOACTIVITY IN POINTS 4 TO 7 AT THE RADIANA SITE, INTERIM MONITORING REPORT 2, TK.D-142-D7

Point	Nuclide, content [Bq/kg]									
	^{54}Mn	^{60}Co	^{134}Cs	^{137}Cs	^{90}Sr	^{238}Pu	$^{239.240}$Pu	^{241}Am	^{242}Cm	^{243,244}Cm
№4	032	067	079	952 ±2.3%	1.490 ±9.4%	00053	0.19 ±6.4%	0.093 ±7%	00029	00021
№7	037	070	083	2.98 ±4.7%	0.59 ±12%	0005	0.051 ±9%	0.021 ±8.6%	00017	00022

The registered activity of technogenic radionuclides in the soils ranges between limits typical of this geographical area, unaffected by the operation of the facilities at the NPP site. The values of most radionuclides are background and near to the background levels. The measured values of gamma spectrometrically determined radionuclides are below MDA, except for ^{137}Cs, which is found in minimum concentrations. The measured traces of technogenic activity are due to the residual effect of the global fallout in the last century. The summary results of soil analyses of the Radiana site for NDF are presented in **Table 3.4-8**.

TABLE 3.4-8 SUMMARY RESULTS OF SOIL ANALYSES OF THE RADIANA SITE FOR NDF, 2013-2014

Soil	Activity, Bq/kg	MDA	Results
Zero measurements 1-8 and points 4, 7 Radiana site	Total Beta	78 ÷ 104	631 ÷ 789
	^{54}Mn	0.22 ÷ 0.40	< MDA
	^{60}Co	0.40 ÷ 0.70	< MDA
	^{134}Cs	0.45 ÷ 0.11	< MDA
	^{137}Cs	0.23 ÷ 0.46	2.98 ÷ 43.82
	^{90}Sr	0.090 ÷ 0.096	0.95 ÷ 1.55
	^{238}Pu	0.0046 ÷ 0.0079	0.0053 ÷ 0.0132
	$^{239+240}$Pu	0.0029 ÷ 0.0041	0.056 ÷ 0.19
	^{241}Am	0.0045 ÷ 0.0053	0.033 ÷ 0.093
	^{242}Cm	0.0029 ÷ 0.0071	< MDA
	$^{243+244}$Cm	0.0021 ÷ 0.0066	< MDA

ExEA data on radionuclide content in soils of the 30-km zone of Kozloduy NPP for the period 2009 - 2013 indicate that in the points within the 30-km zone of Kozloduy NPP, which are part of the radiological monitoring network of the Executive Environment Agency, the measured specific activities of natural and artificial radionuclides in soil samples for the period 2009 - 2013, were within the background levels typical of the region.

These conclusions are also confirmed by the independent radiation monitoring in the region, conducted by the National Centre of Radiobiology and Radiation Protection (NCRRP).

CONCLUSION

No technogenic impact on the radioecological status of soils in the area has been registered around the site of the investment proposal.

The registered technogenic activity in the soils of the monitoring points within the 100-km zone is of transboundary origin of the global deposits and is relatively low compared with other regions in the country.

The analysed soils from Radiana NDF site have typical background levels.

3.5 LANDSCAPE

3.5.1 DESCRIPTION OF THE MAIN LANDSCAPE CHARACTERISTICS IN THE AREA OF THE INVESTMENT PROPOSAL

Landscape is regarded as a natural and territorial complex and a geographical complex with a specific structure and appearance, human environment and natural genetic fund, a source of resources, and social environment.

The site designated for the construction of the NDF is the Radiana site located within the land of the village of Harlets, Kozloduy Municipality, and in the immediate vicinity of the Kozloduy NPP (within the 2-km Precautionary Action Zone (PAZ).

According to the System of Regional Taxonomic Units in Landscape Zoning of the Country (Petrov, Geography of Bulgaria BAS, Sofia 1997), the Radiana site falls within the Northern-Bulgarian zonal region of the Danubian plain. It encompasses:

1. Northern Danubian plain subregion:
   - (4) Zlatiyski area – Kozloduy Municipality and the eastern part of Lom Municipality
   - (5) Dolnoiskarski area – Oryahovo Municipality

The typological classification system of the landscapes in Bulgaria characterizes the condition and functioning of the landscapes as open geosystems with specific internal structures.

According to the Classification system of the landscapes in Bulgaria, the area around the site of the IP falls within:

Class (numeric index 1) – Plain landscapes;

- *Type* (numeric index 1.1) – Landscapes with moderate continental meadow-steppe and forested lowlands;

Sub-type (1.1.1) – Landscapes of meadow-steppe lowlands. Group (1.1.1.1) – Landscapes of meadow-steppe alluvial lowlands with medium degree of agricultural reclamation

Sub-type (1.1.2) – Landscapes of marsh-meadow lowlands; Group (1.1.2.2) – Landscapes of marsh-meadow alluvium lowlands with comparatively low degree of agricultural reclamation

Sub-type (1.1.3) – Landscapes of forested lowlands; Group (1.1.3.3) – Landscapes of forested lowlands on river islands; Group (1.1.3.4) – Landscapes of forested lowlands on the hills of the flooded terrace with relatively low degree of agricultural reclamation

- *Type* (numeric index 1.2) – Landscapes of temperate-continental steppe, meadow-steppe and forest-steppe lowlands (typical for the Radiana site);

Natural components such as climate, bio-climatic resources, relief, hydro-geographic network, geological base, soils, vegetation and ecosystems have a significant role in the determination of the landscape. The anthropogenic factors influence the character of the landscape not only with the degree of intervention, participation and impact but also by determining the leading functions of the territory.

Within its larger regional unit, each landscape area is distinguished from the neighbouring area by the local features of the rock substrate, mesorelief, horizontal and vertical landscape structure.

In the lowland territories the landscape areas are mainly defined according to the combinations of landscape groups, while in mountains they are defined according to the specific range of the landscape altitude zonation. From a geo-ecological point of view, it is imperative to take into account the anthropogenic factor. Anthropogenic activities cause changes in the microclimate and the local climate and, respectively, they lead to changes in the appearance of the local landscape.

The landscape classes and groups, described briefly above, are generally divided into:

1. *Depending on the predominant presence of anthropogenic or natural component* landscapes are divided into:

→ *Natural landscapes* – forest landscape; aquatic (river) landscape, natural landscapes. They are formed under the influence of natural factors but also experience the impact of human activity.

Their horizontal structure is characterized by fragmentation of the territory. The forest landscape occupies the coastal areas and the hilly slopes. It is characterized by high resistance due to its self-regulation and self-renewal capabilities. The tree species that take part in the structure of the landscape are also forming its appearance.

The reaches of the Danube River, Scat River, Ogosta River and Tsibritsa River, as well as the tributaries of their drainage basins, are included in the structure of the river landscapes. The aquatic landscape is not sustainable in time since its existence depends on natural components and the anthropogenic activity.

The sustainability of their structure is determined by the processes of self-development and self-regulation. In most cases, these are also the landscapes that fall under the protection of the nature legislation in the country.

→ *Anthropogenic landscape*– industrial, transport and communication type of landscape; systems of drainage canals and facilities have been constructed on a vast area in the lowlands of the Kozloduy NPP area. Anthropogenic landscapes are a result of human activity, which changes some of the natural components to a different degree, forming their specific character and structure. Most of the contemporary landscapes on Earth belong to the anthropogenic landscapes.

2. *Depending on the degree of human intervention and the changes in the landscapes,* the following types of landscape can be observed: virgin (primitive), slightly altered and cultural.

3. *Depending on the predominant function of the territory there are:* settlement (urbanized) landscapes, agricultural landscapes, industrial, recreational, roadside landscapes etc.

→ *Urbanized landscape* – settlement type;

→ *Agricultural landscape* – arable land, pastures, meadows, which constitute natural and territorial complexes formed by the lands of the settlements in the area

The appearance of this landscape is formed under the influence of purposeful human activity aimed at meeting certain needs and the ability to constantly keep them in a specific condition. The agricultural landscapes are characterized by discontinuity of the biological cycle of substances and mandatory supplementary energetic subsidization (by means of fertilization, irrigation, soil treatment, etc.). Very often the agricultural landscapes are areas, which periodically emit pollutants such as nitrates and herbicides.

The urban areas and the existing roads have the highest degree of anthropogenic transformation. Together with the agrobiocenoses, they determine the different degrees of hemeroby of the respective sections within the local landscapes. Around each settlement, as a constant and complex source of pollution, permanent areas with anthropogenically and technogenically polluted groundwater are formed stretching out in the direction of its movement. Furthermore, any settlement, situated on the banks of the rivers crossing the local landscapes, constitutes a permanent pollution source of variable intensity. It deteriorates the quality of river water to a certain distance along the reaches of the river depending on its self-purifying capacity.

Landscape is an essential element of the natural environment in which new structural and visual elements are introduced.

The internal structure and functioning of landscapes is determined by the characteristics and dynamics of all natural components of the environment as well as by the technogenic and anthropogenic impact exerted on it.

The degree of the landscapes' resistance to external influences is determined by the most stable component – the morpholithogenic basement. It is considered the main criteria for determining the class of the landscapes.

The individual components of the landscape - geology, hydrology, land and soils, flora and fauna, are discussed in detail in the individual sections of the EAIR. Pre-operational monitoring has been conducted for the Radiana site and the results are presented in the various parts of the report. The measured values for the controlled radiation parameters are typical for the area.

According to the *geo-botanical zoning* the area of the site of the Investment Proposal belongs to the Eurasian steppe and forest-steppe region, the Lower Danube Province, Danube River District, Zlatiyski area. In the past, the lands were covered with oak forests, which were subsequently destroyed so that the land can be used for agricultural purposes.

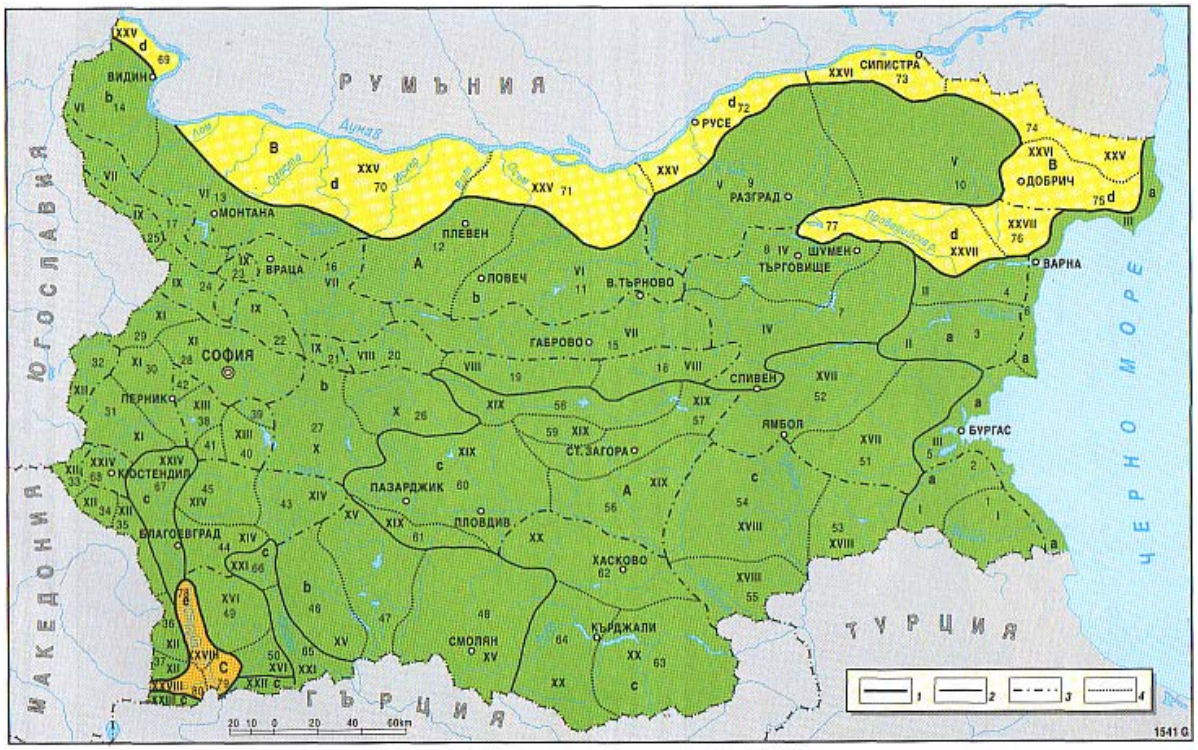
Currently, the area around the site of the future NDF is occupied mainly by agricultural landscape and partially by meadow and forest landscapes, the latter type being also found at the site intended for the construction of the repository, whose land is occupied by woody shrub (woody) vegetation.

3.6 BIODIVERSITY. SENSITIVE AREAS

3.6.1 FLORA

3.6.1.1 CHARACTERISTICS OF THE FLORA IN THE AREA OF THE RADIANA SITE

According to the geo-botanical zoning of the country (Geography of Bulgaria, 2002) presented in the figure below, the Radiana site, which is located near the Danube River and on the territory of Kozloduy Municipality, falls within the territory of the *Eurasian steppe and forest-steppe region, Lower Danube Province, Danube River District, Zlatiyski area.*



Геоботаническо районiране *(по Бондев, 1997).*
1 – области (A, B, C); *2* – провинции (a, b, c, d, e); *3* – окръзи (I-XXVIII); *4* – райони (1-80).

FIGURE 3.6-1 GEO-BOTANICAL ZONING OF BULGARIA

Zlatiyski area encompasses the territory west of Lom up to the lower reaches of the Vit River. In the past the forests in the area consisted of Virgilian oak (*Quercus virgilliana*) and downy oak (*Q. pubescens*). Nowadays there are remnants of forests where the South European flowering ash (*Fraxinus ornus*), more rarely the Turkey oak (*Q. cerris*) and the downy oak (*Q. pubescens*), are predominant. **Artificial black locust plantations (*Robinia pseudoacacia*) can be found in many places, including the area of the investment proposal.** Commonly found here are the following steppe species: stinking ground pine (*Camphorosma monspeliaca), Potentilla pirotensis* and *Chamaecytisus danubialis.*

Different macrophytes and hygrophytes are widespread around the Danube River and the mouths of the rivers of Ogosta and Skat in the areas with swampy and overly wet sections, as well as in areas with slow-moving and more or less stagnant water. They are presented by families below:

→ Buttercup Family - Ranunculaceae: water crowfoot (*Ranunculus aqualilis*), stream water-crowfoot (*Ranunculus penicillatus*), thread-leaved water-crowfoot (*Ranunculus trichophyllus*);

→ Knotweed Family- Polygonaceae**:** Amphibious Bistort (*Persicaria amphibia*);

→ Water Milfoil Family - Haloragaceae: spiked water-milfoil (*Myriophyllum spicatum*), whorled water-milfoil (*Myriophyllum verticillatum*);

→ Parsley Family - Apiaceae: fine-leaved water-dropwort (*Oenanthe aquatica*);

→ Water-starwort Family - Callitrichaceae: water-starwort (*Callitriche cophocarpa*), various-leaved water-starwort (*Callitriche platycarpa*);

→ Flowering Rush Family - Butomaceae: flowering-rush (*Butomus umbellatus*);

→ Water-plantain Family - Alismataceae: common water-plantain (*Alisma plantago-aquatica*), narrow-leaved water-plantain (*Alisma lanceolatum*), ribbon-leaved water plantain (*Alisma gramineum)*, arrowhead (*Sagittaria sagittifolia*);

→ Arrow-grass Family - Juncaginaceae: marsh arrowgrass (*Triglochin palustris*);

→ Pondweed Family - Potamogetonaceae: curled pondweed (*Potamogeton crispus*), broad-leaved pondweed (*Potamogeton natans*);

→ Zannichelliaceae Family: horned pondweed (*Zannichellia palustris*);

→ Naiad Family - Najadaceae: slender naiad (*Najas minor*);

→ Iris Family - Iridaceae: yellow iris (*Iris pseudacorus*);

→ Sedge Family - Cyperaceae: sea club-rush (*Bolboschoenus maritimus*); common spike-rush (*Eleocharis palustris*), *Schoenoplectus tabememontanii*;

→ True Grasses Family - Poaceae: common reed (*Phragmites australis*);

→ Duckweed Family - Lemnaceae: common duckweed (*Lemna minor*), star duckweed (*Lemna trisulc*);

→ Sparganiaceae Family: branched bur-reed (*Sparganium erectum*);

→ Cattail Family - Typhaceae: lesser bulrush (*Typha angustifolia*), broadleaf cattail (*Typha latifolia*).

Numerous ruderal plants are widespread in the parts of the area subjected to anthropogenic impact, including the urbanized areas and the green areas of the industrial zone of the Kozloduy NPP:

→ Equisetaceae Family: Field Horsetail (*Equisetum arvense*);

→ Ranunculaceae Family: creeping buttercup (*Ranunculus repens*);

→ Papaveraceae Family: greater celandine (*Chelidonium majus*);

→ Portulacaceae Family: common purslane (*Portulaca oleracea*);

→ Caryophyllaceae Family: thyme-leaved sandwort (*Arenaria serpyllifolia*), Silene latifolia (*Silene alba*), chickweed (*Stellaria media*);

→ Chenopodiaceae Family: spear saltbush (*Atriplex patula*), *Atriplex nitens*, Good King Henry (*Chenopodium bonus-henricus*), common knotweed (*Persicaria lapathifolia*), common knotgrass *Polygonum aviculare*), broad-leaved dock (*Rumex obtusifolius*), sheep's sorrel (*Rumex acetosella*);

→ Clusiaceae Family: common Saint John's wort (*Hypericum perforatum*);

→ Brassicaceae Family: shepherd's-purse (*Capsella bursa-pastoris*), hoary cress (*Cardaria draba*), narrow-leaf pepperwort (*Lepidium ruderale*), field pepperwort (*Lepidium campestre*), field mustard (*Sinapis arvensis*), tall tumble mustard (*Sisymbrium altissimum*), hedge mustard (*Sisymbrium officinale*);

→ Malvaceae Family: dwarf mallow (*Malva neglecta*), common mallow (*Malva sylvestris*);

→ Urticaceae Family: common nettle (*Urtica dioica*);

→ Euphorbiaceae Family: Bonaparte's crown (*Euphorbia cyparissias*);.

- → Rosaceae Family: Creeping cinquefoil (*Potentilla reptans*);
- → Onargaceae Family**:** common evening primrose (*Oenothera biennis*);
- → Fabaceae Family: black medick (*Medicago lupulina*), common tare (*Vicia hirsuta*);
- → Geraniaceae Family: dove's foot cranesbill (*Geranium molle*);
- → Apiaceae Family**:** wild carrot (*Daucus carota*), rough chervil (*Chaerophyllum temulentum*), bulbous chervil (*Chaerophyllum bulbosum*), parsnip (*Pastinaca sativa*);
- → Dipsacaceae Family**:** common teasel (*Dipsacus fullonum*);
- → Solanaceae Family**:** henbane (*Hyoscyamus niger*), thorn apple (*Datura stramonium*), bittersweet nightshade (*Solanum dulcamara*), black nightshade (*Solanum nigrum*);
- → Convolvulaceae Family**:** field bindweed (*Convolvulus arvensis*);
- → Boraginaceae Family: alkanet (*Anchusa officinalis*), hound's tongue (*Cynoglossum officinale*), viper's bugloss (*Echium vulgare*);
- → Scrophulariaceae Family: common toadflax (*Linaria vulgaris*);
- → Globulariaceae Family: Persian speedwell (*Veronica persica*);
- → Plantaginaceae Family: broadleaf plantain (*Plantago major*);
- → Asteraceae Family: lesser burdock (*Arctium minus*), greater burdock (*Arctium lappa*), wormwood (*Artemisia absinthium*), sweet wormwood (*Artemisia annua*), musk thistle (*Carduus nutans*), creeping thistle (*Cirsium arvense*), prickly lettuce (*Lactuca serriola*), nipplewort (*Lapsana communis*), common groundsel (*Senecio vulgaris*), tansy (*Tanacetum vulgare*), coltsfoot (*Tussilago farfara*), goat's beard (*Tragopogon pratensis*), cocklebur (*Xanthium strumarium*) , common chicory (*Cichorium inthybus*);
- → Cyperaceae Family: goose grass (*Carex hirta*);
- → Poaceae Family: perennial ryegrass (*Lolium* perenne), Italian rye-grass (*Lolium multiflorum*)**,** velvet bent (*Agrostis canina*), downy chess (*Bromus tectorum*), barren brome (*Bromus sterillis*), wall barley (*Hordeum murinum*), annual meadow grass (*Poa annua*), common dandelion (*Taraxacum officinale*), annual everlasting (*Xeranthemum annuum*);

Currently the area of the Radiana site is almost entirely covered by dense forest vegetation, which is artificially planted. The main species used for the afforestation is black locust (*Robinia pseudoacacia*).

According to literary data (Bondev, I., 1991) and the results from the site survey performed it was found that the site is occupied by plant communities of the following types:

- → Agricultural areas replacing mixed Turkey oak (*Quercus cerris*) and Virgilian oak (*Quercus virgilliana*) forests, often with additions of greyish oak (*Q. pedunculifflora*), at present occupied by crops. They are widely distributed in the northern part of the Danubian plain mostly on Chernozems. The main crops, grown on them, are cereal crops – mostly wheat and maize, as well as vines. Such areas are located south and west along the Kozloduy – Harlets road, which passes south of the site.
- → Artificial black locust plantations (*Robinia pseudoacacia*), which according to the vegetation map of Bulgaria in scale 1:600000 (Bondev, I., 1991), occupy precisely the territory of the site designated for the NDF.
- → Mesoxerothermic vegetation with predominance of bulbous bluegrass (*Poa bulbosa*), perennial ryegrass (*Lolium perenne*), Bermuda grass (*Cynodon dactylon*), occasional spots of bluestem (*Dichantium ischaemum*) and, more rarely, scented grass (*Chrysopogon gryllus*), mainly on village common land. Such vegetation is distributed around the village of Harlets and to the southwest of it (around the village of Glozhene), also northwest of the town of Kozloduy, but it is not present near the site.

→ Swamp and marshland hygrophitic (at places also hydrophitic) vegetation with predominance of common reed (*Phragmites australis*), bulrush (mainly *Typha angustifolia* and *T. latifolia*), clubrush (*Schoenoplectus lacustris, Sch. triquetra, Sch. tabernaemontana*) etc. Such vegetation occupies areas east of the Kozloduy NPP site near the Ogosta River, but is not found in the Radiana site.

→ *Agricultural lands replacing forests of field elm (Ulmus minor), Raywood ash (Fraxinus oxycarpa), greyish oak (Quercus pedunculiflora), etc. Such areas are located along the Ogosta River.*

During the performed site survey it was found that both the territory of the Radiana site and most of the adjacent areas (excluding roads and the infrastructure elements of the Kozloduy NPP) are occupied by a forest community dominated by (main share of all species) the black locust (*Robinia pseudoacacia*), which leads to the conclusion that the site is located within a black locust forest. Apart from black locust, the remaining 20% consist mainly of thorny locust (*Gleditschia triacanthos*), small-leaved lime (*Tilia cordata*), English oak (*Quercus robur*), Japanese pagoda tree (*Sophora japonica*), common ash (*Fraxinus excelsior*) and, only occasionally, sycamore (*Acer pseudoplatanus*), silver birch (*Betula pendula*) and field maple (*Acer campestre*). The undergrowth, where present, is occupied by cornelian cherry (*Cornus mas*), common privet (*Ligustrum vulgare*), common dogwood (*Cornus sanguinea*), etc. As it can be seen, the above described tree community is dominated mainly by introduced species (black locust, thorny locust, Japanese pagoda tree) and some others.

The widespread grass species in the afforested territory west of the industrial site of the Kozloduy NPP where the Radiana site is located, including the clearings and the open areas of this territory, are represented mainly by forest plants including:

→ Aspleniaceae Family: hart's tongue fern (*Phyllitis scolopendrium*);

→ Dennstaedtiaceae Family: eagle fern (*Pteridium aquilinum*);

→ Athyriaceae Family: lady fern (*Athyrium filix-femina*);

→ Aspidiaceae Family: narrow buckler fern (*Dryopteris carthusiana*), male fern (*Dryopteris filix-mas*);

→ Aristolochiaceae Family: wolf's bane (*Aconitum lycoctonum*), baneberry (*Actaea spicala*), windflower (*Anemone nemorosa*);

→ Ranunculaceae Family: traveller's joy (*Clematis vitalba*), liverleaf (*Hepatica nobilis*);

→ Hypecoaceae Family: *Corydalis bulbosa*;

→ Caryophyllaceae Family: greater stitchwort (*Stellaria holostea*);

→ Plantaginaceae Family: ribwort plantain (*Plantago lanceolata*);

→ Pyrolaceae Family: serrated wintergreen (*Orthilia secunda*);

→ Primulaceae Family: ivy-leaved cyclamen (*Cyclamen hederifolium*);

→ Violaceae Family: hairy violet (*Viola hirta*), early dog violet (*Viola reichenbachiana*), sweet violet (*Viola odorata*);

→ Brassicaceae Family: perennial honesty (*Lunaria rediviva*);

→ Cannabaceae Family: common hop (*Humulus lupulus*);

→ Euphorbiaceae Family: dog's Mercury (*Mercurialis perennis*);

→ Rosaceae Family: common agrimony (*Agrimonia eupatoria*), snowy Mespilus (*Amelanchier ovalis*), wild strawberry (*Fragaria vesca*), herb Bennet (*Geum urbanum*), common raspberry (*Rubus idaeus*), rowan (*Sorbus aucuparia*);

→ Onagraceae Family: rosebay willowherb (*Epilobium angustifolium*);

→ Fabaceae Family: narrow-leaved everlasting pea (*Lathyrus sylvestris*), *Lathyrus venetus, Arabian Pea* (*Bituminaria bituminosa*), *Chamaespartium sagittale*, black medick (*Medicago lupulina*), hare's foot clover (*Trifolium arvense*), large trefoil (*Trifolium aureum*), lesser trefoil (*Trifolium*

dubium), zigzag clover (*Trifolium medium*), common tufted vetch (Vicia cracca), large yellow vetch (*Vicia grandiflora*);

- → Oxalidaceae Family: wood sorrel (*Oxalis acetosella*);
- → Geraniaceae Family: bloody cranesbill (*Geranium sanguineum*), herb Robert (*Geranium robertianum*);
- → Balsaminaceae Family**:** touch-me-not balsam (*Impatiens noli-tangere*);
- → Apiaceae Family: sanicle (*Sanicula europaea*), fly honeysuckle (*Lonicera xylosteum*);
- → Caprifoliaceae Family: common elder (*Sambucus nigra*), common wayfaring tree (*Vibumum lantana*),
- → Rubiaceae Family: sweet woodruff (*Galium odoratum*);
- → Boraginaceae Family: wood forget-me-not (Myosotis sylvatica), common lungwort (*Pulmonaria officinalis*);
- → Scrophulariaceae Family: small cow wheat (*Melampyrum sylvaticum*), figwort (*Scrophularia nodosa*);
- → Verbenaceae Family: ground ivy (*Glechoma hederacea*), spotted deadnettle (*Lamium maculatum*), water germander (*Teucrium scordium*);
- → Asteracea Family: golden rod (*Solidago virga-aurea*), spear thistle (*Cirsium vulgare*), *Centaurea apiculata*, *Centaurea indurata*, heath groundsel (*Senecio sylvaticus*), *Inula bifrons*, ploughman's spikenard (*Inula conyza*), Irish fleabane (*Inula salicina*), greater burdock (*Arctium lappa*), *Hypochoeris maculata*, milk thistle (*Silybum marianum*);
- → Convallariaceae Family: angular Solomon's seal (*Polygonatum odoratum*);
- → Trilliaceae Family: herb Paris (*Paris quadrifolia*), blue butcher (*Orchis mascula*);
- → Juncaceae Family: great wood-rush (*Luzula sylvatica*);
- → Cyperaceae Family: wood club-rush (*Scirpus sylvaticus*);
- → Poaceae Family: wood blue grass (*Poa nemoralis*), wood melic (*Melica uniflora*);
- → Araceae Family: lords and ladies (*Arum maculatum*);
- → Lamiaceae Family: common Calamint (*Calmintha sylvatica*), spotted deadnettle (*Lamium maculatum*), Iranian Jerusalem Sage (*Phlomis herba-ventis*), Somerset skullcap (*Scutellaria altissima*), downy woundwort (*Stachys germanica*);
- → Campanulaceae Family: *Campanula sparsa*;

3.6.1.2 RADIATION STATUS OF THE FLORA IN THE AREA

3.6.1.2.1 VEGETATION

The vegetation (grass) is examined four times a year at the measurement points at the town of Kozloduy, the village of Harlets and the town of Oryahovo (gamma-spectrometry and ^{90}Sr), twice a year at the NPP site (gamma spectrometry) and the measurement points in the towns of Lom, Pleven and Berkovitsa (gamma spectrometry, ^{90}Sr, once a year). The sampling takes place in close proximity to the measurement points and at the same places where the soil samples has been carried out. About 2 kg of grass are collected at a height of over 2 cm from the ground. The samples delivered to the laboratory are subjected to primary preparation and processing for further analysis, including operations such as milling, homogenizing, drying to constant weight and weighing of the air-dry substance. The prepared samples are directly subjected to gamma spectrometry (Marinelli-1dm3, 60,000 s), and the MDA for ^{137}Cs in these conditions varies in the range of 0.79 ÷ 2.26 Bq/kg a.d.w. The vegetation is burned at 450°C and the aliquots of the ashes are analysed for ^{90}Sr. The determination of ^{90}Sr is based on the isolation of radiostrontium from the ash (k.HCl + k.HNO3), separation of Ca by means of sodium

hydroxide and liquid scintillation spectrometry of ^{90}Y (in "Cherenkov counting" mode) after the establishment of radioactive equilibrium. For measuring time of 10,000 s in the above described conditions, the MDA for ^{90}Sr amounts to a mean of 0.085 Bq/kg a.d.w.

