4.2. Potential Impact on Air

4.2.1. General Data

4.2.1.1. Climate and Meteorological Characteristic Data on the Cernavoda NPP Site

The data sources for this section are the meteorological studies elaborated by INMH (now the National Administration for Meteorology) on the basis of the recorded meteo data at Cernavoda during 1986 - 2003 (Ref. 4.2-2, 4.2-3, 4.2.4, 4.2-5, 4.2-11).

The climate at Cernavoda and in the neighboring regions (the Danube and the Romanian Plains in the west, and the Dobrogea Plateau in the east, crossed by the Danube – Black Sea Canal), is continental, being characterized by (Ref. 4.2-1):

- maximum thermic amplitude of about 68 °C;
- average thermic amplitude of about 23 °C;
- long time sun shinning with an average value of 2200 hours /year;
- low precipitation values versus the other regions of the country: about 500 mm/year (aridity zone I).

Air circulation is mainly channeled along the Danube Valley (north - south) but quite frequently air circulation also occurs on the Romanian Plains direction (east - west). Higher, the air circulation direction is mainly west-east.

Also due to the Danube vicinity, there are the foggy days number per year and a breeze phenomenon during the warm season. The region is semi-arid for vegetation.

As regards meteorological phenomena, the findings are the following (Ref. 4.2-5):

- **fog** is a meteo phenomenon occurring in all months of the year. The lowest number of foggy days is in the warm season, with averagely 0.7 days in June and 0.8 days in July, increasing to 7.7 days in November and 9.1 days in the cold season (in January).

- **hoar frost** is a typical phenomenon for winter days, being present at the beginning and the end of spring, but also at the end of autumn. At Cernavoda, the greatest number of hoar frost days is averagely 3.2 recorded in January. The annual number of hoar frost days is 6.6.
- **glazed frost** is also a winter meteo phenomenon, occurring at the beginning of spring (0.2 days in March) or the end of fall (0.8 days in November). In January and December, the number of glazed frost days exceeds 2. At Cernavoda, the number of glazed frost days is averagely 5.3 annually.
- **windstorms** are meteo phenomena occurring in all months of the year, except winter. Monthly average number increases from 0.1 days at the end of winter and beginning of spring, reaching maximal values in July (5.3 days) and continuously decreasing till November-December, when this phenomenon is not recorded. Annually, 21.1 windstorm days are recorded averagely.
- **blizzard** is a winter phenomenon. The greatest number of blizzard days is 0.7 in December. The annual number of blizzard days is 3 averagely.

4.2.1.2. Data Regarding Temperature, Precipitations, Dominant Wind, Solar Radiation, Pollutants Transport and Diffusion Conditions

Air Temperature

Monthly average air temperature at the Cernavoda meteo station varies from month to month. In the first part of the year, the monthly average temperature is increasing from the minimum in January (- 0.3 °C) to the maximum in July (23.3 °C). Differences from a monthly value to the next one are between 1.7°C and 5.8 °C. Regarding the second part of the year, air temperature is decreasing from August till January, and the decrease steps from one month to the next are between 5.9 °C and 0.7 °C (Table 4.2.1-1).

The average value of air temperature at the Cernavoda meteo station during 1986-2003 is 11.4°C, and the annual average amplitude is 23.6°C.

Sometimes, the first days with **maximum temperature** over 30°C can be in April, their frequency being very low, of 0.1 days average value. Most tropical days are recorded in July and August, when the average number exceeds 15 days. The tropical days number decreases rapidly to an average number of 2.7 days in September and 0.5 days in October. The annual average number of days with maximum temperature equal or higher than 30°C at the Cernavoda meteo station is about 43 days (Table 4.2.1-1).

The **absolute maximum temperature** recorded at the Cernavoda station was 43 °C, on 31 July 1985, due to a very warm tropical-continental air invasion. Table 4.2.1-1 shows that maximum temperatures sometimes in winter months are (due to a warm air invasion) much higher than the respective monthly average temperatures. For example, 18.6°C were recorded in January 2001, much higher than the average of -0.3 °C for this month.

The **absolute minimum temperature** recorded at the same station was -24.6°C, on 5 February 1954 (Table 4.2.1-1). The absolute minimum monthly temperatures had positive values from May till September.

The occurrence probability of such extreme temperatures (maximum and minimum values) is presented in Table 4.2.1-2 (Ref.4.2-4).

The **daily variation of air temperatures** during 1986-2003 shows maximum values at the hours 14-15 in all seasons and a minimum values that are change from season. In winter, the minimum value is recorded approximately at 1-2 hours before sun rise (6-7 hours), and in summer it corresponds to sun rise (4-5 hours). The daily amplitude of air temperatures is influenced by the annual cycle of solar radiation. Thus, the average daily amplitude in August is 10.2°C, and only 3.5°C in December.

Precipitations

The multiannual average of the annual precipitations quantities recorded at the Cernavoda meteo station during 1986-2003 was 453.9 mm. The rainiest month is June, the precipitations average quantity being 60.8 mm. The driest months are February and January with 19.3 mm and 21.4 mm (Table 4.2.1-3).

The greatest monthly precipitations quantities are observed after 1991, and especially after 1996, when the precipitation quantities were twice or three times the multiannual monthly average values. An exception is August 1999, when the monthly quantity of 170.9 mm was five times greater than the August multiannual average value during 1986-2003. The greatest annual precipitations quantity fallen during 1986-2003 was 706.1 mm, in 1999 (Table 4.2.1-3).

The **maximum precipitations quantities fallen in 24 hours**, during 1986-2003, are compared with the values in the extended period 1898-2003. The values from the interval 1986-2003, presented in Table 4.2.1-4, are generally lower than those from the extended period with up to 10 mm in May, June, September and November, with 10 up to 50 mm in January, March, August and December, and with more than 50 mm in February, July and October. The absolute maximum quantity of precipitations fallen in 24 hours was recorded after 1986 only in April (it was 51.3 mm on 12 April 1987).

The **average snow layer thickness specified for ten days intervals**, during 1986-2003, varied from year to year at the Cernavoda station, due to air temperature and soil temperature and to different precipitations quantities fallen as snow. These values are presented in Table 4.2.1-5.

Regarding **the maximum snow layer thickness specified for ten days intervals**, the data during 1945-2003 show that, in general, the snow quantities are not very big (Table 4.2.1-6).

The values of the annual maximum snow layer thickness with different re-occurrence periods show that the occurrence probability of a snow layer with a thickness ≥90 cm is 1% (i.e. 1 case at 100 years), and the occurrence probability of a snow layer with a thickness of 36 cm is 20 % (1 case of 5 years) (Table 4.2.1-7).

Dominant Wind

Analyzing the **wind frequency on 16 directions**, calculated during 1986-2002, it is noticed that for Cernavoda area, the most frequent winds are from north and west with an annual frequency of 10.9 % and 8.8 % respectively, followed by the east winds (7.1 %), the annual frequencies for the other directions being between 1.7 - 5.8 % (Table 4.2.1-8).

During winter months, the dominant wind directions are from north and east, ranging between 0.5-13.6 %. In April and May, the eastern direction is dominant (10.3-10.7 %). During summer months, the dominant wind direction is from north (10.3-11.6 %), and the frequencies from east and west sectors are between 5.0-9.7 %. During autumn, the greatest wind frequency is from north (8.3-12.2%).

Atmospheric calm has an annual average frequency of 25.3 %, monthly values between 20-30 % (monthly average values), with a minimum value in April (19.7 %) and a maximum value in August (31.6 %) (Table 4.2.1-8).

The **wind speed frequency for speed intervals** shows that the greatest frequency is within the 2-5 m/s interval, with an annual percentage of 45.8 % and high monthly frequencies during the whole year, between 39.5 % in February and 51.6 % in June (Table 4.2.1-9).

Regarding the hourly average **wind speed** at the hours 1, 7, 13 and 19, it is noticed that the speeds range most often between 2-4 m/s during the interval May-October (for all the four observation hours and irrespective of the wind direction), while the speeds are higher being between 3-7 m/s during the November-April interval (Ref.4.2-4).

The **annual average wind speed** in the Cernavoda area ranges between 2.6 m/s from south-south-west and 5.1 m/s from north. In winter, though the wind speed is high, due to the baric gradient high values, in the periods in which anticyclone and the air stable stratification regime are present, calm conditions are dominant. In spring, the wind speed is generally 3-5 m/s. During summer and at the beginning of fall, the wind speeds are lower than in the rest of the year. During the whole year, the highest wind speeds are recorded from north and east (Table 4.2.1-10).

The **maximum wind speed** in the Cernavoda area, recorded in January 2000, was 20 m/s from north. The highest wind speeds in the other months were between 14-18 m/s.

The gale of wind at Cernavoda, during 1986-2003, had annual maximum speeds of 18-24 m/s, the maximum value being recorded in December 1991. During a year, the gale of wind had maximum speeds between 16-18 m/s in the May-October interval, 20 m/s from January till April, and 24 m/s in December.

Once at 100 years, maximum wind speed of 42 m/s and gale of wind of 48 m/s may occur at Cernavoda (Table 4.2.1-11).

On 12 August 2000, a great squall phenomenon (occurring at the contact of polar air with existing warm air) was recorded at Facaieni (a locality in the Ialomita County), having an important intensity (judging by its effects). The national network meteo stations in the vicinity of that locality did not identify that phenomenon.

Solar Radiation

Direct solar radiation is a part of solar radiation, reaching the ground surface as parallel rays coming directly from the Sun.

In Romania, direct solar radiation is measured by a network of radiometrical stations, and the closest stations to Cernavoda are the stations at Bucharest and Constanta. Because the radiometric station at Constanta provides local information specific to that area, the Bucharest radiometric station was chosen for the Cernavoda area, due to similar meteorological conditions with the area of interest.

The Bucharest - Afumati radiometric station is located on the north-east direction from Bucharest, at 8 km distance on the Bucharest - Urziceni road, in a partially constructed area.

Direct solar radiation is measured by an AT 50 thermoelectric radiometer.

The intensity of solar radiation at ground surface is influenced by its optical path through the atmosphere, depending on the solar high values. The longer the radiation way is, the stronger the diminution processes are, resulting in the daily and annual variation of the solar radiation intensity at ground surface. The sun high varies over the year, being maximum in June at summer solstice and minimum at winter solstice, variation due to Earth - Sun geometry.

The measurements regarding direct solar radiation rate are performed at the hours 6, 9, 12, 15, 18 solar time (TSA) for Bucharest published in the Astronomic Yearbook. The multiannual average values of the direct solar radiation rate are presented in

Table 4.2.1-12. The daily variation is upward in the first part of the day, reaching the maximum value at mid-day, and downward in the second part of the day.

The optical characteristics of the atmosphere influence the values of the direct solar radiation. Even thin canvas of Cirrus or Altostratus clouds can substantially diminish the direct solar radiation values. The influence of these phenomena is observed in the solar radiation absolute extreme values in Table 4.2.1-13. This table shows that solar radiation can reach values higher than 900 Wm^{-2}. The solar radiation values at the atmosphere upper limit vary between 1326 and 1415 Wm^{-2}, and the average solar constant value is 1370 Wm^{-2} (Ref.4.2-4).

Transport Conditions and a Pollutant Diffusion

The estimation of the air pollutants concentrations due to emission from a source needs information about atmospheric dispersion possibilities in that area. The main meteorological parameters which determine the pollutants diffusion are the wind direction and speed, and the thermal stability of the atmosphere. The wind causes the horizontal transport, and the atmospheric stability determines the pollutants dispersion in the atmosphere. The thermal stability depends on the vertical distribution of air temperature.

The meteorological data presented for Cernavoda meteo station were based on measurement results obtained at 4 daily terms during 18 years of observations (1985 - 2003).

The occurrence frequency of stability categories on wind speed classes presented in Table 4.2.1-14 shows that the meteo state characterized by neutral thermal stability and wind speed >1 m/s occurs at Cernavoda station with a frequency of 41.06 %

Table 4.2.1-15 shows that unstable state of the atmosphere (A, B, C classes) presents the greatest frequencies in May-August, neutral class D in November-April, and the stabile state (E, F classes) in August-October. In all the months, the neutral state D has the greater occurrence frequency of 6 % in January and 2.35 % in August. Analyzing the annual average frequency of stability classes (Table 4.2.1-15) is noticed that, the occurrence frequency of neutral stratification class (D) is 50.50 %, stable (E and F classes) 29.16 % and unstable (A, B, C classes) 20.33 %.

