3. DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Introduction

This Section provides basic information on the environment in the vicinity of the project. The baseline data concerning the description of the site were taken from a Kyivenergoproekt report [3.1] supplemented by information provided by SSEC CSER [3.2].

3.2 Baseline data

3.2.1 Location

Khmelnitsky nuclear power plant (KNPP) is located in the northwestern part of Slavuta district, in the administrative Region of Khmelnitsky (Figure 3.1). It is situated on the left bank of the Goryn River, 18 km west of the town of Slavuta (the district centre), on land which is used for agriculture or occupied by forests which belong to the State Forest Fund (Figure 3.2).

The closest inhabited localities are (Figure 3.3):

- NPP Settlement – town of Netishin – 3 km northwest of the NPP (#8 on Figure 3.3)
- Town of Slavuta – 18 km east of the NPP (#9 on Figure 3.3)
- Urban settlement of Ostrog – 10 km northwest of the NPP (#21on Figure 3.3)
- Town of Iziaslav – 30 km southwest of the NPP (#11 on Figure 3.3)
- Urban settlement of Biloghirya – 50 km south of the NPP (#22 on Figure 3.3)
- Town of Shepetivka – 35 km southwest of the NPP (#10 on Figure 3.3)
- Town of Zdolbuniv – 35 km north of the NPP (#17 on Figure 3.3)
- City of Rivne – 40 km north of the NPP (#1 on Figure 3.3)

The township of Netishin was built 3 km north of the site to accommodate Khmelnitsky NPP's operation, maintenance, construction and assembly, and servicing personnel. Its present population is approximately 35,000.

The regional centre - the city of Khmelnitsky (300,000 inhabitants) - lies 100 km to the south. The capital of Ukraine, Kiyv (3 million inhabitants) lies 370 km to the east.

The distance between the NPP site and the national borders of Ukraine is 165 km to the Romanian border, 180 km to the Polish border and 220 km to the border with the Belarus Republic.

The location of main facilities and buildings at the KNPP site are given in Figure 3.4.

Figure 3.1
Location of Khmelnitsky NPP (Administrative map)

Figure 3.2
Location of Khmelnitsky NPP (Geographical map)

Figure 3.3
Major towns around Khmelnitsky NPP

Figure 3.4
Master plan of Khmelnitsky NPP

Legend:

1 Power unit 2
2 Outdoor power switch-board 750 kV
3 Outdoor power switch-board 330 kV
4 Cooling water reservoir
5 Water inlet channel
6 Water discharge channel
7 Main building
8 Special purpose building
9 Goryn river

Apart from the main buildings, auxiliary buildings and structures for the following functions are envisaged under the project:

- administrative;
- gas handling facilities;
- nitrogen and oxygen station;
- reserve diesel fuel-fired power stations;
- start-up and reserve boiler house;
- oil and lubricant handling facilities;
- laboratory and auxiliary facilities;
- acetylene-generating facilities;
- radioactive waste building complete with a handling unit;
- external radioactive monitoring laboratory; and
- process pipework bridge.

The enclosed area of the NPP site is 90.2 ha. The overall area of the territory occupied by the NPP complex is 3,074.7 ha, with the water reservoir accounting for 2,171.8 ha and the township of Netishin 232.8 ha.

A 4 km railway line to the locality of Siltse provides a link with the general rail network.

A 6 km road provides a connection with the general highway system via the Shepetivka-Ostrog-Rivne highway. The sanitary protection zone around the NPP has a 3 km radius.

3.2.2 Seismicity

Several studies of seismicity in the Khmelnitsky region have been carried out and are summarised in a review document from Kyivenergoproekt [3.3]. Their main conclusions are as follows.

Local earthquakes have not been recorded in the site area. The region would have been affected by force 4-5 earthquakes in the Romanian South Carpathian Mountains (Vrancha massif) in 1802, 1940 and 1977 (magnitude < 7.5, focal point depth h = 100-150 km, epicentre distance L = 500 km approximately).

According to the map of seismic hazard in Ukraine, the Khmelnitsky NPP is located in a zone where the design earthquake (DE) (100-year earthquake) has a magnitude of 5 on the MSK scale and the design basis earthquake (DBE) (10,000-year earthquake) has a magnitude of 6 MSK.

- DE: magnitude 5 (MSK), maximum acceleration of the ground vibration 0.02 g,
- DBE: magnitude 6 (MSK), maximum acceleration 0.05g

Further discussion on seismic issues is presented in Section 9.3.1.

3.2.3 Relief and landform

The KNPP site is located in the outer south eastern part of the Russian platform within the Ostrozska lowland. This is a flat area with a weak slope from the southeast to the northwest. The plain is broken by smoothed heights which are the result of wind erosion acting on crystalline rocks. The hills alternate with valleys which are often waterlogged. Height above sea-level ranges from 190–230 m.

Soils in the 30 km zone are of a uniform nature and represented mainly by gray to dark gray podzolized soils, light loam and loamy sand. Approximately 26,000 ha of land are reclaimed.

The Goryn river (#24) is a right tributary to the Pripyat river (Figure 3.5). The river is 659 km long. The NPP site is situated 462 km away from the estuary, in the vicinity of Netishin (#8), on the boundary between the upper and the middle parts of the river. The flood plain of the river valley in this area is asymmetrical with the right bank moderately steep and the left having no clear boundary. The river has a width of 30 to 35 m and a depth of 0.7 to 0.8 m on sandbars and up to 3 m in reaches. The flood plain is double sided with a width of 1.8 km at the NPP increasing to 3 to 4 km at the town of Netishin. Further downstream the flood plain merges with those of the Viliya river and the Gnilyi Rig.

The main tributaries of the Goryn river, the Viliya (#26) and Gnilyi Rig (#25), join the Goryn river in the area of the NPP.

The Gnilyi Rig is a right tributary of the Viliya river. Its total length is 28 km. The NPP reservoir is formed at its mouth and takes all of its flow. The basin of the Gnilyi Rig is wooded and swampy. In parts there are drainage channels. The river bed is narrow and largely canalised, to 3 to 4 m wide and 0.2-0.5 m deep.