Radionuclide contamination of vegetation in the area (where found) is due to the Chernobyl accident according to the Environmental Protection Programme of Kozloduy Municipality for the period 2004 - 2010. The values set out within the program for radioecological environmental monitoring of Kozloduy NPP for 2013 for the vegetation samples in the area, mainly grasses (air dry weight), are as follows: ^{90}Sr in the range 0.43 ÷ 2.83 Bq/kg, with a mean of 1.11 Bq/kg, ^{137}Cs in the range of the MDA <0.78 ÷ 2.81 Bq/kg. The results are comparable with those measured in previous years. (1994-2012).

Years of examinations of ^{90}Sr in the vegetation of the 100-km zone are presented in **Figure 3.6-2** . Before the commissioning of the Kozloduy NPP, the measured mean activities were 4.4 ± 0.3 Bq/kg a.d.w.

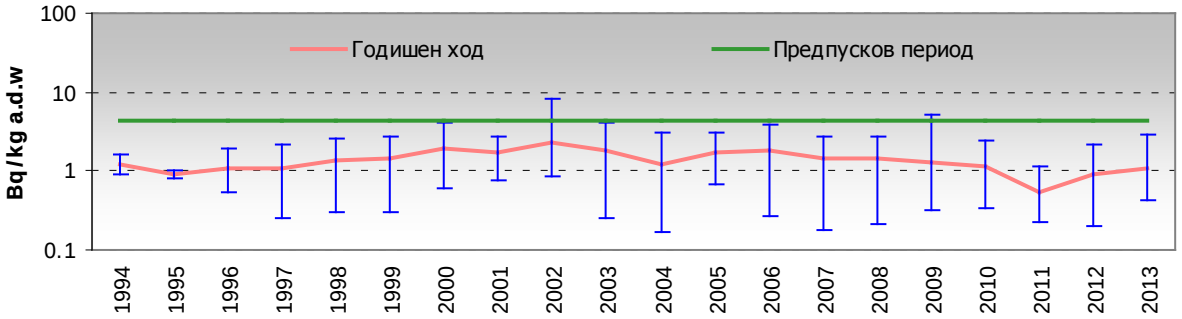


FIGURE 3.6-2 ACTIVITY OF ^{90}SR (BQ/KG A.D.W.) IN THE VEGETATION WITHIN THE 100-KM ZONE OF THE KOZLODUY NPP, 1994 - 2013

The radioactivity in the samples examined is within the normal limits for this plant species. No technogenic radioactive impact on vegetation outside the site of the NPP or in the area of the NDF site has been recorded.

Sampling of vegetation (grass) is carried out four times a year at two control points (Point 4 and Point 7) at the Radiana site for the purposes of the pre-operational monitoring of the site. The sampling takes place in close proximity to the measurement points and at the same places where the soil samples were carried out. About 2 kg of grass are collected at a height of over 2 cm from the ground. The measured values indicate the absence of technogenic activity in the samples - ^{54}Mn : <0.65÷ <2.47 Bq/kg, ^{60}Co: <0.71÷ <2.79 Bq/kg, ^{134}Cs: <0.74÷ <3.41 Bq/kg, ^{137}Cs: <0.66 ÷ <2.05 Bq/kg and ^{90}Sr: 0.45 ÷1.61 Bq/kg. These values are typical for the area. The results of all examined radionuclides are presented in **Table 3.6-1 .**

TABLE 3.6-1 RESULTS FROM THE PRE-OPERATIONAL MONITORING OF VEGETATION (GRASS) AT THE RADIANA SITE OF THE NDF

Vegetation	Activity, Bq/kg	MDA	Results
point 1 (NPP) and points 4 and 7 (Radiana site)	^{7}Be	4.3 ÷ 17.2	49.9 ÷ 157.3
	^{40}K	7.0 ÷ 35.9	419.8 ÷ 520.9
	^{54}Mn	0.65 ÷ 2.47	< MDA
	^{57}Co	0.57 ÷ 1.78	< MDA
	^{58}Co	0.67 ÷ 2.43	< MDA
	^{59}Fe	1.58 ÷ 5.03	< MDA

Vegetation	Activity, Bq/kg	MDA	Results
	^{60}Co	0.71 ÷ 2.79	< MDA
	^{65}Zn	1.86 ÷ 7.1	< MDA
	^{94}Nb	0.58 ÷ 2.38	< MDA
	^{95}Nb	0.70 ÷ 3.73	< MDA
	^{103}Ru	0.60 ÷ 2.29	< MDA
	^{106}Ru	5.28 ÷ 21.5	< MDA
	^{110m}Ag	0.59 ÷ 2.50	< MDA
	^{131}I	0.86 ÷ 6.29	< MDA
	^{134}Cs	0.63 ÷ 2.72	< MDA
	^{137}Cs	0.62 ÷ 2.06	< MDA
	^{226}Ra	6.43 ÷ 36.2	< MDA
	^{235}U	0.40 ÷ 2.22	< MDA
	^{238}U	0.77 ÷ 94.0	< MDA
	^{90}Sr	0.039 ÷ 0.070	0.45 ÷ 1.61

The analysis of the results presented above shows that only the actual values of concentrations of ^{7}Be and ^{40}K were measured, while the values of the other parameters were below the MDA. The quantity of the natural radionuclides in the samples depends on the location of sampling (outdoors or under a tree, for example) for the ^{7}Be and on the specific type of vegetation and its ability to absorb various chemical elements – for the ^{40}K. These conditions and processes can explain the differences in the values of their concentrations in the different samples. The content of ^{90}Sr has typical values for this geographic region.

3.6.1.2.2 AGRICULTURAL PRODUCTION

The monitoring includes examination of the main types of cereal and fodder crops produced in the 3-km zone - barley, wheat, maize, sunflower etc. Cereal grains and straw (sunflower heads, maize cobs) are analysed separately for all samples. The analysis methods are analogous to those used for analysing vegetation. In order to locate any possible impact of the NPP and facilitate the processing of the results, the sampling of agricultural production in the 2-km PAZ is carried out in four sectors, conditionally divided at an angle of 90°, in north-east-south-west direction. Summary of the results for cereal crops carried out by the departmental radiation monitoring in the period 2009-2013 is presented in **Table 3.6-2** .

TABLE 3.6-2 RADIATION MONITORING OF CEREAL CROPS IN THE 2-KM PAZ, 2009-2013

2009	Collected samples: 22 samples with 44 analyses performed /22 gamma-spectrometric analyses, 15 analyses of radiometry of total beta activity and 7 analyses with radiochemical isolation of strontium / RESULTS ▪ total beta activity 82 ÷ 770 Bq/kg a.d.w., mean annual – 254 Bq/kg a.d.w. ▪ activity of ^{90}Sr – 0.03 ÷ 0.65 Bq/kg a.d.w., mean annual – 0.48 Bq/kg a.d.w. ▪ activity of ^{137}Cs - <0.25 ÷ <2.41 Bq/kg a.d.w., mean annual – 0.10 Bq/kg a.d.w.
2010	Collected samples: 20 samples with 56 analyses performed /20 gamma-spectrometric analyses, 20 analyses of radiometry of total beta activity and 16 analyses with radiochemical isolation of strontium / RESULTS ▪ total beta activity 82 ÷ 1074 Bq/kg a.d.w., mean annual – 340 Bq/kg a.d.w.

	▪ activity of ^{90}Sr – 0.05 ÷ 3.09 Bq/kg a.d.w., mean annual – 0.86 Bq/kg a.d.w. ▪ activity of ^{137}Cs - <0.28 ÷ <5.01 Bq/kg a.d.w., mean annual – 1.4 Bq/kg a.d.w.
2011	Collected samples: 18 samples with 43 analyses performed /18 gamma-spectrometric analyses, 18 analyses of radiometry of total beta activity and 7 analyses with radiochemical isolation of strontium / RESULTS ▪ total beta activity 99 ÷ 1083 Bq/kg a.d.w., mean annual – 291 Bq/kg a.d.w. ▪ activity of ^{90}Sr – 0.05 ÷ 6.63 Bq/kg a.d.w., mean annual – 1.25 Bq/kg a.d.w. ▪ activity of ^{137}Cs - <0.03 ÷ <1.75 Bq/kg a.d.w., mean annual – 0.65 Bq/kg a.d.w.
2012	Collected samples: 14 samples with 38 analyses performed /14 gamma-spectrometric analyses, 14 analyses of radiometry of total beta activity and 10 analyses with radiochemical isolation of strontium , / RESULTS ▪ total beta activity 105 ÷ 1692 Bq/kg a.d.w., mean annual – 475 Bq/kg a.d.w. ▪ activity of ^{90}Sr – 0.08 ÷ 1.72 Bq/kg a.d.w., mean annual – 0.65 Bq/kg a.d.w. ▪ activity of ^{137}Cs - < 0.31 ÷ < 4.82 Bq/kg a.d.w., mean annual – 1.27 Bq/kg a.d.w.
2013	Collected samples: 2 samples with 6 analyses performed /2 gamma-spectrometric analyses, 2 analyses of radiometry of total beta activity and 2 analyses with radiochemical isolation of strontium , / RESULTS ▪ total beta activity 124 ÷ 138 Bq/kg a.d.w., mean annual – 131 Bq/kg a.d.w. ▪ activity of 90Sr – 0.09 ÷ 0.11 Bq/kg a.d.w., mean annual – 0.10 Bq/kg a.d.w. ▪ activity of 137Cs - <0.23 ÷ <0.31 Bq/kg a.d.w., mean annual – 0.27 Bq/kg a.d.w.

Arable lands are located in the area from the northern border of the site and on the other side of the road Harlets – Kozloduy. Agricultural production in the area around the Radiana site is represented by the main types of cereal and fodder crops - barley, wheat, maize, and sunflower. The results from the radioecological monitoring of the environment, performed by the Kozloduy NPP, show natural levels of radionuclides in the agricultural production in the areas closest to the plant (within a 3-km zone around the plant). In 2013 the total beta activity of cereal grains varied within normal range: 124 to 138 Bq/kg a.d.w. The results from the gamma-spectrometric measurements show that the total beta activity registered in the samples was almost entirely due to the natural ^{40}K. In 2013, as in previous years, the activity of ^{137}Cs and other technogenic radionuclides did not exceed the natural background radiation values (MDA ^{137}Cs from <0.23 to <0.31 Bq/kg a.d.w). The registered activity of ^{90}Sr was in the range 0.094 ÷ 0.11 Bq/kg a.d.w.

The radiation status of the agricultural crops in the 2-km PAZ in the area of the Radiana site of the NDF is within the typical levels of natural background radiation.

3.6.2 FAUNA

3.6.2.1 CHARACTERISTICS OF THE FAUNA IN THE AREA IN THE RADIANA SITE

According to the zoogeographical zoning of Bulgaria, the site of the Investment Proposal belongs to the *Euro-Siberian subregion* (Georgiev, 1979, 1982), *Danube area* (A.L.). The Danube area encompasses the territory of the Danubian Plain, the Ludogorie and the south part of the Dobrudzha Plateau (without the coast).

The selected site is situated at about 4.3 km northwest of the construction boundaries of the village of Harlets and at about 3.3 km southeast of the regulation line of the town of Kozloduy, as well as at 4.2 km south of the right bank of the Danube River. The site is located in the immediate vicinity of the NPP Kozloduy between two roads, one to the north – controlled by the NPP and considered an internal departmental road of the plant, and one to the south – the section of the republic road II -11 Kozloduy – Harlets – Miziya. The average slope of the site is 8°.30'. The elevation in the area of the IP is in the range of 30 and 100 m - the site itself is located on the slope between the first and sixth loess terraces, with displacement between them of about 55 m (from +39 m elevation to +94 m elevation), and is located between second and sixth non-flooded loess terraces at right side of the Danube River.

The relief in the area of the Radiana site is plain but also folded in some its parts.

The main part of the Precautionary Action Zone of the Kozloduy NPP, which also encompasses the Radiana site, occupies agricultural landscape and, partially, meadow and forest landscapes, the latter type being also found at the site intended for the construction of the repository for short-lived low and intermediate level radioactive waste. According to the forest-vegetation zoning, the territory of the site belongs to the Lower plain-hilly and hilly-submontane belt of the oak forests (altitude of 0-900 m) and, in particular, to the sub-belts of the plain-hilly oak forests (altitude of 0-600 m). The woody vegetation (trees and shrubs species) has a relatively diverse composition of species.

The main environment-forming element on the envisaged site is the woody vegetation (trees and shrubs). In places with shrub vegetation – and the interesting thing here is that it was spread mainly by artificial means, including planting of exotic (alien) trees species – the main dominant species is lack locust (*Robinia pseudoacacia*); but there are also honey locust (*Gleditschia triacanthos*), China tree (*Koelreuteria paniculata*), American ash (*Fraxinus americana*), Chinese Sumach (*Ailanthus glandulosa*), white mulberry (*Morus alba*), common walnut (*Juglans regia*), Japanese pagoda tree (*Sophora japonica*), wild apricot (*Armeniaca vulgaris*) – representing the trees; as well Amur honeysuckle (*Lonicera Maackii*) and desert false indigo (*Amorpha fruticosa*) – representing the bushes. In addition to the more exotic species mentioned above, the territory is also occupied by native species, which have been artificially planted or have spread by themselves, such as the English elm (*Ulmus campestris*), Mahaleb cherry (*Padus mahaleb*), cherry plum (*Prunus cerasifera*), Sycamore maple (*Acer pseudoplatanus*), European ash (*Fraxinus excelsior*), small-leaved lime (*Tilia cordata*), English oak (*Quercus robur*) - representing the trees, and dog-rose (*Rosa canina L.),* common hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), wild privet (*Ligustrum vulgare*) common dogwood (*Cornus sanguinea*), *Rubus fragariiflorus*, traveller's joy (*Clematis vitalba*), European spindle (*Euonimus europaea*) – representing the shrubs, and the bittersweet nightshade (*Solanum dulcamara*) for the half-shrub. Both the afforested territory and the site are crossed by a cemented water channel (channel for backup water supply of the plant from the Shishmanov Val Dam) and a dirt road.

The fauna, including vertebrate and invertebrate, near the site is represented by species typical of the low (flat) parts of the country and the Danubian plain. In zoogeographic terms, the fauna is of Palaearctic type and consists mainly of species from the temperate latitudes in particular. Some species whose ranges are located south on the territories of the European sub-continent, i.e. Mediterranean species, can also be observed. Taking into account what has been said so far, most species in the fauna of the area are Euro-Siberian and European elements. The predominant species among the remaining ones are of Holarctic and Palearctic distribution. In this regard, typical examples are the spiders, among which almost no Mediterranean species are observed. On the other hand, the continental climate is the

reason for a wider variety of animal groups like amphibians, while reptiles are quite poorly represented. There are almost no endemic representatives of the fauna, while the subterranean fauna is represented by 2 Balkan and 4 Bulgarian endemic species. In this region, Mediterranean birds are the most underrepresented compared to other zoogeographic regions and the species with northern type of distribution exceed those of the southern type of distribution by four times.

The nature of the territory of the future NDF site as a habitat determines the characteristics of its fauna. The species are mainly of forest habitats on the one hand, and on the other – species of open, grass-shrub habitats (including agricultural landscapes) that can be found on the territory of the project mainly when they are crossing it, given the presence of agricultural land in the immediate vicinity of the selected site.

According to the site surveys ,carried out during different years, as well as to the data available on the species richness and the conservation importance of biodiversity in the area, the following analysis can be made regarding the fauna:

3.6.2.1.1 INVERTEBRATE FAUNA (INVERTEBRATES)

The first researches on the Bulgarian invertebrate fauna were carried out in 1800 by foreign and Bulgarian scientists. In spite of that, the exact number of invertebrates on the territory of the Republic of Bulgaria is still unknown. In this respect, there are still species that are not well studied, or even not studied at all. Just the Weevils in Bulgaria are represented by more than 1,000 species, and they are only one of the many families from the nearly twenty orders of insects. Insects on the other hand are just one of the dozens of invertebrates in the country. Some basic data on the better studied taxons on the territory of the country is summarized below.

The best-studied groups of invertebrates in Bulgaria are as follows:

- → Subkingdom Protozoa (Unicellular);
- → Class Nematoda (Phylum Roundworms);
- → Class Oligochaeta (Phylum Annelida);
- → Phylum Mollusca (Molluscs);
- → Class Crustacea (Crustaceans of the Phylum Arthropods);
- → Class Arachnida (Arachnids of Phylum Arthropods);
- → Class Myriapoda (Millipedes of Phylum Arthropods);
- → Class Insecta (Insects);

With respect to the distribution of established and known rare and endemic species on the territory of the country from the taxons Protozoa, Nematoda, Oligochaeta, Mollusca, Crustacea, Arachnida and Myriapoda (without Class Insecta), the following is typical:

- → *Rare Species***.** The areas on which the largest number of rare species is observed are as follows: 1) the Black Sea Coast; 2) Vitosha Mountain; 3) Western Rhodopes; 4) the valley of the Struma River and Strandzha Mountain. As seen, the Radiana site selected for the IP is located at a considerable distance from all these areas and has one of the most advantageous locations towards them overall.
- → *Endemic species.* The areas with the highest populations of endemic species (Bulgarian/ Balkan) from the above mentioned taxons are: 1) Western Rhodopes, 2) Western Balkan Mountains, 3) Pirin Mountain, 4) Central Balkan Mountain and Rila Mountain. The NDF site (Radiana) is again located at a significant distance from the areas with high endemism.

Regarding Class Insecta, it is necessary to take into account the fact that this is the richest class of the animal world comprising more species than all the animal phyla and classes together. Available data show that only about 37% of the insect fauna in Bulgaria is represented by the following

orders: Odonata (dragonflies), Ephemeroptera (mayflies), Plecoptera (stoneflies), Homoptera (sucking insects), Heteroptera (true bugs) and Coleoptera (coleopterons). Their families and species are among the most numerous in the modern-day fauna. In this case, the percentage of rare species is greatest in the orders of Plecoptera and Odonata. The greatest percentage of endemic species belongs to the orders of Plecoptera and Ephemeroptera. On the other hand, order Heteroptera has the highest percentage of relict species. Most areas with some of the most valuable communities of these orders are concentrated in the high mountains, along the Black Sea coast and in the southwestern parts of Bulgaria (mainly the southern part of Struma River.). The areas with the most representative samples of biodiversity from the different orders are also concentrated in the mountains, mainly in Rila, Pirin, Vitosha and Western Rhodopes. Most of the groups mentioned above are some of the best studied ones in Bulgaria, and the distribution of rare, endemic and relict species, included in their composition, on the territory of the country is as follows:

→ *Rare species*. The areas with the largest number of rare species on the territory of the country are concentrated in the southern part of the Struma River valley – south of the town of Simitli and near the Greece border, as well as along the South Black Sea Coast near Cape Emine. They are also found, to a lesser degree, in Strandzha Mountain and in Central and Eastern Balkan Mountain. It is interesting to note that a relatively small amount of rare species are observed in the high Bulgarian mountains like Slavyanka, Rila, Belasitsa, in Western Balkan Mountain and Pirin.

→ *Endemic species:* The areas with highest number of endemic species are: 1) Rila Mountain, 2) Western Rhodopes, 3) Pirin Mountain, and Central Balkan Mountain. A large number of endemic species are also found in the southern part of the Struma River Valley, Western Balkan Mountain, Vitosha Mountain, and the South Black Sea Coast. To a lesser degree, endemic species can be found in Strandzha Mountain, along the North Black Sea Coast, in Slavyanka Mountain and Belasitsa Mountain, the case being of lower degree of endemism.

→ *Relict species***.** It should be taken into account that there are no relict species belonging to orders Ephemeroptera and Plecoptera have been found, and in the case of the order Odonata, only one has been found (in Strandzha Mountain). The areas with the highest number of relict species are: 1) Vitosha Mountain, 2) Rila Mountain, 3) Pirin Mountain and 4) Western Rhodopes. Relicts can be found, to a lesser degree, in other regions of the country: Central Balkan Mountain, Western Balkan Mountain, in the mountains of Slavyanka and Belasitsa as well as in the southern part of the valley of Struma River and Strandzha Mountain.

From the analysis made so far, it can be seen that the Danubian Plain and in particular its western part, where the NDF site is to be constructed, does not encompass any of the areas with pronounced distribution of rare, endemic and relict species from the six considered orders of Class Insecta. **In this case, the site in the immediate vicinity of the Kozloduy NPP, selected for the NDF, is sufficiently distant from all of the above listed areas, in which the largest number of species of greatest significance in terms of conservation (from the order Odonata, Ephemeroptera, Plecoptera, Homoptera, Heteroptera and Coleoptera) are distributed.**

Regarding the rest of Class Insecta, about 54 % of the entomofauna of Bulgaria consists of species from the following orders: Blattodea, Mantodea, Isoptera, Orthoptera, Dermaptera, Embioptera, Embiids, Megaloptera, Raphidioptera, Neuroptera, Mecoptera, Hymenoptera, Trichoptera, Lepidoptera and Diptera. The richest orders among them are the Hymenoptera, Lepidoptera and Diptera. The rare, endemic and relict species represent about 11% of the species composition of the 14 orders mentioned above. The largest share of rare species belongs to the orders Neuroptera and Trichoptera. Most of them are observed in the Kresna Defile, in the Sandanski – Petrich area and along the North Black Sea Coast. The largest share of endemic species belongs to the Orthoptera, while the lowest – to the order Diptera. Endemic species are mostly distributed in the mountains of Pirin and Rila, in the Sandanski – Petrich area and the Kresna Defile. Overall, the territories richest in rare, endemic and relict species are: the Kresna Defile, the Sandanski-Petrich area, the Black Sea Coast, the higher parts of the mountains of Pirin and Rila, Western Rhodopes and Vitosha Mountain, as well as the middle reaches of Struma

River. In terms of species, the richest territories are the middle reaches of Struma River, the North Black Sea Coast and Pirin Mountain. It should be taken into account that despite the large number of regional researches preformed; almost all of them were concentrated in the southern part of Bulgaria, while most of the existing researches of the northern parts and the Danubian Plain are incomplete or old. **Table 3.6-3** presents the data on the number and distribution of rare, endemic and relict species (according to the data available), from the above mentioned orders of insects, which are observed on the territory of the Danubian Plain.

TABLE 3.6-3 DATA ON THE NUMBER AND DISTRIBUTION OF RARE, ENDEMIC AND RELICT SPECIES FROM THE 14 ORDERS OF CLASS INSECTA, WHICH ARE OBSERVED ON THE TERRITORY OF THE DANUBIAN PLAIN

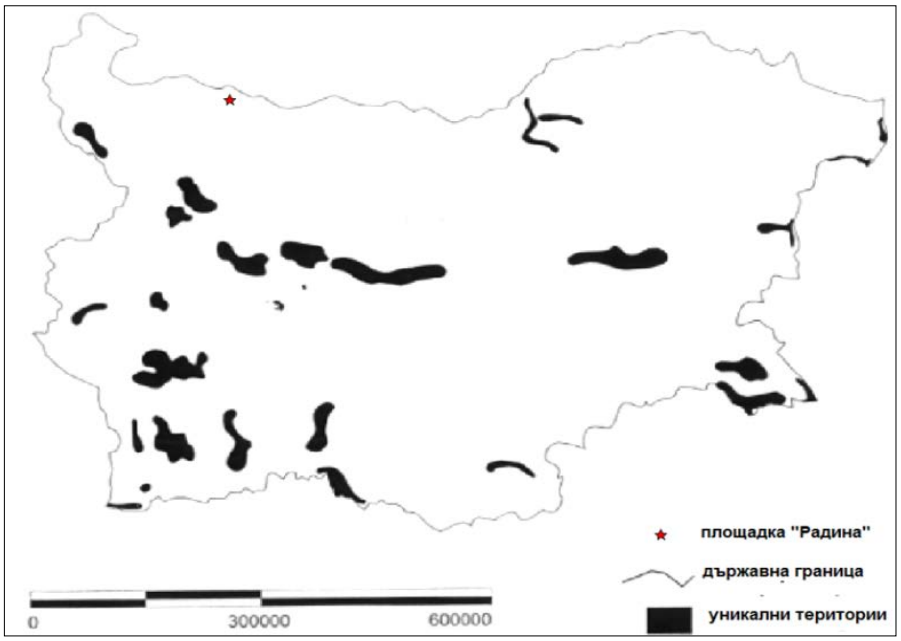
Areas of distribution in the Danubian Plain	Total	Endemic	Rare	Relict
		Number of species		
Danubian Plain		1	-	-
Western part	10	3	7	-
Central part	6	3	3	-
Eastern part	12	4	8	-

In this case, a negligible number of the endemic and rare species from the 14 orders of Class Insecta observed on the territory of the country, are distributed in the western part of the Danubian Plain (including the entire plain), where the Kozloduy NPP and the envisaged NDF site are located. No relict species are observed. The rest of the species are observed in the Balkan Mountain, the mountains and some of the valleys within the Transitional mountain-valley region (including the Kraishtensko-Konyavski area, Strandzha etc.), the mountains and the river valleys of the Rilo-Rhodope Massif, the Black Sea Coast, as well as in the Forebalkan region. The text above indicates the territories with the largest diversity in terms of rare, endemic and relic species typical for the following orders: Blattodea, Mantodea, Isoptera, Orthoptera, Dermaptera, Embioptera, Megaloptera, Raphidioptera, Neuroptera, Mecoptera, Hymenoptera, Trichoptera, Lepidoptera and Diptera.

It should be noted that Bulgaria, as a country of very diverse topography and different climatic influences, and given the fact that it is situated on the border between two continents and two completely different zoogeographical subregions (Euro-Siberian and Mediterranean), has a rich and remarkable entomofauna. The topography, climate and the palaeogeographic evolution during the Tertiary and Quaternary were key factors for the formation and sustention of many unique ecosystems and communities. Overall, the most important groups of invertebrates in Bulgaria are distributed in forest areas, mountains and alpine ecosystems; in Karst areas and cave habitats, coastal habitats (beaches, dunes, lakes and marshes); as well as in river and gorge habitats within valleys. The alpine peat bogs, glacial lakes, mountain streams, caves and riparian wetlands are essential to the existence of many groups.

In practice, the site of the IP and the adjacent areas cannot be considered habitats with such characteristics, and at the same time they are located at a sufficient distance from similar habitats.

Figure 3.6-3 represents a map of the unique areas in terms of significant habitats of invertebrates in the country.



Source: Biodiversity Support Program, c/o World Wildlife Fund

FIGURE 3.6-3 TERRITORIES OF SIGNIFICANT HABITATS OF INVERTEBRATES IN THE REPUBLIC OF BULGARIA

The target invertebrate species, which are subject to conservation in this part of the Danubian plain, where the NDF site is envisaged for construction, coincide with those described in the closest protected areas under the Habitats Directive of the Natura 2000 network. They consist of a total of 5 species: one species of Class Bivalvia, one of Class Gastropoda and other 3 of Class Insecta. No such species were recorded during the site surveys. These species are listed in **Table 3.6-4** , which also presents data on their conservation status, their ecology, and the probability of their presence near or at the site of the NDF.

TABLE 3.6-4 TARGET INVERTEBRATE SPECIES, WHICH ARE SUBJECT TO CONSERVATION, IN THE AREA OF THE INVESTMENT PROPOSAL

Species	BDA (Annex 2,3)	Berne Convention	Directive 92/43 EEC	IUCN Red List (2014)
Thick Shelled River Mussel *(Unio crassus*)	Annex 2,3	-	Annex II,IV	(EN)
Stag beetle (*Lucanus cervus*)	Annex 2,3	Annex 3	Annex II	-
Morimus funereus (*Morimus funereus*)	Annex 2	-	Annex II	+ (VU)
Rosalia longicorn (*Rosalia alpine*)	Annex 2,3	Annex 2	Annex II,IV	+ (VU)
Striped nerite (*Theodoxus transversalis*)	Annex 2,3	-	Annex II,IV	- (EN)

+ Listed EN - **„endangered” species**
- Unlisted VU - **„vulnerable” species**

Thick Shelled River Mussel *(Unio crassus)*. It inhabits the rivers and streams in the area, which have clean, flowing water rich in oxygen and riverbeds covered with gravel or sand. This species is very sensitive to eutrophication. The nearest river providing suitable habitats is Ogosta River, which is situated at a little over 5 km east of the location of the envisaged site.

Stag beetle **(***Lucanus cervus***).** The life cycle of the species is tied to old woodland, primarily oak and mixed deciduous forests. It can also be found in old city parks and gardens, where mature oaks trees are present. The female lays her eggs in old oak stumps. The larvae feed on half-decomposed wood – **this species depends on the availability of dead wood.**

The species is not present at the Radiana site due to the lack of any old oak trees and stumps providing dead wood (only common oak of about 25 years of age can be observed in certain places). No presence of the species or evidence of its life activity has been registered during the performed site survey**.**

Morimus funereus (*Morimus funereus*). It is mainly tied to beech forests. The larvae develop in the dead wood of beech trees. This tree species is not present within the surveyed area, therefore there are no suitable habitats for the Morimus funereus, which is why it has not been observed and is very unlikely to be encountered in the future.

Rosalia longicorn (*Rosalia alpine*). It inhabits mainly old beech woodlands at an elevation within the range of 500 – 1,000 m. Its larva is exclusively tied to these forests, therefore the species is not found in the surveyed area of the site whose average elevation is much below 500 m (between 30 and 100 m).

The last three species are typically forest dwellers whose development depends exclusively on hardwood. The conservation of their habitats is mainly related to the preservation of old oak and beech forests and fallen dead wood, which is their main breeding substrate. Generally, the considered area provides certain habitat conditions for the species; however they are not sufficient and optimally suitable for them to permanently populate it due to the absence of appropriate prerequisites for the successful development of their larvae.

Striped nerite (*Theodoxus transversalis*). This small freshwater snail is widespread in Ogosta River, which is situated at more than 5 km from the IP site, as well as along the banks of the Danube River.