The occurrence frequency of stability categories on the main wind direction at Cernavoda meteo station presented in Table 4.2.1-16 show that the unstable stability (A, B, C classes) occur with the great frequency on NNE, ESE, WNW and SSE directions. The neutral stability (D class) occurs more frequent on NNE, WNW, and ESE directions. The stable thermal stability (E, F classes) occurs with most frequencies on WNW, W and NNE directions.

From the analyses of meteo parameters speed, wind direction and thermal stability of the atmosphere is noticed that in Cernavoda town area exits slightly pollutant dispersion conditions due to the great occurrence frequency of atmospheric calm conditions of 25.3 % (Ref. 4.2-4).

ANM developed the calculations for the atmospheric dispersion of pollutants released through one unit stack of Cernavoda NPP on a radius of 30 km around the Plant (Ref.4.2-4). Fig. 4.2.1.2-1 shows the values of the dispersion parameters (χ/Q) for the meteo data obtained by Cernavoda Meteo Station during 1986-2003.

Table 4.2.1-1. Air temperatures (℃), 1986 - 2003

Months												Annual values
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
a. Annual and monthly average temperatures												
-0.3	1.4	5.2	10.8	16.6	21.0	23.3	22.6	17.4	11.8	5.9	0.5	11.4
b. Number of days with temperature ≥30℃ (tropical days)												
			0.1	1.5	7.9	15.3	15.2	2.7	0.5			43.2
c. Absolute maximum temperatures												
18.6	24.2	30.1	33.1	38.4	37.5	43.0	42.2	37.0	35.8	26.4	20.1	43.0
2001	1995	1952	1998	1950	2001	1985	1945	1946	1952	2000	1989	31.VII.1985
d. Absolute minimum temperatures												
-23.8	-24.6	-14.0	-3.5	1.3	5.7	9.3	6.8	2.1	-5.7	-12.5	-21.6	-24.6
1947	1954	1987	1995	1949	1951	1948	1949	1951	1948	1953	1948	5.II.1954

Table 4.2.1-2. Annual maximum and minimum air temperatures with various probabilities of occurrence

Occurrence probability (%)	**1**	**2**	**5**	**10**	**20**
Re-occurrence period (years)	100	50	20	10	5
Maximum values (℃)	44.2	42.9	41.3	39.9	38.5
Minimum values (℃)	-28.7	-26.4	-23.5	-21.0	-18.4

Table 4.2.1-3. Average annual and monthly atmospheric precipitations quantities (mm), 1986 - 2003

Months												Annual values
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Average annual and monthly quantities												
21.4	19.3	31.7	38.5	41.8	60.8	40.7	34.7	53.4	34.3	37.4	32.5	446.5
The highest annual and monthly quantities												
47.0	62.8	85.0	73.4	107.0	111.0	110.8	170.9	120.3	68.0	70.1	62.9	706.1
2003	1996	2002	1997	1991	1999	1997	1999	2003	1986	1997	1996	1999

Table 4.2.1-4. Maximum quantity (mm) of precipitations fallen in 24 hours

Period	Monthly values												Annual values
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1899 – 1916, 1921 - 2003	56.6	77.1	50.1	51.3	50.3	69.4	103.5	82.4	65.0	144.0	39.5	60.0	144.0 5.10.1945
1986 - 2003	20.6	24.8	31.7	51.3	45.3	60.6	47.6	48.6	61.4	48.2	35.9	16.6	61.4 2.09.1999

Table 4.2.1-5. Average snow layer thickness (cm) specified for ten days intervals, 1986 - 2003

Month	January			February			March			April			November			December		
Interval	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Average thickness	11.8	8.8	4.2	5.9	4.6	3.4	7.5	3.6	0.3	1.0	-	-	-	-	3.3	1.8	6.4	3.8

Table 4.2.1-6. The maximum snow layer thickness (cm) specified for ten days intervals, 1944 - 2003

Month	January			February			March			April			November			December			Annual
decade	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
maximum	40	31	46	55	90	138	90	33	5	8	2		8	6	39	46	32	35	138
year	02	02	58	54	54	54	54	93	69, 95	03	92		80,81	83	73	80	91	89	1954.II.19

Table 4.2.1-7. Annual maximum thickness of snow layer with various probabilities of occurrence

Occurrence probability (%)	1	2	5	10	20
Re-occurrence period (years)	100	50	20	10	5
Snow layer thickness (cm)	90	78	63	57	36

Table 4.2.1-8. Average monthly and annual wind frequency (%) on 16 directions (1986-2002)

Direction	Monthly values												Annual values
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
N	11.9	10.5	13.6	6.7	8.3	10.3	13.9	11.6	8.3	12.2	11.2	13.3	10.9
NNE	3.2	3.2	4.4	2.9	2.8	2.3	2.2	2.5	2.8	3.5	2.1	2.9	3.0
NE	2.3	4.6	5.9	3.7	3.6	2.3	2.8	2.7	2.7	5.8	2.8	3.0	3.6
ENE	1.8	2.1	3.4	3.2	3.2	2.2	2.3	3.3	3.0	3.4	1.3	2.4	2.9
E	4.4	5.7	8.2	10.3	10.7	7.0	8.1	9.2	7.6	7.2	4.2	3.6	7.1
ESE	1.1	1.7	2.8	6.4	6.0	3.8	3.8	4.3	4.3	3.0	3.4	1.2	3.7
SE	1.2	3.5	3.8	9.5	7.2	4.8	4.7	4.2	5.3	4.7	5.1	1.5	4.7
SSE	1.3	2.1	4.4	5.0	4.8	3.9	3.1	2.8	4.6	2.6	3.9	1.5	3.3
S	3.4	3.5	4.3	4.7	4.6	5.0	3.3	3.1	3.7	2.8	3.5	4.4	3.8
SSW	0.8	1.8	2.2	1.9	2.3	2.1	0.7	1.0	1.4	1.9	1.3	2.0	1.7
SW	3.9	5.4	2.5	3.1	2.1	2.9	1.6	1.3	2.1	2.3	2.6	3.3	2.8
WSW	11.5	7.9	6.0	5.1	3.7	4.9	3.9	2.2	5.5	4.4	6.8	7.6	5.7
W	13.6	12.1	6.7	7.4	6.8	9.7	7.8	5.0	7.8	6.9	9.6	13.1	8.8
WNW	3.7	2.0	3.0	2.9	3.1	4.0	3.5	3.0	3.4	2.7	3.3	2.5	3.1
NW	3.9	2.5	2.9	2.8	3.4	6.0	6.1	3.9	4.4	3.6	3.1	3.8	3.9

NNW	4.9	3.7	5.1	4.6	5.6	7.5	7.3	8.3	4.7	6.2	5.7	6.5	5.8
Calm	27.1	27.7	20.7	19.7	21.7	21.3	24.7	31.6	28.1	26.8	30.0	27.6	25.3

Table 4.2.1-9. Average monthly and annual wind frequency (%) as per wind speed intervals (1986-2002)

Speed interval (m/s)	Monthly values												Annual values
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
0-1	36.2	36.1	28.4	27.7	29.8	30.5	34.8	39.0	37.7	37.1	39.6	36.8	34.5
2-5	45.5	39.5	43.2	42.0	48.2	51.6	50.7	48.4	46.6	47.7	42.5	43.2	45.8
6-10	16.7	22.6	26.4	28.8	21.6	17.6	14.3	12.5	15.3	14.7	17.2	17.8	18.8
11-15	1.8	1.5	2.0	1.4	0.3	0.3	0.2	0.1	0.3	0.4	0.8	1.8	0.9
16-20	-	0.3	-	0.1	-	-	-	-	-	-	-	0.4	0.1

Table 4.2.1-10. Annual and monthly average wind speed (m/s) on directions (1986 - 2002)

Directions	Monthly values												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
N	5.4	6.5	5.6	4.9	4.3	4.4	6.0	3.7	4.3	4.4	5.7	5.7	5.1
NNE	4.2	5.9	4.8	4.3	4.8	3.3	3.5	3.8	3.5	4.2	4.4	5.1	4.3
NE	5.6	5.8	5.6	4.5	4.6	3.6	3.5	3.9	3.7	4.5	4.8	5.8	4.7
ENE	6.0	5.4	5.4	5.5	5.1	3.9	3.9	3.9	3.8	3.8	4.9	5.7	4.8
E	5.1	4.7	5.5	5.8	5.1	4.7	4.4	4.1	3.7	4.3	4.4	6.2	4.8
ESE	4.1	4.9	4.7	5.8	4.4	4.6	4.3	3.9	3.8	4.3	5.0	5.1	4.6
SE	3.8	4.2	5.0	5.1	4.7	4.2	3.8	3.7	4.2	3.5	4.0	3.5	4.1
SSE	3.7	5.6	4.7	5.2	4.2	3.9	3.4	3.6	3.7	2.8	3.9	2.7	3.9
S	3.6	4.1	3.4	3.7	3.4	3.3	3.2	2.4	3.3	2.7	2.9	3.1	3.3
SSW	2.8	2.7	2.9	2.6	2.5	2.5	2.2	2.0	3.9	2.1	2.0	3.0	2.6
SW	2.8	3.3	3.1	3.1	3.1	2.8	2.6	2.5	2.9	2.0	2.5	3.2	2.8
WSW	3.5	3.5	3.1	4.0	3.4	2.9	2.6	2.4	3.1	2.5	2.7	3.2	3.1
W	3.6	3.8	3.9	3.8	3.4	3.8	3.0	3.5	3.6	3.1	3.3	3.6	3.5
WNW	2.8	3.4	2.9	2.9	2.9	3.1	3.3	4.4	3.5	2.7	2.5	2.9	3.1
NW	3.2	3.3	3.8	4.0	3.4	3.4	3.5	3.5	3.9	3.4	4.2	2.9	3.5
NNW	3.3	4.5	4.6	4.0	3.5	3.5	3.3	3.7	3.4	3.5	3.5	3.9	3.7

Table 4.2.1-11. The maximum gale wind speed with various occurrence probabilities

Occurrence probability (%)	20	10	5	2	1
Re-occurrence period (years)	5	10	20	50	100
Wind speed (m/s)	27	31	34	39	42
Gale wind speed (m/s)	31	35	39	44	48

Table 4.2.1.-12. The multiannual average values of the direct solar radiation rate to ground surface (Wm^{-2}), at the Bucharest station, during 1961-2003

Hour	Monthly values											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
6				237	363	475	370	283	188			
9	404	523	593	649	670	705	684	677	649	593	482	398
12	579	649	698	746	753	768	747	747	740	719	635	544
15	390	523	614	642	670	684	670	663	621	579	482	356
18				216	335	377	349	237	167			

Table 4.2.1-13. Absolute extreme values of direct solar radiation to ground surface (Wm^{-2}), at the Bucharest station, during 1961-2003

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Maximum	879	949	970	970	942	928	963	928	977	921	866	956
Minimum	147	161	168	188	121	178	156	179	151	193	175	137

Table 4.2.1-14. Occurrence frequency (%) of stability classes for various speed classes

Speed classes	Frequencies of stability classes					
	A	B	C	D	E	F
1	1.17	1.35	0.00	2.74	0.95	3.12
2	0.57	1.22	2.32	5.75	1.94	4.72
3	0.00	1.32	1.40	5.39	2.95	0.00
4	0.00	1.15	1.61	5.11	2.87	0.00
5	0.00	0.00	0.68	6.02	0.00	0.00
6	0.00	0.00	0.53	5.44	0.00	0.00
7	0.00	0.00	0.12	4.31	0.00	0.00
8	0.00	0.00	0.15	9.04	0.00	0.00
Calm	3.16	3.57	0.00	6.69	1.90	10.72

Table 4.2.1-15. Monthly and annual frequencies (%) of stability classes

Month	Frequencies of stability classes					
	A	B	C	D	E	F
1	0.00000	0.41283	0.41283	6.00962	0.74728	1.30121
2	0.00000	0.57483	0.32400	4.70840	0.81522	1.45276
3	0.32922	0.51735	0.17768	5.29369	0.79431	1.52592
4	0.31355	0.35535	0.27174	4.92788	0.86747	1.10263
5	0.60619	0.91973	0.85702	3.86183	0.73683	0.96154
6	0.78909	1.01902	1.10786	2.91597	0.95109	1.09741
7	0.97722	1.21760	1.17579	2.38294	0.95631	1.64611
8	0.70025	1.49457	1.14444	2.35159	0.96154	1.85514
9	0.58528	0.62709	0.26651	3.32880	1.18102	2.37249
10	0.60619	0.54870	0.28219	3.98202	1.10263	2.25230
11	0.00000	0.49122	0.42329	5.05330	0.78909	1.62521
12	0.00000	0.42851	0.37625	5.68562	0.70025	1.36915
Annual	4.90698	8.60681	6.81961	50.50167	10.60305	18.56187