The 77 km Viliya river is a left tributary of the Goryn river. Its valley is straight, with convex sides. In places the sides of the valley are steep and reach a height of approximately 20 m on the left bank and 6 to 7 m on the right. Its flood plain is low, dry and, for the most part, two-sided, and slightly marshy near its mouth. The river bed is moderately winding and has an even bottom. The steep banks and occasional bluffs are 0.5 to 1.0 m high, covered with turf and overgrown with scrub.

3.2.4 Demography

3.2.4.1 Population and age distribution within 30 km of the NPP

There are two hundred and eleven inhabited localities with a resident population of 250,700 within the 30 km zone around the NPP (Table 3.1).

Figure 3.5
Khmelnitsky NPP region

Table 3.1
Distribution of the population in the 30 km zone by regions [3.1]

Zone	Number of Inhabited Localities	Number of residents (thousands)			
			Under Working Age	Working Age	Over Working Age
1	2	3	4	5	6
1. KHMELNITSKY REGION					
Up to 5 km	3	36.3	8.35	18.51	9.44
5-10 km	9	11.4	2.62	5.81	2.97
10-15 km	13	55.9	12.86	28.51	14.53
15-20 km	22	11.4	2.62	5.81	2.97
20-25 km	44	44.1	10.14	22.49	11.47
25-30 km	41	26.4	6.07	13.46	6.87
TOTAL:	132	185.5	42.66	94.59	48.25
2. RIVNE REGION					
Up to 5 km	-	-	-	-	-
10-15 km	13	11.4	2.62	5.81	2.97
15-20 km	23	13.3	3.06	6.78	3.46
20.25 km	21	11.7	2.69	5.97	3.04
25-30 km	19	13.6	3.13	6.94	3.53
TOTAL:	79	65.2	15.0	33.25	16.95
3. TOTAL FOR THE 30-KM ZONE AROUND NPP:					
Up to 5 km	3	36.3	8.35	18.54	9.44
5-10 km	12	26.6	6.12	13.56	6.92
10-15 km	26	67.3	15.48	34.32	17.5
15-20 km	45	24.7	5.68	12.59	6.43
20-25 km	65	55.8	12.83	28.46	14.51
25-30 km	60	40.0	9.2	20.4	10.4
TOTAL:	211	250.7	57.66	127.87	65.2

Note: Data provided by the Khmelnitsky Regional Administration (letter 273 of 25/07/96) and by the Rivne Regional administration (letter 01/32/0-3765 of 08/08/96).

Table 3.2 shows the distribution of the population in the region with a breakdown by 5 km concentric circles and by sector. Table 3.3 shows the age distribution of the population in different sectors.

Table 3.2
Distribution of population by sector/segment of concentric circles of the 30 km zone [3.1]

Segments by zone	SECTOR																Sector total by segment	
	I		II		III		IV		V		VI		VII		VIII			
	a.	b.	a.	b.	a.	b.	a.	b.	a.	b.	a.	b.	a.	b.	a.	b.	a.	b.
up to 5 km	-	-	2	0.7	-	-	-	-	-	-	-	-	-	-	1	35.6	3	36.3
5-10 km	1	1.97	2	1.39	1	0.1	2	0.6	1	0.19	1	0.02	2	15.0	2	7.33	12	26.6
10-15 km	5	3.95	3	42.8	-	-	3	3.9	3	5.2	4	3.29	4	3.6	4	4.56	26	67.3
15-20 km	9	3.43	5	2.32	3	0.85	4	2.96	2	1.7	8	3.24	9	3.81	5	6.39	45	24.7
20-25 km	9	5.16	7	3.46	6	5.25	11	23.87	8	3.73	8	4.15	8	3.16	8	7.02	65	55.8
25-30 km	8	6.93	6	4.57	2	1.5	10	9.25	11	4.21	9	2.32	7	5.62	7	5.6	60	40.0
Total by sectors	**32**	**21.4**	**25**	**55.24**	**12**	**7.7**	**30**	**40.58**	**25**	**15.03**	**30**	**13.02**	**30**	**31.19**	**27**	**66.5**	**211**	**250.7**

a. - number of inhabited localities
b. - number of residents (thousands)

Table 3.3
Age distribution of the population by sector [3.1]

SECTOR	Number of residents by sectors	ZONE SEGMENTS (thousands)																	
		up to 5 km			5-10 km			10-15 km			15-20 km			20-25 km			25-30 km		
		UWA	WA	OWA	UWA	WA	OWA	UWA	WA	OWA	UWA	WA	OWA	UWA	WA	OWA	UWA	WA	OWA
1	21.44	-	-	-	0.45	1.00	0.52	0.90	2.01	1.04	0.79	1.75	0.89	1.18	2.63	1.35	1.59	3.53	1.81
II	55.24	0.16	0.36	0.18	0.32	0.70	0.37	9.85	21.80	1.15	0.53	1.18	0.61	0.79	1.76	0.91	1.05	2.33	1.19
III	7.70	-	-	-	0.02	0.05	0.03	-	-	-	0.19	0.43	0.23	1.20	2.70	1.35	0.34	0.76	0.40
IV	40.58	-	-	-	0.14	0.30	0.16	0.9	1.99	1.01	0.70	1.50	0.76	5.49	12.20	6.18	2.12	4.70	2.43
V	15.03	-	-	-	0.04	0.09	0.06	1.19	2.6	1.41	0.40	0.86	0.44	0.86	1.90	0.97	0.97	2.15	1.02
VI	13.02	-	-	-	0.004	0.01	0.006	0.76	1.68	0.85	0.74	1.65	0.85	0.95	2.12	1.08	0.53	1.18	0.61
VII	31.19	-	-	-	3.45	7.65	3.90	0.83	1.8	0.97	0.88	1.94	0.99	0.73	1.61	0.82	1.29	2.87	1.46
VIII	66.50	8.19	18.16	9.25	1.68	3.73	1.92	1.05	2.32	1.19	1.47	3.26	1.66	1.61	3.58	1.83	1.29	2.86	1.45

Note: 1. Distribution by age:UWA - under working age (18 years)
WA – working age (55 for females and 60 for males)
OWA – over working age

2. Percentage of distribution by age is regarded as mean by regions in the 30 km zone:
UWA = 23%
WA = 51%
OWA = 26%

3.2.4.2 Population of large towns (>20,000 people) within 100 km of the NPP

There are 14 large inhabited localities and towns with a population in excess of 20,000 located within the radius of 100 km around the NPP (Table 3.4). Iziaslav in Khmelnitsky region had a population of 18,800 people as of 1 January 1996.