3.6.2.1.2 VERTEBRATE FAUNA (VERTEBRATES)

Class Pisces

The nearest biotopes of this vertebrate group are in the Danube River (at about 4 km) and, respectively, the service channels of the Kozloduy NPP (at a little more than 1 km).

Overall, the Bulgarian section of the Danube River and its tributaries (including Ogosta River and Skat River) constitute a single ichthyocomplex, in which 77 species and subspecies of fish can be found. Twenty of them are observed only in the Danube River and are not present in its tributaries (*Hucho hucho*, *Alosa caspia nordmani*, some sturgeons, etc.). Conversely, ten cold-loving species (mainly species of genus *Salmo*, genus *Cobitis*, genus *Cottus*, etc.) inhabit only the upper parts of the middle reaches of the tributaries. Thus, 65 species of fish are observed in the Bulgarian part of the Danube River. The most abundantly represented family is the Cyprinidae Family, followed by the Percidae, Cobitidae and Gobiidae. Overall, the Danube Basin and its Bulgarian sector are an important centre in terms of species diversity. Endemic species such as *Sabanejwia bulgarica* (Bulgarian loach), *Gymnocephalus schraetzer* (Striped ruffe), *G. baloni*, *Hucho hucho* (Danube salmon), *Barbus barbus* (common barbel), *Vimba vimba* (zarte), *Aspro streber*, can also be observed in the area.

Well distributed in the section of the Danube River and the lower parts of its tributaries as well as in area of the town of Kozloduy are species such as: Bream (*Abramis brama*), Bleak (*Alburnus alburnus*), common Barbel (*Barbus barbus*), Gudgeon (*Gobio gobio*), chub (*Leuciscus cephalus*), perch (*Perca fluviatilis)*, northern pike (*Esox lucius*), tench (*Tinca tinca*), Crucian carp (*Carassius carassius*), Silver carp (*Hypophthalmichthys molitrix*), spined loach (*Cobitis taenia*), nase (*Chondrostoma nasus*), monkey goby (*Neogobius fluviatilis*), zarte (*Vimba vimba*), racer goby (*Neogobius gymnotrachelus*), round goby (*Neogobius melanostomnus*), roach (*Rutilus rutilus*), also, more rarely, silver bream (*Blica bjoercna*), ide (*Leuciscus idus*), Pontic shad (*Alosa pontica pontica*) – and during breeding season – Russian sturgeon (*Acipenser gueldenstaedtii*).

The fish species of conservation significance in this area of the Danube River and its tributaries (around the town of Kozloduy) coincide with the species that are subject to protection in the nearest protected areas - **Table 3.6-5** .

TABLE 3.6-5 FISH SPECIES OF CONSERVATION SIGNIFICANCE IN THE DANUBE RIVER WITHIN THE AREA OF THE INVESTMENT PROPOSAL

Species	BDA (Annex 2,3)	Berne Convention	Directive 92/43 EEC	IUCN Red List (2014)
Target species				
Streber (*Zingel streber*)	Annex 2	Annex 3	Annex II	+ (LC)
Pontic shad (*Alosa immaculata*)	Annex 2	-	Annex II	+ (VU)
Asp (*Aspius aspius*)	Annex 2	Annex 3	Annex II	+ (LC)
Mediterranean barbel (*Barbus meridionalis*)	Annex 2	Annex 3	Annex II	+ (NT)
Balkan loach (*Cobitis elongata*)	Annex 2	Annex 3	Annex II	+ (LC)
Spined loach (*Cobitis taenia*)	Annex 2	Annex 3	Annex II	+ (LC)
Ukrainian Brook Lamprey (*Eudontomyzon mariae*)	Annex 2	Annex 3	Annex II	+ (LC)
White-finned Gudgeon (*Gobio albipinnatus*)	Annex 2	Annex 3	Annex II	+ (LC)
Balon's Ruffe (*Gymnocephalus baloni*)	Annex 2,3	Annex 3	Annex II, IV	+ (LC)
Striped Ruffe (*Gymnocephalus schraetzer*)	Annex 2	Annex 3	Annex II	+ (LC)
Ziege (*Pelecus cultratus*)	Annex 2	Annex 3	Annex II	+ (LC)
Weatherfish (*Misgurnus fossilis*)	Annex 2	-	Annex II	+ (LC)
European bitterling (*Rhodeus sericeus amarus*)	Annex 2	Annex 3	Annex II	+ (LC)
Golden Loach (*Sabanejewia auratabalcanica*)	Annex 2	Annex 3	Annex II	+ (LC)
Zingel (*Zingel zingel*)	Annex 2	Annex 3	-	+ (LC)
+ Listed **- Unlisted**	NT -**"near threatened" species** VU - **"vulnerable" species** LC - **"least concern" species**			

There are no water bodies in the immediate vicinity of the envisaged NDF site where the above mentioned species can be found – the closest suitable water bodies are the service channels of the Kozloduy NPP, which are located at a distance of a little more than 1 km from the Radiana site.

Class Amphibia and Class Reptilia

Due to its geographical position and its diverse relief, the hepterofauna in Bulgaria is one of the richest in Europe. So far, over 52 species of amphibians and reptiles have been identified, of which two types of snakes (*Vipera aspis* and *Vipera ursinii*) are considered extinct since they have not been detected in the last 60 years, and two species of marine turtles are occasional visitors to the Black Sea Coast (resp. 48 species). More than 20 years ago the majority of Bulgarian herpetofauna (31 species) was protected from extinction by a special order of the MoEW No 729/1986 (then Ministry of Environment); later on 14 species were included in the Red Data Book of Bulgaria (Beshkov, 1985) and in the new Red Data Book (edition of BAS and MoEW, 2011) they increased to 15 species.

Bulgarian amphibian and reptile fauna can be divided into 3 groups depending on their zoogeographical distribution: 1. North European and European species, which are widespread in the mountains, especially in the coniferous belt; 2. Middle and South European species distributed throughout Bulgaria, including the Danubian Plain – this group is typical for the area of the selected NDF site; 3. Mediterranean and Middle Eastern species entering only the warm and low parts of Southern Bulgaria. Overall, the most important ecosystems and habitats of unique significance for amphibians and reptiles in the country are located in areas where the Mediterranean climatic influence is greatest – the valley of Struma River, the valley of Maritsa River, Eastern Rhodopes, as well as the southmost Black Sea Coast (south of Burgas), **all of which are significantly remote from the Radiana site.** No presence of

amphibians and reptiles was recorded during the site survey performed at the accessible areas of the future site. A characterization of the herpetofauna distributed in this part of the Danubian Plain, including the conservation status of individual species and the probability to be encountered at site depending on its characteristic ecology, is presented below.

3.6.2.1.3 AMPHIBIANS (AMPHIBIA)

The species observed in all water bodies of the area are Eurasian marsh frog (*Rana ridibunda*) and edible frog (*Rana esculenta*). The standard forms of the closest protected areas (PA "Ogosta River", PA "Skat River", etc.) under the Habitats Directive describe a total of 9 species of amphibians, 5 of which are classified as significant and 4 as target species of conservation significance subject to protection in the area under Directive 92/43/EEC – **Table 3.6-6** .

TABLE 3.6-6 AMPHIBIAN SPECIES OF CONSERVATION SIGNIFICANCE DISTRIBUTED IN THE AREA OF THE INVESTMENT PROPOSAL

Species	BDA (Annex 2,3)	Berne Convention	Directive 92/43 EEC	IUCN Red List (2014)
Target species				
Fire-bellied toad (*Bombina bombina*)	Annex 2,3	Annex 2	Annex II,IV	+ (LC)
Yellow–bellied toad (*Bombina variegate*)	Annex 2,3	Annex 2	Annex II,IV	+ (LC)
Southern crested newt (*Triturus karelinii*)	Annex 2,3	Annex 2	Annex II,IV	+ (LC)
Danube crested newt (*Triturus dobrogicus*)	Annex 2,3	Annex 2	Annex II	+ (NT)
Significant species				
Agile frog (*Rana dalmatina*)	-	Annex 2	Annex IV	+ (LC)
Common spadefoot (*Pelobates fuscus*)	Annex 3	Annex 2	Annex IV	+ (LC)
Eastern spadefoot (*Pelobates syriacus*)	Annex 3	Annex 2	Annex IV	+ (LC)
Green toad (*Bufo viridis*)	Annex 3	Annex 2	Annex IV	+ (LC)
European tree frog (*Hyla arborea*)	Annex 3	Annex 2	Annex IV	+ (LC)
+ Listed NT -**„near threatened” species**				
- Unlisted LC - **„least concern" species**				

The presence of several specimens of green toad (*Bufo viridis*), including one run over by the traffic on the interdepartmental road of the Kozloduy NPP, has been recorded during the surveys performed at the accessible areas of the Radiana site. The above described species are found in biotopes that are typical for them and the probability for encountering them at the site or in its vicinity is analysed below.

3.6.2.1.3.1 Target amphibian species

Fire-bellied toad (*Bombina bombina*). It inhabits natural and artificial lakes, rivers, streams, canals, temporary puddles and flooded wheel tracks, preferring water areas that are overgrown with water vegetation. The species is very closely tied to water, which is why it is not encountered at the site of the Investment Proposal and near it – there are no surface water bodies or formations. The closest habitat of the species is the Danube River west of the mouth of Lom River (in Naumov, B., M. Stanchev).

Yellow–bellied toad (*Bombina variegata*)**.** The yellow-bellied toad is not registered within the area considered. It is spread throughout the country. It inhabits both plains and mountains, where its presence is recorded even at an elevation of 1,900 m. Although it hibernates on land, during its active period (warm season) the species occupies different water reservoirs, with both flowing and stagnant water – rivers, streams, marshes, canals, dams, lakes, fountain troughs, flooded wheel tracks on dirt roads, as well as small puddles, in which water is retained over longer periods. It rarely moves away from water

at a distance larger than 0.5-0.6 m (max. 1.0 m) and therefore it is not encountered at the site of the Investment Proposal and its vicinity and there is no probability for that to happen due to the lack of surface water bodies and formations. The closest habitat of the species is located at the end of the middle reaches of the Ogosta River (according to Naumov, B., M. Stanchev). Most sites of the species are concentrated in the southern part of the country.

Southern crested newt (*Triturus karelini*). It is encountered in marshes, lakes and slow-moving rivers, which it periodically leaves during the summer. Most often the species hibernates on land, near water ecosystems. It is not present at the area where the IP site is located and is unlikely to be encountered, including the vicinity of site, due to the lack of surface water bodies and formations in the area. The closest habitat of the southern newt is located in the area of the upper reaches of the Skat River (according to Naumov, B., M. Stanchev).

Danube crested newt (*Triturus dobrogicus*). It is encountered in the Danube Delta and along its lower reaches, on the territory of Bulgaria and Romania. It is widespread in marshlands, estuaries of the tributaries of the Danube River and the islands in the river. Accordingly, there is no way to be encountered at the site or its vicinity. A habitat of this species is recorded near Oryahovo, between the town and the mouth of Ogosta River.

The closest habitat of the above listed species is the habitat of the *Triturus dobrogicus*, located at about 13 km in beeline.

3.6.2.1.3.2 Significant amphibian species

Agile frog (*Rana dalmatina*). It prefers moist habitats such as riparian meadows, mesophilic deciduous and mixed forests in the lower and middle mountain belt, as well as marshes. Sometimes it moves away from water reservoirs to a great distance. It often enters into settlements. The terrain of the Investment Proposal creates some favourable habitat conditions for this species, however it lacks wet areas – it is dry during most of the year, and the trees that occupy it are of pronounced Xerothermic character. No presence of specimens is determined from direct observations or other sources. The closest habitats of Agile frog are located in the area of the town of Vidin and the area of the town of Vratsa (according to Naumov, B., M. Stanchev).

Common spadefoot (*Pelobates fuscus*) and eastern spadefoot (*Pelobates syriacus*) mainly inhabit open areas with steppe vegetation and loose soil, including arable land and areas overgrown with shrubs, but not forest habitats, which is why they are not encountered within the area of the IP and its vicinity. They are likely to inhabit adjacent arable lands south and west of the site. The closest known habitat of the common spadefoot is located in the area of the town of Svishtov, while the one of the eastern spadefoot is located near the town of Belene (according to Naumov, B., M. Stanchev).

Green toad (*Bufo viridis*). This species is quite resistant to droughts and can be found in locations without closely located water reservoirs. It prefers open grassed areas, as well as dry karst terrains. It adapts well to intensively cultivated lands, as can be found near the site envisaged for construction, on the other side of the Harlets-Kozloduy road. In Bulgaria, the green toad is observed throughout the entire country up to 1,200 m elevation. While included in Annex № 3 of the BDA, Annex II of the Bern Convention and Annex IV of Directive 92/43/EEC, this species is too widespread in the country. In some cases it may be even more numerous in rural backyards than outside settlements. It even appears in large urban centres, including spaces between residential blocks (based on personal observations in the city Sofia, the towns of Plovdiv, Peshtera, Belogradchik, etc.), where it very often becomes victim of various anthropogenic factors. The species was identified in several places during the site survey, including one specimen that had been run over by the traffic on the interdepartmental road of the Kozloduy NPP. The nearest habitat of the species is located at the end of the middle reaches of the Ogosta River (according to Naumov, B., M. Stanchev).

European tree frog (*Hyla arbore*) prefers moist areas - mesophilic mixed and deciduous forests, mountain meadows, urban park, etc., usually sticking close to stagnant water reservoirs, which are absent at or near the site. In Bulgaria, it is encountered throughout the entire country up to about 1,300

m. elevation. The site provides partially suitable conditions, but the species is neither observed nor heard in the area. The nearest habitat of the species is found at the end of the middle reaches of the Ogosta River (according to Naumov, B., M. Stanchev).

3.6.2.1.3.3 Other amphibian species

As mentioned above, the Eurasian marsh frog (*Rana ridibunda*) and the edible frog (*Rana esculenta*) are spread in all water bodies in the area and along their banks, however no such reservoirs can be found near the site.

3.6.2.1.4 REPTILES (REPTILIA)

The standard forms of the closest protected areas (PA "Ogosta River", PA "Skat River", etc.) under the Habitats Directive describe a total of 11 reptile species, 8 of which are classified as significant and 3 as target species of conservation significance subject to protection in the area under Directive 92/43/EEC – **Table 3.6-7** .

TABLE 3.6-7 REPTILE SPECIES OF CONSERVATION SIGNIFICANCE UNDER ANNEXES 2 AND 3 OF THE BDA IN THE AREA OF THE INVESTMENT PROPOSAL

Species	BDA (Annex 2,3)	Berne Convention	Directive 92/43 EEC	IUCN Red List (2014)
Target species				
European pond turtle (*Emys orbicularis*)	Annex 2,3	Annex 2	Annex II,IV	+ (NT)
Hermann's tortoise (*Testudo hermanni*)	Annex 2,3	Annex 2	Annex II,IV	+ (NT)
Four-lined snake (Elaphe quatuorlineata)	Annex 2,3	Annex 2	Annex II,IV	+ (NT)
Significant species				
Schmidt's whip snake (*Coluber caspius*)	Annex 3	Annex 2	Annex IV	+ (LC)
Aesculapian ratsnake (*Elaphe longissima*)	Annex 3	Annex 2	Annex IV	+ (LC)
Nose-horned viper (*Vipera ammodytes*)	Annex 3	Annex 2	Annex IV	+ (LC)
Tessellated water snake (*Natrix tessellate*)	Annex 3	Annex 2	Annex IV	-
Balkan wall lizard (*Podarcis taurica*)	Annex 3	Annex 2	Annex IV	+ (LC)
Common wall lizard (*Podarcis muralis*)	Annex 3	Annex 2	Annex IV	+ (LC)
Green lizard (*Lacerta viridi*)s	Annex 3	Annex 2	Annex IV	+ (LC)
European copper skink (*Ablepharus kitaibelii*)	Annex 3	Annex 2	Annex IV	+ (LC)

+ Listed NT -**„near threatened” species**
- Unlisted LC - **„least concern” species**

No presence of reptiles was recorded at the envisaged NDF site and its vicinity during the site survey performed at the accessible areas. The species have habitats with different environmental conditions and the probability for encountering them at the site or in its surroundings is analysed below.

3.6.2.1.4.1 Target reptile species.

European pond turtle (*Emys orbicularis*). It inhabits diverse slow-moving water or marshlands, some of which may dry up completely during the summer. Typical examples are drainage channels, breeding-ponds, swamps, lakes, rivers and small streams, brackish waters of estuaries and riparian waters. Typical of their habitat is the presence of rich water vegetation. There are no such habitats at the IP site, and therefore this species cannot be encountered there. The nearest suitable habitats are the service channels of the NPP, which are located at a little more than 1 km. The closest habitats of European pond turtle are located near the mouth of Lom River and at the end of the middle reaches of the Ogosta River (according to Naumov, B., M. Stanchev).

Hermann's Tortoise (*Testudo hermanni*). No presence is registered. Hermann's tortoise prefers sparse forests (low tree and shrub vegetation), unlike the spur-thighed tortoise, which is typical of grass landscapes. The area, subject to the assessment, is quite shady and dank, which does not imply that it is a permanent habitat of this species – it is likely to be encountered mainly during its migration in search of hibernating lair. The species is slightly affected when chased away or disturbed. Most adult specimens are conservative in terms of their individual territory, however cases have been observed of the movement of different specimens carried out at great distances. There are no suitable habitats for these species at the IP area because there is a combination of dense tree vegetation and adjacent arable land. The nearest habitat of the species is found at the end of the middle reaches of the Ogosta River (according to Naumov, B., M. Stanchev).

Four-lined snake (*Elaphe quatuorlineata*). It prefers dry and rocky ground, with well-developed microrelief, overgrown with sparse forests and bushes. Within the country, its significant habitats in term of conservation are concentrated in Southwest Bulgaria in the Valley of Struma River up to the Kresna Gorge to the north. The species was not found during the site surveys and there is a very low probability of appearing on this territory and its vicinity due to its zoogeographic distribution in the country (mostly in the southern part of Struma Valley). No habitats of the four-lined snake are located in this part of the country and throughout North Bulgaria in general (according to Naumov, B., M. Stanchev).

3.6.2.1.4.2 Significant reptile species

Red-bellied racer (*Coluber caspius*). It inhabits dry, open areas with grasses and shrubs, rocky slopes with sparse forests, often entering agricultural areas (vineyards, orchards and fields where it sticks close to headlands), therefore the area of the Investment Proposal lacks suitable habitats and it is less likely to be encountered compared to the neighbouring arable lands across the Harlets-Kozloduy road, as well as some other areas nearby. The closest habitat of the species is found east of the mouth of Ogosta River (according to Naumov, B., M. Stanchev) at about 10 km from the Radiana site.

Aesculapian ratsnake (*Elaphe longissima*). It is distributed throughout the country up to 1,600 m elevation. More rarely, it is encountered in lowland areas with intensive agriculture. Aesculapian ratsnake prefers old moist deciduous and mixed forests, especially their sparse areas, wet meadows and scrubland near forests and rocky (especially karst) terrains. The presence of specimens has not been recorded, but the territory has somewhat suitable biotopes and there is a certain probability for the species to be encountered in different parts during additional site surveys. The nearest habitat of the species is found near the uppermost part of the lower reaches of Ogosta River (according to Naumov, B., M. Stanchev) in the area of the village of Butan, at about 10 km south of the Radiana site.

Nose-horned viper (*Vipera ammodytes*). It is found throughout the entire country up to 1,450 m elevation with the exception of some high fields in the western part of the country, although it is present on the neighbouring mountain slopes. It prefers open, rocky, sunny places, overgrown with high grass vegetation, ferns, shrubs and usually having enough holes for underground shelters. There are no suitable habitats on the territory of the Investment Proposal, and the species has not been encountered and is unlikely to be encountered (including in nearby arable lands). The closest habitat of the species is found at the end of the middle reaches of Ogosta River (according to Naumov, B., M. Stanchev).

Tessellated water snake (*Natrix tessellate*). It is tied to water and rarely moves more than 20 m away from it. This species feeds mainly on fish, which determines its absence on the territory of the Investment Proposal and its immediate vicinity. The nearest habitat of the species is found near the mouth of the Ogosta River (according to Naumov, B., M. Stanchev) at about 8-9 km from the Radiana site.

Balkan wall lizard (*Podarcis taurica*). It is found up to about 500 m elevation, preferring dry sunny grasslands with sparse shrubs or trees. Therefore no presence of specimens has been recorded at the site; there are no data on its presence within the territory of the Investment Proposal from other sources, however it is most likely to be encountered in certain biotopes near the site because of the suitability of some areas in its vicinity. The nearest habitat of the Balkan wall lizard is found east of the mouth of the Ogosta River (according to Naumov, B., M. Stanchev), at about 10 km from the Radiana site.

Common wall lizard (*Podarcis muralis*. It is found throughout the entire country up to 2,100 m elevation. It inhabits only rocky terrains, including artificial ones, such as rail and road embankments, retaining walls, quarries and others. The species does not inhabit the very territory of the Investment Proposal, but may appear at or near the site of the Kozloduy NPP in the area of some remote buildings. There is a high probability for specimens to inhabit the site after the construction of the repository and the service buildings, as they will create favourable habitats for the species. The closest habitats of common wall lizard are located near the upper reaches of the Lom River and near the town of Vidin (according to Naumov, B., M. Stanchev), i.e. at a considerable distance from the area of the IP.

Green lizard (*Lacerta viridis*). It is widely distributed throughout the entire country up to 600-800 m elevation. It prefers dry and sunny places - rocky terrains and meadows overgrown with bushes or sparse forests, which it uses as shelter. The species does not inhabit the territory of the Investment Proposal itself, but is certain to be encountered in some of the more neglected (uncultivated) adjacent areas, which are not covered by dense tree vegetation. The nearest habitat of the species is found near the uppermost parts of the lower reaches of the Ogosta River (according to Naumov, B., M. Stanchev) in the area of the village of Butan at about 10 km south of the Radiana site.

European copper skink (*Ablepharus kitaibelii*). It is distributed in separate detached populations in most of the country at an elevation of 1,100 m. It prefers dry, sunny, grassy areas with plenty of stones and sparse shrubs or trees. It also inhabits clearings, meadows, sparse forest areas, which are conditions that the IP site does not provide – the conditions under the canopy of the trees, which occupy the territory, are quite dank. The nearest habitats of the species are found at the area of the upper reaches of Lom River and in the area above the upper reaches of the Skat River, i.e. around the town of Vratsa.

3.6.2.1.4.3 Other reptile species

Slowworm (*Anguis fragilis*). This type of legless lizard inhabits shady, moist places, overgrown with tall vegetation as well as forests and brushes. It hides under stones, stumps, holes of rodents, leaves, etc. It is encountered in the entire country up to 1,900 m elevation. There are suitable conditions for this species at the site of the IP and although no presence of specimens have been recorded there, it is very likely to be encountered during longer stay or observations. It is included in Annex 3 of the BDA, but does not fall under any of the Annexes of the Bern Convention, Directory 92/43 EEC, and is not included in the IUCN Red List of Threatened Species, and the new Red Data Book of Bulgaria (edition of BAS and MoEW, 2011).

3.6.2.1.5 CLASS MAMMALIA

The following species are reported on the territory of the country: 23 species of large mammals (Macrommamalia), one of which is considered extinct; 42 species of small mammals (Micromammalia), of which 28 species are encountered on the territory of the Danubian Plain; and 33 species of bats (Chiroptera). The highest diversity of bats occurs within the 400 m elevation belt, where relatively small areas are inhabited by 17 to 20 species (the elevation of the Radiana site is 50 to 90 m)

and at least 10 species are "forest bats" – species closely tied to forests as a residence and feeding place (all bat species are strictly protected under national and international law).

Regarding the site envisaged for the NDF, the standard forms of the closest protected areas under the Habitats Directive describe a total of 10 species of mammals, 7 of which are classified as significant and 3 as target species of conservation significance subject to protection in the area under Directive 92/43/EEC - **Table 3.6-8** .

TABLE 3.6-8 MAMMAL SPECIES OF CONSERVATION SIGNIFICANCE UNDER ANNEXES 2 AND 3 OF THE BDA IN THE AREA OF THE INVESTMENT PROPOSAL

Species	BDA (Annex 2,3)	Berne Convention	Directive 92/43 EEC	IUCN Red List (2014)
Target species				
Eurasian otter (*Lutra lutra*)	Annex 2,3	Annex2	Annex II, IV	+ (NT)
Romanian hamster (*Mesocricetus newtoni*)	Annex 2,3	Annex2	Annex II, IV	+ (NT)
European ground squirrel (*Spermophilus citellus*)	Annex 2	Annex2	Annex II, IV	+ (VU)
Significant species				
Wild cat (*Felis silvestris*).	Annex 3	Annex2	Annex IV	+ (LC)
Lesser shrew (*Crocidura suaveolens*)	-	Annex 2	-	+ (LC)
Bicolored shrew (*Crocidura leucodon*)	-	-	-	+ (LC)
Black-bellied hamster (*Cricetus cricetus*)	Annex 3	Annex 2	Annex IV	+ (LC)
Lesser Mole rat (*Nannospalax leucodon*)	-	-	-	-
Southern water shrew (*Neomys anomalus*)	-	-	-	+ (LC)
Steppe polecat (*Mustela eversmannii*)	Annex 2,3	Annex 2	Annex II, IV	+ (LC)
Least weasel (*Mustela nivalis*)	Annex 3	Annex 3	-	+ (LC)
Southern white-breasted hedgehog (*Erinaceus concolor*)	Annex 3	-	-	+ (LC)
+ Listed	NT -**„near threatened” species**			
	VU - **"vulnerable" species**			
- Unlisted	LC - **„least concern” species**			

No presence of the above listed mammal species or evidence of such have been registered within the surveyed accessible areas during the preliminary site survey of the NDF. The probability for encountering certain species at the site or in its vicinity in the future is analysed below depending on their typical habitat.

3.6.2.1.5.1 Target mammals

Eurasian otter (*Lutra lutra*). This species is typical of mountain rivers rich in fish and 2/3 of its natural habitats are concentrated below 1,000 m elevation. It inhabits various water bodies rich in fish – rivers, lakes, dams, marshes, forest rivers, natural rivers and oxbow lakes with abundant riparian vegetation – riparian forests, alder groves and reeds. It comes out on land during the night, looking for sleeping and brooding birds. It is distributed almost throughout the entire country, with the exception of Dobrudzha

and much of the Ludogorie. There is evidence that one of the highest population densities of the species within the country is located in Southeastern Bulgaria. It inhabits self-dug holes in the roots of riparian trees with 1-2 entrances underwater, but it can also inhabit the lairs of other specimens. It often feeds in private breeding-ponds (fish breeding), especially if they are located near rivers where the species can be found. Regarding the area designated as site of the IP or its vicinity, the species is not encountered and there is no such probability due to the lack of habitat.

Romanian hamster (*Mesocricetus newtoni*). The species is rare and most often inhabits uncultivated grassland, virgin soil, fields of cereal crops, alfalfa, etc. Such areas can be found on the other side of the Harlets-Kozloduy road and east of the Kozloduy NPP site, but not on the territory designated for the implementation of the NDF and its accompanying surface infrastructure. In Bulgaria, it is mostly encountered in Dobrudzha, the middle and eastern parts of the Danubian Plain west to Ogosta River, from which the IP is situated at about 5-6 km westward. The adverse factors for the Romanian Hamster population constitute mainly of the application of chemicals and machinery in agricultural practises as well as of its natural enemies - predatory birds and mammals, primarily foxes, which are very likely to hunt on the territory of the site.

European ground squirrel (*Spermophilus citellus*). The nearest reported habitats of this species are located in the non-urban areas within the land of the town of Oryahovo (Peshev, 1977, 1987; Markov, 1957; Tsonev, R., 2005; Paspalev, G., Ts. Peshev, 1957), situated at about 13 km east of the IP, as well as near the village of Zlatiya (survey in 1996), situated at 20 km west of the site. The species inhabits open uncultivated areas covered with low grass (meadows, pastures, dry steppes, outskirts of cultivated fields, along roads, etc.), and therefore it is not encountered at the IP site, which is located on a wooded territory. It feeds mainly on grasses and seeds. As shelters the European ground squirrel uses holes in the ground, which it digs by itself. It uses those holes to spend the night, hide from predators, raise its offspring and hibernate. There are several different types of holes: temporary, permanent and holes for hibernation. Given the above described characteristics of the species, the latter is not located within the area of the IP whose surface is covered by dense trees; while the neighbouring area is occupied by arable land to the south and the industrial site of Kozloduy NPP to the north.

3.6.2.1.5.2 Significant mammals

Wild cat (*Felis silvestris*). Overall, the IP site provides suitable shelters for this species, however it is highly unlikely to be encountered due to the anthropogenic nature of the surrounding area – roads, the NPP site and arable lands.

Lesser shrew (*Crocidura suaveolens*) and bicolored shrew (*Crocidura leucodon)*. They belong to the eurytopic species, which are encountered throughout the country. However, they are more frequently observed in lowlands since they prefer open areas with grass and shrub vegetation, which are absent at the IP site, but are also encountered, albeit more rarely, in wooded areas.

Black-bellied hamster (*Cricetus cricetus*). It is more widespread in Dobrudzha and in some territories in Northern Bulgaria near the Danube River (General Toshevo, transect between Balchik-Kaliakra, Durankulak). Similar to the Romanian hamster, it inhabits virgin soil, fields of cereal crops, alfalfa, etc., as can be found at the other side of the Harlets-Kozloduy road and east of the Kozloduy NPP site but not at the territory designated for the implementation of the facility, service buildings and the associated infrastructure.

Lesser mole rat (*Nannospalax leucodon*). It is mainly encountered in arable lands and gardens, as can be found not far from the territory of the IP but not within it.

Southern water shrew (*Neomys anomalus*). It is not encountered on the territory of the Investment Proposal, which, along with its vicinities, does not provide suitable habitats and shelters since the species inhabits woodland areas and mainly areas near flowing water bodies.