Table 4.2.1-16. Occurrence frequency (%) of stability classes on wind directions

Direction	Frequencies of stability classes					
	A	*B*	*C*	*D*	*E*	*F*
NNE	0.16	0.46	0.70	7.79	0.82	0.62
NE	0.05	0.15	0.16	2.01	0.21	0.25
ENE	0.07	0.17	0.26	2.55	0.22	0.14
E	0.05	0.11	0.21	1.74	0.19	0.15
ESE	0.08	0.53	0.70	4.30	0.75	0.45
SE	0.07	0.28	0.36	1.84	0.39	0.25
SSE	0.11	0.45	0.57	3.77	0.78	0.63
S	0.14	0.41	0.58	2.36	0.74	0.67
SSW	0.15	0.30	0.43	1.47	0.58	0.67
SW	0.06	0.20	0.14	0.43	0.27	0.33
WSW	0.09	0.28	0.30	1.03	0.41	0.55
W	0.19	0.30	0.48	2.52	0.85	0.92
WNW	0.16	0.48	0.81	4.82	1.13	1.03
NW	0.08	0.27	0.28	1.42	0.37	0.35
NNW	0.09	0.24	0.36	2.22	0.49	0.34
N	0.19	0.39	0.46	3.52	0.51	0.47
Calm	3.16	3.57	0.00	6.69	1.90	10.72

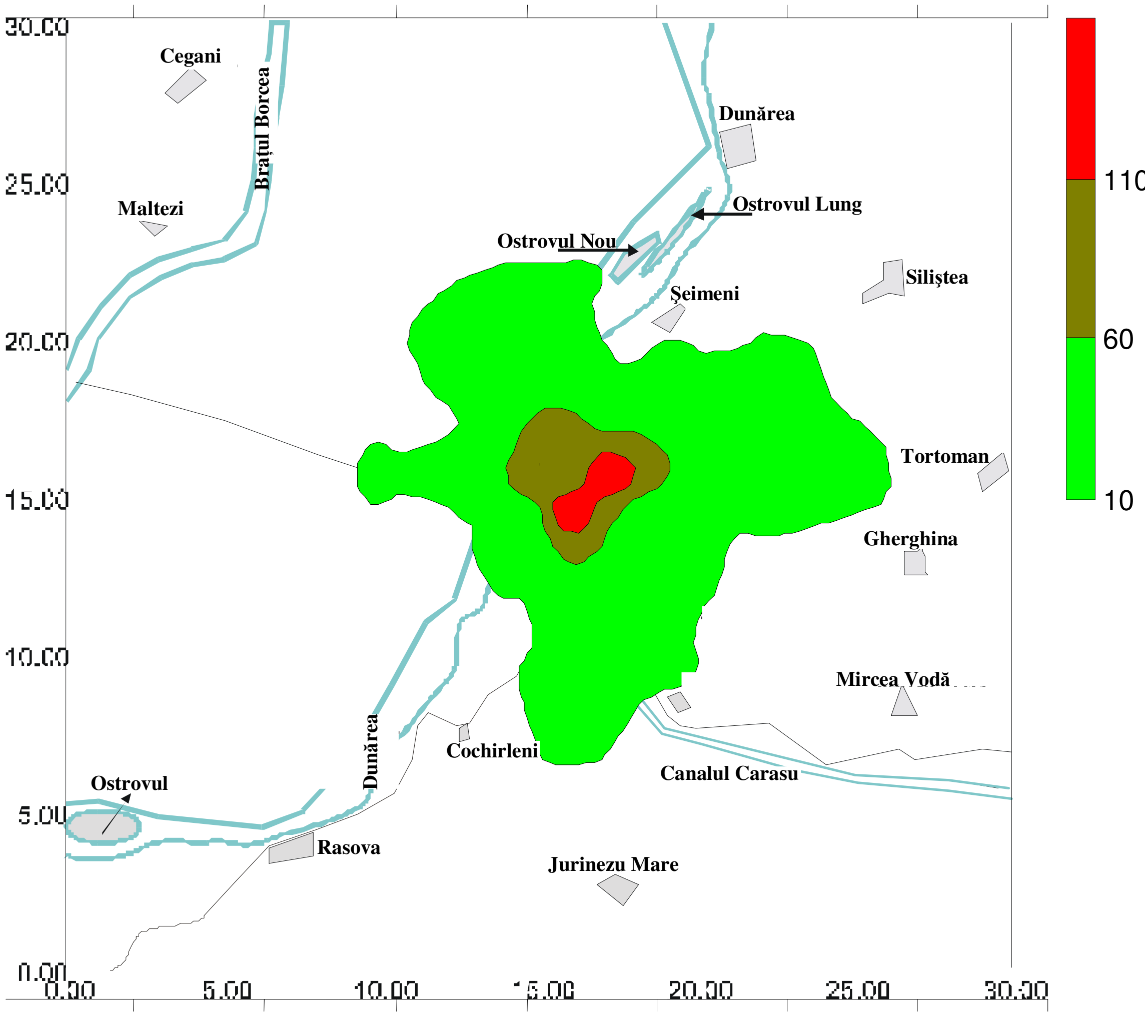

Figure 4.2.1.2-1. Dispersion factors (10^{-9} s/m^3)

4.2.1.3. Characterization of Pollutant Sources in the Zone of Unit 3 and Unit 4

The existing pollutant sources in the neighborhood of Unit 3 and Unit 4 are Unit 1 and Unit 2 of the Cernavoda NPP, and also auxiliary activities and construction site temporary activities.

Other sources are due to road transport, railway transport and naval transport.

If a much larger area is taken into consideration, the economic activity consists of extractive industry (quarries of limestone, sands, diatomite, bentonite, clay), facilities in the industrial areas of the towns Cernavoda, Fetesti and Medgidia, economic units (agrarian-industrial) spread in the rural places in the area.

Within a zone of 10 km radius around the Cernavoda NPP Unit 3 and Unit 4, there are the Cernavoda - Saligny industrial zone, the Cernavoda-harbor industrial zone, economic activities in the Cernavoda town and in some villages.

Figure 4.7-1 (Chapter 4.7.2) present the economic objectives in an area with 10 km radius around Cernavoda NPP Unit 3 and Unit 4.

Within 30 km, there are the Medgidia North industrial zone, Medgidia East – harbour industrial zone, Fetesti North-West industrial zone, Fetesti – East harbour industrial zone.

The roads network developed in the neighborhood of the Cernavoda NPP consists of the county road 223, and the National road 22C Cernavoda - Basarabi (Fig. 4.7-1). The Bucharest - Constanta highway (A2), section Cernavoda - Constanta, will be built at a longer distance. Other roads are at distances longer than 5 km from Cernavoda NPP (village roads DC60 and DC61, in NNE and respectively NE).

The existing railway is represented by the railway, Bucharest – Constanta; the nearest station is Cernavoda Bridge; in the influence area there is the secondary railway Saligny – Cernavoda town; the hazardous materials carried on this railway are used only by Cernavoda NPP.

The waterways transport nearby Cernavoda NPP is represented by the shipping waterways: Danube river and the canal Danube- Black Sea. The waterway used for transport in the neighborhood of Cernavoda NPP is race 1 of the DBSC.

Except Units 1 and 2, all the other activities in this zone do not discharge specific emissions similar to the Cernavoda NPP Unit 3 and Unit 4.

4.2.1.4. Air Pollution Data in the Units 3 and 4 Neighbor Area, Noise Level, Radioactivity

4.2.1.4.1. Air Quality

The results of the measurements carried out by ICIM in 2001 (Ref. 4.2-8) show the air quality in several points of the NPP site. The samples were collected from the following points:

- P1 at the 400 kV station;
- P2 over the tunnel for heated water discharges to the Danube;
- P3 at the access point to Unit 5, on the west side of the NPP platform;
- P4 in front of the CPPON building.

The analyzed parameters were sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon oxide (CO) and suspended particulate matter (average values at 30 minutes). The results were compared to the maximum allowable concentrations (STAS 12574-87). Table 4.2.1.4-1 shows that the measured concentrations were bellow the maximum allowable values.

Other air quality analyses were carried out by ICIM in 2004. Air samples were taken from the administrative building area and behind the turbine building of Unit 1. The analyzed air quality indicators were sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3) and suspended particulate matter. The concentrations were 3.5 - 6.8 $\mu g/m^3$ SO_2, between 9.8 and 19.6 $\mu g/m^3$ NO_2, between 0.040 and 0.078 mg/m^3 NH_3, between 0.059 and 0.082 mg/m^3 suspended particulate matter. The results (Ref. 4.2-12) were compared with the provisions of the regulations in force (STAS 12574-87, Order 756/1997, Order 592/2002). The measured concentrations were below the maximum values specified by these regulations.

Air quality analyses were also performed by ICIM in the year 2006. Air samples were taken from areas between Units 2 and 3, between Units 3 and 4, and also between Units 4 and 5. The values of the indicators sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3) and total suspended particulate matter were determined. The concentrations were 0,066 - 0,081 mg/m^3 for SO_2, between 0,031 and 0,058 mg/m^3 for NO_2, between 0,005 and 0,009 mg/m^3 for NH_3, between 0,124 and 0,137 mg/m^3 for suspended particulate matter. The results were compared with the provisions of the regulations in force (STAS 12574-87 and Order 592/2002). The measured concentrations were under the maximum values admitted by these regulations.

Table 4.2.1.4-1. Results of air quality analyses performed in 2001

	P1	P2	P3	P4	Maximum admitted concentration
SO_2 (mg/m^3)	0.032	0.027	0.051	0.057	0.750
NO_2 (mg/m^3)	0.038	0.041	0.068	0.062	0.300
CO (mg/m^3)	0.72	0.83	1.75	1.32	6
Suspended particulate matter (mg/m^3)	0.051	0.054	0.098	0.070	0.500

4.2.1.4.2. Noise Level

Noise in the Units 3 and 4 neighbor area results from the activities performed on the NPP platform, from the construction sites, as well as from the adjacent transport routes.

The Unit 1 specific activities are performed in buildings. The noise-generating equipment and installations from Unit 1 have dampers and noise attenuating devices and the same for Unit 2, resulting in significant noise level reduction.

Other noise can be generated by activities of material handling in existing storehouses, activities in workrooms, the working concrete station, the sorting station of the concrete station, the industrial transport (light and heavy vehicles)and traffic outside (vehicles of all categories). Other noise sources are due to transport along the road near the Cernavoda NPP site.

The measurements carried out by ICIM in January 2001 (Ref. 4.2-8) showed noise level in some points inside the Cernavoda NPP platform and also outside, near the county road (Table 4.2.1.4-2). Noise in points inside the Cernavoda NPP site was measured over a 30 minutes period, in an area with auxiliary activities. The equivalent noise level measured at the county road border near the Cernavoda NPP site, over a 1 hour period, was mainly due to road traffic (the limit in STAS 10009-88 for a II category road is 70-dB (A)). The noise measurements were performed by using a CEL 573 sonometer.

Table 4.2.1.4-2. Noise level measured in 2001

Location	Measurement period	Level dB(A)	Noise sources
4 points inside the Cernavoda NPP site, west area	30 min	45.9 39.7 35.9 43.0	Concrete mixer, light and heavy vehicles that run on the inside industrial route, storehouses
County road border near the NPP site	1 hour	66.8	Road traffic

In August 2004, noise was measured by ICIM in 6 points. The results (Table 4.2.1.4-3) were compared with the allowable limits specified by STAS 10009-88 (Urban acoustics - Admissible limits of noise level). It was found that the measured noise level was within the admissible limit.

Table 4.2.1.4-3. Noise level measured in 2004

Location	Equivalent noise level (L_{eq}) [dB(A)]	Admissible limit for L_{eq} dB(A)
Point 1, county road border (outside the site)	62.3	65
Point 2, NPP site entrance (outside)	56.1	65
Point 3, south-east limit of the site (outside)	54.0	65
Point 4, east limit (outside)	51.7	65
Point 5, east limit (outside)	56.2	65
Point 6, north limit (outside)	55.2	65

The noise level was also measured in August 2006 in the same points as in 2004. The results are presented in Table 4.2.1.4-4. It is remarked that the measured noise level was within the admissible limit.