Table 3.4
List of towns and inhabited localities and their population within 100 km of KNPP [3.1]

Name	Population (thousands)	Distance from KNPP (km)	Remarks
1. KHMELNITSKY REGION			
Urban-type settlement Netishin	35.6	3	NPP Settlement
Slavuta	38.3	16	
Shepetivka	52.6	32	
Iziaslav	18.8	24	Included conditionally
Polonne	25.6	64	
Starokostiantiniv	37.8	72	
Krasiliv	22.5	77	
Volochisk	25.0	90	
Khmelnitsky	259.0	100	Regional centre
Total for Region:	**515.2**		
II. RIVNE REGION			
Kostopil	33.6	65	
Zdolbuniv	28.5	35	
Dubno	42.8	65	
Rivne	246.5	40	Regional centre
Total for region:	**351.4**		
III. ZHITOMIR REGION			
Novograd-Volinsky	57.8	75	
Total for region	**57.8**		
IV. TERNOPIL REGION			
Kremenets	24.0	67	
Total for region	**24.0**		
Total for four regions:	**948.4**		

Note: All towns are shown on Figure 3.3 or Figure 3.5.
Data supplied by the regional administrations of Khmelnitsky and Rivne as of 1 January 1996 for Khmelnitsky region and 1 July 1996 for Rivne region.

There are four settlements within 5 km of the NPP: Netishin (3 km), Siltse (2 km), Komariuka (5 km) and Pivneva Gora (5 km).

3.2.4.3 Diet of the urban and rural population of the neighbouring area (10–20 km)

The basic diet of both the urban and rural population of the area located within 10 and 20 km of the NPP comprises agricultural and livestock products, fish and processed foods. The most typical foods for this area are potatoes, buckwheat, peas, beans, sunflower and all types of garden and orchard crops. Macaroni brought in from elsewhere is widely consumed.

Milk and dairy products account for 24% of the diet. Meat and meat products are consumed in the countryside predominantly in their natural state and in the towns as processed foods, 30% of which are supplied from elsewhere. Poultry products are also widely consumed.

Fish accounts for 10%-12% of the protein consumption as compared with meat products. Fish is farmed, in the main, by local pond farms. River fishing is of an exclusively amateur nature. Canned fish foods produced beyond the borders of the region are widely consumed.

Both the urban and rural population consume sugar. Honey consumption is less than 3% that of sugar.

Forest products, such as mushrooms, berries and nuts, are an insignificant addition to the population's nutrition in terms of quantity.

3.2.4.4 Socio-economic data

According to census data of 1989, 79% of the population was employed in material production branches with the largest proportions attributed to industry, agriculture and forestry. More recent data have not been obtained.

In the 30 km zone around Khmelnitsky NPP, there are 85 industrial enterprises manufacturing a variety of products. Major enterprises include the mechanical repair plant at Slavuta, the "silica wall materials" plant and the Stroifarfor plant. Other enterprises are generally either light industry or food industry.

According to Khmelnitsky and Rivne regional administrations, within the NPP 30 km area, there are no facilities whose operation could cause accidents accompanied by fires or explosions resulting in atmospheric releases of toxic and radioactive substances.

3.2.5 Land use

The total area of the Netishin District is reported as 6592 ha including 2859 ha agricultural, 1712 ha woods and 1622 ha urban [3.2]. Of the agricultural area, 52% is ploughed land, 29% is used for production of hay, 18% as pastures and 2% as gardens. Built up ground represents 1149 ha. The cooling reservoir accounts for 618 ha, the Goryn river 43 ha, and lakes 79 ha.

50% of the land in an area of 30 km radius around the NPP (i.e. 140,000 ha) is worked by 82 farming enterprises. This farmed land includes 11,400 ha of forest.

According to information from the regional directorate for agriculture, the cattle population is about the same size as that of pigs and sheep on the collective and individual farms. They number more than 60,000 head of cattle, approximately 40,000 pigs and about 5,000 sheep.

The main agricultural crops are: winter wheat, barley, oats, buckwheat, peas, sugar beet, chicory, fodder crops, potatoes, fruits and vegetables.

The majority of unfarmed land is covered with forest.

3.2.6 Meteorology

Three meteorological stations of the Ukrainian State Committee for Hydrometeorology (#1, 11, 10) are situated 20 to 40 km from the NPP site, territorially making up an equilateral triangle with the NPP site in the centre. The three stations are at Rovno, Izyaskav and Shepetivka.

The longest period of observations has been registered at the weather station of Shepetivka, which is also an air quality station and representative for a large territory of the Western Ukrainian Polissia. Observations at the station have been conducted since 1887.

The schedule for monitoring hydrological and meteorological parameters in the vicinity of KNPP is set out in Table 3.5.

The Khmelnitsky NPP is located in a zone with a temperate climate characterised by a mild and humid winter, relatively cool and rainy summer, damp autumn and unsettled weather during the transition seasons.

The mild winter with frequent thaws is created by western and eastern winds. Sharp cold spells in winter result from the penetration of Arctic air, which causes sudden and considerable drops in temperature, frosts and snow.

The onset of spring is associated with weakening northeasterly air currents and growing western currents. Sharp and brief cold spells occur in April and May caused by the penetration of Arctic air.