Steppe polecat (*Mustela eversmannii*). This is a rare and scarce species in the country, which is not encountered at the site of the Investment Proposal and in the neighbouring areas. It inhabits open grassy

landscapes, the so called "steppe regions". It is widespread in such areas especially in Dobrudzha and the neighbouring areas of the Ludogorie, west to the village of Chomakovtsi near Cherven Bryag. Habitat loss and poaching are the reasons why the steppe polecat is extremely rare in Bulgaria today.

Least weasel (*Mustela nivalis*). It inhabits the forest in low mountain areas and areas near settlements so it is very likely that this species can be encountered on the territory, although it was not registered during the site surveys.

Southern white-breasted hedgehog (*Erinaceus concolor*). It is likely to be encountered at the site, mainly during its search for hibernation shelter and food. The species is often encountered on the territory of settlements.

3.6.2.1.5.3 Other mammal species

The territory and its vicinity provide suitable conditions for shelter and habitation of the following species: cape hare (*Lepus capensis*); red fox (*Vulpes vulpes*); golden jackal (*Canis aureus*); stone marten (*Martes foina*) – including in settlements; European polecat (*Mustela putorius*) – including in settlements; Eurasian red squirrel (*Sciurus vulgari*); European mole (*Talpa europaea*); house mouse (*Mus domesticus*); long-tailed field mouse (*Apodemus sylvaticus*); wild boar (*Sus scrofa*) – according to the data provided by the workforce of the SE RAW, at the beginning of summer in 2014 the territory was continuously inhabited by one female with offspring; European roe deer (*Capreolus capreolus*) - autumn-winter season. Common vole (*Microtus arvalis*), striped field mouse (*Apodemus agrarius*), etc., are encountered in the nearby arable lands. Homeless pets are also observed – domestic dog (*Canis fammiliaris),* domestic cat (*Felis domestica*) and so on.

Regarding the bat fauna, currently there are no suitable shelters for resting and reproduction of such species on the territory of the IP. The tree vegetation at the site consists mainly of relatively young trees, along with several middle-aged ones, and the surveyors did not found any hollows, cracks and other similar formations in trees, which the so called "forest bat" species (at least 10 species) use for resting, rearing their offspring or hibernating. In practice, the site of the IP mainly provides conditions for hunting and feeding for some of these species. In this document, the bat fauna is not presented by individual species since there are no sufficient specific data on them in the area of the IP, but also because the IP area, as mentioned, is not a reproductive habitat for bats. It can be expected that in the future certain "urban" bats will surely settle in parts of the auxiliary buildings to the NDF. These species include noctule (*Nyctalus noctula*), common pipistrelle (*Pipistrellus pipistrellus*), pygmy pipistrelle (*Pipistrellus pygmaeus*), serotine (*Eptesicus serotinus*), Savi's pipistrelle (*Hypsugo savii*) and some others. Currently the buildings and halls of the Kozloduy NPP, which is located next to site, also provide suitable shelters and hideouts for some of the bat species that inhabit settlements. The numbers in the colonies of "urban" bat species ranges from 5-20 up to 50-150 specimens and, in exceptional cases, they can reach over 1,000 specimens. They settle in attics, basements, bunkers, underground garages, joints and cladding of buildings, shafts, chimneys, ventilation facilities, under bridges, in shutters and many other places.

3.6.2.1.6 CLASS THE AVES. STATE OF AVIFAUNA IN THE AREA OF THE IP

The fauna, including vertebrates (phylum Chordata, subphylum Vertebrata), which is the best studied type of fauna and whose conservation status is best regulated in the country, is represented in this area by species typical of the lower parts of the country, including the Danubian Plain. In zoogeographic terms the fauna consists of species typical of the Palearctic area and in particular of species inhabiting mainly the temperate latitudes. It also includes some species with ranges located south on the territory of the European sub-continent, i.e. area in or partly in the Mediterranean subregion of the Palearctic, also called Mediterranean species, which is not entirely correct definition of this species, as the areas of some of them are located predominantly in other zoogeographical regions and subregions.

Of the vertebrate fauna within the area to which the IP site belongs, the most abundant are birds (Aves). The nature of the IP area as a habitat determines the characteristics of its animal world – forest species and species typical of open areas and scrub habitats.

Regarding the area of the site – its own land (the wooded ground formation rising to the south) and its adjacent territories – the following species **(List 1)** can be indicated as characteristic and **typical of the avifauna**:

List 1.

Birds (Aves)

1. White stork (*Ciconia ciconia* (L.)) – it nests in settlements
2. Eurasian buzzard (*Buteo buteo* (L.))
3. Rough-legged buzzard (*Buteo lagopus* (Pontoppidan)) – in autumn-winter period
4. Northern goshawk (*Accipiter gentilis* (L.)) – specimens flying through
5. Eurasian sparrowhawk (*Accipiter nisus* (L.)) – specimens flying through
6. Western marsh-harrier (*Circus aeruginosus* (L.)) – in autumn-winter period
7. Montagu's harrier (*Circus pygargus* (L.)) – in autumn-winter period
8. Hen harrier (*Circus cyaneus* (L.)) – in autumn-winter period
9. Eurasian hobby (*Falco subbuteo* L.) – specimens flying through
10. Merlin (*Falco columbarius* L.) – in autumn-winter period
11. Common kestrel (*Falco tinnunculus* L.)
12. Eurasian woodcock (*Scolopax rusticola* (L.)) – in autumn-winter period
13. Grey partridge (*Perdix perdix* (L.)) – in open areas around the site
14. Common quail (*Coturnix coturnix* (L.)) – in open areas around the site
15. Common pheasant (*Phasianus colchicus* L. *ssp.*)
16. Domestic pigeon (*Columba livia* (Gmelin)f. *domestica*) – in settlements
17. Common woodpigeon (*Columba palumbus* L.)
18. European turtle-dove (*Streptopelia turtur* (L.))
19. Eurasian collared-dove (*Streptopelia decaocto* (Friv.)) – in settlements
20. Common cuckoo (*Cuculus canorus* L.)
21. Northern long-eared owl (*Asio otus* (L.))
22. Short-eared owl (*Asio flammeus* (Pontoppidan)) – in autumn-winter period
23. Little owl (*Athene noctua* (Scopoli)) – in settlements
24. Common swift (*Apus apus* (L.))
25. Alpine swift (*Apus melba* (L.))
26. European bee-eater (*Merops apiaster* L.) – during seasonal migrations
27. Eurasian green woodpecker (*Picus viridis* L.)
28. Great spotted woodpecker (*Dendrocopos major* (L.)) –in autumn-winter period
29. Syrian woodpecker (*Dendrocopos syriacus* (Ehr.)) – mainly in settlements
30. Lesser spotted woodpecker (*Dendrocopos minor* (L.))
31. Eurasian skylark (*Alauda arvensis* L.)
32. Crested Lark (*Galerida cristata* (L.)) – near and in settlements
33. Barn swallow (*Hirundo rustica* L.)

34. Northern house-martin (*Delichon urbica* (L.))
35. Tree pipit (*Anthus trivialis* (L.)) – during seasonal migrations
36. Water pipit (*Anthus spinoletta* (L.)) – in autumn-winter period
37. White wagtail (*Motacilla alba* L.) – including in settlements
38. Black-headed yellow wagtail (*Motacilla flava feldeggi* Michaheles)
39. Whinchat (*Saxicola rubetra* (L.)) – during seasonal migrations
40. Common stonechat (*Saxicola torquata* (L.))
41. Common nightingale (*Luscinia megarhynchos* C. L. Brehm) – including in settlements
42. European robin (*Erithacus rubecula* (L.))
43. Eurasian blackbird (*Turdus merula* L.)
44. Mistle thrush (*Turdus viscivorus* L.)
45. Song thrush (*Turdus philomelos* C.L.Brehm)
46. Fieldfare (*Turdus pilaris* L.) – in autumn-winter period
47. Redwing (*Turdus iliacus* L.) – in autumn-winter period
48. Icterine warbler (*Hipolais icterina* ((Vieillot)) – during seasonal migrations
49. Blackcap (*Sylvia atricapilla* (L.))
50. Common whitethroat (*Sylvia communis* Latham)
51. Lesser whitethroat (*Sylvia curruca* (L.))
52. Common chiffchaff (*Phylloscopus collybita* (Vieillot))
53. Wood warbler (*Phylloscopus sibilatrux* (Bechstein)) – during seasonal migrations
54. Willow warbler (*Phylloscopus trochilus* (L.)) – during seasonal migrations
55. Marsh tit (*Parus palustris* L.) – in autumn-winter period
56. Coal tit (*Parus ater* L.) – in autumn-winter period
57. Blue tit (*Parus caeruleus* L.)
58. Great tit (*Parus major* L.)
59. Long-tailed tit (*Aegithalus caudatus* (L.))
60. Wood nuthatch (*Sitta europaea* L.) – in forests around the site
61. Spotted flycatcher (*Muscicapa striata* (Pallas)) – during seasonal migrations
62. Collared flycatcher (*Ficedula albicollis* Temminck)
    - ssp. Collared flycatcher (*Ficedula albicollis albicollis* Temminck) – during seasonal migrations
    - ssp. Semicollared flycatcher (*Ficedula albicollis semitorquata* (Homeyer)) – during seasonal migrations
63. European pied flycatcher (*Ficedula hypoleuca* (Pallas)) – during seasonal migrations
64. Winter wren (*Troglodytes troglodytes* (L.)) – in autumn-winter period
65. Great Grey shrike (*Lanius excubitor* L.) – in autumn-winter period
66. Red-backed shrike (*Lanius collurio* L.)
67. Common raven (*Corvus corax* L.)
68. Hooded crow (*Corvus corone cornix* L.)
69. Rook (*Corvus frugilegus* L.) – numerous in autumn-winter period
70. Eurasian jackdaw (*Corvus monedula* L.) – in settlements
71. Black-billed magpie (*Pica pica* (L.)) – including in settlements
72. Eurasian Jay (*Garrulus glandarius* (L.))
73. Eurasian golden oriole (*Oriolus oriolus* (L.))
74. Common starling (*Sturnus vulgaris* L.) – including in settlements

75. House sparrow (*Passer domesticus* (L.)) – in settlements
76. Eurasian tree sparrow (*Passer montanus* (L.)) – in settlements
77. European greenfinch (*Carduelis chloris* (L.)) – including in settlements
78. European goldfinch (*Carduelis carduelis* (L.)) – including in settlements
79. Eurasian siskin (*Carduelis spinus* (L.)) – in autumn-winter period
80. Eurasian linnet (*Acanthis cannabina* (L.))
81. Eurasian chaffinch (*Fringilla coelebs* L.)
82. Brambling (*Fringilla montifringilla* L.) – in autumn-winter period
83. European serin (*Serinus serinus* (L.)) – in autumn-winter period – rare
84. Eurasian bullfinch (*Pyrrhula pyrrhula* (L.)) – in autumn-winter period – including in settlements
85. Hawfinch (*Coccothraustes coccothraustes* (L.))
86. Corn bunting (*Emberiza calandra* L.) – in open territories
87. Yellowhammer (*Emberiza citrinella* L.) – in autumn-winter period
88. Black-headed bunting (*Emberiza melanocephala* Scopoli)

List 1 includes 88 bird species. For a territory of such size (the site and its surrounding areas) this is a significant number of species.

The species presented in **List 1**, however, should not be considered the complete (final, maximum possible) species composition of birds in the described area since, especially during seasonal migrations, others species can be registered there. For example, in this part of the country the following species are also encountered: birds - black stork (*Ciconia nigra* (L.)), lesser kestrel (*Falco naumanni* Fleicher), common pheasant (*Phasianus colchicus* L. ssp.), European roller (*Coracias garrulus* L .) – during seasonal migrations; tawny pipit (*Anthus campestris* (L.)), garden warbler (*Sylvia borin* (Boddaert)), lesser grey shrike (*Lanius minor* Gmelin), rosy starling (*Sturnus roseus* (L.)) – very rare species; Spanish sparrow (*Passer hispaniolenssis* (Temminck)) and others.

Among the birds in the afforested area most abundant are the common nightingale, the Eurasian golden oriole and the Eurasian chaffinch, while for arable agricultural landscapes this is the Eurasian skylark. In the settlements within the area, most abundant are the house sparrow and the Northern house-martin, followed by the barn swallow, domestic pigeon, Eurasian collared-dove, common starling, great tit, European goldfinch, etc. Moreover, numerous specimens (including flocks) of several species concentrate and feed in various parts of the area (especially in open areas) and in different seasons and periods (mainly in the autumn-winter period) – European goldfinch, European greenfinch, Eurasian siskin, Eurasian linnet, Eurasian chaffinch, brambling, yellowhammer, common starling, rook, Eurasian jackdaw, etc.

As stated above, the species composition in List 1 refers to the area where the IP will be located – the land of the IP (the wooded ground formation rising to the south) and its adjacent territories. From this very large territory, the area of the IP covers a very insignificant portion, respectively share; furthermore it is of wooded nature. In the current case, the relevant species are those most closely related to the territory of the site, which primarily includes the species **breeding** (in this case **nesting** - marked with "**P**") on the territory of the site and **those for which the area is an important food base (List 1a)**:

List 1a.

Birds(Aves)

1. Eurasian buzzard (*Buteo buteo* (L.))
2. Common kestrel (*Falco tinnunculus* L.)
3. Eurasian woodcock (*Scolopax rusticola* (L.)) – in autumn-winter period
4. Grey partridge (*Perdix perdix* (L.)) – in open areas around the site
5. Common quail (*Coturnix coturnix* (L.)) – in open areas around the site
6. Common woodpigeon (*Columba palumbus* L.)
7. European turtle-dove (*Streptopelia turtur* (L.)) – **P**
8. Common cuckoo (*Cuculus canorus* L.) – **P**
9. Eurasian skylark (*Alauda arvensis* L.) – in open areas around the site
10. Black-headed yellow wagtail (*Motacilla flava feldeggi* Michaheles)
11. Common nightingale (*Luscinia megarhynchos* C. L. Brehm) – **P**
12. Eurasian blackbird (*Turdus merula* L.) – **P**
13. Song thrush (*Turdus philomelos* C.L.Brehm) – **P**
14. Blackcap (*Sylvia atricapilla* (L.)) – **P**
15. Common whitethroat (*Sylvia communis* Latham) – **P**
16. Red-backed shrike (*Lanius collurio* L.) – **P**
17. Hooded crow (*Corvus corone cornix* L.)
18. Eurasian jay (*Garrulus glandarius* (L.)) – **P**
19. Eurasian golden oriole (*Oriolus oriolus* (L.)) – **P**
20. European greenfinch (*Carduelis chloris* (L.)) – including in settlements – **P**
21. European goldfinch (*Carduelis carduelis* (L.)) – including in settlements – **P**
22. Eurasian chaffinch (*Fringilla coelebs* L.) – **P**
23. Corn bunting (*Emberiza calandra* L.) – in open territories
24. Black-headed bunting (*Emberiza melanocephala* Scopoli)

As seen from **List 1a**, considerably lesser number of species (almost 3 times) is included therein – 24 species, of which 13 species can be indicated as breeding, however not annually.

The species in **List 1,** which are included in Annex № 2 of the Biological Diversity Act (BDA) (SG 77 Section II – Protected areas, Art. 6 item 4 (2) and (3)) – the Annex on plant and animal species endangered from extinction, the preservation of which on the territory of the country is a priority - are presented in List 2:

List 2.

1. White stork (*Ciconia ciconia* L.)) – nestles in settlements
2. Western marsh-harrier (*Circus aeruginosus* (L.)) – in autumn-winter period
3. Montagu's harrier (*Circus pygargus* (L.)) – in autumn-winter period
4. Hen harrier (*Circus cyaneus* (L.)) – in autumn-winter period
5. Merlin (*Falco columbarius* L.) – only in autumn-winter period

6. Short-eared owl (*Asio flammeus* (Pontoppidan)) – in autumn-winter period
7. European bee-eater (*Merops apiaster* L.) – during seasonal migrations
8. Syrian woodpecker (*Dendrocopos syriacus* (Ehr.)) – mainly in settlements
9. Collared flycatcher (*Ficedula albicollis* Temminck)
   ssp. Collared flycatcher (*Ficedula albicollisalbicollis* Temminck) – during seasonal migrations
   ssp. Semicollared flycatcher (*Ficedula albicollis semitorquata* (Homeyer)) – during seasonal migrations
10. European Pied flycatcher (*Ficedula hypoleuca* (Pallas)) – during seasonal migrations
11. Red-backed shrike (*Lanius collurio* L.)

As seen from **List 2**, 11 species form Annex 2 of the BDA are included therein. This is not a very large number but is a significant number of species of conservation priority.

The white stork in the area and elsewhere in this part of the country nests exclusively in settlements and other anthropogenic (built) areas. Due to this circumstance the area of the project (site) is not a breeding habitat and because of its wooded nature it is not a feeding habitat for the species either.

Regarding the four species of diurnal rapacious birds (Falconiformes -with numbers 2-5), only circling and flying through specimens have been observed near the site. The territory of the IP is not suitable for nesting of the three harrier species, which inhabit nests built on the ground, and only in open areas (western marsh-harrier and Montagu's harrier also inhabit and nest in wetlands, including the areas of water reservoirs). Only the western marsh-harrier is observed nesting in this part of the country. The merlin can be encountered in the country and the area only in autumn-winter period (wintering specimens), and the same applies to the only species of nocturnal rapacious bird (Strigiformes) – the short-eared owl. These 5 species (the 4 diurnal rapacious birds and the short-eared owl) hunt in open areas, therefore the area of the IP is not a feeding habitat for them. The specimens of these 5 species could use the woody and shrub vegetation of the afforested area for resting or spending the night, but such vegetation is also present in sufficient quantity in other parts of the area, where the site is located, therefore its implementation will not threaten the need of these species for rest and spending the night in the area.

The European bee-eater – flying and hunting specimens – in the area of the IP is observed both during the breeding period and during seasonal migrations (including larger or smaller flocks). There are no suitable nesting places for this species on the territory of the IP (steep banks in which pairs dig their nesting shelters). The species belongs to the group of birds hunting in or from the air – in particular the subgroup hunting in the air, and the specimens do not hunt under the canopy of trees. As a result, the implementation of the IP would not in any way directly impact the feeding and breeding of this species. The specimens of this species could use the woody and shrub vegetation of the afforested area only for resting or spending the night during seasonal migrations, but such vegetation is present in sufficient quantity in the area of the IP.

The collared flycatcher (both subspecies) and the European pied flycatcher are observed in the area only during seasonal migrations – specimens that feed and rest on the woody vegetation. Due to the small size of the area, the implementation of the IP will take only a negligibly small part (as area and percentage) of the food base in this section of the Kozloduy Valley.

Of the other 2 species, the Syrian woodpecker in the area is observed, including as nesting, mainly in settlements. In the area of the afforested territory, to which the IP site belongs, no specimens of the species were recorded during nesting period but it is possible to be encountered during the post-breeding period (when searching for food). Moreover, this is the most abundant woodpecker species observed within the settlements in Bulgaria (Yankov, 1986) and in the lower parts of the country (up to 900-1,000 m elevation). Only in forest areas with greater degree of afforestation and areas with significant canopy

and considerable age of the stands the spotted woodpecker may be equal or surpass it in number. The implementation of the IP, due to the small size of its area, will take a negligibly small part (as area and percentage) of the food base in this area of the valley.

The last species – the red-backed shrike – inhabits and nests in the lower woody and shrub vegetation of open areas, in forest edges or sparse forest sections, in settlements such as the city of Sofia and the towns of Plovdiv, Pazardzhik, Stara Zagora, Nova Zagora, Burgas, Varna, Vidin, Shumen, Silistra, Pernik, and Sandanski, but also in villages and various built-up areas (yards of manufacturing enterprises, warehouses, etc.) and in their interior. This species is too abundant and, furthermore, it can be found from sea level elevation up to very high elevation. During breeding period specimens of this species have been registered at 1,600 m and even at 1,800 m elevation (e.g. Mursalitsa Peak and its adjacent peak to the east, in the Western Rhodopes – respectively at 1,791.6 m and 1,795.2 m elevation (on 22.06.2006), and at the end or after the breeding season it has been observed at over 2,000 m elevation in the subalpine parts of the mountains Rila and Pirin. Specimens of the species, including nests, have been recorded in the low woody or shrub vegetation in the peripheral parts (edges) of the afforested areas (it is possible to be also found in sparse areas inside the forest, which within the IP area are, in practice ,only present in the edges of the dirt road and the big cement channel). Due to its small size in comparison to the area to which it belong, the territory of the IP will affect a rather insignificant part of the food base and even less of the breeding base of the species in the area. Furthermore, my personal opinion is that the last two species do not belong in Annex № 2 of the BDA, which should include only rare and endangered species in the country as BPA itself is a document, and more specifically a Biological Diversity Act, concerning the territory of the country, and not the entire subcontinent of Europe. If during the mining activities, the nesting habitat of a nesting pair in a certain period (in a certain year) is possibly affected, it will not pose any difficulty for the specimens to move their nesting place to the neighbouring areas or to a lesser or greater distance from the area of the site since there are plenty of other suitable habitats within the project’s area and its vicinity.

Among these species and in the area of the afforested territory to which the IP site belongs, only the red-backed shrike has been registered during the nesting period. Individual specimens of the Syrian woodpecker are also likely to be encountered in search for food mainly in the autumn-winter period. The collared flycatcher (both subspecies) and the European pied flycatcher can be observed only during periods of seasonal migration and over a longer period during spring migration. Individual specimens of the rest of the species would only use the woody vegetation in the afforested area when landing in order to rest or spend the night, which they have probably done already with the possible exception of the white stork.

3.6.2.2 RADIATION STATUS OF THE FAUNA IN THE AREA

Animal production in the region is examined for the presence of radioactive contaminants within the Radioecological Environmental Monitoring Programme of the Kozloduy NPP and the Pre-operational Monitoring Programme for the site designated for the construction of a NDF. Such quality indicators for radiation monitoring are milk and fish. Milk is a typical food product of the area and a good indicator of potential radioactivity that can reach humans through the food chain.

Milk samples are taken and analysed from three farms in the area – the town of Kozloduy, the village of Harlets and the town of Miziya. 1.8 litres from each sample are subjected to direct gamma spectrometry (Marinelli-2l) for a measurement time of 60,000 s. Under these conditions the MDA for ^{137}Cs varies within the range 0.010 ÷ 0.13 Bq/l. Separately, 3.0 litres of each sample are ashed at 450°C and 300 mg of the resulting ash is analysed for total beta activity. For measurement time of 6,000 s, the MDA amounts to a mean of 0.65 Bq/l. The ashed monthly samples from each farm are combined each trimester and the resulting aggregate sample is analysed for radiochemical content of ^{90}Sr. The method for determination of ^{90}Sr is based on isolation of radiostrontium from the ash (k.HCl + k.HNO3), separation of Ca by means of sodium hydroxide and liquid scintillation spectrometry of the daughter isotope ^{90}Y (in "Cherenkov counting" mode) after the achievement of

radioactive equilibrium. The MDA for ^{90}Sr at measurement time of 10,000 s amounts to a mean of 0.0023 Bq/l.

The total mean value in 2013 for the three farms amounted to 40.4 Bq/l. According to the data provided by the NCRRP the mean annual value of total beta activity in milk from the area of Kozloduy NPP for the period 1972 -1974 (before the commissioning of the first block of the NPP) was 44.0 ± 1.5 Bq/l. With an average content of potassium of 1.3 g/l per litre of cow milk, the specific activity of ^{40}K is 40 Bq/l. From the results shown, it is clear that virtually all measured total beta activity is due to the natural isotope ^{40}K. Gama spectrometric measurements of milk in 2013, as in previous years, did not register activity of ^{137}Cs, and the results were within the limits of MDA (<0.010 ÷ <0.13 Bq/l). In 2013 the activity of radiostrontium varied within the range 4.2 ÷ 19.8 mBq/l, a mean of 14.7 mBq/l.

Summarized results for the total beta activity for the period 2009-2013 are presented in **Table 3.6-9** . Data on the total beta activity and the content of ^{90}Sr over a long-term period are presented in **Figure 3.6-4** .

TABLE 3.6-9 TOTAL BETA ACTIVITY OF MILK IN THE AREA OF THE KOZLODUY NPP, BQ/L

Farm	Kozloduy		Miziya		Harlets	
Year	Mean	Maximum	Mean	Maximum	Mean	Maximum
2009	31.9	38 ± 0.7	34.8	47 ± 0.8	38.5	43 ± 0.7
2010	31.2	40 ± 0.7	34.4	46 ± 0.7	33.7	46 ± 0.8
2011	35.8	43 ± 0.7	38.4	55 ± 0.8	39.2	51 ± 0.8
2012	39.8	48 ± 0.7	42.2	49 ± 0.8	42.9	47 ± 0.8
2013	37.0	43.3 ± 0.7	42.6	51.2 ± 0.8	41.6	47.3 ± 0.8

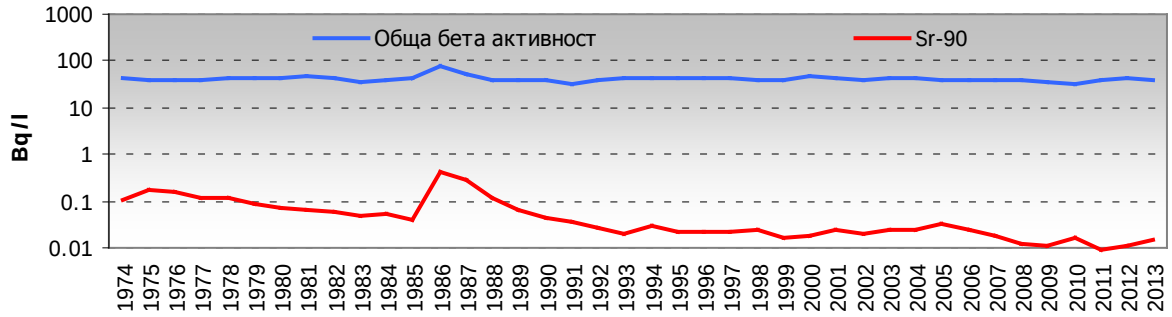


FIGURE 3.6-4 ACTIVITY OF ^{90}SR (BQ/L) IN COW MILK IN THE AREA OF THE KOZLODUY NPP, 1974–2013

The measured total activity is within typical natural limits and is entirely due to the natural isotope ^{40}K. Radiation purity of milk from the area complies with the statutory requirements in the region (Ordinance №10 of the MH, 2002**). No technogenic impact has been registered.**

In order to ensure the sampling of fish from the Danube River in the area of the Kozloduy NPP, sampling of the ichthyofauna is carried out within the departmental radioecological monitoring in the area of the riverbank pumping station /RPS/. Catches are made in the approach of the cold channel (before the NPP) and the confluence of the hot channel (after the NPP) in the Danube River. The activity of radiocaesium in the flesh of fish samples analysed in 2013 was within MDA limits (<0.10÷ <0.18 Bq/kg f.w.). The activity of ^{90}Sr in fish bones varied in the range 1.10 ÷ 1.12 Bq/kg f.w. These results are within normal limits for the examined biological object. It should be noted that in past years of radioecological examinations the results for Danube fish caught in the area of the RPS (before and after the outlet channel) are much lower than the norms (600 Bq/kg,

Ordinance №10 of the MH from 18.04.2002). Data for 2013 are presented in **Table 3.6-10** and the ones for the long term period are shown on **Figure 3.6-5** .

TABLE 3.6-10 ACTIVITY OF FISH FROM THE AREA OF THE KOZLODUY NPP IN 2013, BQ/KG F.W

Sample	Date	^{90}Sr (bones)	^{134}Cs	^{137}Cs
Fish from the outlet (hot) channel				
Fish (zarte)	01.2013	1.10 ± 0.11	< 0.11	< 0.073
Fish (various)	05.2013	-	< 0.12	< 0.12
Fish (carp)	08.2013	-	< 0.14	0.11 ± 0.018
Fish (carp)	09.2013	1.12 ± 0.11	< 0.17	0.14 ± 0.021
Fish (carp)	11.2013	-	< 0.16	< 0.17
Fish from the feeding (cold) channel				
Fish (bream and zarte)	02.2013	-	< 0.11	< 0.12
Fish (bream and zarte)	04.2013	-	< 0.10	< 0.11
Fish (barbel)	05.2013	-	< 0.12	< 0.14
Fish (barbel)	06.2013	-	< 0.15	< 0.11
Fish (barbel)	07.2013	-	< 0.17	< 0.11
Fish (nase)	12.2013	0.62 ± 0.077	< 0.18	< 0.16
Fish, 2013 (mean)	2013	0.95	< MDA	0.13

No determined difference is observed in the activities of fish from the Danube River before and after the Kozloduy NPP. This is due to the lack of assessable impact of the NPP on the large volume of the water body – the Danube River, as well as to the mobility of the object. During the years of examinations, no technogenic radionuclides (^{54}Mn, ^{60}Co, etc.) were found except for traces of ^{137}Cs and ^{90}Sr in some of the samples. The results for ^{137}Cs activity over a long period are presented in **Figure 3.6-5** . It should be noted that all results for the Danube fish caught in the area of the RPS (before and after the outlet channel) are much lower than the norms (600 Bq / kg, Ordinance №10 of the MH from 18.04.2002).