Table 4.2.1.4-4. Noise levels measured in the year 2006

Location	Equivalent noise level (L_{eq}) [dB(A)]	Admissible limit for L_{eq} dB(A)
Point 1, county road border (outside the site)	66,8	65 (STAS 10009/88)
Point 2, NPP site entrance (outside)	59,2	65 (STAS 10009/88)
Point 3, south-east limit of the site (outside)	57,0	65 (STAS 10009/88)
Point 4, east limit (outside)	51,4	65 (STAS 10009/88)
Point 5, east limit (outside)	53,3	65 (STAS 10009/88)
Point 6, north limit (outside)	53,9	65 (STAS 10009/88)

At present the usual noise level in the residential areas is not influenced by the activities of Unit 1, and from the NPP platform, because of the distance and the hill between the site and the Cernavoda Town.

4.2.1.4.3. Radioactivity

For estimating the air radioactivity level, ICIM performed in 2004 measurements of gamma dose rate in air in several location in the CNE PROD Cernavoda influence area, within a radius of 60 km from the power plant. From the location Campus CNE PROD Cernavoda, samples were taken of atmospheric aerosols, total atmospheric deposition, precipitations.

Atmospheric aerosols

Table 4.2.1.4-5 presents the average value of gross beta activity in samples of atmospheric aerosols, and also the minimum and maximum values recorded for the aspiration in the hour interval 02-07 (03-08), for the location Campus Cernavoda, in comparison with the reference locations Calarasi and Slobozia. The gross beta activity include the contribution of the radon and toron descendants, natural radionuclide.

Tabelul 4.2.1.4-5. Gross beta activity of atmospheric aerosols samples, aspiration 02-07 (03-08)

Location	Gross beta activity min. val. [Bq/m^3]	Gross beta activity average val. [Bq/m^3]	Gross beta activity max. val. [Bq/m^3]
Campus Cernavoda	0.53 ± 0.03	3.11 ± 0.16	8.51 ± 0.43
Calarasi	0.21 ± 0.01	1.07 ± 0.03	3.50 ± 0.03
Slobozia	0.27 ± 0.01	2.17 ± 0.11	8.72 ± 0.44

For comparison, Figure 4.2.1.4-1 presents the gross beta radioactivity levels in the atmospheric aerosols samples, for the aspiration interval 02-07 (03-08) in the period February – August 2004, recorded in the locations Cernavoda, Constanta, Calarasi, Slobozia, Bucharest and Zimnicea.

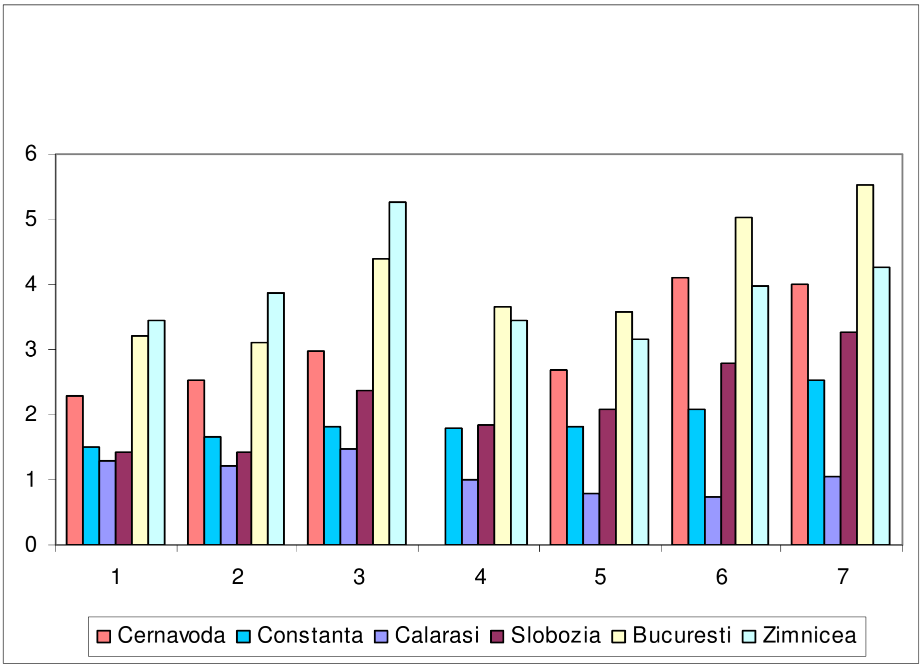

Figure 4.2.1.4-1. Gross beta activity (Bq/m^3) of atmospheric aerosols samples, aspiration 02-07

Table 4.2.1.4-6 presents average, minimum and maximum values of the gross beta activity in atmospheric aerosols samples, for the location Campus Cernavoda, in comparison with the reference locations Calarasi and Slobozia, values recorded for the aspiration 08-13, respectively 09-14.

Table 4.2.1.4-6. Gross beta activity of atmospheric aerosols samples, aspiration 08-13 (09-14)

Location	Gross beta activity min. val. [Bq/m^3]	Gross beta activity average val. [Bq/m^3]	Gross beta activity max. val. [Bq/m^3]
Campus Cernavodă	0.30 ± 0.02	1.31 ± 0.07	5.55 ± 0.28
Călăraşi	0.10 ± 0.01	0.47 ± 0.02	1.13 ± 0.04
Slobozia	0.24 ± 0.02	0.86 ± 0.04	3.21 ± 0.16

Figure 4.2.1.4-2 presents the gross beta radioactivity levels in the atmospheric aerosols samples, for the aspiration interval 08-13 (09-14), in the period February – August 2004, recorded in the location Campus Cernavoda, in comparison with Constanta, Calarasi, Slobozia, Bucharest and Zimnicea.

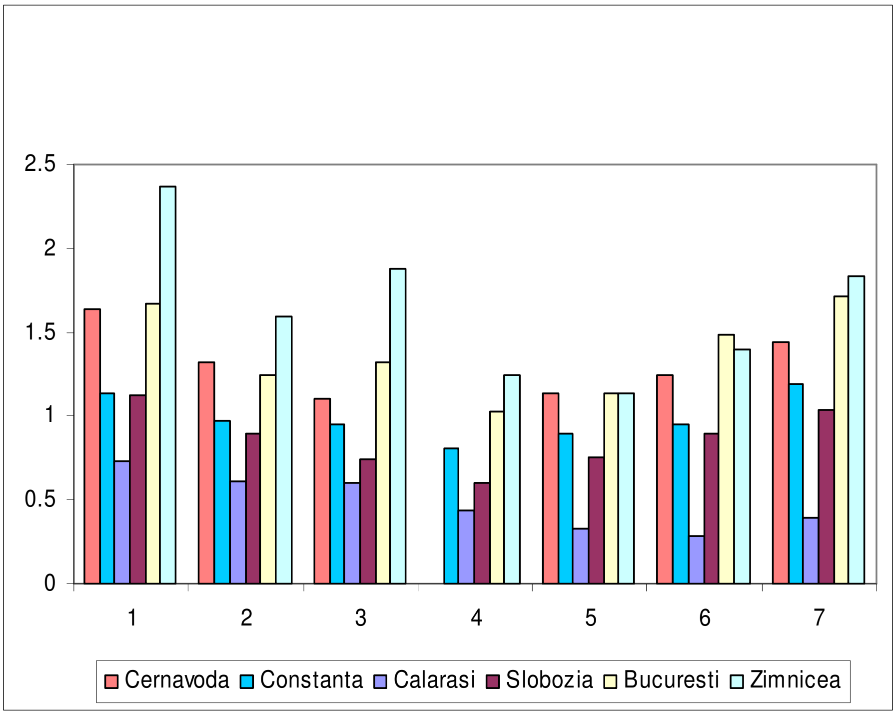

Figure 4.2.1.4-2. Gross beta activity (Bq/m^3) of atmospheric aerosols samples, aspiration 08-13

For the air samples, an average value of total tritium concentration was obtained of 3.3 ± 0.2 Bq/m^3. Table 4.2.1.4-7 presents the average, minimum and maximum values of total tritium concentration in air, from the location Campus Cernavoda, in the period April – July 2004.

Table 4.2.1.4-7. Tritium concentrations in aer - Campus Cernavoda

Monthly concentration of tritium in air		**Mounth**	**Monthly average value**
minimum value	2.0 ± 0.1 Bq/m^3	May	3.3 ± 0.2 Bq/m^3
maximum value	4.1 ± 0.3 Bq/m^3	April	

It is mentioned that the pre-operational values of tritium in air, determined by IFIN –HH for the period 1994 – 1996, vary between 0.03 and 0.2 Bq/m^3.

Figure 4.2.1.4-3 presents the monthly average concentration values for tritium gas, tritiated water vapors and total tritium in the period April – July 2004.

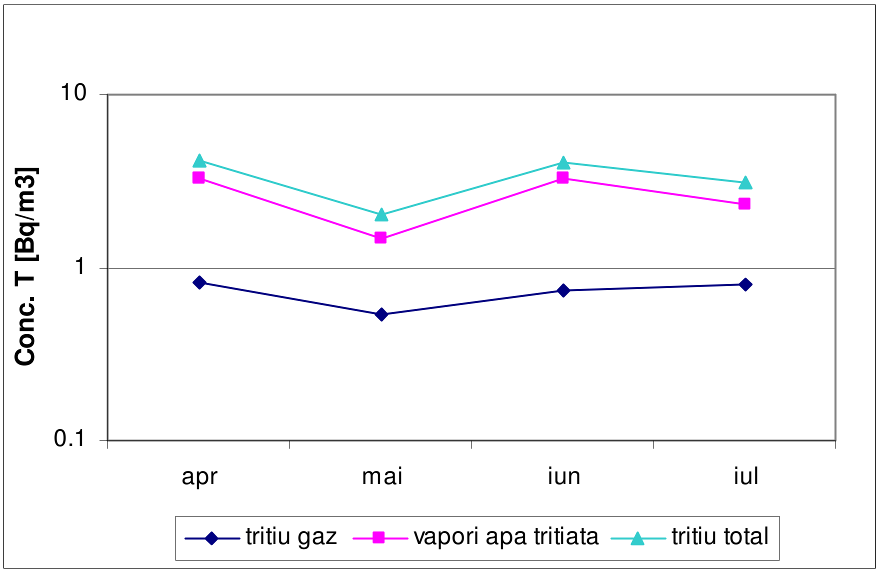

Figure 4.2.1.4-3. Concentrations of tritium gas, tritiated water vapors and total tritium in air - Campus Cernavoda - in the period April – July 2004

Figure 4.2.1.4-4 presents the total tritium levels in air, from the period April – July 2004, in comparison with the same period from 2003.

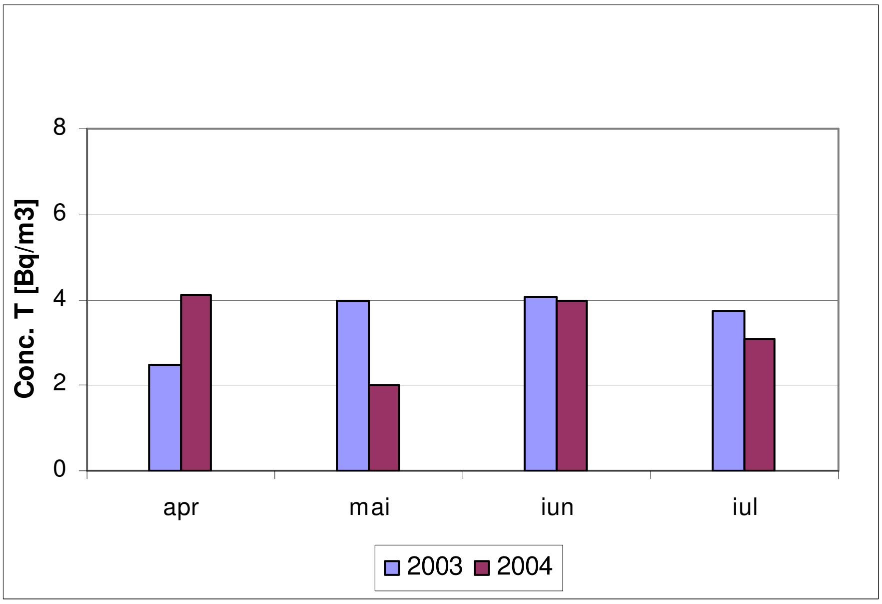

Figure 4.2.1.4-4. Concentrations of tritium gas, tritiated water vapors and total tritium in air, in the location Campus Cernavoda in the period April – July, 2003 and 2004

The values of the gamma dose rate in air are those recorded at the GDDS detectors within the automatic systems for gamma dose rate monitoring located in the CNE –

PROD Cernavoda influence area. Table 4.2.1.4-8 presents the minimum, average and maximum values for the period February – August 2004. Figures 4.2.1.4-5 and 4.2.1.4-6 present the gamma dose rates in air for locations on the site and respectively outside the site.