Weather conditions in the summer season are characterised by considerable rises in temperature caused by the warmed ground surface, frequently recurring bright days, rare mists, growing precipitation and thunder activity.

3.2.6.1 Air temperature

Average, maximum and minimum air temperatures (^{o}C) at KNPP in 1996 and 1997 were as follows [3.2].

		Month											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1996	**Av.**	-10	-8	-3	9	19	19	22	22	13	11	8	-3
	Max	-2	0.4	5	19	25	27	29	27	24	16	18	8
	Min	-22	-20	-10	0.2	12	12	16	17	6	5	0	-20
1997	**Av.**	-4	2	5	8	19	22	22	24	16	9	5	-2
	Max	5	11	16	20	29	30	28	27	24	22	16	4
	Min	-16	-9	-4	2	9	12	17	18	8	-0.4	-3	-20

In 1996 and 1997 the coldest month was January with the absolute minima occurring in either December or January. Absolute maxima occurred in July or August. The mean annual temperatures were 8.1 ^{o}C for 1996 and 10.1 ^{o}C for 1997.

3.2.6.2 Humidity

Vapour pressure (absolute humidity) changes in accordance with fluctuations of air temperature. It reaches its lowest monthly values (approximately 2 millibars) in January and highest values (approximately 12 millibars) in August (based on data for 1996 and 1997).

Relative humidity is characterised by the degree of saturation of air with vapour. The highest monthly relative humidity (approximately 85%) is observed during the lowest temperatures in December and January (80%), and the lowest values (approximately 55%) in May (based on data for 1996 and 1997).

3.2.6.3 Cloud cover, precipitation and snow

The nature of cloud cover and its area during cold and warm periods of the year differs markedly. Low-lying cloud cover of layered forms of vertical development prevails in winter. Cloud cover of vertical development is distinctive for the warm periods of the year.

The maximum amount of both general and low-lying cloud cover is observed throughout November and December, and the minimum in August and September.

Mean annual precipitation is stated to be 649 mm. The highest level of daily precipitation within the 30 km zone of the NPP, 112 mm, was registered by the Shepetivka weather station on 13 July 1996. Annual precipitation in 1996 was 570.8 mm (Table 3.6) and in 1997 was 526.5 mm.

Table 3.5
Hydro-weather minimum schedule [3.2]

No.	Type of observation	Term and frequency
	1. METEOROLOGICAL AREA	
1	Temperature, humidity, pressure, wind speed and direction, visual range; precipitation; atmospheric phenomena, weather conditions	Around the clock : 4;8;12;16;20;24 h.
2	Observation of extreme meteorological phenomena	At all times during phenomenon
3	Observation of snow cover depth	Daily at 9^{00}; 15^{00} (if there is snow)
	2. DELIVERY CHANNEL	
1	Observation of range and temperature of water	Daily at 10^{00}
2	Observation of silting	1 /year, August
	3. REMOVAL CHANNEL	
1	Observation of range and temperature of water	1 / 5 days
	4. WATER SUPPLY CHANNEL from GORYN RIVER	
1	Observation of range and temperature of water	Daily at 6 ; 14 ; 20 h.
2	Observation of silting	1 /year, August
	5. WATER STORAGE BASIN	
1	Observation of water area	1 / m.
2	Observation of range and temperature of water near flood water disposal	Daily at 6; 14; 20 h. 1 /m.
3	Observation of water surface disturbance	Daily 6; 14; 20 h. Every 3 h. Under 10 m/s and more wind
4	Observation of extreme hydrological phenomena	At all times during phenomenon
5	Observation of ice phenomena	Daily if there is ice
6	Observation of water temperature at depth	1 / m.
7	Observation of water humidity	1 / m.
8	Observation of silting	1 / year, August
9	Observation of bottom precipitation	2 / year
10	Observation of water storage basin coastal zone status	2/ year

Table 3.6
Precipitation by month (mm) during 1996 [3.2]

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Monthly	52.8	18	26	40.3	70	70	50.5	44.6	97.2	29.1	35	37.3
Daily max	19	7.2	5.7	12	15.2	19.8	15	21.8	20.7	8	15	13
Daily min	0.2	0.4	0.4	0.5	0.4	1	0.2	0.5	0.5	0.3	0.5	1

The snow cover persists for an average of 93 days. The thickness of the snow increases gradually and reaches a maximum after 10 February; on average it is 9-12 cm thick in open areas and 15-16 cm in sheltered areas. The thickest snow cover registered in sheltered areas reaches 51-58 cm.

Average characteristics of precipitation and snow cover are stated [3.1] to be as follows.

- Average annual precipitation……...704 mm
- Highest monthly precipitation (July)……..226 mm
- Lowest monthly precipitation (March)…….….1 mm
- Maximum daily precipitation…….. 112 mm
- Thickness of snow cover:
  highest ……..….33 cm
  average……..… 12 cm

3.2.6.4 Wind

Monthly average wind velocities (Table 3.7) range from 2.6 to 4.5 m/s. The highest wind velocities occur in winter with highest velocities associated with northwesterlies [3.4]. The average number of days with strong winds ranges from 13 to 37 days and storms occur on average 3-4 days in winter months and for 1-2 days in summer months. The maximum wind velocity is 36 m/s (1% frequency) or 30 m/s (10% frequency).

Table 3.7
Average monthly and annual wind speed in the Khmelnitsky region [3.2]

Month	**1**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Ann**
Speed	3.8	4.5	4.2	3.6	3.0	2.9	2.6	2.6	3.0	3.6	4.0	4.2	3.0

Maximum registered levels of wind velocity in the NPP zone are 28-30 m/s and gusts can be up to 34 m/s.

The prevailing winds are from the northwest. Data from the Shepetivika weather station are provided in Table 3.8.