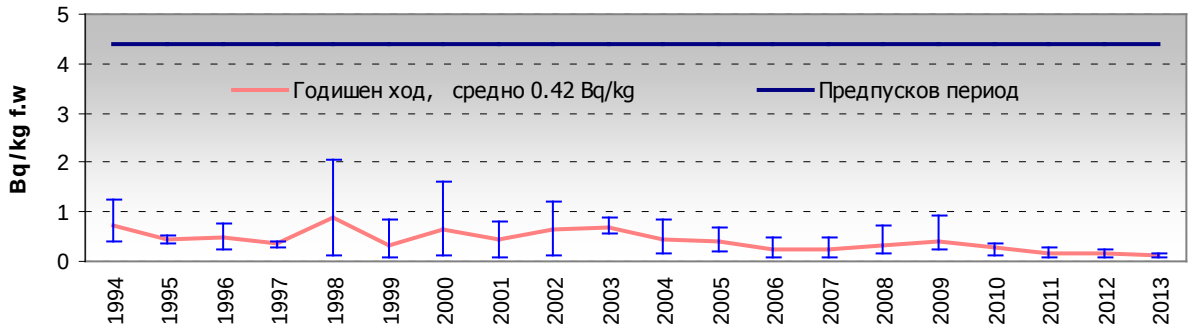


FIGURE 3.6-5 ACTIVITY OF ^{137}CS IN FISH (BQ/KG F.W.) FROM THE DANUBE RIVER WITHIN THE AREA OF THE KOZLODUY NPP, 1994–2013

There is no assessable impact on the radiation condition of the ichthyofauna in the Danube River Basin caused by the operation of facilities at the Radiana site. Fish in the area is ecologically clean.

3.6.3 NATURAL SITES. PROTECTED AREAS (PA)

The territory closest to the NDF site, that has conservation status under the Protected Areas Act and information for which was obtained from the electronic Register of Protected Areas in Bulgaria published on the EEA website, is the Protected site (PS) Kozloduy located at 9.8 km in a beeline northwest of the site envisaged for the NDF.

The PS has an area of 10 ha and falls within the land of the town of Kozloduy, Kozloduy Municipality, a few kilometres away from the settlement, and is under the jurisdiction of RIEW Vratsa. It was announced by Ordinance № 913 from 04.08.1972, the SG, issue № 41/1972, and was re-categorized by Ordinance № 639 from 26.05.2003, SG, issue № 60/2003. The aim of the declaration is to protect the landscape, which is the result of a harmonious coexistence of man and nature.

The location of the NDF site toward the Kozloduy Protected Site is depicted in **Figure 3.6-6** .

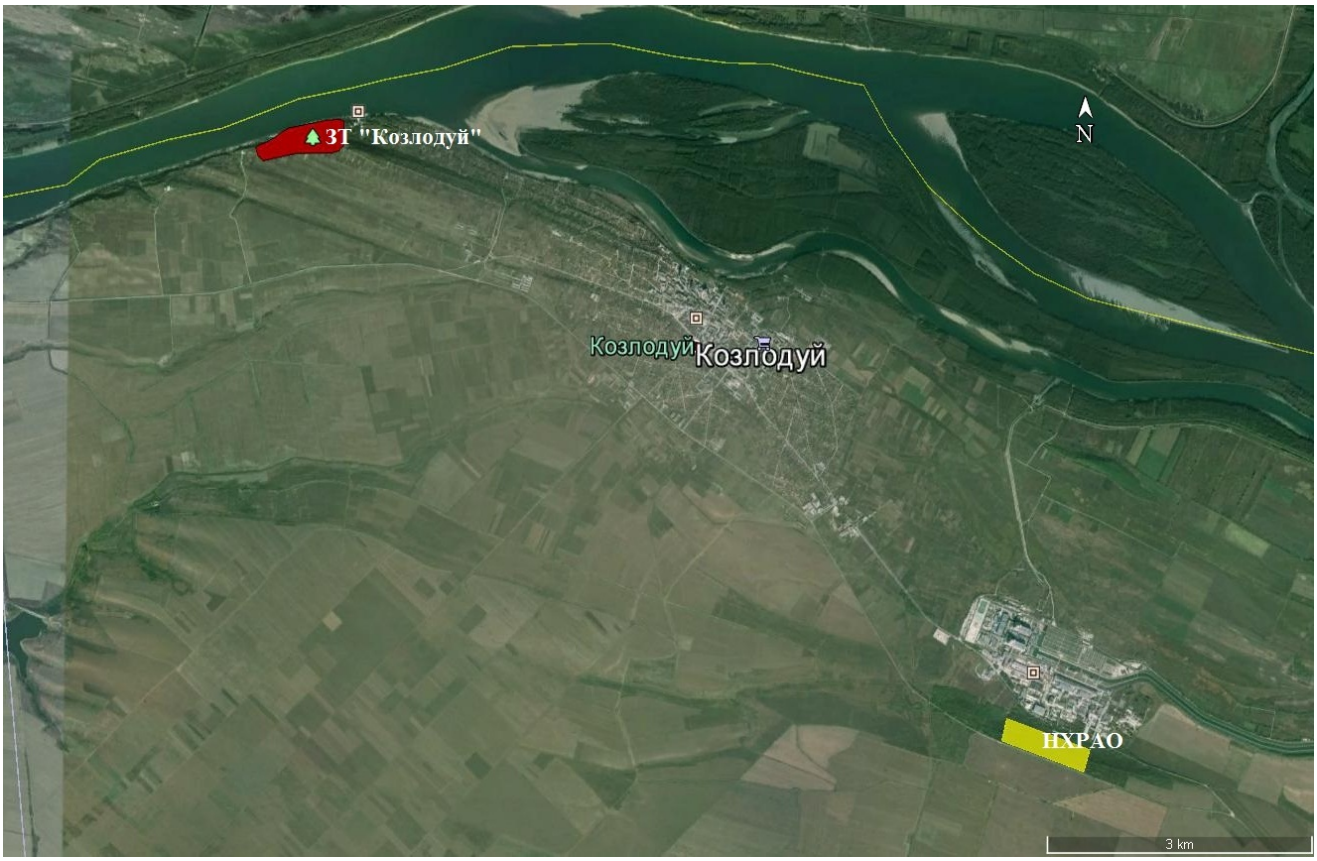


FIGURE 3.6-6 KOZLODUY PROTECTED SITE

The regime of activities in the Kozloduy PS includes the following prohibitions:

- → Prohibition on felling, except for sanitary and landscape purposes aimed at improving the sanitary and landscape condition of sites;
- → Prohibition on grazing of livestock at any time;
- → Prohibition on building quarries, breaking stones, extraction of sand, disposal of slag and other industrial waste, as well as on any other actions disrupting or destroying the natural environment in them.

The construction and the operation activities of the NDF do not contradict the prohibitions and restrictions on the territory of the protected site, as they will be implemented outside its area and at a reasonable distance – the activities are in no way associated with any entry into NM and disruption of the adopted regime of prohibited activities in them.

The other protected areas, closest to the site and located at a distance between 10 and 30 km, are presented in **Table 3.6-11** .

TABLE 3.6-11 PROTECTED AREAS

Code of PA, №	Name of PA	Aims of declaration	Date of announcement	Area (ha)	Settlement	Dis-tance (km)
1.	PS Daneva Mogila	Protection of typical river landscape and a group of ancient trees.	10.05.1982 , SG, issue № 43/1982	4.9	The village of Sofronievo	11.5
2.	PS Koritata	1. Conservation of the natural habitat of red peony. 2. Conservation of exceptional landscape..	7.05.1982 , SG, issue № 43/1982	2.0	The village of Sofronievo	13
3.	PS Ostrov Tsibar	Protection of habitat for nesting, hibernating, and resting during migration of protected bird species	10.04.2007 РД-292, SG, issue № 49/2007	101.48	The village of Gorni Tsibar The village of Dolni Tsibar	18
4.	Managed Nature Reserve (MNR) Ibisha	Typical Danube island communities - floodplain forests and swamps inhabited by protected species of plants and animals.	15.06.2010 (re-categorized) РД-602, SG, issue № 77/2010	34.3	The village of Dolni Tsibar	21
5.	PS Kalugerski Grad - Topolite”	Conservation of the plant Stratiotes aloides	26.05.2003 (re-categorized) РД 644, SG 60/ 2003	0.2	the village of Selanovtsi	22.2
6.	PS Kochumina	Conservation of habitat of water lily.	26.05.2003 (e-categorized) РД 642, SG 60/ 2003	2.5	the village of Selanovtsi	24.6
7.	PS Gola Bara	Conservation of habitat of water lily.	26.05.2003 РД 643, SG 60/ 2003	2.0	the village of Selanovtsi	25.1

Other more significant natural sites in Kozloduy Municipality that can be considered unique are single specimens of ancient trees of more than 100 years of age. According to the Report of RIEW Vratsa on the state of the environment in 2013, 150 trees were officially declared ancient in the area of Vratsa, of which only one is situated on the territory of Kozloduy Municipality. This is the oldest tree in the municipality - Danforov Gorun (a durmast oak), aged 680 years, and it is located at a distance of about 24 km south-east, between the villages of Galiche and Altimir in the Gorno Livade locality. There are four oak trees aged 170 to 300 years located in Lazarovtsi locality, within the land of the village of Sofronievo. These trees are preserved and are developing normally.

The historic site Botev Park, spread over an area of 16.3 hectares, was proposed for registration as a protected site, but it was rejected.

Sensitive areas within the municipality are the so called "wetlands". The nearest "wetlands" around Shishmanov Val Dam, the islands and the Danube River, are all located at a distance of 5-10 km from the Radiana site. They are a habitat for hydrocharition vegetation like reeds, loosestrife,

bulrush, bugleweed, willow herb and some rare species. The wetlands are also intermediate stations for spring and autumn migrations of many rare species of birds. According to data provided by the Danube Region Basin Directorate in the town of Pleven, all water bodies in the catchment area of the Danube River are sensitive areas.

3.6.4 PROTECTED AREAS UNDER 2000

The site selected for the implementation of the NDF does not fall **within the European ecological network Natura 2000**. A map of the location of the areas in the Republic in Bulgaria toward the NDF site is presented in **Figure 3.6-7** .

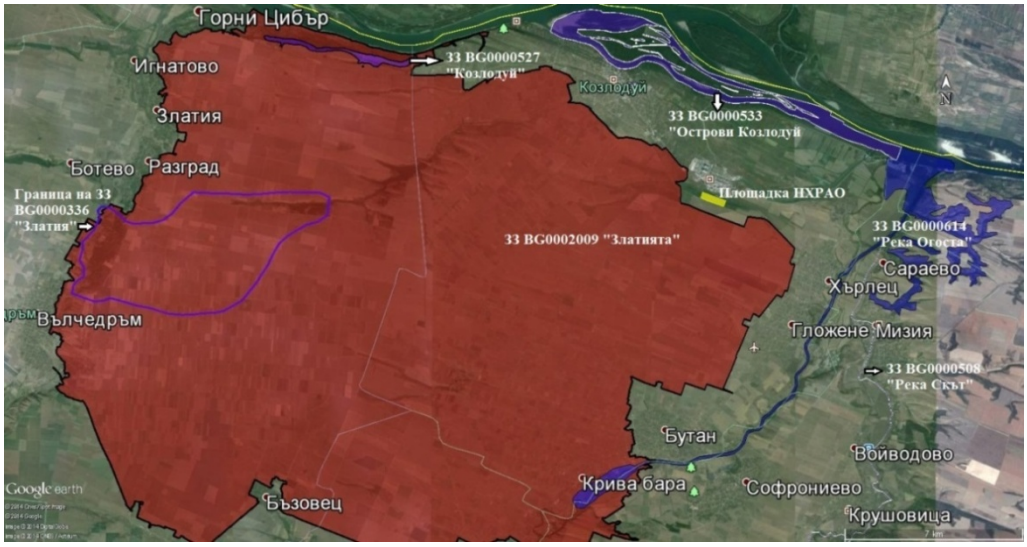


FIGURE 3.6-7 PROTECTED AREA AROUND THE NDF SITE IN BULGARIA

The nearest protected areas within this network are situated in the following sequence:

- The following Protected area are located in the 10-km zone around the NDF:
  - → *Protected area Zlatiyata with code BG0002009, declared under Directive 2009/147/EC on the conservation of wild birds* – the zone is situated at 0.45 km south and west of the NDF site.
  - → *Protected area Ostrovi Kozloduy with code BG0000533, declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna* – the zone is located at 3.8 km north of the NDF site.
  - → *Protected area Reka Ogosta with code BG0000614 declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna* – the zone is located 6 km east of the NDF site.
  - → *Protected area Reka Skat with code BG0000508 declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna* – the zone is situated at 6.3 km east of the NDF site.

A Report on the assessment of the degree of impact (RADI) [73] of the IP, which includes the object and purpose of conserving protected areas for the above mentioned PA, is applied as a separate stand-alone Annex to the EIA Report[74].

- The following PAs are situated at a distance of more than 10 km from the borders of the site:
  - → *Protected area Kozloduy with code BG0000527, declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna* – the zone is located at 12.4 km northwest of the NDF site.
  - → *Protected area Zlatiyata with code BG0000336 declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna* – the area is situated at 14.5 km west of the NDF site.

The IP does not impact the two PAs mentioned above.

Another 3 protected areas under Natura 2000, one of which overlaps with the other two, are located in the Republic of Romania, on the other side of the Danube River, at 5.5 km and 18 km west of the NDF site - **Figure 3.6-8** .

FIGURE 3.6-8 PROTECTED AREAS CLOSEST TO THE NDF SITE AND LOCATED IN THE REPUBLIC OF ROMANIA

These areas are:

1. **PA ROSCI0045 „Coridorul Jiului”** declared under Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna;
2. **PA ROSPA0023 „Confluenţa Jiu – Dunăre”** declared under Directive 2009/147/EC on the conservation of wild birds.
3. **PA ROSPA0010 Bistreţ** declared under Directive 2009/147/EC on the conservation of wild birds.

3.7 WASTE

Currently there is no waste accumulated at the Radiana site.

[73] Ordinance on the terms and procedures for assessing the compatibility of plans, programmes, projects, and investment proposals with the object and purposes of the preservation of protected areas (adopted by Decree of the Council of Ministers № 201 from 31.08.2007, Prom. SG issue 73 of September 11, 2007)

[74] Art. 12 (2), item 6 of the ORDINANCE on the terms and procedures for performance of environmental impact assessment (OTPPEIA)

During the implementation of the IP strict control and effective waste management shall be performed for the waste generated in the course of various activities related to the staged construction, operation and decommissioning of modules in the NDF site in order to avoid negative impact on the individual environmental components and factors.

3.8 HAZARDOUS SUBSTANCES

There is no storage or temporary storage of substances classified as "hazardous" (containers with oils, petroleum products and others, pesticide warehouses and others, plant protection means) on the territory of the Radiana site.

During the implementation of the IP strict control of working with substances classified as hazardous shall be carried out in order to prevent negative impact on the individual environmental components and factors, as well as health risk for the workers at the site and the population in the area.

3.9 HARMFUL PHYSICAL FACTORS

3.9.1 NOISE

The site designated for the construction of the NDF shall be located next to the Kozloduy NPP site. During the site survey, it was established that currently there are no sources of noise at the Radiana site. The sources of noise in the area are: vehicles on the road II-11 and on the road leading to the NPP, as well as the activities of the production site of the plant.

The noise characteristic of the traffic flow on the road II-11, based on the traffic load data provided by the Current Traffic Conditions under RIA, is 69.6 dBA, at 7.5 m from the axis of traffic, at a speed of 80 km/h.

There are six units located on the Kozloduy NPP site of which Units 5 and 6 are currently in operation while the others have been decommissioned. The noise regime at the NPP site is determined by noise measurement in real conditions for the purposes of a number of developments. (The noise measurement comprised of measurement of the equivalent noise level at selected points on the site located near more significant sources of environmental noise – outdoor switchgear, WWTP, ventilation systems, vehicles, etc.). It has been found that the activity of the Kozloduy NPP, along the borders of its production site, is not a source of noise levels exceeding the norms.

3.9.2 VIBRATIONS

There is no presence of technological vibrations in the environment caused by the Radiana site.

Vehicles on the Class II roads from the national road network (Road II-11) are not sources of vibrations in the environment, since the road layout (earth bed and pavement) is suitable for this category of traffic and the vibrations from vehicles fade quickly in the ground around the road layout.

3.9.3 RADIATION

3.9.3.1 NON-IONIZING RADIATION

The existing parameters of non-radiation energy risk factors at the Radiana site is determined by the operation of the Kozloduy NPP. The parameters of electromagnetic fields do not exceed the admissible sanitary norms. The requirements for the sanitary protection zones around the substations and the high-voltage power distribution lines are complied with.

3.9.3.2 IONIZING RADIATION

The NDF site falls within the 2-km zone (PAZ) of the Kozloduy NPP. It is known that 3 separate control zones of different radius have been established for the localization and assessment of possible impact of the Kozloduy NPP on the environment and the population around the nuclear plant: Supervised zone - the supervised parameter at the site of the existing Units 1-4 and Units 5 and 6 of the Kozloduy NPP, PAZ /2 km/ (Precautionary Action Zone) and a Surveillance zone - (SZ) /30 km/. Potential source of radiation are the nuclear facilities on this site:

3.9.3.2.1 UNITS 1 AND 2

Units 1 and 2 were decommissioned on 31.12.2002. They were declared facilities for radioactive waste management by decision of the Council of Ministers from 20.12.2008. On 18.10.2010, the NRA issued licences to the State Enterprise "Radioactive Waste" for the operation of Units 1 and 2 as facilities for radioactive waste management, which are subject to decommissioning. No nuclear fuel is stored at the site of Units 1 and 2.

3.9.3.2.2 UNITS 3 AND 4

Units 3 and 4 were decommissioned on 31.12.2006. By decision of the Council of Ministers № 1038/12.19.2012, the Units 3 and 4 of Kozloduy NPP EAD were declared facilities for radioactive waste management, which are subject to decommissioning. On 26.02.2013, the NRA issued licences to the State Enterprise "Radioactive Waste" for the operation of Units 3 and 4 as facilities for radioactive waste management, which are subject to decommissioning and terminated the licences of the Kozloduy NPP for the operation of the two units in operating mode – state "E". No nuclear fuel is stored at the site of Units 3 and 4.

Units 1÷4 have been transferred for management to the SE RAW, Sofia and are managed by a specialized division: SD Decommissioning of Units 1-4.

3.9.3.2.3 UNITS 5 AND 6

Units 5 and 6 were put in operation in 1987 and 1991 respectively, and there are on-going procedures for extending their service life and for possible increase in their power. Both units operate in base mode at rated power, complying with the terms of the license for operation.

3.9.3.2.4 SFSF

The spent fuel storage facility is located southwest of Units 3 and 4 at the Kozloduy NPP site. The SFSF provides the possibility of underwater temporary storage of the spent nuclear fuel (SNF) from the WWER-440 and WWER-1000 reactors for a 10-years period of operation of all the units in the Kozloduy NPP.

3.9.3.2.5 SFDSF

The site of the SFDSF is located to the north-northwest of the building of the SFSF. The storage technology in the SFDSF of Kozloduy NPP uses casks with air cooling on the principles of natural convection. The casks are of CONSTOR440/84 type with a capacity of 84 fuel assemblies from WWER-440. The SFDSF is located within the existing boundaries of the Kozloduy NPP and is an expansion of the NPP activities performed to date – temporary storage of spent nuclear fuel in the SFSF.

3.9.3.2.6 OTHER FACILITIES AND SITES, PROPERTY OF THE SE RAW

→ **RAW Processing Shop (RAWPS**) - main facility, designed to perform the activities related to the preliminary treatment, treatment and conditioning of the RAW generated by the Kozloduy NPP; The basic assembly unit for forming the packages for the conditioned RAW is a reinforced concrete

container (RCC), which is manufactured and tested according to the terms of the permit issued by the NRA.

→ **Depot for storage of conditioned RAW** (DSCRAW) - designed for temporary storage (until their disposal) of conditioned RAW from the Kozloduy NPP. It is an above ground reinforced concrete facility, providing the required engineering barriers between the stored RAW and the environment and the personnel.

→ **Lime Plant Site**

The Radioecological Monitoring Programme approved by the NCRRP and the Nuclear Regulatory Agency (NRA) is performed in this zone. A radiation monitoring programme is performed separately for the industrial site (supervised zone) for preventive monitoring at the source of radiation.

Laboratory and automated control of environmental components is carried out in the Surveillance zone. The sampling for laboratory analysis and the measurements of the activity of technogenic radionuclides in the samples is carried out in a total of 36 control points for the terrestrial ecosystem and 7 points for the aquatic ecosystem established within the Surveillance zone. Air, soil, vegetation, water and bottom sediments are analysed and the background gamma radiation is measured. Almost all points are located within the 12-km controlled zone and 3 benchmark points are situated outside of it – in Lom, Pleven and Berkovitsa. Beside the radioecological monitoring, radiation measurements at the industrial site are carried out in the 100-km surveillance zone around NPP.

The background radiation in the area at the time when the impact assessment of the Investment Proposal was carried out comprised mainly of gaseous emissions from the ventilation pipes of the Kozloduy NPP, the building of the units and the special buildings located on the industrial site. The reports of the RM department of the Kozloduy NPP prove that these radiation emissions do not change the radioecological status of the individual environmental components during normal operation. More detailed data on the radioecological status are given in sections 3.1- 3.4 of this report.

Subject to monitoring are the background gamma radiation, groundwater, air, atmospheric fallout, vegetation, soil and products of the food chain. The equivalent dose rate of gamma radiation is measured by means of 10 thermoluminescent dosimeters /TLD/ placed on the fence of the NPP, 20 TLDs in the area of the facilities of SD RAW Kozloduy and 10 TLDs on the fence of the SFSF.

The lack of impact outside the fence of the supervised zone caused by radiation from the operation of the reactors of the Kozloduy NPP is proven in the annual reports of the RM department and MoEW.

The background gamma radiation has values typical of the area – 0.07 - 0.14 μSv/h, and is within the range of the natural background radiation in the area. [75].

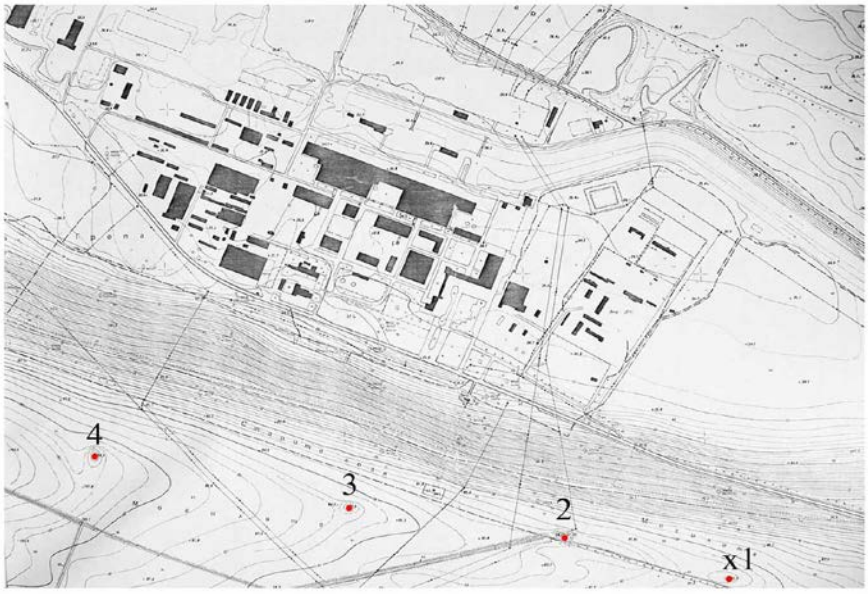
3.10 IMMOVABLE CULTURAL HERITAGE

In relation to the preparation of an environmental impact assessment report for the imminent construction of a National Repository for the Disposal of Low and Intermediate Level of Radioactive Waste and according to the Terms of Reference for the Environmental Impact Assessment that has been sent, the Regional Historical Museum in Vratsa has informed that a Thracian mound necropolis has been registered in the area. According to Art. 161 (1) of the Cultural Heritage Act, SG 19/13.03.2009, it is necessary for preliminary archaeological researches (field surveys) to be performed in order to determine whether the excavation works will affect or distort the immovable cultural values.

[75]NPP Annual Report, 2013

No temples, buildings of architectural value or places of cultural significance are located within the 2-km zone for radiation protection around the Kozloduy NPP, respectively the site.

After a visit at the site and the field surveys conducted in the area of the perimeter for the construction of a National Repository for the Disposal of Low and Intermediate Level of Radioactive Waste in the Mogilite locality situated on the land of Kozloduy Municipality, is was determined that **not a single one** of the four burial mounds, arranged equidistant from each other in a row in east-west direction, falls within the borders of the site – **Figure 3.10-1** .



Фиг. 4. Топографска карта М 1: 5 000 (1985 г.)

FIGURE 3.10-1 LOCATION OF THE BURIAL MOUNDS IN THE AREA OF THE NDF

The mounds found near the borders of the Radiana site are indicated accordingly with 1, 2, 3 and 4 (the number increases from east to west, **Figure 3.10-1**) and mounds A and B, again increasing from east to west. They have been researched by the New Bulgarian University – Laboratory of Archaeometry and Experimental Archaeology, and the Regional Historical Museum – Vratsa under a contract concluded between SE RAW and RHM Vratsa, incl. the partially revealed mound. The entire area where mounds 2, 3, and 4 are located is called Mogilite. In the report on the performed survey the mounds are characterized by their coordinates, sizes and archaeological features, as has been done for the mounds of the western group (2 -4).

Mound №2 (Maguraluy Sherbanoy) has dimensions at the base of 45-40 m and preserved height of 5.10 m at the concrete benchmark. The mound has been the subject of numerous anthropogenic interventions and has completely lost its original appearance – its southern periphery was destroyed in the construction of the secondary road II-11 Kozloduy-Harlets-Miziya; its western periphery has also been destroyed due to unclear reasons. In the northern part of the mound a large pit is observed, and a concrete benchmark has been placed at its highest point (in the southern part). Archaeological research has been performed at the mound by means of profiles resulting in the discovery of artefacts – pieces of pottery. Since mound №2 is located under a high voltage power distribution line, which influences the geomagnetic field, no geomagnetic research has been carried out at this mound.

FIGURE 3.10-2 BURIAL MOUND

Mound №3

Mound №3 is the smallest of the considered mounds. It has dimensions at the base of 50-50m, and preserved height of 1.5m. It has been strongly affected by intensive agricultural cultivation and as a result of systematic ploughing the top of the mound is very rounded, while its periphery is too flat. After the geomagnetic surveys performed at the mound and the analysis of the anomalies found, a conclusion has been drawn for the presence of a rectangular structure oriented northwest-southeast or of a large funeral pyre. There are also indications of the presence of iron objects (weapons, elements of horse trappings) and small hearths testifying to the rituals associated with the accumulation stages of the mound.

Mound №4

Mound №4 (Maguraluy Krastoy) has dimensions at the base of 60-70 m and preserved height of 4.5 m. Regardless of the large displacement towards the centre of the mound, it is also a subject to cultivation by means of agricultural machinery, the southern edge of the mound being the most affected. The results of the geomagnetic survey indicate the presence of a large funeral pyre in the centre of the mound.

The above described sites are characterized in detail and are indicated on the maps applied to the Expert report prepared by the Laboratory of Archaeometry and Experimental Archaeology under the New Bulgarian University.

TABLE 3.10-1 DISTANCE BETWEEN THE MOUNDS

Mound №	Meters	Deviation
4-3	725	98.3º
4-2	1,335	100º
4-1	2,750	100.5º

<u>No other immovable monuments of cultural heritage have been recorded</u> in the area of the periphery of the site intended for the construction of National Repository for the Disposal of Low and Intermediate Level of Radioactive Waste.

3.11 HEALTH AND HYGIENIC ASPECTS OF THE ENVIRONMENT

3.11.1 DETERMINING THE POPULATION POTENTIALLY AFFECTED BY THE IMPLEMENTATION OF THE INVESTMENT PROPOSAL; AREAS, ZONES AND/OR SITES WITH SPECIFIC SANITARY PROTECTION STATUS AND SUBJECT TO HEALTH PROTECTION

The selected Radiana site is located in Kozloduy Municipality, Vratsa District, south of the Kozloduy NPP, in the land of the village of Harlets and at a distance of 4.2 km away from it. It is situated at 4.3 km southeast of the town of Kozloduy, in immediate proximity to the southern border of the Kozloduy NPP site and at about 4.2 km southwest of the right bank of the Danube River. The site covers an area of approximately 46 ha – (about 1250x470 m).

The data on the location of the project show that there are no sites with sanitary protection status within the 2-km zone of the Kozloduy NPP, where the Radiana site of the NDF is located. There are no recreation areas, hospitals, sanatoriums, schools, protected areas or sanitary protection zones around water sources and facilities for drinking water supply in the area. There are no oil and gas pipelines routes constructed. No air traffic corridors of the civil aviation pass through the airspace over the site.

Table 3.11-1 presents the number of the population in the municipalities and settlements in 2013, fully or partially included in the 30-km SZ[76], in which the Radiana site is located, according to a reference in the National Register of Populated Places[77].

TABLE 3.11-1 POPULATION FALLING PARTIALLY OR ENTIRELY WITHIN THE 30-KM SZ IN 2013[78]

MUNICIPALITIES/POPULATION ENTIRELY WITHIN THE 30-km zone, 2013 – 41,864 people					
KOZLODUY MUNICIPALITY			**14**	The village of Krushovitsa	1,588
	Mayoralties		**15**	The village of Lipnitsa	725
1	Municipal mayoralty – the town of Kozloduy	12,723	**16**	The village of Sofronievo	1,434
2	The village of Harlets	1,968		Mayoral delegation:	
3	The village of Glozhene	2,723	**17**	The village of Saraevo	34
4	The village of Butan	2,828	**VALCHEDRAM MUNICIPALITY**		
5	The village of Kriva Bara	358		Mayoralties:	
HAYREDIN MUNICIPALITY			**18**	Municipal mayoralty - Valchedram	3,439
	Mayoralties:		**19**	The village of Mokresh	781
6	Municipal mayoralty – the village of Hayredin	1,455	**20**	The village of Septemvriytsi	1,116
7	The village of Manastirishte	957	**21**	The village of Dolni Tsibar	1,551
8	The village of Mihaylovo	1,062	**22**	The village of Razgrad	651
9	The village of Rogozen	967	**23**	The village of Zlatiya	777
	Mayoral delegations:		**24**	The village of Cherni Vrah	490
10	The village of Barzina	240		Mayoral delegations:	
11	The village of Botevo	76	**25**	The village of Botevo	62
MIZIYA MUNICIPALITY (7,185 people)			**26**	The village of Bazovets	96
12	Municipal mayoralty – the town of Miziya	3,102	**27**	The village of Gorni Tsibar	164

[76] NSI http://www.nsi.bg/nrnm/index.php?ezik=bul&f=9&search=%D5%FA%F0%EB%E5%F6

[77] NSI, National Register of Populated Places, http://www.nsi.bg/nrnm/index.php?f=9&ezik=bul

[78] NSI, National Register of Populated Places, http://www.nsi.bg/nrnm/index.php?f=9&ezik=bul, the reference was made on 09.08.2014.