Table 4.2.1.4-8. Gamma dose rates in air – minimum, average and maximum values – locations on the site and locations outside the site

No.	Location	Minimum [μSv/h]	Average [μSv/h]	Maximum [μSv/h]
Locations within the CNE – PROD Cernavoda site				
1.	CNE Cernavoda DIDR	0.08	0.099	0.13
2.	CNE Cernavoda tld I-8	0.08	0.097	0.23
3.	CNE Cernavoda tld I-9	0.08	0.092	0.21
4.	Depozit Seiru	0.07	0.083	0.11
Locations outside the CNE – PROD Cernavoda site				
5.	APM Calarasi	0.08	0.100	0.14
6.	APM Constanta	0.07	0.089	0.12
7.	APM Slobozia	0.08	0.101	0.16
8.	Stație Meteo Călăraşi	0.10	0.117	0.16
9.	Complex Cazare	0.09	0.103	0.15
10.	Ecluza braț stâng	0.08	0.092	0.13
11.	Ecluza Poarta	0.07	0.109	0.15
12.	Gara Cernavodă	0.08	0.101	0.16
13.	Policlinica CNE	0.08	0.099	0.16
14.	Poliția Peştera	0.09	0.106	0.13
15.	Poliția Rasova	0.09	0.102	0.14
16.	Poliția Seimeni	0.07	0.105	0.13
17.	Primăria Cernavodă	0.08	0.105	0.14
18.	Primăria Tortomanu	0.09	0.109	0.17
19.	Stația Ecluza Cernavodă	0.07	0.086	0.11
20.	Stație400KV-1	0.08	0.099	0.17
21.	Stație400KV-2	0.07	0.086	0.11
22.	Stație400KV-3	0.08	0.101	0.16
23.	Stație Meteorologica	0.08	0.097	0.13
24.	Campus Cernavodă	0.08	0.100	0.15
25.	Turnul Meteo Cernavodă	0.09	0.108	0.17
26.	UM 0495 - Jandarmi	0.06	0.091	0.12
27.	UM 01459 - Medgidia	0.08	0.099	0.17
28.	UM 2060 - Mangalia	0.08	0.102	0.17

The locations APM Calarasi, APM Constanta, APM Slobozia and Statia Meteo Calarasi are reference locations.

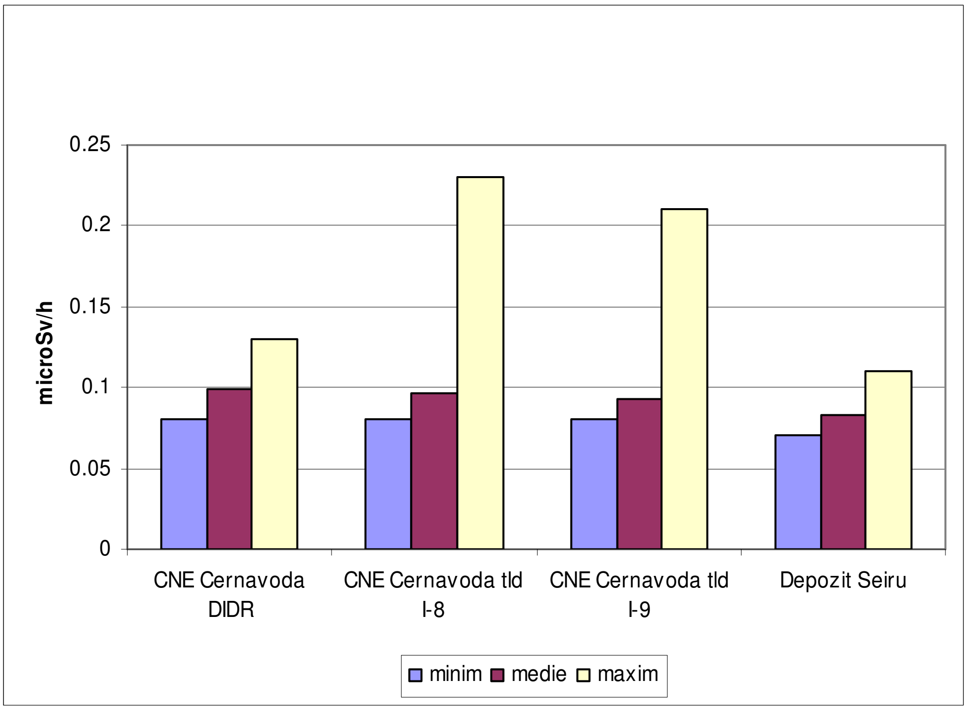

Figure 4.2.1.4-5. Gamma dose rates in air in the CNE – PROD Cernavoda site

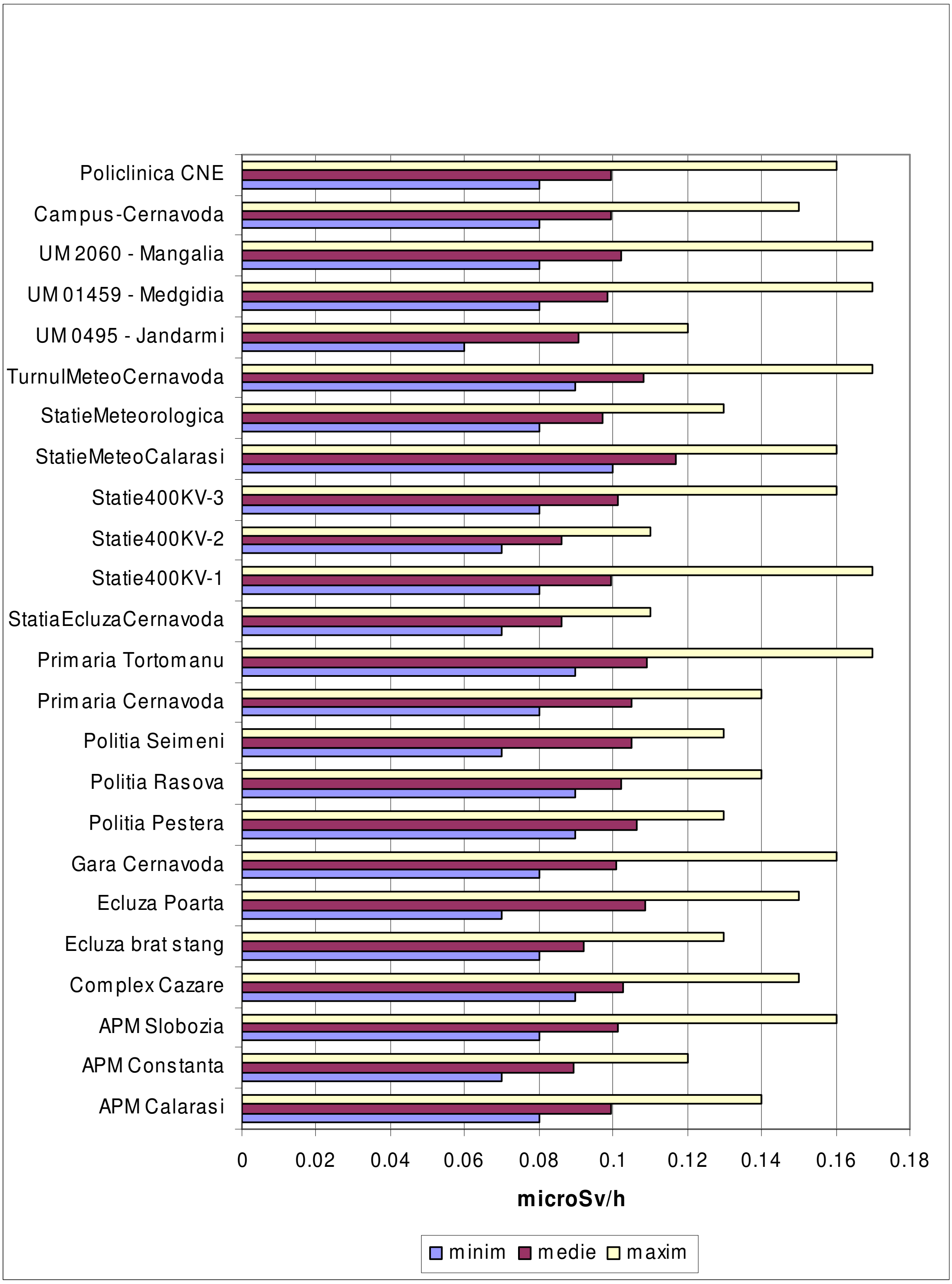

Figure 4.2.1.4-6. Gamma dose rates in air outside the CNE – PROD Cernavoda site

Total atmospheric depositions and precipitations

Table 4.2.1.4-9 presents the average, minimum and maximum values of gross beta activity in total atmospheric depositions samples, recorded for the location Campus Cernavoda, in comparison with the reference locations Calarasi and Slobozia.

Table 4.2.1.4-9. Gross beta activity of atmospheric deposition samples

Location	Gross beta activity min. val. [Bq/m²/day]	Gross beta activity average val. [Bq/m²/day]	Gross beta activity max. val. [Bq/m²/day]
Campus Cernavoda	0.41 ± 0.13	2.89 ± 0.31	30.16 ± 2.21
Călăraşi	0.39 ± 0.13	1.11 ± 0.17	14.89 ± 0.79
Slobozia	0.37 ± 0.12	1.25 ± 0.20	10.20 ± 1.03

Figure 4.2.1.4-7 presents the gross beta radioactivity levels in atmospheric depositions samples, in the period February – August 2004, recorded in the location Campus Cernavoda, in comparison with Constanta, Calarasi, Slobozia, Bucharest and Zimnicea.

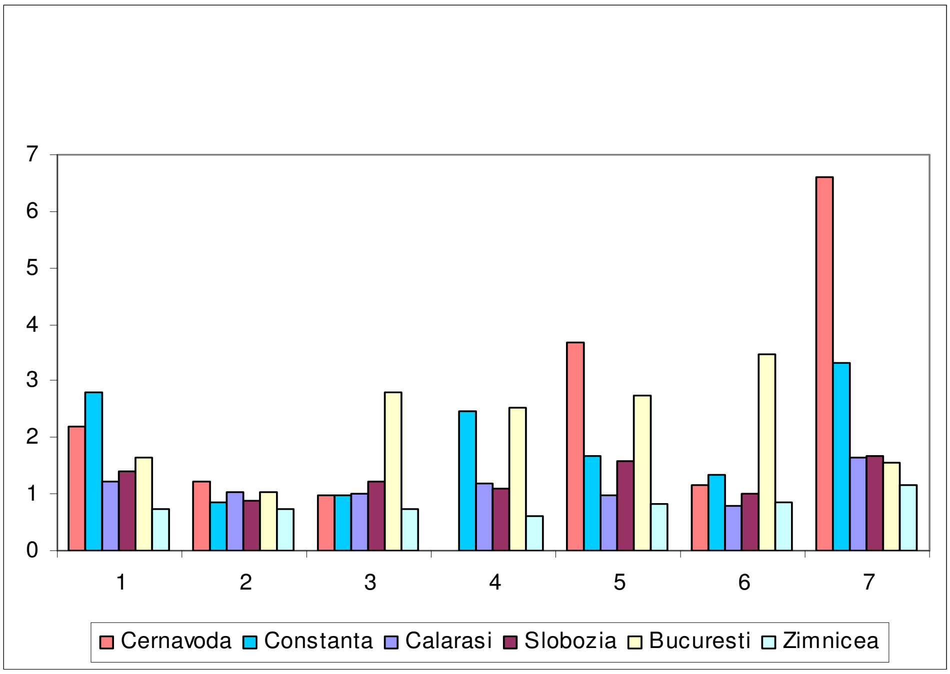

Figure 4.2.1.4-7. Gross beta activity of atmospheric deposition samples

For the samples of precipitations, it was obtained an average value of tritium concentration of 448.4 ± 31.3 TU, for the location Campus Cernavoda.

Table 4.2.1.4-10 presents the domains of variation of the tritium concentration (in TU = tritium unit, the equivalent of a concentration of 10^{-18} atoms of ^3H to 1 atom of ^1H) in samples of precipitations, taken daily (when precipitation fall existed), in the period January – August 2004, for the indicator location – Campus Cernavoda, and also the data from Calarasi and Slobozia (reference locations) and Bucharest.