Figure 3.6
Wind rose for the KNPP area (Frequency, %)

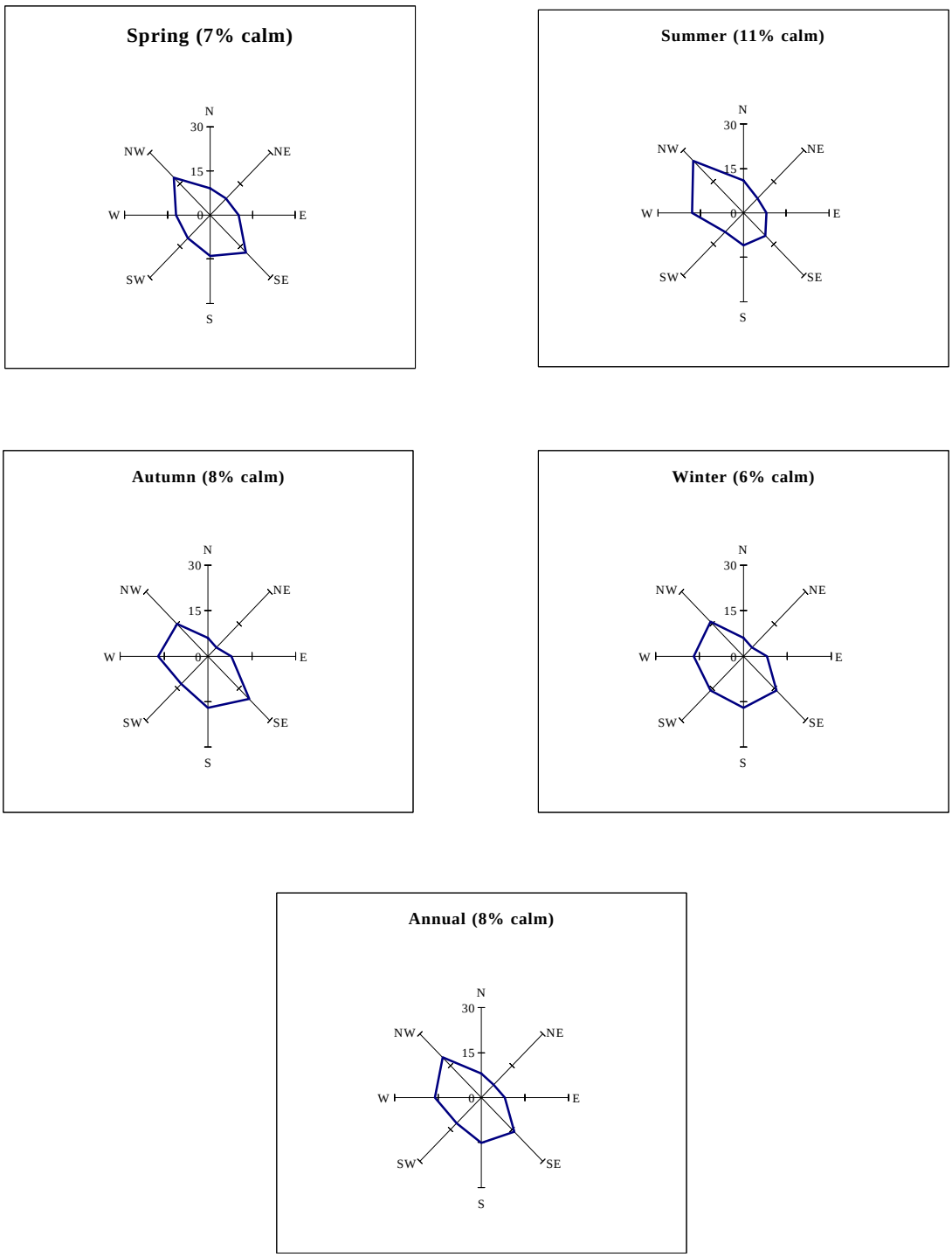

Table 3.8
Wind direction (%) at the Shepetivka station [3.2]

Seasons	N	NE	E	SE	S	SW	W	NW	Calm
Spring	9	8	10	18	14	11	12	18	7
Summer	11	7	8	11	11	9	18	25	11
Autumn	6	4	8	20	174	13	17	15	8
Winter	6	4	8	16	17	16	17	16	6
Annual	8	6	8	16	15	12	16	19	8

The wind rose based on these data is given in Figure 3.6

3.2.6.5 Atmospheric stability

Atmospheric stability characteristics for the KNPP site are summarised in Table 3.9 on a seasonal and annual basis.

Table 3.9
Atmospheric stability characteristics for KNPP site.

Category of stability	Winter	Spring	Summer	Autumn	Annual
A. Strong instability	0	2.8	8.9	1.7	3.4
B. Moderate instability	0.6	7.5	19.8	6.4	8.6
C. Weak instability	5.2	6.4	26.6	11.0	12.3
D. Indifferent stratification	36.8	43.5	24.1	46.9	37.8
E. Weak stability	19.2	14.1	5.8	14.6	13.4
F. Moderate stability	23.0	21.6	14.4	11.9	17.7
G. Strong stability	15.2	4.1	0.4	7.5	6.8

3.2.6.6 Monitoring of non-radioactive discharges to air and air quality

The schedule for monitoring of discharges to air and air quality is given in Table 3.10.

Results of analyses of oxides of nitrogen and sulphur and of suspended materials are provided for 1996 and 1997 in Table 3.11.