13	The village of Voyvodovo	242	**28**	The village of Ignatovo	255
MUNICIPALITIES/POPULATION PARTIALLY WITHIN THE 30-km ZONE, 2013 – 85,776 people					
BOROVAN MUNICIPALITY			**60**	The village of Bardarski Geran	719
	Mayoralties:		**61**	The village of Barkachevo	684
29	Municipal mayoralty – the village of Borovan	2,239	**62**	The village of Vranyak	1,002
30	The village of Malorad	1,776	**63**	The village of Gabare	1,062
31	The village of Dobrolevo	868	**64**	The village of Galiche	1,799
32	The village of Nivyanin	432	**65**	The village of Drashan	182
33	The village of Sirakovo	208	**66**	The village of Komarevo	230
LOM MUNICIPALITY			**67**	The village of Popitsa	1,794
	Mayoralties:		**68**	The village of Sokolare	540
34	Municipal mayoralty – the town of Lom	21,787	**69**	The village of Tlachene	409
35	The village of Kovachitsa	1,119	**70**	The village of Tarnava	2,285
36	The village of Traykovo	848	**71**	The village of Tarnak.	1,552
37	The village of Zamfir	964	**KRIVODOL MUNICIPALITY**		
38	The village of Staliyska Mahala	1,285		Mayoralties:	
	Mayoral delegations:		**72**	Municipal mayoralty – the town of Krivodol	2,944
39	The village of Dobri Dol	307	**73**	The village of Baurene	387
40	The village of Dolno Linevo	240	**74**	The village of Gradeshnitsa	442
41	The village of Slivata	196	**75**	The village of Kravoder	907
42	The village of Orsoya	92	**76**	The village of Lesura	755
43	The village of Stanevo	302	**77**	The village of Pudriya	618
	BOYCHINOVTSI MUNICIPALITY		**78**	The village of Rakevo.	932
	Mayoralties:			Mayoral delegations:	
44	Municipal mayoralty – the town of Boychinovtsi;	1,446	**79**	The village of Botunya	155
45	The village of Vladimirovo	1,354	**80**	The village of Galatin	606
46	The village of Gromshin	754	**81**	The village of Glavatsi	235
47	The village of Erden	528	**82**	The village of Golemo Babino	262
48	The village of Lehchevo	1,721	**83**	The village of Dobrusha	181
49	The village of Madan	708	**84**	The village of Osen	327
50	The village of Marchevo	821	**85**	The village of Furen	244
51	The village of Ohrid	361	**86**	The village of Urovene.	119
52	The village of Portitovtsi	440		**ORYAHOVO MUNICIPALITY**	
	Mayoral delegations:			Mayoralties:	
53	The village of Beli Breg	86	**87**	Municipal mayoralty – the town of Oryahovo	4,820
54	The village of Beli Brod	215	**88**	The village of Gorni Vadin	276
55	The village of Kobilyak	298	**89**	The village of Leskovets	591
56	The village of Palilula	67	**90**	The village of Ostrov	,1359
BYALA SLATINA MUNICIPALITY			**91**	The village of Selanovtsi.	3,349
	Mayoralties:			Mayoral delegations:	
57	Municipal mayoralty – the town of Byala Slatina	10,781	**92**	The village of Dolni Vadin	197
58	The village of Altimir	1,128	**93**	The village of Galovo	249
59	The village of Bukovets	192			

3.11.2 DEMOGRAPHIC CHARACTERISTICS OF THE POPULATION IN THE AREA

The average population density in Kozloduy Municipality for 2012 was 74.4 inhabitants/km^2 – it is commensurate with the national average, but higher than that of Vratsa District (50.2 inhabitants/km^2). [79] . In 2013 the population in Kozloduy Municipality, which comprises 5 settlements, was 20,600 people (**Table 3.11-2**), showing a trend towards stabilization: in 2012 compared to 2011, the population decreased by 306 people, while in the next annual period 2012-2013 the decrease was of 189 people.

TABLE 3.11-2 KOZLODUY MUNICIPALITY – POPULATION IN THE LAST THREE YEARS

Kozloduy Municipality	2011	2012	2013
The town of Kozloduy	12,856	12,775	12,723
The village of Harlets	2,045	2,013	1,968
The village of Glozhene	2,763	2,733	2,723
The village of Butan	2,890	2,850	2,828
The village of Kriva Bara	416	418	358
Total	21,095	20,789	20,600

In the longer term (1934-2013), the demographic development in Kozloduy Municipality (**Figure 3.11-1** and **Figure 3.11-2**) is too specific, while at the same time typical of similar municipalities with a single large industry established.

In small settlements this is due to the migration of a part of the population (common in rural areas) to larger settlements, in this case from the villages to the town of Kozloduy. This process begins after the commissioning of Units 1-2 of the Kozloduy NPP in 1974-75, and later on continues with the construction and commissioning of the remaining units of the NPP: **Figure 3.11-1** (B and C) and **Figure 3.11-2** (D).

After 2000-2001, the number of residents in the villages decreased on the one hand due to ageing, and on the other due to the increased migration both internal (to the capital and major towns) and external, especially the migration of young people abroad.

Furthermore, the town of Kozloduy underwent further expansion after the commissioning of the NPP construction in 1970, **Figure 3.11-1** (A). During this period, the growth in the population of the town of Kozloduy was the result of migration of construction workers and specialists for the construction and operation of the NPP and activities related to it from all over the country.

After a long period of population growth up to 2000, when the town of Kozloduy reached its maximum number of residents (15,508 people), the number of town residents began to decrease. The analysis of the data from the last two censuses (2001 and 2011) shows that for a 10-year period the population of the town Kozloduy decreased by 1,834 people, which is due to the decommissioning of the first four units of the NPP.

As already mentioned above, the following municipalities are located within the 30-km urgent protective action planning zone (UPZ) [80], where the Radiana site selected for the implementation of the Investment Proposal is located: Kozloduy, Valchedram, Hayredin, Miziya (28 settlements) and partially the municipalities of Lom, Byala Slatina, Oryahovo, Boychinovtsi, Krivodol and Borovan, and a total of 19 settlements of Dolj County, Oltenia Region in Romania.

[79] NSI, Statistical Yearbook, 2013

[80] UPZ of 30 km is designated for the purposes of the emergency planning. The same zone of 30 km used for the purposes of the radiation monitoring is called Surveillance zone (SZ).

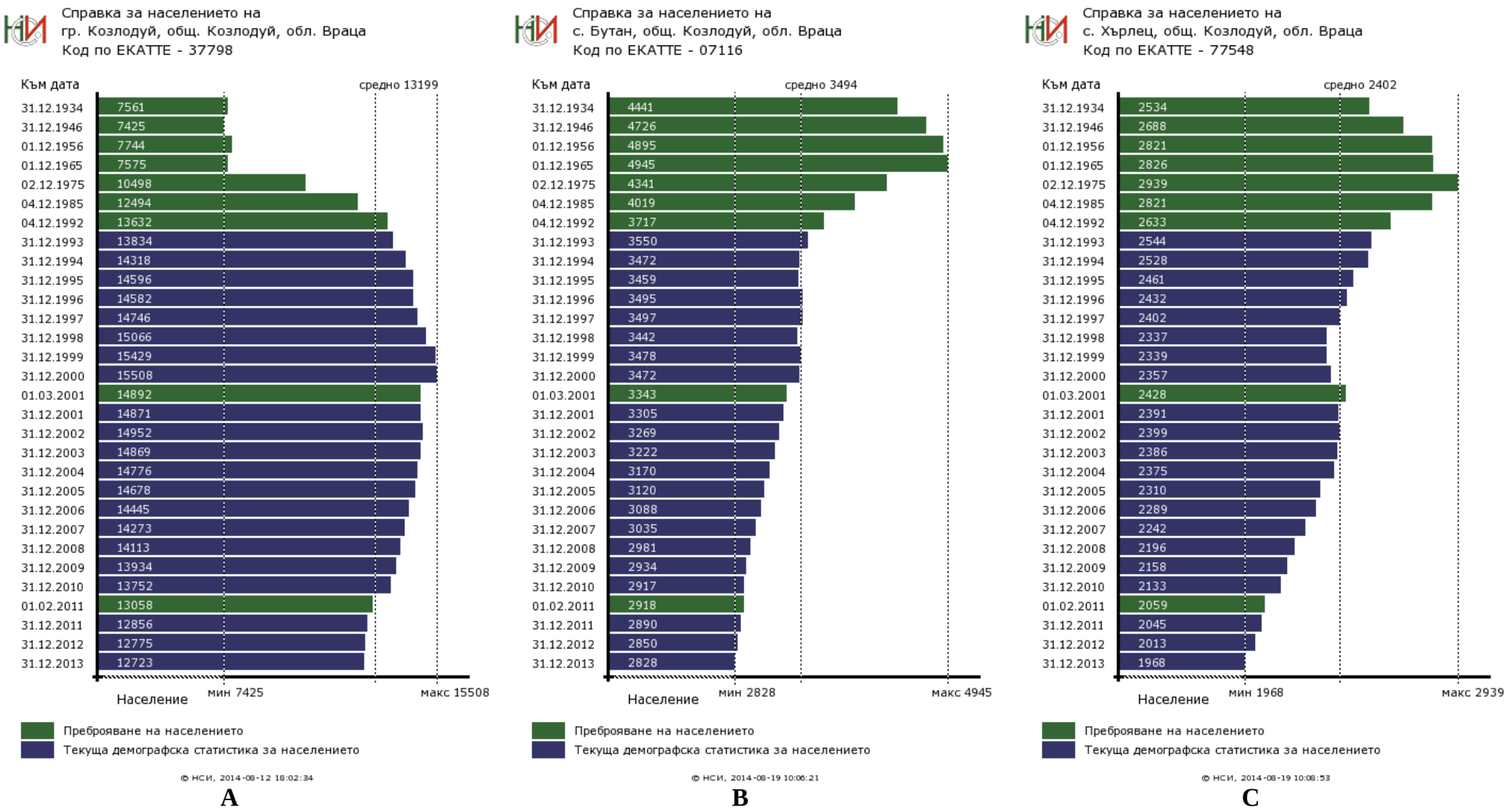
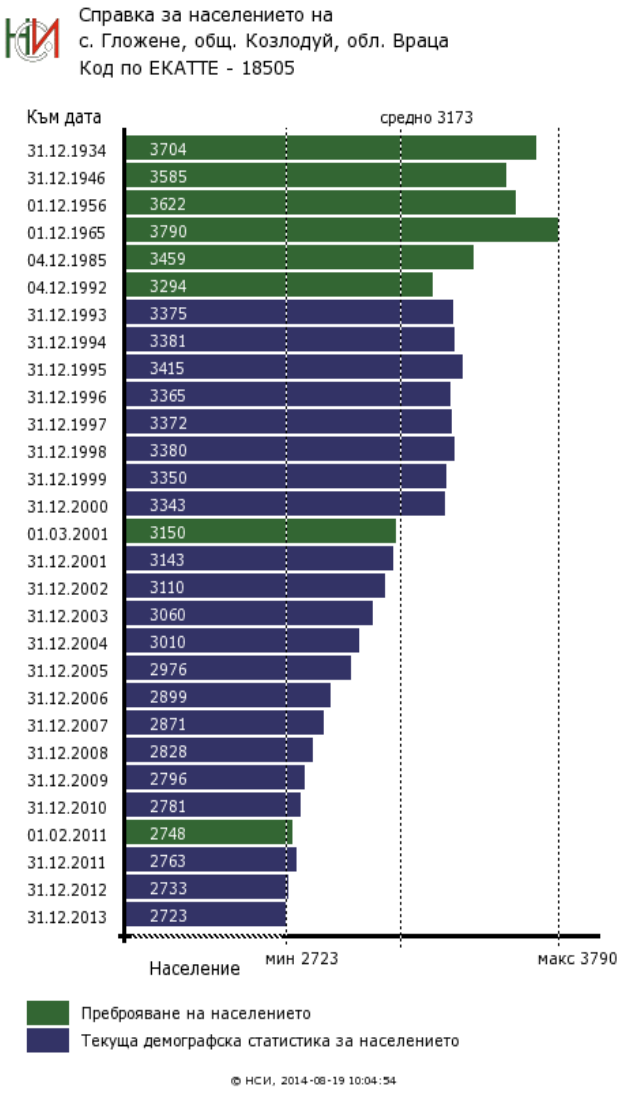
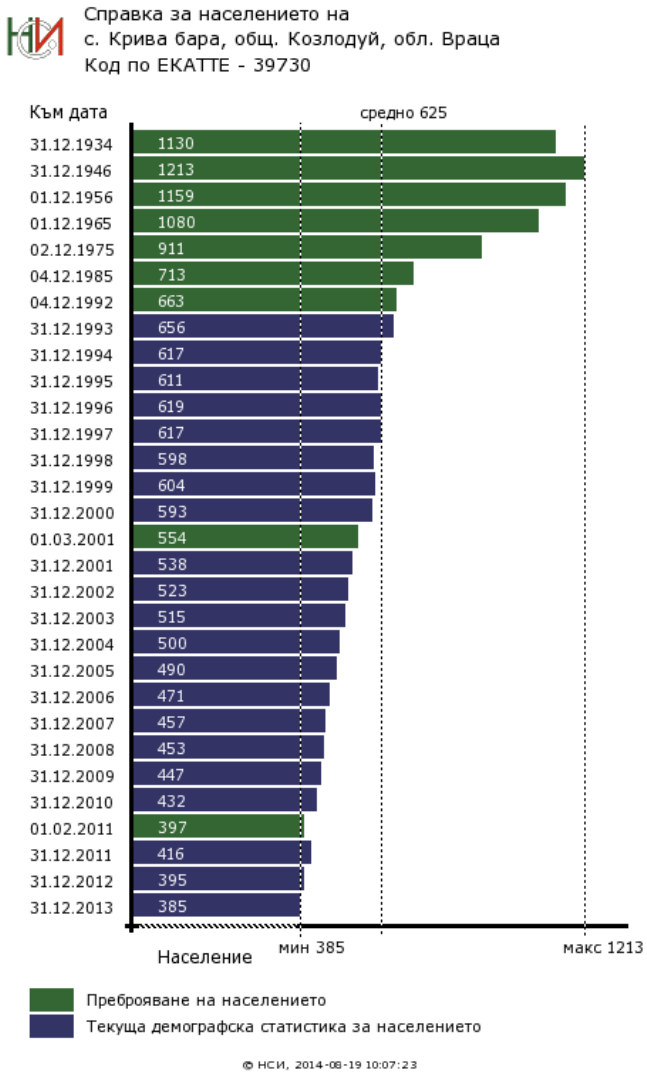


FIGURE 3.11-1 POPULATION DYNAMICS FOR KOZLODUY MUNICIPALITY WITHIN A 79-YEAR PERIOD – A, B AND C



D



E

FIGURE 3.11-2 POPULATION DYNAMICS FOR KOZLODUY MUNICIPALITY WITHIN A 79-YEAR PERIOD – D, E

Table 3.11-3 presents the municipalities included in the 30-km zone around the Radiana site ,selected for the implementation of the Investment Proposal, along with their area, population density and their administrative subdivision up to 31.12.2012.

TABLE 3.11-3 AREA, POPULATION DENSITY AND SETTLEMENTS UP TO 31.12.2012 IN VRATSA DISTRICT AND MONTANA DISTRICT AND THE MUNICIPALITIES WITHIN THE 30-KM ZONE[81]

Districts Municipalities	Area in km^2	Population density per km^2	Settlements - number	Towns - number	Villages- number	Mayoralties - number
Total for the country	111,001.9	65.6	5,278	257	5,021	2,008
Vratsa	3,619.8	50.2	123	8	115	67
1. Borovan	210.7	26.6	5	-	5	3
2. Byala Slatina	572.3	41.9	15	1	14	11
3. Kozloduy	284.9	72.9	5	1	4	4
4. Krivodol	326.9	28.1	15	1	14	7
5. Miziya	209.3	34.8	6	1	5	3
6. Oryahovo	326.5	34.1	7	1	6	4
7. Hayredin	189.1	25.7	6	-	6	3
8. Montana	3,635.6	39.5	130	8	122	49
9. Boychinovtsi	308.3	28.9	13	1	12	8
10. Valchedram	431.5	22.1	11	1	10	6
11. Lom	323.9	84.8	10	1	9	4

The number of the population in the municipalities of Vratsa District and Montana District, located within the 30-km SZ, is presented in **Table 3.11-4** . The data show progressive trend of population decrease in the last three years, more pronounced for the rural population compared to urban. The total number of residents of the municipalities entirely or partially located within the 30-km SZ amounted to, respectively, 131,734 people in 2011, 129,842 in 2012, and 123,755 people in 2013. In other words, within 3 years the population decreased by 7,979 people, i.e. 2.85%. The population number decreased two times faster than the national average during the same period (1.13%).

TABLE 3.11-4 AVERAGE ANNUAL POPULATION BY DISTRICTS AND MUNICIPALITIES (ENTIRELY OR PARTIALLY LOCATED WITHIN THE 30-KM SZ) AND PLACE OF RESIDENCE[82]

Municipalities	2011			2012			2013		
	Total	In towns	In villages	Total	In towns	In villages	Total	In town	In villages
Borovan	5,708	-	5,708	5,642	-	5,642	5,561	-	5,561
Byala Slatina	24,499	11,152	13,347	24,185	10,992	13,193	23,798	10,858	12,940
Kozloduy	21,095	12,971	8,124	20,868	12,815	8,053	20,696	12,749	7,947
Krivodol	9,412	3,124	6,288	9,294	3,054	6,240	9,098	2,984	6,114
Miziya	7,518	3,234	4,284	7,374	3,197	4,177	7,209	3,141	4,068
Oryahovo	11,469	5,020	6,449	11,257	4,967	6,290	10,982	4,875	6,107
Hayredin	4,972	-	4,972	4,895	-	4,895	4,806	-	4,806
Boychinovtsi	9,215	1,546	7,669	9,030	1,497	7,533	8,859	1,458	7,401

[81] NSI, Regions, Districts and Municipalities in the Republic of Bulgaria 2012 Sofia, 2014 http://www.nsi.bg/bg/nsi_publications.xml

[82] NSI

Municipalities	2011			2012			2013		
	Total	In towns	In villages	Total	In towns	In villages	Total	In town	In villages
Valchedram	9,838	3,634	6,204	9,640	3,559	6,081	9,458	3,481	5,977
Lom	28,008	22,419	5,589	27,657	22,182	5,475	27,308	21,923	5,385

Unlike the average data for the country, according to which nearly 3/4 of the population lives in towns – 5,291,675 people (73.0%), and 1,954,002 people (27.0%) live in villages, the urban/rural population ratio in the 30-km SZ is 52.2% to 47.8%. These data show a significantly low level of urbanization in the surveyed area compared to the national average.

Overall, according to the data for 2013 provided by the NSI, the analysis of gender structure of the population within the 30-km SZ of Kozloduy NPP, in which the Radiana[83] site is located, indicates minor differences between the number of men and women. The difference in their percentage ratio is 3.1% in total for the municipalities throughout the area (**Table 3.11-5** .). It is slightly larger in rural areas, where the share of men is 48.3% and the share of women is 51.7%, compared to urban areas (men - 48.8%, women - 51.2%). This is related to the larger number of women over working age in the villages. The gender structure of the population throughout the country is similar - the number of women is 51.4% of the total population, compared to 48.6% for men. The trend for increasing ratio of women/men after 53 years of age is similar.

TABLE 3.11-5 POPULATION UP TO 31.12.2013 BY MUNICIPALITIES AND GENDER

Municipalities	2013		
	Total	Men	Women
Borovan	5,523	2,780	2,743
Byala Slatina	23,588	11,609	11,979
Kozloduy	20,627	10,183	10,444
Krivodol	9,023	4,460	4,563
Miziya	7,125	3,526	3,599
Oryahovo	10,841	5,349	5,492
Hayredin	4,757	2,349	2,408
Boychinovtsi	8,799	4,373	4,426
Valchedram	9,382	4,584	4,798
Lom	27,140	13,159	13,981

The analysis of the distribution of population by gender shows higher relative share of women in the range of 0.8%-1.4% above the average. Gender differences in the population of working age have the following characteristics: the number of girls and boys below working age is approximately equal. The relative share of men of working age is higher than that of women of working age, but the differences are not statistically significant. The relative share of men over working age is significantly reduced compared to women. This is related to the known trend for higher mortality rate among men than women over the age of 60. Such type of age-gender distribution has a pronounced unfavourable characteristic in terms of socio-economics.

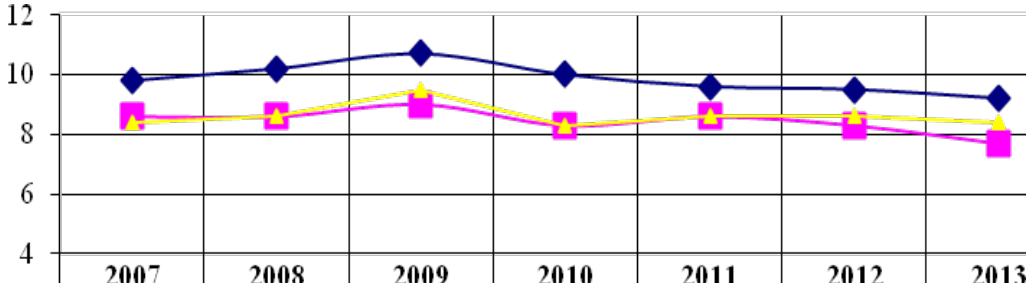
The data from the Analysis of the Health and Demographic Indicators in Vratsa District[84] and from the NSI for Montana District[85], where the settlements of the 30-km SZ are located, are presented in

[83] The Surveillance zone around the NDF is below 4 km, while the Precautionary action zone of the NDF is within the borders of its fence.

[84] RHI Vratsa. Analysis of the Health and Demographic Indicators in Vratsa District in 2013

Figure 3.11-3 to **Figure 3.11-6** and indicate that there is a process of permanent decrease in the total number of population in the area.

The birth rates in the districts of Vratsa and Montana have close values and decreasing trends after 2013, remaining higher in towns, but below the national average (**Figure 3.11-3**).



	2007	2008	2009	2010	2011	2012	2013
България	9.8	10.2	10.7	10	9.6	9.5	9.2
Област Враца	8.6	8.6	9	8.3	8.6	8.3	7.7
Област Монтана	8.4	8.6	9.5	8.3	8.6	8.6	8.4

FIGURE 3.11-3 BIRTH RATE IN VRATSA DISTRICT, MONTANA DISTRICT AND THE COUNTRY (PER 1,000 LIVE BIRTHS)

Figure 3.11-4 presents the data on the number of live births in the municipalities located entirely or partially within the 30-km zone for the last three years, which support the above presented data for the districts of Vratsa and Montana.

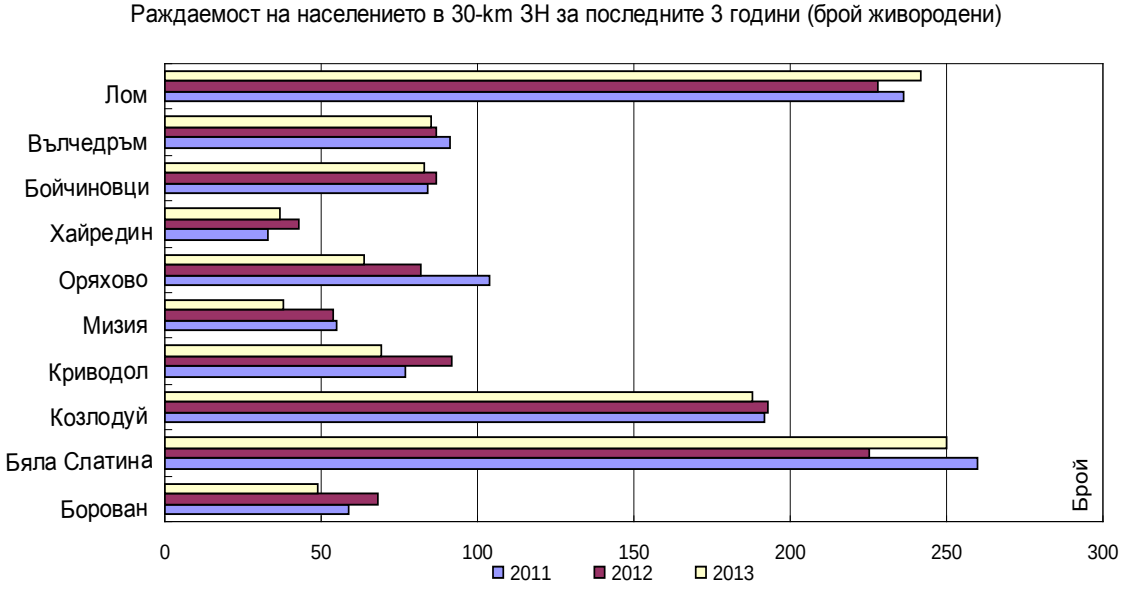


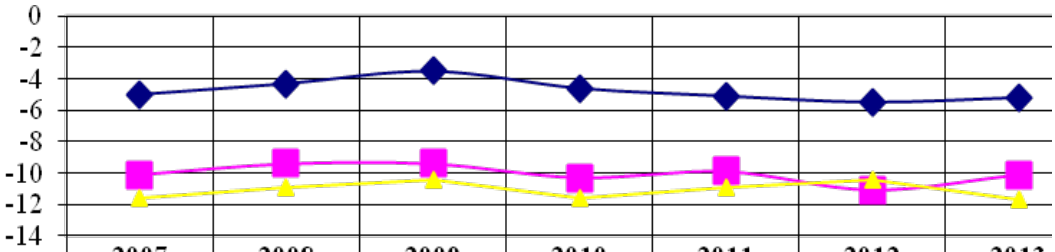
FIGURE 3.11-4 POPULATION BIRTH RATE IN THE 30-KM SZ FOR THE PAST 3 YEARS (NUMBER OF LIVE BIRTHS)

The total mortality rates in the districts of Vratsa and Montana (**Figure 3.11-5**) in the period 2007-2013 are significantly above the national average, particularly in Montana District. Throughout the surveyed period, the mortality rates are significantly higher for the rural population.

[85] NSI

	2007	2008	2009	2010	2011	2012	2013
България	14.8	14.5	14.2	14.6	14.7	15	14.4
Обл. Враца	18.7	18	18.4	18.6	18.5	19.4	17.8
Обл. Монтана	20	19.4	19.9	20.5	20.9	21.4	20.1

FIGURE 3.11-5 TOTAL MORTALITY RATE IN VRATSA DISTRICT, MONTANA DISTRICT AND THE COUNTRY (PER 1,000)



	2007	2008	2009	2010	2011	2012	2013
България	-5	-4.3	-3.5	-4.6	-5.1	-5.5	-5.2
Обл. Враца	-10.1	-9.4	-9.4	-10.3	-9.9	-11.1	-10.1
Обл. Монтана	-11.6	-10.9	-10.4	-11.6	-10.9	-10.4	-11.7

FIGURE 3.11-6 POPULATION GROWTH RATE IN VRATSA DISTRICT (PER 1,000)

The declining birth rate and the high mortality rate determine the extremely low population growth rate, about 1.5 times lower than the national average - **Figure 3.11-6** .

All of the above presented is related to the **significant changes in the age structure of the population over the last decade**. These processes are influenced by the changes in the birth-rates, mortality rates, average life expectancy, migration, living standards, political changes, etc.

According to the data provided by the NSI, the process of **demographic ageing has continued** for the past 3 years, and is characterized by a decrease in the number and share of the population aged below 15 and an increase in the share of the population aged over 65 years. A decreasing trend in the share of children under the age of 15 is observed. The population aged over 65 is more than 1/5 in 15 districts of the country.

The total age dependency ratio for the country in 2013 was 50.0%, i.e. nearly 50 persons aged below 15 or 65 years and over per 100 persons in the age group 15-64 completed years. This ratio is more unfavourable in Vratsa District (55.4%) and Montana District (61.0%) and an increasing trend has been observed for the past three years. The data on the ratio of the population aged 65 and over to the population aged 15 to 64 years in both areas compared to the national average over the past three years (**Table 3.11-6**) is similar.

TABLE 3.11-6 STRUCTURE OF THE POPULATION IN VRATSA DISTRICT AND MONTANA DISTRICT BY AGE DEPENDENCY IN THE LAST 3 YEARS

	2011		2012		2013	
	Ratio of the population aged below 15 and population aged 65 or over to the population aged from 15 to 64 years	Ratio of the population aged 65 or over to the population aged from 15 to 64 years	Ratio of the population aged below 15 and population aged 65 or over to the population aged from 15 to 64 years	Ratio of the population aged 65 or over to the population aged from 15 to 64 years	Ratio of the population aged below 15 and population aged 65 or over to the population aged from 15 to 64 years	Ratio of the population aged 65 or over to the population aged from 15 to 64 years
	%					
Total for the country	47.5	27.8	48.7	28.5	50.0	29.3
Vratsa	53.0	32.5	54.0	33.3	55.4	34.6
Montana	58.1	37.7	59.3	38.4	61.0	39.6

As a result of the process of demographic ageing of the population its distribution in the three age groups ‘below’, ‘at’ and ‘over working age’, has changed significantly, which has a direct impact on the economic and social sphere. **The number of people below working age in the municipalities within the 30-km zone is significantly lower than the number of people over working age, indicating an ageing of the population in this area.** The number of residents at and over working age is nearly equal in the municipalities of Hayredin and Valchedram (**Table 3.11-7**).