Table 4.2.1.4-10. Minimum, average and maximum tritium concentrations in precipitations

Locaţion	Monthly minimum [TU]	Month	Monthly average level [TU]	Monthly maximum [TU]	Month
Campus Cernavodă	127.1 ± 8.9	July	448.4 ± 31.3	763.7 ± 53.5	March
Călăraşi	61.5 ± 8.6	April	68.2 ± 9.5	72.4 ± 10.1	May
Slobozia	66.8 ± 9.4	January	72.4 ± 10.1	77.2 ± 10.8	April
Bucharest	52.1 ± 7.3	April	60.6 ± 8.5	67.6 ± 9.5	July

1 TU = 0.118 Bq/l

Figure 4.2.1.4-8 presents the tritium levels in precipitations from Cernavoda, in comparison with the reference locations Calarasi, Slobozia and Bucharest, in the period January – August 2004.

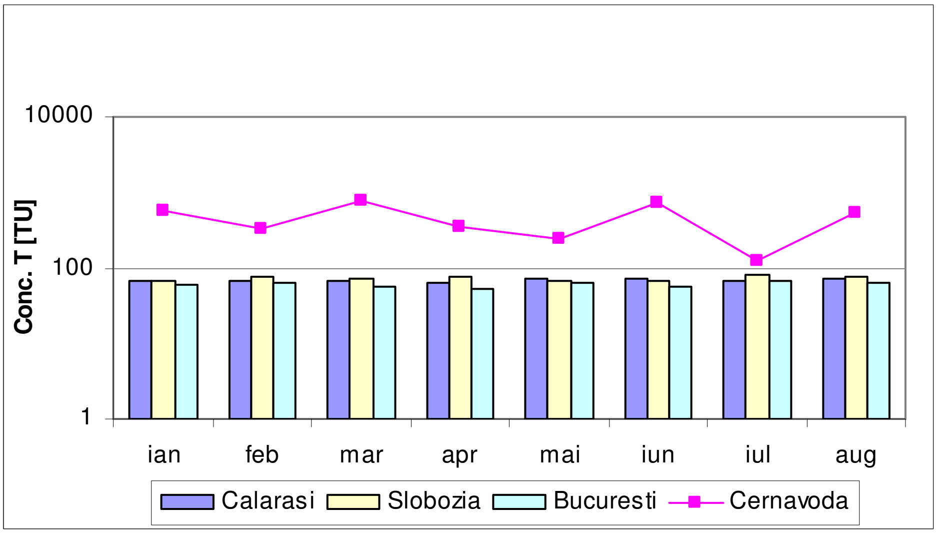

Figure 4.2.1.4-8. Tritium concentrations in samples of precipitations from Cernavoda, in comparison with Calarasi, Slobozia and Bucharest

4.2.2. Pollutant Sources During the Construction Period

The activities generating air emissions during the construction works at Unit 3, respectively Unit 4 are construction works, equipment and pipes installation work, afferent transport, electrical and automation installations, as well as some works for road network rehabilitation according to needs (Ref. 4.2-11).

These activities generate pollutant emissions through combustion processes, and also dust particles in air. The activities of the machinery and vehicles on the building site, that use diesel fuel, required for construction-installation works in order to finalize each of the Units 3 and 4, are estimated to be the equivalent of the activities of 20 trucks of 16 tons. The machinery types used will be cranes, loaders and lifting equipment, large off-road trucks, compressors, pumps, concrete mixers, bulldozers. Table 4.2.2-1 presents bulk emission factors from the Diesel engines of the mentioned machinery. Other equipments used during the period of construction-installation use electric power.

Table 4.2.2-1. Bulk emission factors (g/kg fuel) from the Diesel engines of the building site machinery

NO_x	CO	Pulberi	CH_4	NM-VOC
48.8	15.8	2.29	0.17	7.08

The sanding equipment used for pipes cleaning produces dust. The air filtering system can collect this dust.

The air pollution due to the emissions from welding in inner spaces can be controlled by exhausting installations, properly equipped.

Other releases come from building finishing and painting. Their effects can be prevented by work safety measures and by exhausting.

It is not necessary to produce thermal energy (it is supplied by Unit 1 or by electrical power), so there are no air releases due to this cause.

4.2.3. Sources and Pollutants Generated During the Operation Period

4.2.3.1. Characterization of Air Pollutant Sources during the Operation Period

I) Characterization of Radioactive Pollutant Sources

The gaseous radioactive effluents in the plant come from (Ref. 4.2-11):

- fuel fission products;
- stable elements of process fluid activation products.

According to Ref. 4.2-9, the gaseous effluents resulted from plant operation contain noble gases, particulates, iodine, tritium and C-14 (Ref. 4.2-5).

The potential areas where gaseous radioactive wastes can result are:

A. Reactor Building

B. Spent Fuel Storage Bays

C. Decontamination Center

D. Heavy Water Management

A. Sources of gaseous wastes in the Reactor Building

A1 Emissions from Primary Heat Transport (PHT) Circuit (Ref. 4.2-5):

- Continuous escape of D_2O from the PHT circuit into the Reactor Building atmosphere; the contained noble gases remain in the air and circulate with it until the Reactor Building atmosphere is purged; this is not one of the significant pathways for noble gas releases;
- D_2O leakage from Primary Coolant Collection System; this kind of wastes includes noble gases and tritiated water vapours which are not retained in D_2O recovery system to which the vent of the collection tanks are connected;
- Cover Gas Purge from the Primary Circuit D_2O Collection Tanks; these purged gases can contain a low activity of noble gases (due to the infrequent purge, the decay period of radioactive isotopes is long);

- Primary Circuit Degasser-Condenser, during degassing operation of the primary circuit (at startup or during normal operation); if the degassing is performed during a startup, the released gases are oxygen and nitrogen, with small quantities of deuterium and a low concentration of noble gases; the activity would be low, since the reactor would have been shut down for a short period of time and the primary circuit would have been opened during the maintenance period; if the degassing is performed during normal operation, the released gases will be controlled by recirculation in the accessible area of the Reactor Building (F/M and boiler room areas); the contained noble gases will have about an eight hour decay period prior to their release (this period has been estimated considering normal ventilation and purge flows and a standard volume of the Reactor Building accessible area).

Generally, the emissions from primary circuit do not contain radioactive iodine, because the partition coefficient for the gaseous-liquid states of iodine, in the primary circuit conditions, is about 10^{14} in favour of the liquid state.

A2 *Fuel Bundles with Defective Sheath*

there is the possibility of release of noble gases, iodine and particulates contained in the gap (interspace between the fuel elements and the sheath);

A3 *Annulus Gas Purge*

activation with neutrons of Ar-40 from CO_2 cover gas air trace leads to the Ar-41 production, which is a radioactive noble gas.

A4 *Activation with neutrons of C-13, N-14 and O-17 in process fluids or gasses*

leads to the production of radioactive isotopes: C-14 (beta emitter), N-16 and respectively O-19.

B. Spent Fuel Storage Bays

The atmosphere of the rooms, in which the spent fuel storage bays are located, may contain noble gases and radioactive iodine.

C. Decontamination Center

The probability that radioactive gases or airborne may exist in the Decontamination Center rooms is low. The majority of wastes in this case are formed from vapours of liquid radioactive wastes resulted from decontamination.

D. Heavy Water Management

The D_2O vapour recovery system is designed to retain the heavy water and tritium vapours released from the primary circuit, the moderator, the steam generators and the F/M into the atmosphere of the associated rooms. In this way, all the gas releases passing through the D_2O vapour recovery system will mainly contain non-condensable radioactive gases, which will be captured and processed by the ventilation system.

The radioactive effluents are discharged through the plant exhaust stack, which has a height of 50.3 m and an internal diameter of 2.3 m. The total air flow discharged to the stack is 175.140 m^3/h in the summer time, respectively 142.520 m^3/h in the winter time.

II) Characterization of Nonradioactive Pollutant Sources

The main chemical pollutants are accompanying the gases released from the R/B and S/B and they are taken over by the ventilation systems of the plant and properly treated and diluted via the D_2O vapor recovery systems and the ventilation systems.

The air in Service Building is taken over by the non-contaminated air-released system and directly discharged to the atmosphere.

Other potential gaseous pollution sources which are not controlled by the plant ventilation systems are: the steam coming from the valves on the steam piping and from the safety valves which discharge the steam to the atmosphere only during abnormal operation conditions, as well as the vapor releases coming from the Diesel generators, from the oil storage tanks and from the Water Treatment Plant Drainage system.

All these pollutant discharges are limited to the surface of NPP Site; they are quite small and fall in the allowable limits from the standards.

Steam discharge to the atmosphere is occasionally and it does not represent negative effects because it can generate local clouds which are integrated into the water circuit in nature.

Regarding the oil storage tanks, located in open space, the main effect is the oil vapor or drops release to the atmosphere; the release is a continuous process throughout the plant operation life; it is reduced and confined. So, the unfavorable effects on the environment are insignificant.

The Diesel generators, which operate only during emergency regime (loss of class IV power supply) are started, periodically, to be tested at regular intervals; they have the unfavorable effect of gases releases to the atmosphere, during operation only, releases which have a low level and are local, without toxic effects on the environment, population and operation personnel.

The Auxiliary Boiler Station is an important potential source of pollution with non-radioactive gases. Actually, the Station is in stand-by and is operated only upon the plant start –up. There is the possibility to start Unit 3&4 by taking over the required steam from the in-service U1 or from U2. The Auxiliary Boiler Station was constructed for all the NPP units on NPP Site and it was licensed, in point of environmental protection when U1 was commissioned.

4.2.3.2. Emissions of Radioactiv Pollutants to Atmosphere

The estimated volume of radioactive gases released at a typical CANDU 6 reactor is of 283 m^3/min. The estimation has been made based on the average values of gaseous radioactive waste releases from six CANDU reactors, for a period of seven years (Ref. 4.2-5). The values of gaseous emissions activity estimated and reported at Cernavoda Unit 1, during 1996÷2004 are indicated in the Table 4.2.3.2-1 (Ref. 4.2-5). Referring to isotopes contained in these gaseous emissions, C-14, tritium, iodine and noble gases were recorded.

The Derived Emission Limits (DEL) have been estimated for Cernavoda nuclear site. DELs represent the maximum allowed concentration for an isotope or a group of radionuclide, so that the annual dose to a member of the public critical group does not exceed the limit value of 1 mSv/year, as prescribed in the Fundamental Norms for Radiological Safety (Ref. 4.2-6).

The methodology and the gaseous effluent DEL estimation is presented in the NPP procedure for DEL (Ref. 4.2-7); the estimation takes into consideration the Cernavoda site specific atmospheric conditions and all the possible exposure pathways (from all nuclear sources located on this site) for the critical group. These values are the maximum permissible activity concentrations of each radionuclide emitted during routine operation of the nuclear facilities located in Cernavoda NPP site.

For estimation of critical groups exposure, taking also into consideration the contribution of the other radiation sources on the Cernavoda NPP site, a more restrictive administrative limit was established, representing the operating target for each nuclear power unit, namely 50 μSv/year, representing 5 % of the allowed dose to the public (1 mSv/y) as established by the regulatory body.

In the event that radioactive effluent emission exceeds this operating target for an extended period of time, steps will be taken to identify the causes and to take practical action to remediate the situation.

During the licensing process of a nuclear facility, the regulatory body (CNCAN) shall define a dose constraint for this facility, value which must not be exceeded during normal or abnormal operating conditions (Ref. 4.2-6). CNCAN have defined, in the operating license no. SNN U1-5/2003, the dose constraint for Cernavoda NPP Unit 1, namely 0.1 mSv/year.

Since the operating target at Unit 1 (administrative dose limit) represents 50% of the dose constraint recommended by CNCAN, a good margin is ensured during Cernavoda NPP operation. This option will be also respected during Unit 3, respectively Unit 4 exploitation. By analyzing the gaseous emissions reported at Cernavoda NPP Unit 1 (represented in Table 4.2.3.2-1) one remarks that all the activity concentrations are within the administrative limit of 5 % DEL; evidently these activity concentrations lead to an effective dose for a member of the critical group smaller than the dose constraint value.