Table 3.10
1998/99 schedule for monitoring of non-radioactive discharges to air and air quality at KNPP [3.2]

Source # on NPP map, sample point #	Type of production, shop, suction, sample point	Checked material	Frequency of inspection	Frequency of inspection under UMC
1	2	3	4	5
1	Back-up boiler house (during preventive maintenance) exhaust fan 1 exhaust fan 2 exhaust fan 3 exhaust fan 4	 -dust content, -nitrogen oxides sum. -sulphur oxides sum.	 2 / w. 2 / w. 2 / w.	
2	p.1 Site area Hothouses	-dust content, -nitrogen oxides sum. -sulphur oxides sum.	2 /m. 2 / m. 2 / m.	1 / m. 1 / m. 1 / m.
3	p.2 Settlement, SSZ border	-dust content. -nitrogen oxides sum. -sulphur oxides sum.	2 / m. 2 / m. 2 / m.	1 / m. 1 / m. 1 / m.
4	Car garage, petrol engine cars	toxicity, hydrocarbons	1/6 m. 1/6 m.	
5	Car garage, diesel engine cars	smoke formation gases	1/6 m. 1/6 m.	
6	Cement plant, Zdolbuniv town	-dust content. -nitrogen oxides sum. -sulphur oxides sum.	2 /qr. 2 /qr. 2 /qr.	1 / m. 1 / m. 1 / m.
7	v. Komarivka, radiation post	-dust content. -nitrogen oxides sum. -sulphur oxides sum.	2 /m. 2 / m. 2 / m.	1 / m. 1 / m. 1 / m.
8.	Asphalt-bitumen facility	-dust content. -nitrogen oxides sum. -sulphur oxides sum.	1/6 m.	

Note: 1. UMC = unfavourable meteorological conditions (wind speed less than 2.7 m/s)
qr = quarter, w= week, m = month

Table 3.11

Results of analysis of atmospheric sampling for non-radioactive materials (mg/m^3) near Netishin town in 1996 and 1997 [3.2]

a) 1996

Month:	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Oxides of sulphur	0,05	0.15	0,13	0,12	0,24	0,278	0,07	0,092	0,091	0,077	0,064	0,067	0,102
Oxides of nitrogen	0,016	0,006	0,006	0,007	0,032	0,024	0,015	0,015	0,01	0,01	0,01	0,01	0,013
Dust	4,0	3,1	5,0	10,0	12,0	3,1	2,1	2,4	1,3	7,5	4,8	2,3	4,8

b) 1997

Month:	I	II	III	IV	V	VI	VII	VIII	IX	X	Annual
Oxides of sulphur	0,069	0.17	0,1	0,082	0,05	0,048	0,073	0,05	0,028	0,054	0,072
Oxides of nitrogen	0,01	0,01	0,007	0,01	0,01	0,01	0,01	0,01	0,011	0,01	0,01
Dust	2,5	7,1	1,7	3,1	5,9	2,0	2,5	11,5	3,0	7,3	4,7

Data supplied by the Laboratory of Environment Protection of KNPP.

3.2.7 Hydrology

The greatest flows of the Goryn and Gnilyi Rig rivers are caused by water from melted snow and occur during spring floods. In summer and winter brief rises in levels are observed as a result of rainstorm precipitation. The highest levels of rain floods are occasionally higher than the levels of spring floods (once every 10 years).

The highest flood level occurs, as a rule, on the second day after the rivers open. The average date when the rivers open is 20 March. The flood ends in the latter half of April, sometimes during the first 10 days of May.

The distribution of the flow of the Goryn and Gnilyi Rig is uneven throughout the year. Its highest value is during the period of spring floods.

The average (50% probability) water flow of the Goryn river at the NPP intake is presented in Table 3.12.

Table 3.12
Average (50% probability) water flow distribution (m^3/s) of the Goryn river at the NPP intake [3.1]

Water flow	Month												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Average (50%)	12	17	47	21	12	6.1	11	13	10	9.2	18	8.6	15.6

Minimal flow rates for the Goryn river at the NPP water intake are given as daily and monthly averages in Table 3.13.

Table 3.13
Minimal flow rates characteristic of the Goryn river at the NPP water intake site [3.1]

Minimal flow rate (m^3/sec)	Average year	Years of low flow (probability)			
		(50)	(75)	(95)	(97)
a) monthly average					
summer – fall	8.69	8.11	6.27	4.32	3.94
Winter	5.73	5.34	4.00	2.57	2.29
b) daily average					
summer – fall	7.75	7.18	5.49	3.70	3.36
Winter	4.21	4.21	3.20	2.14	1.94

The flow of the Gnilyi Rig accumulates in the cooling reservoir of the NPP (see below).

The flow rate through the dam of the cooling reservoir in an average year is given in Table 3.14.

Table 3.14

Average (50% probability) water flow (m^3) of the Goryn river at the dam site [3.1]

Water Supply	Month												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Average (50%)	0.6	1.6	2.2	1.3	0.67	0.26	0.33	0.66	0.19	0.25	0.34	0.60	0.77

The Goryn river is the largest water artery flowing through the Khmelnitsky Region. The rivers' water is used for economic and domestic purposes, industrial water supply and irrigation.

In the 30-km zone downstream of the NPP there are no substantial water consumers. Here the river is used mostly for angling, watering of cattle and irrigation. The river is not navigable.

An artificial water reservoir was built on the flood lands of the left bank of the Goryn. It performs two functions.

- It receives wastewater from the main cooling system of the NPP and of group B consumers.
- It regulates the outflow of the Goryn.

The dam is placed near the confluence of the Gnilyi Rig and the Viliya river. It has a length of 7.5 km and is in the form of a horseshoe. The reservoir fills the valley of the Gnilyi Rig up to a distance of 6–6.5 km from the dam. The reservoir collects water in an area of 195 km^2 and, at capacity has an area itself of 20.2 km^2. It has a maximum capacity of 120 million m^3 and, when full, a depth ranging from 6.0 to 12 m.

The NPP is allowed to take water from the Goryn exclusively within the non-vegetation period, i.e. from October through May. At any other time, replenishment of the reservoir by water from the Goryn is prohibited and the NPP gets water from the reservoir at the expense of its volume.

3.2.8 Geology and hydrogeology

The KNPP site is located within the eastern borders of the Volyno-Podilsky artesian basin, in the zone of its junction with the Ukrainian crystalline massive. It has a widely developed system of ground waters related to the Proterozoic and Cainozoic strata.

Waters of the Quaternary deposits are developed within the bounds of the corresponding complexes (lake-bog, modern alluvial, Middle and Upper Quaternary alluvial, Upper and Middle Quaternary fluvial-glacial deposits).

According to geology, the following waters exist in the region of KNPP.