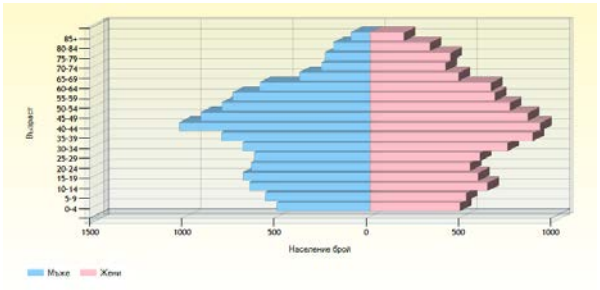
TABLE 3.11-7 POPULATION BELOW, AT AND OVER WORKING AGE IN 2013

Municipalities	Below working age			At working age			Over working age		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
Borovan	1,013	557	456	2,790	1,542	1,248	1,796	722	1,074
Byala Slatina	3,965	2,025	1,940	13,495	7,338	6,157	6,547	2,470	4,077
Vratsa	9,948	5,081	4,867	45,041	23,892	21,149	16,719	6,228	10,491
Kozloduy	3,465	1,781	1,684	13,524	7,117	6,407	3,777	1,361	2,416
Krivodol	1,229	631	598	4,254	2,428	1,826	3,690	1,457	2,233
Miziya	967	503	464	4,022	2,234	1,788	2,304	867	1,437
Oryahovo	1,517	796	721	5,849	3,270	2,579	3,757	1,433	2,324
Hayredin	546	275	271	2,453	1,406	1,047	1,856	721	1,135
Berkovitsa	2,599	1,329	1,270	10,175	5,507	4,668	5,431	2,040	3,391
Valchedram	1,522	767	755	4,730	2,641	2,089	3,282	1,243	2,039
Lom	3,908	1,979	1,929	15,972	8,549	7,423	7,596	2,799	4,797

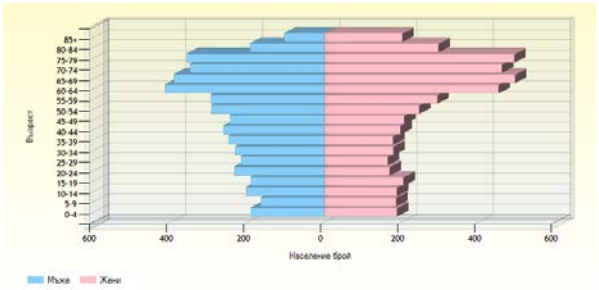
As seen from **Figure 3.11-7** , only Kozloduy Municipality shows some differences in the age-gender structure of the population in it. The demographic development in Kozloduy Municipality is specific, while at the same time typical of similar settlements with a single large industry established. On the one hand this is due to the migration of a part of the population (common in rural areas) to the larger settlements, in this case from the villages to the town of Kozloduy. Overall, the population in Kozloduy Municipality has decreased compared to previous years. This is a clear indicator of a worsening demographic situation. The decrease in population below working age is particularly strongly expressed, especially in municipalities with a predominantly rural population. The problem with the ageing of the population and the distorted age structure is very significant because it will determine the reproduction of the population and the workforce in the coming decades.

The increasing number and share of elderly people (aged over 65) sets and will continue to set serious challenges to the social insurance system, social assistance system, healthcare and education

KOZLODUY

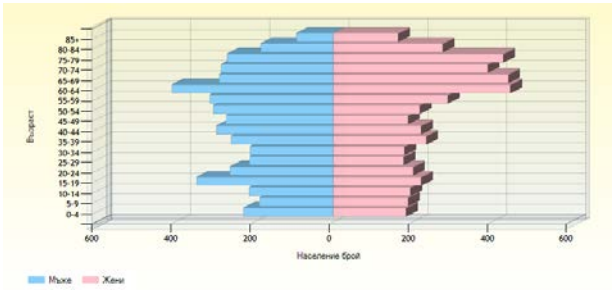


KRIVODOL

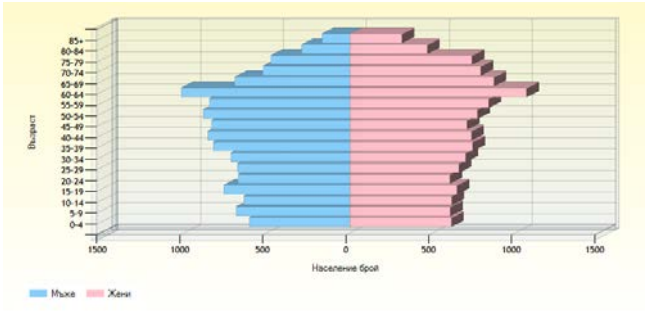


BOROVAN

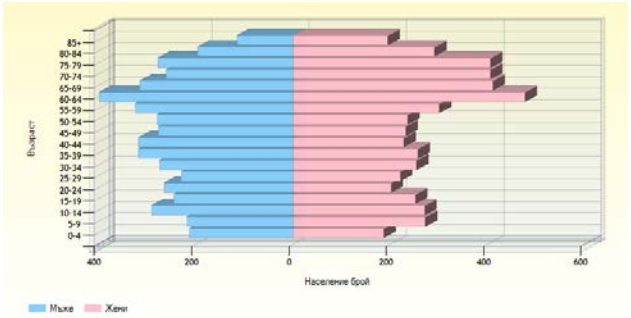
BOYCHINOVTSI



BYALA SLATINA



VALCHEDRAM



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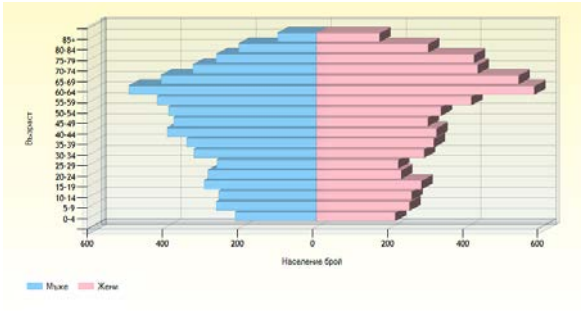

LOM

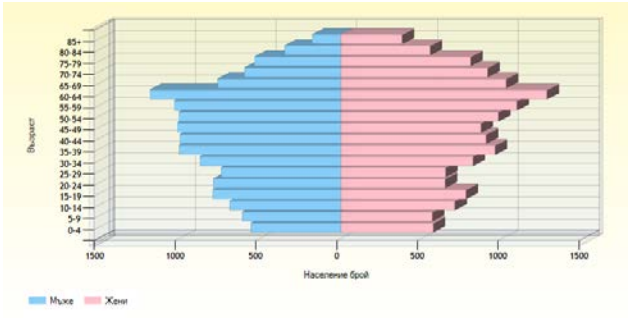

FIGURE 3.11-7 POPULATION AGE PYRAMID OF THE MUNICIPALITIES LOCATED ENTIRELY OR PARTIALLY IN THE 30-KM SZ

3.11.3 HEALTH STATUS OF THE POPULATION IN THE AREA

One of the main indicators that determine the health status and health insurance status of the population are: data on the total and hospitalized morbidity rates, data on the socially significant diseases (cardiovascular, oncologic, respiratory, etc.), total mortality rate and mortality rate by causes.

3.11.3.1 HOSPITALISED MORBIDITY

The statistical data on the hospitalised morbidity rates for the period 2005-2013[86] indicate that the number of hospitalised cases in medical institutions in Bulgaria increased from 1,614,313 (20,857.0‰) to a total of 2,221,115 (30,572.3‰) and mainly in the age groups over 18 years The number of hospitalisations in medical institutions **per 100,000 population** (‰) is largest among persons over 65 years of age (52,614.2), followed by the group of children aged from 0 to 17 (26,159.7‰) and is lowest in the age group 18-64 years (25,058.9‰) – two times lower than the age group over 65 years. The case with the hospitalised morbidity rate in Kozloduy Municipality is similar, the difference being that the pathology treated at the Multiprofile Hospital for Active Treatment (MHAT) St. Ivan Rilski EOOD, the town of Kozloduy, is not very diverse. All classes of diseases, as a cause of hospitalisations in the MHAT St. Ivan Rilski EOOD, **have a lower relative share compared to the country.**

No sick people have been hospitalised due to diseases caused by a radiation factor – blood diseases, disease of the blood-forming organs and congenital anomalies. **The hospitalised cases of cancer are over 7 times less than the national average (0.64% and 7.1% respectively).**

It can be assumed that the residents of the town, the vast majority of which work in the Kozloduy NPP, are under strict medical supervision by the Occupational Medicine Department at the NPP. This fact is clearly confirmed by the lower respiratory system morbidity compared to the population in areas related to other business activities.

The analysis of hospitalised morbidity rates shows that the number of sick people who have been admitted to MHAT St. Ivan Rilski EOOD is lower compared to other hospital in the district and the other municipalities. In the structure of diseases, causing hospitalisation, the chronic non-communicable diseases (diseases of the circulatory and respiratory system) have a leading role. Overall, they are caused by common, modifiable and preventable behavioural risk factors such as smoking, unhealthy diet, low physical activity and alcohol abuse.

3.11.3.2 PROPHYLACTIC OBSERVATION OF HEALTH INSURED PERSONS (HIP)

The total number of health insured persons who underwent prophylactic examinations in 2013 was 2,265 people, the highest relative share being among the HIP aged over 65 years.

As throughout the country, the diseases classes under the ICD-10 with the largest number of sick people over the age of 18, who underwent prophylactic examinations, are: "Diseases of the circulatory system" – 1,672 and "Endocrine, nutritional and metabolic diseases" - 389 (mainly diabetes). Among children under the age of 17, the ones who underwent prophylactic examination are only **four**.

TABLE 3.11-8 HOSPITALISED MORBIDITY IN KOZLODUY MUNICIPALITY FOR 2013

№ Under ICD-10	Classes	Number of prophylactic examinations	Number of people who underwent prophylactic examination	Number of prophylactic examinations	Number of people who underwent prophylactic examination	Number of prophylactic examinations	Number of people who underwent prophylactic examination
		0-17 years	0-17 years	18-64 years	18-64 years	over 6 years 5	over 65 years
IV.	Endocrine, nutritional and metabolic diseases			312	197	234	192
VI.	Nervous system diseases	5	4	13	12	20	20

[86] NCPHA

VII.	Diseases of the eye and adnexa			5	5	14	19
IX.	Circulatory system diseases			881	767	986	905
X.	Respiratory system diseases			86	82	68	62
	TOTAL	5	4	1,297	1,063	1,322	1,198

Both nationwide and in Vratsa District, priority diseases and conditions in prophylactic observation are **the main chronic non-communicable diseases** - namely, cardiovascular disease, diabetes and chronic lung diseases.

In 2013 the average number of examinations under prophylactic observation of HIPs reported in the municipality amounted to 2,624. The total reported prophylactic examinations of all age groups within the algorithm for prophylactic observation is 1.16 examinations per 1 HIP and is close to the data for Vratsa District (1.29) and significantly lower than the national average (1.65 examinations per 1 HIP). The data provided by the National Health Insurance Fund (NHIF) and the National Centre for Public Health and Analysis (NCPHA) indicate that Vratsa District has the lowest average number of examinations compared to other districts in the country.

3.11.3.3 MORTALITY

Mortality is an integral indicator that gives indirect information about morbidity rates of the population. The level of the total mortality rates is a problem both for Bulgaria, and for the population in Vratsa District[87], in which the Radiana site is located – **Table 3.11-9** .

According to the NSI data, after 1964, when the lowest total mortality rate per 1,000 people of the population in the country (7.9 ‰) was registered, the indicator has been steadily increasing and the number of deceased persons in 2013 was 104,345, with mortality rate of 14.4 ‰. The data for Vratsa District are comparable to the national average mortality rate.

TABLE 3.11-9 MORTALITY RATE BY DISTRICTS AND GENDER FOR THE LAST THREE YEARS

Districts	**2011**			**2012**			**2013**		
	Mortality rate in ‰ (per 1,000 people of the population)			Mortality rate in ‰ (per 1,000 people of the population)			Mortality rate in ‰ (per 1,000 people of the population)		
	total	men	women	total	men	women	total	men	women
Total for the country	14.7	15.8	13.7	15.0	15.9	14.0	14.4	15.5	13.3
Vratsa	18.5	19.4	17.6	19.4	20.6	18.3	17.8	19.7	16.1

The higher mortality rates in Vratsa District compared to the national average are due to the **significantly higher number of ageing rural population in the district**. A proof for that is the analysis of data on the total mortality in the towns, which shows that the mortality rate per 1,000 people of the urban population in Vratsa District (11.9 ‰) is lower than the national average (12.1 ‰) and the one in the Northwestern Region (13.3 ‰). Overall Vratsa District is among the 10 districts **with the lowest total mortality rate per 1,000 people in the towns.**

Mortality in the villages, however (26.4 ‰) is higher than the national average for rural population (20.5 ‰). The ageing rural population and the total mortality in the villages within the districts of Pernik (28.4 ‰), Gabrovo (33.6 ‰), Vidin (34.3 ‰), is greater compared to Vratsa District.

[87] Due to the fact that no data on the mortality rates in Kozloduy Municipality were provided to us, the NSI the examined data will be for Vratsa District.

The higher mortality rates are due to the deaths of people aged over 65. The main reason for this is the demographic ageing, particularly strongly pronounced in the villages where this age group is the largest.

The main risk factors for mortality from these diseases in Vratsa District, except for the pronounced ageing of the rural population, are those related to lifestyle (smoking, alcohol abuse, lack of appropriate exercise regimen, lack of active movement, stress and unbalanced nutrition), socio-economic conditions (high unemployment rates, reduced purchasing power) risk groups (ethnic minorities, people with disabilities and people in the age group over 65 years).

3.11.3.4 EXAMINATION OF THE HEALTH STATUS OF THE POPULATION BY THE INDICATORS OF MORBIDITY AND MORTALITY FROM RADIATION INDUCED DISEASES

Morbidity and mortality from radiation induced diseases include the following groups of diseases: malignant neoplasms, blood diseases, diseases of the blood-forming organs and certain disorders involving the immune mechanism and congenital anomalies (developmental defects), deformations and chromosomal aberrations.

Morbidity caused by malignant neoplasms. According to the National Cancer Registry 2013[88], 34,864 cases of malignant diseases were registered in Bulgaria in 2011, of which 18,659 (53.5%) were men and 16 205 (46.5%) women. These are 581 cases more than the cases registered in 2010 and 1.48 times more than the ones in 1993. The morbidity of malignant diseases (total for all types of cancer except for non-melanoma skin cancers) in Bulgaria is lower than the European average. The actual morbidity is 521.5 per 100,000 men and 429.8 000 per 100,000 women.

Against this background, the Vratsa District, with indicators for standardized morbidity of 241.5 per 100,000 for men and 203.8 per 100,000 for women, is under the national average and ranks in the last ten among the 28 districts - Figure 3.11-8 .

According to the data provided by the NCPHA[89], the morbidity from malignant neoplasms increased in 2013 compared to the previous year. The indicators per 100,000 people of the population (‰) for Bulgaria are a total of 461.9‰. In Vratsa District, the number of newly registered cases of malignant neoplasms per 100,000 population is slightly lower than the national average - 458.9‰. Morbidity is higher in the districts of Haskovo (634.5‰), Pleven (548.‰) and Ruse (512.0‰).

Mortality from malignant neoplasms. The data from the National Cancer Registry 2013 show that deaths from malignant diseases in 2011 were 16,844, of which 9,820 were men (58.3%) and 7,024 (41.7%) women - **Table 3.11-9** . This means 282 more deaths from cancer than in 2010, and 1.08 times more than in 1993.

The actual mortality rate is 274.5 per 100,000 men and 186.3 per 100,000 women. The standardized mortality rate for men in Bulgaria is higher than the European average (231.7 per 100,000 and 222.6 per 100,000, respectively), while it is lower for women (126.3 per 100,000 and 128.8 per 100,000, respectively). It must be stressed that the five-year survival rate in patients with malignant diseases in Bulgaria is almost 1.5 times lower than the European average, respectively 39.7% and 54.2%. – **Figure 3.11-8** .

Against the background of low morbidity (Figure 3.11-8), the cancer mortality rates in Vratsa District, are most likely due to problems with the health system – limited access to specialized health services, which hinders the early detection of the disease and its adequate treatment. Overall, the health system, particularly at district level, is not prepared to respond

[88] http://www.sbaloncology.bg/assets/files/rakov_registar/Cancer_incidence_BG_2011.pdf, National Hospital of Oncology, Cancer Incidence in Bulgaria, 2011

[89] NCPHA, Incidence of malignant neoplasms. Unpublished data

effectively and equitably to the health needs of the population in terms of oncological diseases. The proliferation of a number of risk factors (smoking, unhealthy diet), the low efficiency or the lack of preventive actions (female breast cancer, cervical cancer, prostate cancer, colon and rectum cancer) and the rapidly growing ageing population require adequate actions in the field of cancer, aimed mainly at prevention and early diagnosis, with possible equal access to them even in the smallest settlements.

In Vratsa District the mortality rate from blood diseases and diseases of the blood-forming organs is close to the national average (2.8‰ and 2.0‰, respectively). The mortality due to these diseases per 100,000 people is almost twice as high in Veliko Tarnovo (4.8‰), Sliven (4.6‰) and Stara Zagora (4.9‰).

Mortality from congenital anomalies in Vratsa District **was not registered** in 2012 and the mortality rates registered in 2013 (1.7‰) are **lower than the national average** (2.1‰). Mortality due to this group of diseases is higher in the districts of Razgrad (5.8‰), Sliven (5.1‰), Sofia District (3.3‰), Yambol (3‰), etc.

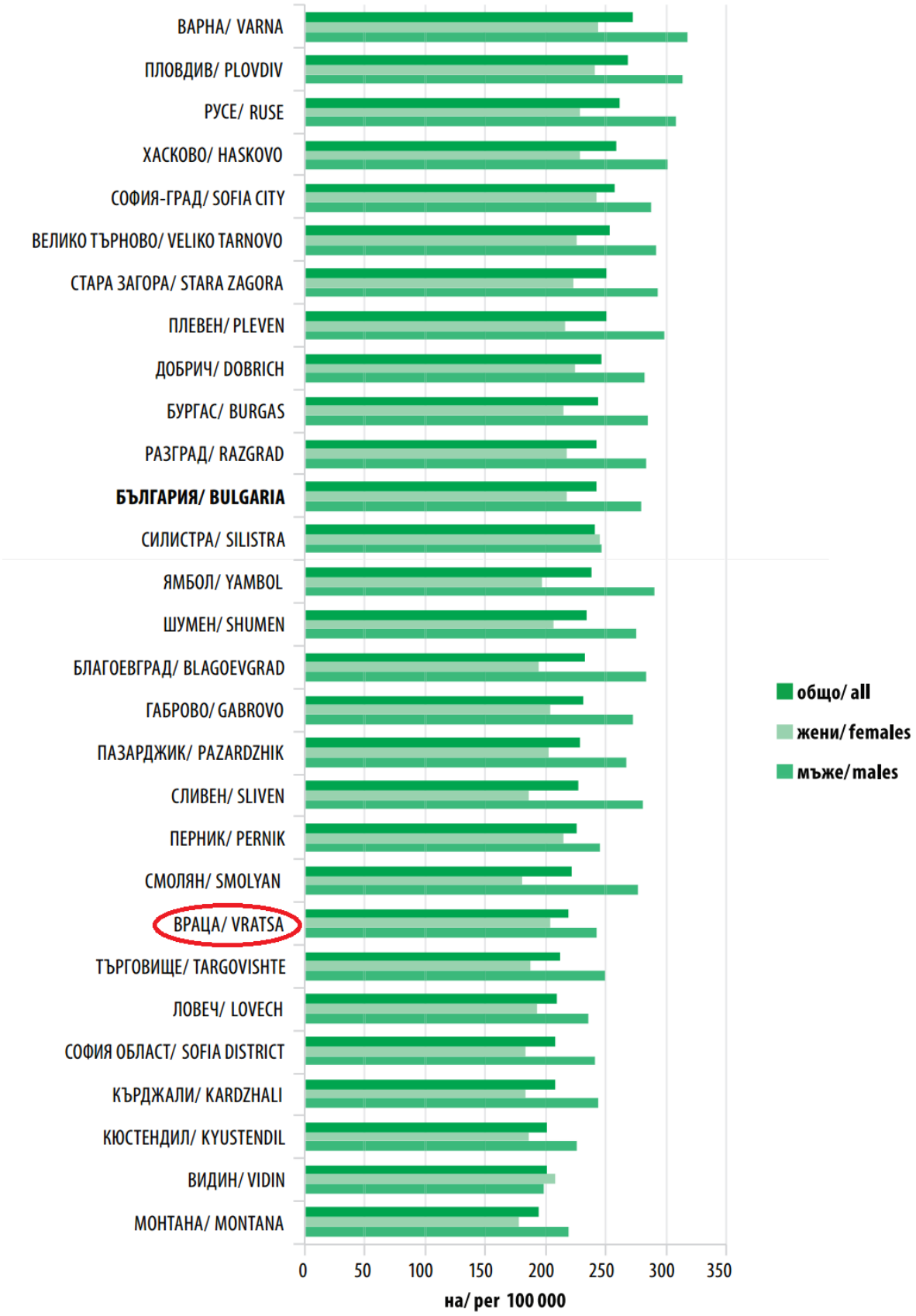

FIGURE 3.11-8 MORBIDITY RATES (STANDARDIZED UNDER THE GLOBAL STANDARD PER 100,000 POPULATION) FOR MALIGNANT DISEASES (C00 - C96, ICD10) BY GENDER AND DISTRICTS IN BULGARIA, 2011

3.11.3.5 HEALTH STATUS OF THE STAFF IN KOZLODUY NPP EAD

The health analysis for 2013 was provided by the head of the Occupational Health Service (OHS) – Dr. K. Serafimov, and by Dr. R. Yotova. The analysis was carried out by applying a complex methodology oriented towards the use of statistical information about the available factors of the environment and the working process as well as the absenteeism registered with a fit note.

The analysis has been prepared in accordance with the requirements of Ordinance № 3/25.01.2008 of the Ministry of Health and theMinistry of Labour and Social Policy (MLSP) and The Unified Methodology for Evaluating and Analysing the Health Status of Insured Workers (2001.).

The results from the analysis of the health status of the staff of Kozloduy NPP EAD cover the total average number of employees of the NPP – 3,987 people, from which:

- women – 1,265
- men – 2,722

Data on the employees on sick leave in 2013:

- Frequency of persons with registered disease (by fit notes): 1,287- 32.27 per 100 of the employees.
- Frequency of persons without registered disease (by fit notes) – 67.72 per 100 of the employees.
- Absolute number of cases (first /or only/ fit note) - total and by nosological structure, according to ICD 10 – 2,603 sick persons
- Number of days of temporary incapacity for work – 30,403 days
- Number of cases with temporary incapacity for work up to 3 days – 851, or 32.69%
- Number of employees with 4 or more cases of temporary incapacity for work – 239, or 9.18%.
- Number of employees with 30 or more days of temporary incapacity for work caused by disease – 287 or 11.02%.
- Number of newly registered occupational diseases – none
- Number of employees with registered occupational diseases - none
- Number of employees with decision of the Territorial Expert Medical Commission (TEMC) for a disease with permanent incapacity for work – 91 employees or 2.28%
- Occupational accidents in 2012 – none

3.11.3.5.1 FREQUENCY OF CASES WITH TEMPORARY INCAPACITY FOR WORK

In 2012, the frequency of cases in the Kozloduy NPP was 65.29 per 100 employees and is assessed as 'low' according to the indicative scale of assessment.

Frequency of calendar days lost due to temporary incapacity for work – 762.2 per 100 employees and is assessed as "low".

3.11.3.5.2 AVERAGE DURATION OF 1 CASE AND 1 PERSON WITH TEMPORARY INCAPACITY FOR WORK

The average duration of 1 case in 2012 was 7.62 days and is "lower" than the reference one – 10 days.

Employees with frequent and long sick leaves (EFLSL) with temporary incapability for work – in 2013 the group of employees with frequent and long periods of illness is represented by 526

employees, i.e. 17.60% of the average number of employees of the Kozloduy NPP, which is a "high" indicator.

The number of cases of temporary incapacity for work with duration up to three days was 851 cases, i.e. 21.34% or a “low” share.

In 2012, the number of workers with an expert decision of the TEMC was 46, of which the new cases were 11. The frequency of primary disability was 7,324 per thousand and according to the reference groups of Batkis - Lekarev it is "average".

3.11.3.5.3 DATA ON THE MANDATORY PERIODIC MEDICAL EXAMINATIONS PERFORMED IN 2013

→ Number of employees subject to mandatory periodic medical examinations: 3,987.

→ Number of employees who underwent mandatory periodic medical examinations: 3,271 or 82.04%

→ The number of diseases found during mandatory periodic medical examinations performed is 153.

→ The number of employees with diseases found during the mandatory periodic medical examinations performed is a total of 137

3.11.3.5.4 ANALYSIS AND ASSESSMENT OF THE INDICATORS CHARACTERIZING THE HEALTH STATUS OF EMPLOYEES:

→ Frequency of employees on sick leave due to a disease causing temporary incapacity for work: 32.3 (low)

→ Frequency of cases of temporary incapacity for work: 65.3 (low)

→ Frequency of working days lost due to temporary incapacity for work: 762.6 (low).

→ Average duration per case of temporary incapacity for work: 11.7.

TABLE 3.11-10 INDICATORS OF MORBIDITY RATES WITH TEMPORARY INCAPACITY FOR WORK BY GENDER

Indicators/ symptoms	Relative share of employees on sick leave	Frequency of cases	Frequency of days	Average duration per case	Relative share of EFLSL in %	Cases per single employee on sick leave	Days per singe employee on sick leave
total number	32.3	65.3	762.6	11.7	9.7	2.0	23.6
men	28.7	57.9	686.2	11.9	8.7	2.0	23.9
women	40.1	81.2	926.8	11.4	11.8	2.0	23.1

TABLE 3.11-11 INDICATORS OF MORBIDITY WITH TEMPORARY INCAPACITY FOR WORK BY AGE GROUPS

Indicators/ symptoms	Relative share of employees on sick leave	Frequency of cases	Frequency of days	Average duration per case	Relative share of EFLSL in %	Cases per single employee on sick leave	Days per singe employee on sick leave
Up to 25 years	39.8	107.5	823.7	7.7	12.9	2.7	20.7
25 – 35 years	39.3	83.2	753.5	9.1	10.0	2.1	19.2
36 – 45 years	31.3	61.8	683.6	11.1	8.6	2.0	21.8
46 – 55 years	31.0	63.2	758.8	12.0	10.2	2.0	24.5
over 55 years	30.2	56.6	1,022.3	18.1	10.4	1.9	33.9

→ Relative share of employees on frequent and long sick leaves: 9.7% (low)

→ Relative share of short-term temporary incapacity for work: 21.3% (low).

→ Frequency of employees with occupational diseases: No data has been provided.

→ Structure of employees with occupational morbidity by nosology: No data has been provided.

→ Frequency of employees with occupational accidents: 0.03.

→ Frequency of employees with morbidity with permanent incapacity for work: 2.28.

→ Frequency of persons with diseases found during the periodic medical examinations: 4.19.

3.11.3.5.5 ANALYSIS OF RELATION BETWEEN THE DATA ON MORBIDITY RATES AND THE OCCUPATIONAL ACTIVITIES, CONCLUSIONS AND RECOMMENDATIONS:

The indicators of morbidity with temporary incapacity for work (MTIW) primarily reflect temporary illnesses, leading to a temporary decrease in the capacity for work. To a considerable degree their frequency is influenced by the epidemic situation (presence of infectious diseases) during the year. The structure of MTIW in general coincides with the average data for the country, in the first place being acute viral infections, infections of the upper respiratory tract and acute respiratory diseases. The frequency and severity of these diseases is due on the one hand to the emergence of entirely new strains of the agents, and on the other to the increasing resistance to treatment of the known causes. Partly this is due to self-treatment.

The above mentioned are followed by diseases of the peripheral nervous system, discopathies and diseases of the bone-muscle system. In this case, in addition to the mechanical overloading (the International Classification of Diseases, ICD, includes a group of diseases related to overloading and pressure) the role of the age factor should be noted. With the increase of age the number of degenerative diseases of the bone system also increases.

The number of diseases of the gastrointestinal tract is relatively high and represents 1.05% of all employees. This is due to the irrational and irregular eating habits.

It should be noted that the number of first (or only) fit notes with malignant diseases is low - 5. Compared to the previous two years there is a decreasing trend in the frequency of malignant neoplasms.

Diseases of the cardiovascular system are an important part of the analysis of the temporary incapacity for work. They represent 1.05% of all employees. The reasons for this are outlined in the text below. The arterial hypertension is the most frequently registered disease during the performed prophylactic examinations. It was found in 1.2% of the examined people. This is mainly associated with unhealthy diet, obesity, adynamia, and smoking. Hereditary factors are also essential.

Analysing the frequency and severity of morbidities with temporary incapacity for work, it should be noted that they significantly coincide with those of 2012.

The entire staff of the NPP is subject to prophylactic examinations. Certain groups working in the control room are subjects to prophylactic examinations twice a year (every six months). The number of workers with newly found diseases represents a relatively small share of the total staff and amounts to 3.8%.

In conclusion, it should be noted that there is no direct relation between the registered diseases and the occupational conditions. The observations of the health status of employees at the Kozloduy NPP site have not indicated registered cases of radiation injury. In assessing the priority of the factors of production in the analysis of the MTIW, **the non-production factors such as health behaviour in the workplace and outside working hours, meals, and conventional risk factors should not be excluded.**

3.11.3.6 HEALTH AND HYGIENIC ASPECTS OF ENVIRONMENT AND RISK TO THE HUMAN HEALTH

3.11.3.6.1 NON-RADIATION RISK FOR THE POPULATION

The main sources determining the air quality in the area of the Kozloduy NPP and in the concerned zones around it are not radioactive pollutants, but industrial, and are as follows:

→ Workshops, productions and diesel generator stations at the plant;

→ The road transport servicing the plant;

→ Household sites in the area;

→ Industrial enterprises at and around the site.