Table 4.2.3.2-1. Gaseous emissions activity estimated for one Unit and gaseous emissions reported at Cernavoda Unit1

Isotope	Regulatory limit for a unit Annual DEL kBq	Gaseous emissions activity estimated for one Unit kBq	Gaseous emissions recorded at Cernavoda NPP Unit 1								
			1996	1997	1998	1999	2000	2001	2002	2003	2004
			kBq	kBq	kBq	kBq	kBq	kBq	kBq	kBq	kBq
C-14 (gaseous)	1.1E+11	1,05E+9*)	5.76E+07	1.77E+08	2.90E+08	1.70E+08	2.32E+08	1.64E+08	1.24E+08	1.18E+08	1.92E+08
H-3 (oxide)	5.3E+13	1,65E+11	1.37E+09	2.55E+10	5.08E+10	8.53E+10	2.08E+11	1.80E+11	2.86E+11	1.71E+11	1.98E+11
I-131	3.44E+08	2,00E+4	-	7.06E+03	7.55E+02	-	-	1.42E+03	-	-	-
Noble Gases	2.2E+13	4,90E+10	6.03E+10	6.17E+10	1.75E+10	2.13E+10	6.95E+09	2.72E+10	-	8.42E+08	2.28E+10
Particulate	6,9E+7	3,00E+4	-	-	-	-	-	-	-	-	-

*) Envisaged value for the C-14 activity, based on available data from Point Lepreau, averaged during 1989-1994

4.2.4. Estimated Impact Regarding Air Pollution and Noise During the Units 3 and 4 Construction Period

The gases and dust emissions from equipment and vehicles used for construction will have local, temporary and low effects. The emissions will be smaller than during the completion periods of the Units 1 and 2 because the fuels and the machinery engines are in conformity with more restrictive norms.

The impact due to the sanding equipment, used for pipes cleaning, will be minimized if the dust will be collected by air filtering systems.

The impact due to emission from the welding operations will be significantly reduced by personnel protection equipment and by exhausting.

The toxic and hazardous substances used during execution are paints and acetylene. These substances will be stored in special spaces, respecting the norms for their handling and use, in order to reduce as possible the impact. The ventilation of inner spaces will contribute to impact prevention.

The equipment inspection and regular maintenance, the roads maintenance represent additional measures taken in order to limit emissions to air and dust.

With thermal energy provided by Unit 1 for heating, fossil fuel combustion for this purpose is not necessary avoiding air pollution.

The noise and vibrations generated by vehicles and construction equipments act within limited areas, especially within the site, during short periods, so it can be assessed that the impact to human settlements will be insignificant. The Cernavoda town is protected by the hill that separates it from the site. The effects on the personnel will be reduced by noise level limitation within the admitted values for industrial activities and by protection equipment use where necessary.

4.2.5. Estimated Air Pollution and Noise Level During the Units 3 and 4 Operation Period

The Units 3 and 4 commissioning and operation involves its own installations and other utilities, services and installations that are common to the Units envisaged to be realized on the NPP Site.

The main pollutants that are found in the released gases are collected, properly treated and controlled by various systems (presented below in section 4.2.7). There are no possibly contaminated air releases from the plant systems without being controlled and filtered and then diluted. The gaseous emission are limited so that to comply with the regulations and requirements (section 4.2.3).

The radiological impact is assessed in section 4.9.

Other potential gaseous emission sources, which are not controlled by ventilation systems, are the steam valves that can release steam during abnormal conditions.

There are also sources of vapor and smell releases: the Diesel generators, the oil storage tanks (where the vapors and drops amounts are notable, collecting systems are designed) and the water treatment station sewage system. These pollutant releases are small and they do not cause any significant impact, as shown by the situation at Unit 1.

The Diesel generators are practically in stand-by, their operation being necessary only under electrical energy supply failure, and only for a limited duration. The Diesel generators used Euro 3 Diesel fuel (Ref. 4.2-12) with about 0.05 % sulphur content (0.035 % in 2003). Their average fuel consumption is 1 tonne/hour at the 4.4 MW maximum power. The pollutant concentrations resulting at a total outflow of 13000 m^3/hour burnt gases are within the admissible emission limits (Fig. 4.2.5-1, Table 4.2.5-1). The Diesel generators work during short time intervals only (when they are tested), and therefore they do not influence systematically air quality or other environment components. Hence, they can not be considered permanent or daily emission sources to be taken into account in relation to air quality in that area.

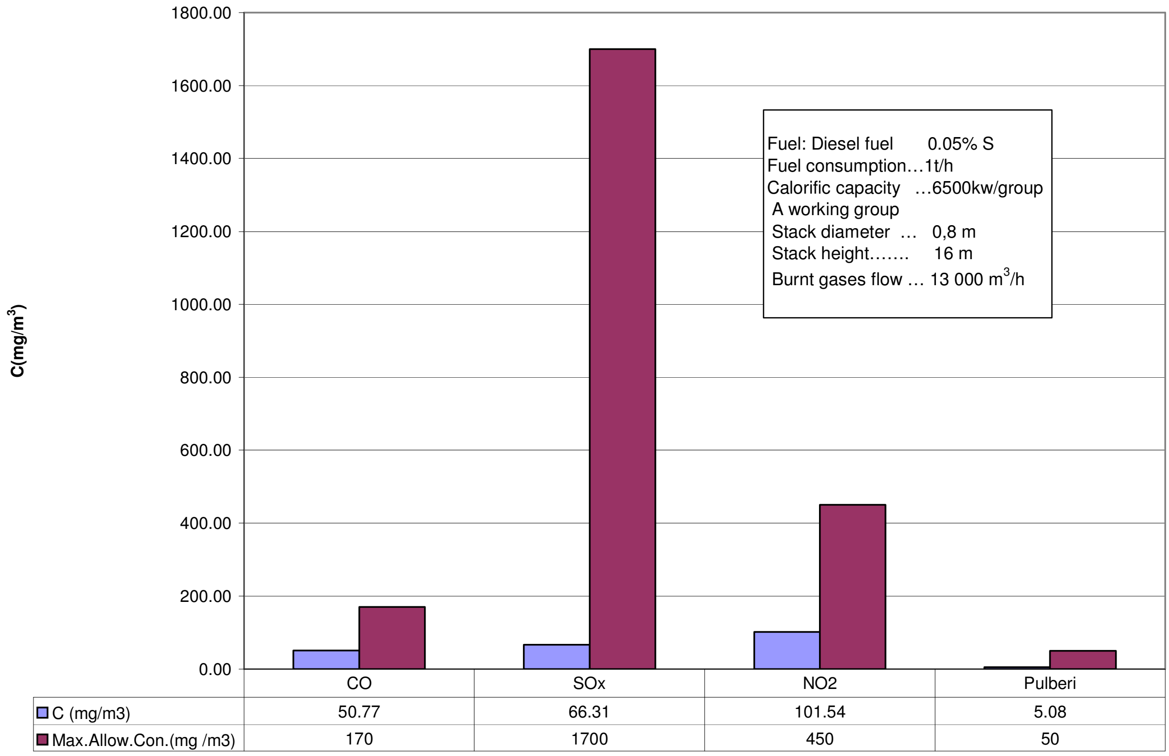

Figure 4.2.5-1. Estimated concentrations from a Diesel generator

Table 4.2.5-1. Estimated emissions from a Diesel group

Source	Pollutant	Mass flow (g/h)	Gaseous flow (m^3/h)	Emission concentration (mg/m^3)	Alert threshold (mg/m^3)	Emission limit (mg/m^3)
Diesel group	SO_x	862	13000	66.31	1190	1700
Diesel group	NO_2	1320	13000	101.54	315	450
Diesel group	CO	660	13000	50.77	119	170
Diesel group	Particulate matter	66	13000	5.08	35	50

Environmental protection is ensured mainly through administrative and design measures, as well as through a reduced volume of gases releases from spaces without ventilation systems.

The noise and vibrations impact on human settlements due to the various equipments and installations, will be insignificant. Many of noise and vibrations generating installations (pumps, ventilators) are equipped with attenuators and damper and they are placed in buildings. The noise and vibrations level generated by other equipments (steam valves, electrical transformers) will not exceed the limits specified by regulations, or, where these limits will be exceeded adequate equipment will be provided for the personnel protection.

Between the Cernavoda town and the site, there is a natural obstacle (a hill). Due to the attenuation with the distance, by air absorption and diffraction, the Units 3 and 4 contribution to the equivalent noise level in the town is assessed as negligible.

4.2.6. Impact Mitigation Measures During the Construction Period

Maintaining and watering the roads will reduce the dust pollution during transport along the unpaved roads.

The sanding equipment used for pipe cleaning also generates dust. The dust will be collected by air filtering systems.

Air pollution by emissions from welding in inner spaces can be adequately controlled by ventilation systems.

The effects of emissions from building finishing operations and from dyeing works will be prevented or diminished by labor protection measures and ventilation systems.

4.2.7. Impact Mitigation Measures During the Unit 3 and Unit 4 Operation Period

4.2.7.1. Collection Systems and Effluent Control

Gaseous Radioactive Effluent Collection System

The collection of gaseous effluents is made by the ventilation system. The overall ventilation system is so designed that the air circulation should be carried-out from low-potential contamination areas to high-potential contamination areas, and finally, after filtering, the air is exhausted through a ventilation stack (Ref. 4.2-11).

Gaseous Radioactive Effluents Control

The control of the gaseous radioactive effluents is performed both by filtering on the release ways and by automatically isolating of containment, when radioisotopes are detected.

At CANDU type plants, the control of gaseous emissions is ensured by:

- filtering before the discharging to atmosphere, to retain the particulates and radioiodine;
- two drying steps, to control tritium and D_2O vapour;
- dispersion by releasing at height above the ground (ventilation exhaust stack).

a) Filtering of Gaseous Radioactive Effluents

Reactor Building Ventilation System is provided with an exhaust air filter unit located in Service Building.

Filtering is carried out in stages, as follows:

- Stage I – provides high-efficiency filtering for retaining the contaminant particles and it consists of a pre-filter (efficiency min 85% ASHRAE) and a high-efficiency filter (HEPA) (99.97%);
- Stage II – provides the retention of the radioactive iodine existing in the contaminated air as elemental iodine or methyl iodide and consists of an active

cool bed with efficiency 99.99% for elemental iodine and 99.90% for methyl iodide;

- Stage III – provides the retention of the possible active coal particles driven by the air stream and consists of a high-efficiency filter (HEPA) identical with the one existing for the first filtering stage.

Service Building Ventilation System is provided with one filter unit on the air discharge line from the Spent Fuel Bay and an exhaust air filter unit on the air discharge line from all the contaminated areas.

The first filter unit includes the following filtering stages:

- Stage I – provides high-efficiency filtering for retaining the contaminant particles and consists of an auxiliary pre-filter, a pre-filter (efficiency 85% NBS) and a high-efficiency filter (99.97%);
- Stage II – provides the retention of the radioactive iodine existing in the contaminated air as elemental iodine or methyl iodide and consists of an active cool bed with efficiency 99.99% for elemental iodine and 99.90% for methyl iodide;
- Stage III – provides the retention of the possible active coal particles driven by the air stream and consists of a high-efficiency filter identical with the one existing for the first filtering stage.

The second filter unit, on the air discharge line from all the contaminated areas provides high - efficiency filtering in order to retain the contaminant particles and consists of an auxiliary pre-filter, a pre-filter (efficiency 90 - 95 % NBS) and a high – efficiency filter (99.97 %, for 0.3 micron particles per DOP test).

b) D_2O Vapor Recovery in Reactor Building

Recovery of D_2O vapors from Reactor Building is carried out by the drier system which entraps the D_2O vapors from the air, and the recovered water is next upgraded and used in the plant. A further advantage of this system is the reduction of the tritium concentration in air and of the emissions from the plant.

The dryers consist of desiccant beds, which retain the D_2O vapors from the air and collect them in the desiccant. The desiccant beds are subsequently regenerated while the D_2O, which carries radioactive materials, is transferred to D_2O purification system for cleaning, upgrading and possible return to the plant D_2O systems.

In this way, 95 % D_2O and tritium vapors are recovered and the tritium releases are decreased by a factor of minimum 20 (data resulted from the CANDU plants operation experience).

c) Radioactive Gaseous Effluents Release and Dispersion in the Atmosphere

Gaseous radioactive effluents are released, in a controlled manner, to the stack after the continuous monitoring of the air by GEM (radioactive gaseous effluent monitor). Release at a certain height, provides a better dispersion of the radioactive isotopes and thus a reduction of their concentration, namely of the radiation dose for the public.

4.2.7.2. Radioactive Gaseous Effluent Monitoring

The plant is provided with the following gaseous effluent monitoring systems (Ref. 4.2-5):

- monitoring of stack releases;
- monitoring of containment atmosphere.

Stack releases are monitored by the Gaseous Effluent Monitor (GEM) and the Monitoring System of D_2O in Air.