- Waters of the Quaternary sediments, used for water supply in rural areas.
- Waters of sediments of the Sarmat layer, used for water supply in rural areas.
- Water of the Marl-Cretaceous layer of the Turon stratum, one source of water.
- Water of sediments of the Senoman layer widely used for water supply.
- Water of sediments of the Upper Proterzoan Era, widely used for water supply.

- Water in rocks of the crystalline massive and its weathering products, widely used for water supply.

Industrial and drinking waters for the KNPP and for Netishin are supplied from the sediments of the Upper Proterozoic Era at depths between 150 and 200 metres. The artesian source is located near Netishin.

Quaternary waters are widespread and, on occasion, reach the ground surface.

Under the influence of industrial activity (filling of the cooling reservoir, intake and effluent channels, drainage and overall development of the site) the hydrological conditions changed. After the water reservoir was filled up to the 203 m mark (Baltic Sea Datum) the predicted level of ground waters in a steady operation regime at the site of the main building of power Unit No. 1, with allowances made for the ground-water dam and the impact of technogenic flooding factors, must not exceed the 202.5-203.0 m mark.

Before the dam was constructed and the reservoir filled, the groundwater level was between 192.7-193.0 m in October 1976; in June 1990 it ranged between 194.21 and 194.74 m. Ground water levels (m) in the vicinity of the cooling reservoir dam have been recorded as follows.

	Year and month		
Well No.	1976, October	1990, June	1997, not stated
1	193.0	194.74	194.32
2	192.90	194.60	194.34
3	192.70	194.21	194.01

The upward tendency in groundwater levels, especially downstream of the water reservoir dam, was most notable in the first years after the reservoir was filled.

Protection of aquifers:

- The ground waters are not protected against pollution.
- The aquifer related to the fractured upper part of the aleurite-argillite stratum of the Upper Proterozoic is relatively protected.
- The Upper Proterozoic aquifer, used for industrial and domestic water supply of the towns of Netishin and Slavuta, is protected (depth 150-160 m, thickness 100 m, covered by 120 m of slightly permeable sinter).

Within the boundaries of the NPP site a network of 186 hydrogeological wells has been constructed for the Quaternary and Upper Proterozoic aquifers. Observations are conducted on level, temperature and chemical composition of ground waters. There are no established reserves of ground water for industrial and drinking water supply within the boundaries of the NPP site.

3.2.9 Water quality

3.2.9.1 Water temperature

Monthly average and daily maximum/minimum temperatures in the Goryn river during 1996 are provided in Table 3.15. Maximum temperatures occurred in June and July.

Table 3.15
Monthly average and daily (14.00) maximum and minimum temperatures (^{o}C) in the river Goryn during 1996 [3.2]

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average	0,6	1	1,3	8	19,2	20,1	18,8	19,8	13,3	10,8	7,8	2,5
Max	1,8	2	2,9	16,5	23,3	26	24	22,5	20,5	14	11	7
Min	0	0,7	0,4	1,4	15,3	15,6	12,8	16	9	8	4,5	0

Note: Abstraction of water is not allowed during the period May to October

3.2.9.2 Other parameters

The total content of dissolved solids in the Goryn, Gnilyi Rig and Viliya rivers fluctuates from 250 mg/l during spring floods to 405 mg/l during the lowest water level in winter and 430 mg/l during the lowest water level in summer.

Such seasonality is also true for the overall water hardness which ranges from 4.8 meq/l to 17.4 meq/l. During spring floods the rivers' water is of the moderate hard type and during the rest of the year it is of the hard type.

The content of bicarbonate ions fluctuates from 214 to 360 mg/l in the Goryn and Viliya and from 128 to 284 mg/l in the Gnilyi Rig.

The chloride and sulphate concentration is in the range of 21-35 and 24-42 mg/l respectively.

The concentration of other ions fluctuates from 80 to 116 mg/l, dropping to 60-70 mg/l during spring floods.

Amongst biogenic substances, the river water contains ions of silica (SiO_2 4.0-8.0 mg/l) and nitrogen compounds (0.00-0.7 mg/l, occasionally up to 2.8 mg/l).

pH is in the range of 7.1-8.4.

Aggressive CO fluctuates from 2 to 8 mg/l, sometimes rising to 20 mg/l.

Average COD of river water, which characterises the amount of organic substances in water, varies from 5 mg/l in the Goryn to 7.8 mg/l in the Gnilyi Rig. Lowest COD is observed during the period of the lowest water level, and highest COD during spring floods, which is explained by the inflow of a large amount of organic substances – decomposition products of aquatic organisms and humus substances washed off the soil and bogs.

The BOD in the rivers' water is within the range of 2 to 5 mg/l, and in some cases (Viliya river) up to 10.4 mg/l.

Faecal coliform count varies from 0.04 to 4.3/ml, which reflects the influence of sewage effluents. The latter is also confirmed by the total number of microorganisms—from 800 to 73,000/ml.

Information on water quality of both the Goryn River and the cooling water reservoir for 1996 is provided in Table 3.16.

Table 3.16
Water quality in the Goryn river and NPP cooling reservoir during 1996 [3.2]