The most significant source of air pollution in the area is road transport.

The presented in **section 3.1** results of the analyses of total suspended dust and major air pollutants such as SO_2, CO, NO_2, H_2S, methane and non-methane hydrocarbons, O_3 and NH_3 show that they are significantly below the limit values. Increased amount of nitrogen oxides are observed as a result of the transport traffic.

3.11.3.6.2 RADIATION RISK FOR THE POPULATION

There is a known method of assessing the potential impact of ionizing radiation, which is based on regulations approved by the Ministry of Health, developed by the NCPHA and the NCRRP in accordance with EU Directives, as well as on developments of the U.S. EPA 133, 134. The method consists of 4 separate stages:

1. Hazard identification
2. Dose-response assessment
3. Exposure assessment
4. Risk characterization

A more specific and updated method used worldwide is the proposed in the ICRP Publication 103 method for assessing the risk and damage from ionizing radiation. The ICRP introduces risk coefficients for stochastic effects, which are attributed per unit of dose. Since the dose of a certain ionizing radiation can be measured and/or assessed, it is not necessary to use the development of the US EPA. Thus all assessments of radio-biological risk are carried out in an identical way in all countries, and the assessed risk can be compared. The annual dose limits for employees and population are determined on the basis of these risk coefficients.

The ICRP introduces three terms to define the degree of acceptability of exposure or risk. The first term is "unacceptable", which means that the radiation during the performance of an activity or practice is not acceptable. The second term is tolerable and the third is acceptable. All these terms have their dose criteria. Dose limits are associated with the unacceptable risk. In the case of a member of the population, the level of risk acceptability according to the ICRP is one case out of 1,000,000 per year. The ICRP defines a total nominal risk coefficient for an adult of 4.2h10-2 Sv-1 for stochastic effects at radiation exposure under the annual dose limit for a member of the population.

In this case, if we take the average value in 2013 of the individual effective dose for a member of the population in the area (4.75 μSv/a) for radiation exposure, the risk of radio biological effect is $2x10^{-7}$ per year (4.75 μSv x $4.2.10^{-2}$), which is about 5 times below the acceptable risk of 10^{-6}.

As described in **section 3.9.3.,** there are a number of nuclear facilities in the area around the Investment Proposal that have controlled emissions in the environment and the radiation status of all components of the environment that could impact the population in radio-ecological aspect is monitored in accordance with the regulations in the BNRP-2012 and the Regulation for radiation

protection during activities with sources of ionizing radiation. Up to date the population in this area, near the Radiana site, is mainly subjected to potential radiation impact from the operation of the Kozloduy NPP. The background radiation in the area, at the time the impact assessment of the Investment Proposal was performed, comprised mainly gaseous emissions (from the ventilation pipes of the Kozloduy NPP and the building of the units and special buildings, located at the industrial site) and liquid discharges.

Gas and aerosol releases

The assessments of the population doses for 2012 were calculated in parallel with the meteorological data for the year and the data on the microclimate. The maximum individual annual effective dose within the 30-km zone from the gaseous releases (RNG + LRA + ^{131}I + ^{3}H + ^{14}C) of the Kozloduy NPP is estimated at $1.33x10^{-6}$ Sv/a with meteorological data. The annual collective effective dose was estimated to be $2.65x10^{-2}$ man.Sv/a. The normalized annual collective effective dose to the population of the 40-km zone from the gaseous emissions amounted to $1.47x10^{-2}$ man.Sv/GW.a. The calculated amount of radioactive noble gasses (RNG), LRA and ^{131}I for the Kozloduy NPP are fully comparable with the data for a large number of PWR reactors in the world (UNSCEAR-2000, 2008).

Liquid discharges

The collective dose to the population in the 30-km zone from liquid radioactive discharges in 2012 was estimated to be $4.7x10^{-3}$ man.Sv/a. The normalized collective dose per unit of electricity produced amounted to $2.61x10^{-3}$ man.Sv/GW.a. This radiation is only 13% of the average value for PWR reactors in the world: $2x10^{-2}$ man.Sv/GW.a. (UNSCEAR'2000).

The maximum individual annual effective dose within the 30-km zone is estimated to be $6.37x10^{-7}$ Sv/a, while to a representative of the critical group of the population along the Danube River (the town of Oryahovo, the village of Ostrov and the village of Gorni Vadin) it is $4.49x10^{-6}$ Sv/a. This radiation exposure is negligibly low and is below 0.5% of the annual effective dose limit of 1 mSv (BSRP-2012) and hundreds of times lower than radiation exposure from natural background radiation (2.33 mSv/a). Compared to the administrative quota for the limit of radiation from radioactive discharges from the new nuclear unit (NNU) under all operating conditions, defined to be 0.05 mSv/a (instructions of NRA with letter № № 47-00-171/12.02.2013), the maximum calculated dose is only 9%.

According to the annual report of the NRA for 2012, the results of radiation monitoring and the model assessments of public radiation exposure in the area of the Kozloduy NPP show that the maximum individual effective dose to the population from liquid discharges and gaseous releases into the hydrosphere and atmosphere, taking into account the contribution of ^{14}C and ^{3}H, was 5.82 μSv/a in 2012. In 2013, the estimated maximum individual effective dose to the population formed as a total from the gaseous and aerosol (with ^{14}C and ^{3}H) and the liquid discharges from Kozloduy NPP in the environment was 4.75 μSv/a. This radiation exposure from artificial background radiation is only 0.2% of the radiation exposure from natural background radiation for the country (2.33 mSv/a). In the last 5 years the estimated maximum individual effective dose from exposure to artificial background radiation to any person from the population, due to the operation of the Kozloduy NPP, has varied in the range 4 ÷ 7 μSv/a, which according to Article 8 of BNRP- 2012 is below 10 μSv/a and is not subject to regulation under the Act on the Safe Use of Nuclear Energy (ASUNE).

The assessed artificial background radiation doses to the population have been verified with the results from the measurements performed by the NCRRP/MH and are fully comparable with the values for other plants in the EU and worldwide (UNSCEAR and EURATOM reports). The mathematical modelling programme for assessment have been verified and validated, based on the CREAM methodology adopted by the EU, taking into account the specific characteristics of the area.

Examination of radiation exposure in childhood

In most cases, analysis of radiation impact on the child's body is different from that in adults, which affects the overall forecast for the health status of future generations.

In 2003 and 2012, under operating conditions of the Kozloduy NPP, the NCRRP performed examinations of children from the area in order to determine the possible variations in the thyroid gland.

The measurements in 2003 were performed in 150 children from Kozloduy, Oryahovo, Miziya, Selanovtsi and Harlets. The content of ^{131}I was assessed. The final analysis of the obtained results showed that there were no indication for the presence of artificial radionuclides in the body of the examined children, as well as no presence of ^{131}I in their thyroid glands. There were no difference in the spectral distributions and numerical values of the individual measurements between the control (pure) area and the area of the NPP. According to the comparison of the spectra of the measurements it can be said that in both areas the internal radiation exposure measured in the children was due only to natural radionuclides (^{40}K), which normally varies between individuals, according to the area and the biological indicators of the individuals. Regarding the ^{131}I, again no presence of radionuclides was detected in the thyroid gland. [90]

In 2012 an assessment of the content of radionuclides in the body of 180 children living in the surveillance zone of Kozloduy NPP (the town of Kozloduy, the town of Oryahovo, the town of Miziya and the village of Harlets) was performed. Direct whole body measurements were carried out for this purpose. Optionally, some adults were included in the test sample and so the measurements were carried out on 219 persons. [91]

The results showed that no presence of radioactivity caused by technogenic gamma emitting radionuclides was registered in any of the examined persons, both for the whole body measurements and the measurements of the thyroid gland of patients. Based on the obtained results it can be concluded that during its operation the Kozloduy NPP has been complying with the technological mode, and no contamination of the environment above the established norms and respectively exposure of the population to artificial radionuclides, which could lead to increase in the internal radiation exposure, has been allowed. Due to the fact that most of the parents of the measured children were employees of the NPP, the lack of intake of radionuclides allows the conclusion that sanitary checkpoint regime functions well and no transfer of activity from the plant to the homes of the employees is allowed.

Under the Action Plan on Environment and Health, Section 5 "Children’s Health and Environment", in 2013 the Inspection for Control of Nuclear Energy carried out measurements of the concentration of radon in the air in 2 schools in Miziya and Oryahovo. The results of the performed monitoring indicate that natural background gamma radiation in the area of PSFRAW (permanent storage facility for radioactive waste) and the area within the 6-90 km zone around the nuclear power plant was not affected by the operation of the nuclear facilities and did not differ from the local background gamma radiation typical for the respective areas. Radioactivity in air, water, soil, flora and fauna varied within normal limits. There were no deviations from the regulatory requirements for radiation protection. The annual effective dose from artificial background radiation exposure to the population living around the NPP and the PSFRAW is below 10 μSv according to the assessment, based on the results from the radiation monitoring in these

[90] Independent expert assessment of the content of technogenic radionuclides in the body of 150 children living in the area of the Kozloduy NPP, Contract assignment,Kozloduy NPP and NCRRP, 2003

[91] REPORT ON CONTRACT № 226000016 / 15.10.2012 BETWEEN KOZLODUY NPP and the NCRRP. "Independent expert assessment, by means of direct methods, of the content of technogenic radionuclides in the body of 180 children living within the 30-km surveillance zone of Kozloduy NPP EAD", 2013

areas. This indicates that no further measures are necessary to optimize the radiation protection of the population.

On the other hand, the analysis of the results from the health monitoring of the Kozloduy NPP for the period 1974-2012[92] has shown that there is a decrease in both the doses and the reported chromosomal damage. Even in terms of the micronucleus test, the level of control in 2007 was higher than that of the exposed individuals. The obviously strict radiological control, which is performed by the Safety and Quality Directorate of the NPP, the application of the ALARA principle and the decrease in the annual effective doses explain the good results from genetic research in recent years.

Monitoring of the area of Kozloduy NPP, of commercial food and drinking water has been carried out for years by the NCRRP[93]. The results indicate that natural background gamma radiation in the 6-90 km zone around the Kozloduy NPP is not affected by the operation of nuclear facilities and sites with SIR (sources of ionizing radiation) and do not differ from the local background gamma radiation typical for the respective areas. Radioactivity in air, water, soil, flora and fauna varies within normal limits. There are no deviations from the regulatory requirements for radiation protection.

The annual effective dose from artificial background radiation exposure to the population living around the Kozloduy NPP is less than 10 μSv according to the assessment, based on the results from the radiation monitoring in these areas. The additional radiation exposure to the population of the 30-km zone per year is an average of about 400 times lower than that received from natural background radiation (2,330 μSv/a). In recent years, the values of the maximum individual effective dose to the population has varied in the range 1÷4 μSv/a and has been below the level of 10 μSv/a, at which the control can cease, BSRP-2012.

3.11.3.6.3 RADIOBIOLOGICAL EFFECTS AND RADIATION RISK

Human exposure to ionizing radiation can cause various biological and health effects in terms of organotropy, severity and time of occurrence. Typical of the radiation damage is that it can occur in exposed individuals (somatic effects) or in their offspring (hereditary or genetic effects). Both malignant neoplasms and non-malignant diseases are associated with the somatic effects.

Generally, radiation effects are deterministic (non-stochastic, non-probabilistic or threshold-based) and stochastic (probabilistic or non-threshold).

The deterministic effects are characterised by the presence of a limit of the exposure dose, under which the effect is not clinically manifested. If the threshold is exceeded, the severity of the damage increases with the increase in the exposure dose. The manifestation of deterministic effects depends both on the exposure dose and the dose rate. The threshold doses for the occurrence of various deterministic effects depend on the radiation sensitivity of the tissues and organs. Deterministic or non-stochastic are some effects specific to individual organs, such as cataract (threshold dose of 0.15 Gy/y), non-malignant skin damage, etc.

The stochastic effects are characterised by the absence of a threshold dose for their occurrence. The biological effect increases with the increase of the dose intake, and its clinical manifestation requires a latency period. This is where all genetic (hereditary) effects belong, and from the somatic ones – the radiation-induced malignant neoplasms. It is precisely carcinogenesis that primarily determines the somatic risk from chronic exposure to low doses of ionizing radiation.

The main components of the harmful impact of ionizing radiation are the following stochastic parameters:

[92] NCRRP Radio-biological effects in occupational exposure in nuclear energy, 2013

[93] NCRRP Radioecological monitoring of working and living environment, 2013.

- → probability of lethal cancer (malignant);
- → probability of non-lethal cancer;
- → probability of severe hereditary effects and reduced life expectancy if the damage is manifested.

For people working in an environment with ionizing radiation, the following values of the so-called nominal probability coefficients for the occurrence of stochastic effects (**a total of-5.6x10-^{2} Sv^{-1})** have been defined, distributed by:

- → lethal cancer - $4.0x10^{-2}$ Sv^{-1}
- → non-lethal cancer - $0.8x10^{-2}$ Sv^{-1}
- → severe heredity effects - $0.8x10^{-2}$ Sv^{-1}

The probability for increased radiation-induced damage in irradiated individuals goes up with the increase of the received individual annual dose and the overall cumulative exposure dose received during the whole period of radiation exposure.

3.11.3.6.4 RADIATION RISK FOR THE POPULATION WITHIN THE 30-KM SZ AROUND THE SITE FOR THE CONSTRUCTION OF THE INVESTMENT PROPOSAL:

Deterministic effects

There is no risk of development of deterministic effects in the population within the 30-km zone of the Kozloduy NPP.

In recent years, the values of the maximum individual effective dose to the population has varied in the range 4÷7 μSv/a. Individual doses from gaseous and aerosol releases are within $7.18x10^{-9}$ ÷ $2.72x10^{-6}$ Sv.

These doses are much lower than the threshold set as a limit of the annual effective dose in accordance with Art. 10 of the BNRP, which is 1 mSv for the population.

The statement that there is no risk of developing deterministic effects for the population in the surveillance zone of Kozloduy NPP is based the above mentioned.

Stochastic effects

The probability of occurrence of radiation-induced cancer for the entire population is $2.01x10^{-8}$, while the probability for hereditary diseases is $7.32x10^{-10}$, i.e. the risk of stochastic effects is negligibly small.

In conclusion, it can be said that the current radiation situation, resulting from the normal operation of the existing nuclear facilities near the Radiana site, is within the limits of acceptability compared to the radiation risk per a member of the population.

3.12 SOCIAL AND SOCIO-ECONOMIC CONDITIONS. SOCIAL SIGNIFICANCE OF THE IP

3.12.1 SOCIO-ECONOMIC CONDITIONS

According to the NSI data, Kozloduy Municipality which is located in the Danubian Plain, occupies an area of 285 km^{2} with mostly flat terrain at 25 m elevation. The territory of the municipality falls within the so called *Zlatiyata* area.

The area is a typical agricultural area characterized by high productive grain production comprising mainly wheat, barley and maize (40% of the arable land), and less technical crops – sunflower (20% of the arable land). Vegetables and perennial crops are grown mainly in private agricultural holdings. The agricultural land comprises 84% of the total territory of the municipality. Animal husbandry is not well developed and is intended primarily for self-sufficiency of the population. The share of forest and other areas is much lower. The area is characterized mainly by the grain production. Four

agricultural cooperatives grow mainly wheat, barley and maize (40% of the arable land), less technical crops – sunflower, rapeseed and sugar beet etc. (20% of arable land). Growing of vines, potatoes and vegetables is concentrated in private agricultural holdings. Animal husbandry in the municipality is not well developed and is concentrated in the hands of private breeders. Leading livestock sectors are cattle, sheep, goat and poultry breeding.

Overall the structure of the industry is determined by the following subsectors: energy, construction, food industry, light industry.

Currently the town of Kozloduy is the centre of the nuclear energy industry and the local economy is mainly influenced by the presence of the Kozloduy NPP. Companies, most of which specialize in the construction (residential and industrial construction) and repair and installation activities, also operate within the municipality. These companies are located around the Kozloduy NPP and carry out their activities both at the units and sites of the NPP and on the territory of Northwestern Bulgaria.

Beside the energy industry, the main commodity productions of the industry by sectors are as follows:

- → Construction and processing industry;
- → Food industry - production of meat products, sausages, poultry meat products, flour, bread and pastries, eggs, forage;
- → Light industry - production of male and female clothing

There are 15 branches and offices of various commercial banks on the territory of the municipality.

After 2008, the indicators for the sectors of agriculture, forestry and fish-farming, construction, trade, repair of motor vehicles and motorcycles, hotel and restaurant industry, real estate, renting and business services, show some stability and an increasing trend is observed in some of them. A decreasing trend in the indicators is observed in the sectors of the processing industry, transport, storage and communications, human healthcare and social activities.

The Municipal Development Plan of Kozloduy Municipality for the period 2014-2020 considers the economic trends in Kozloduy Municipality and present and analysis of indicators for a seven-year period – from 2005 to 2011. (**Table 3.12-1**)[94].

TABLE 3.12-1 NUMBER OF ENTERPRISES WITH ACTIVITIES OUTSIDE THE FINANCIAL SECTOR

Sectors	2005	2006	2007	2008	2009	2010	2011
A. Agriculture, forestry and fish-farming	11	9	12	14	27	78	31
C. Process industry	12	16	17	20	19	18	17
D. Production, distribution of electricity and heat energy	1	3	4				
F. Construction	29	32	31	28	27	25	26
G. Trade, repair of motor vehicles and motorcycles	194	227	202	213	246	252	242
H. Transport, storage and communications	25	28	27	19	21	22	20
I. Hotel and restaurant industry	38	37	35	39	46	50	55
L. Real estate, renting and business services	14	20	22	5	6	7	12
P. Education	2	2	3	3	3	5	5
Q. Human healthcare and social activities	26	28	26	23	31	33	30
S. Other activities, social and personal services	9	11	14	13	21	22	20
Total for Kozloduy Municipality	**362**	**414**	**394**	**408**	**482**	**550**	**495**

[94]Municipality Development Plan for Kozloduy Municipality for the period 2014-2020, pp.:27-28

The data show that the largest relative share in the total number of enterprises belongs to the enterprises from the trading industry, repair of motor vehicles and motorcycles – 50.77%, followed by the hotel and restaurant industry the construction industry,– 9.67%. The enterprises producing and distributing electricity and heat energy have the smallest share.

Therefore, the largest share in the net incomes of Kozloduy Municipality belongs to the sector of production and distribution of electricity and heat energy - 78.98%, due to the undisputed economic leader in the municipality and the district – the Kozloduy NPP, the town of Kozloduy. The next in terms of contribution to the net income is the construction sector – 11.50%, manufacturing industry – 4.53% and trade, repair of motor vehicles and motorcycles – 3.38%, which together with the production of electricity comprise the main share of net income – 98.39%. Each of the other sectors generates less than one present of the total net incomes.

The data presented in **Table 3.12-2** show that the net income per inhabitant of Kozloduy Municipality is about four times higher than the same indicator in Vratsa District, which is due to the operation of Kozloduy NPP EAD, the town of Kozloduy.

TABLE 3.12-2 NET INCOME PER INHABITANT

	2009	2010	2011
Net income per inhabitant in Vratsa District (in thousands BGN)	11.45	11.11	12.55
Net income per inhabitant in Kozloduy Municipality (in thousands BGN)	43.14	43.42	47.08

3.12.2 LABOUR FORCE AND ECONOMIC ACTIVITY RATE

Kozloduy Municipality has the highest economic activity rate – 68.6%, 7.7 percentage points higher than that of the district, followed by Mezdra Municipality (66.2%) and Vratsa Municipality (64.7%). The employment rate in Kozloduy Municipality is also the highest – 56.6%, 7.4 percentage points higher than the average for the district, Vratsa Municipality (54.2%) and Mezdra Municipality (52.8%).

The data from **Table 3.12-3** [95] show that a decrease in the total amount of employed persons is observed, which is typical for the majority of sectors in recent years and is manifested mainly in the construction industry. An increase in employment is observed only in the sectors of agriculture, forestry, fish-farming and the hotel and restaurant industry.

Over the years, the **unemployment rate** in Kozloduy Municipality, although showing indications of decrease in absolute values (probably the significant migration of labour from the municipality should be noted here) has been higher than the national average, 5.0% and 7% respectively. The Programme for Management of Social Consequences after the decommissioning of Units 1-4 of the NPP has been developed against this background. Its main objective is to provide up to mid-2018 the prerequisites for reducing the negative impacts of this process by optimizing human resources in the process of decommissioning and requalification of the employees in the NPP.

TABLE 3.12-3 NUMBER OF EMPLOYED PERSONS BY SECTORS OUTSIDE THE FINANCIAL SECTOR FOR THE PERIOD 2005-2011

Sectors	2005	2006	2007	2008	2009	2010	2011
A. Agriculture, forestry and fish-farming	83	69	68	51	70	84	87
C. Process industry	957	1,032	1,021	1,044	1,146	1,067	1,056
D. Production, distribution of	5,045	4 897	4,747	4,563	4,452	4,118	4 13

[95] Municipality Development Plan for Kozloduy Municipality for the period 2014-2020, pp. 41-42

electricity and heat energy							
F. Construction	2,165	2,398	2,720	2,502	2,122	1,785	1,520
G. Trade, repair of motor vehicles and motorcycles	523	639	553	597	542	474	447
H. Transport, storage and communications	81	66	89	46	30	29	27
I. Hotel and restaurant industry	287	287	266	111	139	153	358
J. Creation and distribution of information and creative products, telecommunications	…	…	…	…	…	…	…
L. Real estate, renting and business services	…	…	…	…	…	…	…
M. Professional activities and scientific studies.	…	…	…	…	…	…	…
N. Administrative and support service activities.	…	…	…	…	…	…	…
O. State government	…	…	…	…	…	…	…
P. Education	…	…	…	…	…	…	…
Q. Human healthcare and social activities	255	278	234	192	201	195	190
R. Culture, sport and entertainment.	…	…	…	…	…	…	…
S. Other activities, social and personal services		82	96	12	17	14	12
Total persons employed	**9,610**	**9,748**	**9,877**	**9,558**	**9,177**	**8,680**	**8,414**

3.12.3 TOTAL HOUSEHOLD INCOME AND AVERAGE SALARY

The data on the average annual salary in Kozloduy Municipality, compared to the data for the district and the country, are used as an indirect indicator of the welfare of the population in the municipality. Statistical data published in the Municipality Development Plan for Kozloduy Municipality for the period 2014-2020 (p. 40) show that in 2011 the average annual salary in the municipality (18,330 BGN) was approximately twice as high compared to the values in Vratsa District (8,567 BGN) and the country (83,627 BGN). The indicators for Kozloduy Municipality are higher due to the higher salaries in Kozloduy NPP EAD.

Overall the negative aspects of the economy in the municipality according to the SWOT analysis in the "Municipal Development Plan of Kozloduy Municipality for the period 2014-2020" are:

- → High dependence of the local economy on the small number of large enterprises in the energy sector;
- → Inefficient institutional structure for the support of business development, as well as lack of means and mechanisms for such support at municipal level;
- → Existence of hidden unemployment.
- → Significant number of long-term unemployed women and youth;
- → Limited activity of the various stakeholders;
- → Insufficient quality of the labour force to meet the challenges of an economy based on knowledge.

3.12.4 CULTURE

The main activity in the field of culture is carried out by the community centres and the libraries to them. Five community centres and their libraries operate in the municipality – in the town of Kozloduy, the village of Harlets, the village of Glozhene, the village of Butan and the village of Kriva Bara, along with their 5 libraries.

The National Museum Steamship "Radetzky", as a branch of the National History Museum, carries out popularization and fund raising activity related to the life and work of Hristo Botev, the battle

route of Botev’s detachment, the national liberation movement, the study of cultural heritage etc., under the administration and financing of the Ministry of Culture. The Municipal Museum Collection “Kozloduy – the New Station of Bulgaria", dedicated to the local national liberation movement, was stared in May 2004.

The House of Energy under the Kozloduy NPP EAD is a cultural institute that meets the cultural needs of nuclear engineers and the population of the town and the municipality. The created artistic and creative groups (theatre, ballet, folk dance, etc.), the language and music schools, as well as the art studio contribute to broadening the cultural worldview of the population in the municipality.

There is a monthly publication – Ot I Za Obshtinata (From and About the Municipality), and the idea is for the bulletin to be published once a month presenting the most important events in the municipality, opinions of citizens, decisions of the meetings of the Municipal Council, etc. The newspaper Kozloduy Dnes (Kozloduy Today) – private edition, the information portal www.kozloduy-bg.info and the local TV channel VIZH TV have been developing their activity for several years.

The only private radio is Elto with a registered office at the town of Kozloduy and range expanding beyond the territory of the municipality

3.12.5 EDUCATION AND HEALTHCARE

A network of schools and kindergartens is located in each of the five settlements in the municipality except for the village of Kriva Bara, where there is no school. The schools’ facilities are designed especially for the purpose and meet the sanitary requirements, making them competitive in terms of the choice of school and education opportunities.

The location of the school network allows each settlement to provide compulsory education for children up to 16 years (except for the village of Kriva Bara), as well as day-care for children aged 1 to 7 years in kindergartens.

Good educational conditions have been created for students and children. The schools’ facilities are optimally organized for the purposes of the qualitative educational process. They are designed especially for the purpose and meet the sanitary requirements, making them competitive in terms of the choice of school and education opportunities. The municipality has:

- → 8 kindergartens (3 full-day kindergartens and 5 kindergartens with nursery), covering 716 children in preschool age and 88 infants and toddlers, and 1 facility for out-of-school-hours childcare .
- → 6 schools divided by level of education as follows – 1 primary school (Kozloduy), 3 middle schools (the village of Butan, the village of Glozhene, the village of Harlets), 2 secondary schools (the town of Kozloduy), 2 vocational schools (the town of Kozloduy, the village of Butan). During the academic year 2009/2010 2,834 students were taught in a total of 129 classes. It is noteworthy that the overall demographic trend is reflected in a permanent decrease –from 2007/2008 academic year to 2009/2010 academic year the children of school-age decreased by 269 (a fact which once again highlights the negative trends in the demographic processes in the municipality).

The following institutions can be found on the territory of Kozloduy Municipality: one multiprofile hospital for active treatment with 80 beds – MHAT "St. Ivan Rilski EOOD, in the town of Kozloduy, the Occupational Health Service of Kozloduy NPP, 4 diagnostic consultative centres and 11 General practitioners (8 in Kozloduy and one for each of the village of Harlets, Glozhene and Butan), dental centre and consulting offices in the villages and 9 pharmacies.

The Social care facilities (nursing homes, day centres for children and adults with mental disabilities, social service offices, disabled clubs, public kitchens etc.) in the Vratsa District are 8 with a capacity for 2,100 people.

3.12.6 SPORT AND TOURISM

There is a well maintained sports hall and stadium in the town of Kozloduy. There are stadiums constructed in all of the villages, which are managed by the municipalities. Currently, a project for the "Construction of the Hristo Botev stadium and a sports complex in the town of Kozloduy and reconstruction and modernization of the sports complex the village of Butan, Kozloduy Municipality" is in the process of implementation.

There is a well maintained equestrian sport base offering sport activities and a training school in the village of Butan. Football and table tennis are well developed sports in the municipality. Handball and chess are well developed in the village of Glozhene, while volleyball, football, taekwondo, judo, kick-boxing, badminton, etc. are among the well-developed sports in the town of Kozloduy.

Two outdoor sport grounds with artificial covering are operating on municipal territory – in the town of Kozloduy and the village of Glozhene along with 2 tennis courts in the town of Kozloduy.

The sports complex owned by the Kozloduy NPP creates excellent opportunities for swimming sports, with its two swimming pools – one indoor and an Olympic-size outdoor pool.

The tourist infrastructure is poorly developed, the accommodation facilities have few beds and the nights spent are also few.

The hotel and restaurant industry indicates certain development, though qualitative changes in the level of service are required. Most of the accommodation facilities are privately owned, but the private entrepreneurial activity of citizens is not sufficiently developed.

The municipality has a Tourism Development Programme for the period 2008-2011 related to the historical complex "Botev Pat", the National walking tour "In the footsteps of Botev’s detachment Kozloduy -Okolchitsa", some interesting cultural sites such as the church "Sv. Troitsa" in the town of Kozloduy, "Sv.Voznesenie" church in the village of Butan, "Community Centre Hram-pametnik Hristo Botev – 1879" in the town of Kozloduy, the Roman excavations "Augusta", as well as to the possibility of development of water tourism in the Danube River, sports competitions and horse-riding in the equestrian base in the village of Butan, ecotourism associated with the wetlands along the Danube River.

Overall, the economy in Kozloduy Municipality is highly dependent mainly on the NPP. Since only Units 5 and 6 of the NPP are currently operational, an increase in hidden unemployment dominated by low-educated unemployed people is possible to occur, regardless of the relative decrease in the number of unemployed registered in labour offices (unemployment rates in the area are higher than the national average), according to the data on the reduced employment and negative population growth rates. On the other hand, agriculture is not particularly significant for the local economy and cannot provide employment to these people in case of any loss of work.

Due to the decommissioning of nuclear units of Kozloduy NPP and the permanent upward trend of uncultivated lands in the new economic environment, the socio-economic conditions are currently degraded.

In conclusion, **it should be emphasized that at the background of the above described demographic and socio-economic trends, the Investment Proposal has a pronounced health and social significance due to the potential for achieving effective RAW management and control. The construction and operation of the NDF will lead to the opening of additional job positions as a result of which positive social impact is expected. Given the nature of the property, on which the IP will be constructed, involuntary resettlement is not expected, since the area, necessary for the implementation of the investment plan (46 hectares), is within the boundaries of state/municipal property.**