4.2.7.2.1. Gaseous Effluent Monitor

The Gaseous Effluent Monitor (GEM) is located in the S/B and consists of:

- monitoring systems for: radioactive aerosols, radioactive iodine, low range noble gases activity and high range noble gases activity;
- tritium sampler;
- C-14 sampler.

The GEM fulfills the following functions:

- provides alarms which annunciate the operator in the Main Control Room if there is an unexpected activity increase of aerosol, iodine and noble gas, in the gaseous effluents;
- collects for detailed analyses aerosols, iodine, water vapors (for tritium) and gases that contain carbon (for C-14) in the effluents, existent in the filters or absorbent materials;
- measures and records the activity released for each vector (aerosols, noble gases, iodine);
- sums up the effluents releases for a week and compares the results with Derived Emission Limit (DEL).

The components of the gaseous effluent monitoring system of stack are presented below.

Sampling System

In order to obtain a representative sample from the discharge duct, an isokinetic nozzle sampler with multiple inputs is installed in the ventilation stack.

The system also includes a device for measuring the flow rate through the stack. An alarm warns the operator when there is a duct airflow velocity change of more than 1.6 m/s. The speed of the air-stream in the sampling system is automatically adjusted as a function of the flow rate through the stack.

The sampling system automatically responds to the duct permanent flow velocity changes, ignoring the transient changes of less than 5 minutes duration. The sampling nozzle is easily removable from the outside of the duct for cleaning purposes. Stainless steel tubing length is provided to run from the nozzle to the collection system. There is the secondary collection system before collectors situated.

Aerosol (Particulate) System

The samples extracted from the air released through the ventilation stack are passed through a glass fiber particulate filter, which is measured with a beta scintillation detector to determine the activity collected in it. The detector includes a scintillating crystal, a photomultiplier tube and an amplifier. The detected signal will be passed through a preamplifier, an amplifier, a logarithmic rate meter and a signal conditioning circuit to produce a five decade logarithmic signal. The activity accumulated on the aerosol filter is proportional to the radioactive aerosol concentration from the last change of filter. The range of total particulate activity expected to be released through the ventilation exhaust is $1x10^{-4}$÷10 GBq/day. The filter is changed weekly and a detailed analysis is performed in the Health Physics Laboratory.

Radioactive Iodine System

After the removal of aerosols, the sample taken from the stack is passed through an impregnate with TEDA coal filter cartridge. The activity accumulated on the iodine filter is proportional with the I–131 concentration integrated from the last change of filter, except for the decay. The activity collected in the filter cartridge is detected with a scintillation gamma detector which includes a Thalium activated sodium iodine crystal, a photomultiplier tube and an amplifier discriminator with dual window (iodine and background, background alone). The range of total iodine activity release expected from the ventilation exhaust is $0.4x10^{-4}$÷40 GBq/day.

The filter is changed weekly and sent to the Health Physics Laboratory.

Noble Gas System

The noble gas system consists of a detector with scintillation whose output signal is proportional with the total detected gamma energy for low level activity noble gas releases expected during routine operation and a GM detector for high gamma levels anticipated in an emergency. A third, external GM detector is used to monitor the background radiation level.

The range of total activity release expected from the ventilation stack is for noble gas low level: $0.45x10^{-3}$÷$0.45x10^{2}$ TBq-MeV/day and for high level: $0.45x10^{-1}$÷$0.45x10^{2}$ TBq-MeV/day.

The display is manually reset daily.

Tritium Sampling System

This system consists of a collector with molecular or silicagel strainer. The collector must not become saturated or collect chemical species that would interfere in tritium activity analysis by a liquid scintillation counter. The collector is not required to collect elemental tritium.

A sample of gas taken from the ventilation stack is passed through a desiccant (molecular strainer or silicagel), which retains the tritiated water vapors. The molecular strainer is changed twice a week and the water collected is analyzed daily by determination of tritium in the Health Physics Laboratory, with the help of a Liquid scintillation counter. The amount of tritium released through the stack is determined by measuring the volume of gas released by the stack as well as the volume of the sampled gas.

C-14 Sampling System

A fraction of the gas sample taken from the ventilation stack is passed through a bubbler and bubbled through a liquid solution of sodium hydroxide, which retains carbon as carbon dioxide. The sample may also be directed through a catalytic converter upstream of the collector, which oxidizes other components of carbon to CO_2. The bubbling solution is changed weekly and the respective sample is analyzed in the Health Physics Laboratory by determining the content of C-14, by means of a liquid scintillation measurement system. The total amount of C-14 released can be determined, since the volume of gas released through the stack and the volume of the sampled gas are known.

In order to eliminate the interference of tritium in the C-14 collector the two collectors are arranged in series. Two complete loops for tritium and C-14 are provided for redundancy.

4.2.7.2.2. Monitoring System for D_2O in Air

The D_2O in air monitoring system detects the heavy water leaks to the atmosphere through the ventilation stack (4.2-10).

Control pertaining to the D_2O in air monitoring system is manual. Indication of the sample flow is provided locally.

The heavy water loss is measured by using a cold finger condenser connected to the ventilation duct. This cold finger condenses a sample of water vapour from the ventilation duct. The sample is then analyzed to determine the heavy water concentration. The heavy water flow rate discharged through the ventilation stack is determined by combining the heavy water concentration so obtained with the relative air humidity, the temperature determined with the dry thermometer and the air flow rate circulated in the ventilation duct.

The air sample is extracted from the ventilation duct by the sample condenser 63864-CD 1, consisting of a glass vacuum trap placed in a thermos flask. This flask contains a small amount of liquid nitrogen, or dry ice. When an air sample enters the vacuum trap, most of the moisture will be precipitated onto the surface of the trap leaving a coating of ice. Once a day the ice is collected and this sample is taken to the laboratory. There it is melted and analyzed for concentration of D_2O in H_2O. On very dry winter days the sampling interval could increase, if no frozen sample can be extracted during a period of the day.

On the operator's demand, the following ventilation duct measurements will be displayed in the main control room on a monitor and recorded on an hourly log:

- relative humidity;
- temperature;
- air flow;
- pressure.

Annunciation must be initiated and an alarm window should be activated in the main control room whenever Reactor Building ventilation flow is low.

4.2.7.2.3. Containment Atmosphere Monitoring

There are two assemblies for monitoring the containment radioactivity (one on the ventilation line and one on the D_2O vapor recovery line), each monitoring three control channels: N, P, Q. An independent detector for radioactivity measurement is provided for each channel. When measuring activity, if any two out of three channels indicate that the radioactivity exceeds the set point, containment isolation is initiated by automatic closure of the pneumatic valves on the discharge lines, thus preventing radioactive releases into the atmosphere. The containment monitoring system is part of the containment system.

4.2.7.3. Other Measures for Mitigating the Impact on Air

The maintenance activities will be performed rigorously, contributing to the good condition of the equipments, so that all the plant systems work properly. Consequently, the emissions to air will be properly treated and they will be within the parameters mentioned above.

The internal procedures will include fast identification of any unexpected emission causes so that to take appropriate measures.

References

4.2-1. ICIM, *Studiu de impact pentru CNE Cernavodă Unitatea 2*, 2001.

4.2-2. Institutul Național de Meteorologie şi Hidrologie- *Reactualizare studiu meteorologic şi de dispersie a poluanților în zona CNE Cernavodă Unitatea 1*, decembrie 1994.

4.2-3. Institutul de Meteorologie, Hidrologie şi Gospodărire a Apelor, *Reactualizarea studiului meteorologic şi de dispersie a poluanților în zona CNE Cernavodă,* octombrie 2000.

4.2-4. Administrația Națională de Meteorologie, *Studiu meteorologic şi de dispersie a poluanților în zona CNE Cernavodă*, 2004.

4.2-5. SITON, CNE Cernavoda Unitatea 2, *Raport Final de Securitate*, 2005.

4.2-6. Norme Fundamentale de Securitate Radiologică, Ordinul CNCAN nr.14/2000.

4.2-7. CNE-PROD,RD-01364-RP4, rev.2, *Limite Derivate de Evacuare pentru CNE Cernavodă Unitatea 1,* 1995

4.2-8. ICIM, *Studiu de impact pentru DICA*, 2001.

4.2-9. SITON, CNE Cernavoda Unitatea 1, *Raport Final de Securitate*, 2001.

4.2-10. 82-63864-6100-DM, Rev.0 NPP Cernavoda U2, *Sistem de monitorare D_2O în aer*, 2005.

4.2-11. SITON, *Documentație U3/U4 - 08233 - 6023 - STI,* august 2006.

4.2-12. ICIM, *Bilanț de mediu de nivel II pentru CNE-PROD Cernavodă,* 2004.

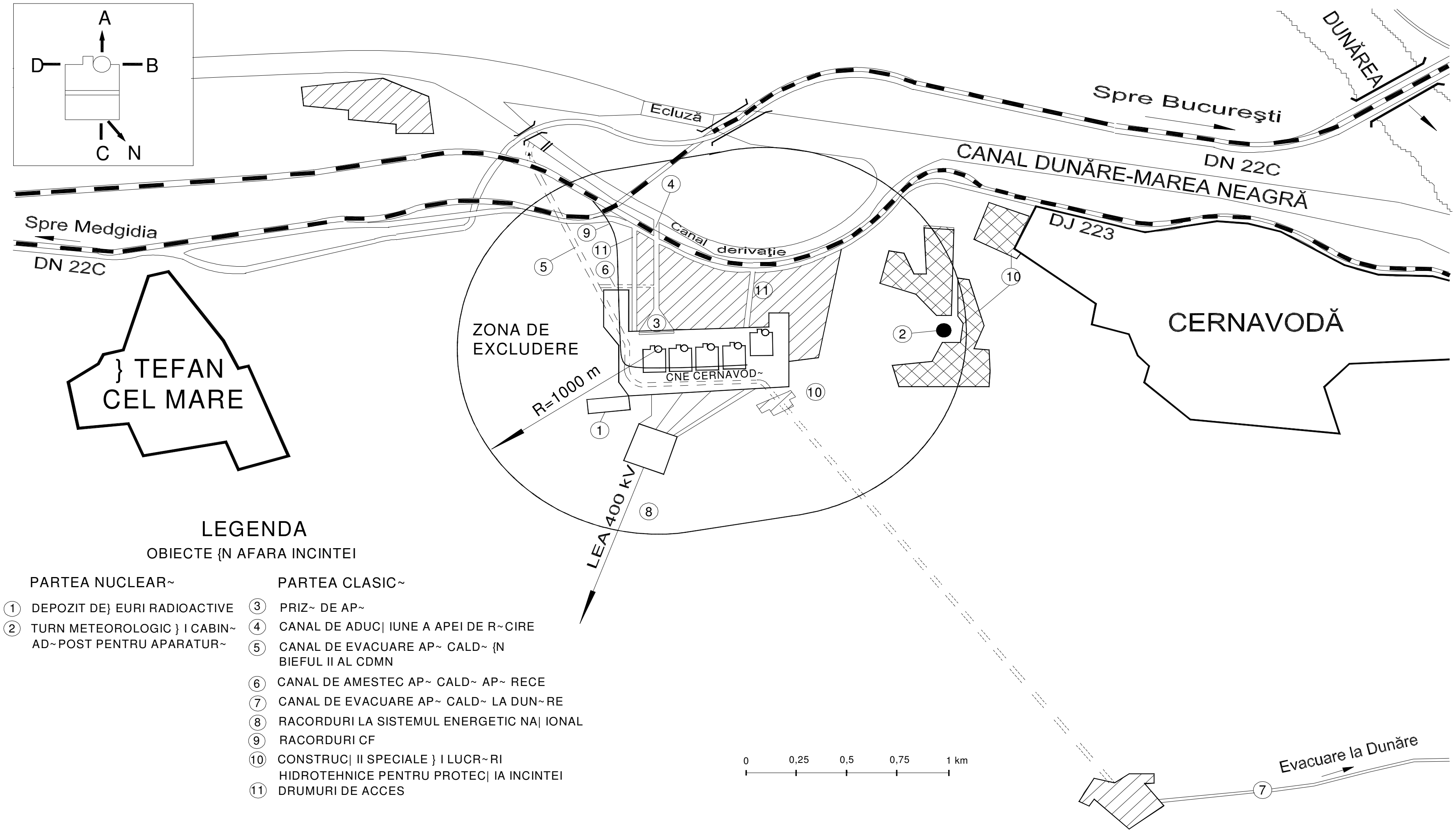

Figure 4.2.7-1. Scheme of objects used by Cernavoda NPP