Month	Zn mg/l	Fe mg/l	Mn mg/l	Cu mg/l	PO_4 mg/l	NO_3 mg/l	NO_2 mg/l	NH_4 mg/l	BOD mgO/l	COD mgO/l	Hardness meq/l
Goryn river 1996											
1		0.43			0.068	0.7	0.040	0.733	3.2	16	7.8
2	0.027	0.22	0.036	0.044	0.100	7.6	0.080	0.82	5.2	18	6.5
3		0.71			0.070	7.1	0.055	0.77	4.3	19.5	6.45
4	0.030	1.89	0.040	0.050		9.6	0.214	1.65	6.9	10	4.6
5	0.026	0.328	0.360	0.046	0.011	1.8	0.034	0.235	8.65	25.5	5.1
6	0.021	0.385	0.011	0.023	0.193	3.8	0.028	0.225	7.3	23.5	4.75
7		0.245			0.009	2.0	0.040	0.85	4.75	32	5.6
8		0.17			0.265	8.5	0.055	0.165	4.65	19.5	5.4
9	0.018	0.239	0.008	0.018	0.270	16.5	0.039	0.19	3.5	7.55	5.8
10	0.017	0.22	0.059	0.007	0.260	14.6	0.040	0.2	5.25	10.9	6.2
11		0.42			0.200	12.5	0.040	0.2	5.2	25.9	6.15
12	0.015	0.53	0.036	0.010	0.120	13.5	0.048	0.35	4.45	16.4	6.05
Cooling water reservoir KNPP 1996											
1	0.030	0.22	0.009	0.039	0.08	0.16	0.04	0.39	3.75	25.05	4.3
2	0.025	0.2	0.011	0.054	0.05	0.6	0.049	0.375	4.6	25	4.4
3	0.030	0.21	0.010	0.049	0.07	0.65	0.07	0.5	5.2	27	4.5
4	0.026	0.34	0.011	0.052	0.25	0.63	0.019	0.383	6.67	19.8	4
5	0.029	0.315	0.020	0.046	0.03	0.58	0.015	0.188	8.65	27.5	3.73
6	0.029	0.35	0.018	0.048	0.03	0.5	0.012	0.183	9.13	28.67	3.7
7	0.025	0.307	0.016	0.027	0.04	0.6	0.015	0.190	7.07	27.6	3.2
8	0.019	0.26	0.018	0.020	0.13	1.67	0.031	0.380	6.63	32.07	3
9	0.028	0.27	0.021	0.016	0.04	0.6	0.013	0.183	7.53	23.13	3.67
10	0.033	0.402	0.020	0.010	0.07	1.67	0.029	0.233	3.43	16.8	3.77
11	0.020	0.26	0.027	0.010	0.09	1.9	0.026	0.243	4.87	23.13	3.57
12	0.026	0.313	0.017	0.033	0.09	3	0.018	0.243	6.23	25.7	3.87

3.2.10 Hydrobiology

3.2.10.1Fishing

In the area of the NPP professional fishing is not pursued on the rivers Goryn, Viliya and Gnilyi Rig. Commercial fishing does not exist and only angling is practised on the rivers.

A fish farm was established in 1996 at the junction of the intake channel with the cooling reservoir. This consists of five ponds with a total area of 20 ha and was designed for raising grass carp, silver car and wels. In 1996, 2,700 three year old carp were imported and 13 t

(185,000 fish) were raised. In the same year, 7.2 t of sander, bream, white bream and reaches were caught and sold [3.2]

The Slavuta and Iziaslav districts contain fish ponds with a total area of 300 ha. These are not used for industrial fishing purposes [3.2].

3.2.10.2Bacteria, phytoplankton, zooplankton and benthos

In the upper reaches of the Goryn river in summer bacteria number 4.82 x 10^6 cells/l.

The phytoplankton is dominated by blue-green algae numbering in the winter period 8.4 x 10^6 cells/l of the total phytoplankton population of 8.5 x 10^6/l . In autumn their number is considerably less – 1.8 10^6/l.

Zooplankton is poorly developed at 2,200/m^3 and the biomass is 0.5 g/m^3.

Benthos, which develops in silted sands, is weak and during summer numbers 1,000/m^3 with a biomass of 3.5 g/m^3, and in winter the number is 1,500/m^3 with a biomass of 1.5 g/m^3.

In the middle reaches of the Goryn river phytoplankton consists of green diatom algae which in winter number 234 x 10^6 cells/l, in spring 6.5 10^6 cells/l, in summer 6.7 x 10^6cells/l and in autumn 0.7 x 10^6 cells/l.

Zooplankton in the middle reaches is poorly developed, its biomass fluctuating from 3.5 mg/m^3 in winter to 16 mg/m^3 in summer.

Benthos in the middle reaches of the river consists, in the main, of three groups: oligochaet, Tendipedidea and molluscs. Benthos reaches its peak of development in summer (up to 5,200 m^3 and a biomass of 700 g/m^3) and is at its lowest in spring (400 per m^3 and a biomass of 1 g/m^3).

3.2.10.3Higher plants and fish

Higher plants on the Goryn river are poorly developed**.** In contrast, higher plants are well developed within the cooling reservoir up to a water depth of 2 m. The most common plants here are reed (*Phragmites communis*), bullrush (*Scirpus lacustris*) and cats tail (*Typha latifolia*)

Ichthyofauna in the vicinity of the Goryn's intake is represented mainly by crucian carp, roach, perch, rarely by sandre, bream and common carp.

In the Goryn river and other rivers there are about 30 types of native fish of which the most common are: carp, river perch, sander, pike, asp, reaches, white bream, bream, ruppe, break, monkey goby, crucian carp, tench, orpe, burbot and rudd. A similar diversity of native fish is reported for the cooling reservoir [3.2]. However the reservoir also includes imported herbivorous species such as silver carp, grass carp, gibmouth buffalo and chennel wels, which are cultured for bioremeditation purposes.

3.2.11 Flora and fauna

3.2.11.1Flora

Flora in the 30 km zone is typical of that of the Ukrainian Polissia with a mixture of forest made up of oak, birch and pine but rarely beech, and a diversity of shrubs and herbs in open clearings or wetter areas forming forest steppe. Pine, fir, larch and juniper are the most widespread conifers. The most widespread deciduous trees are oak, maple, sycamore maple, lime, ash, hornbeam, elm, birch, black alder, aspen and white violet willow. Shrubs include hazel, alder, buckthorn, black and red elder, spindle, hawthorn and blackthorn. All in all there are more than 300 kinds of tree and bush.

The distribution of forest plantings is shown in Table 3.17.

Table 3.17
Distribution of different species within forest plantations [3.2]

Tree species or genus	Area occupied	
	ha	%
Pinus sylvestris	12284	59
Picea abies	1143	5.5
Larix	0.5	-
Quercus	3886	19
Fagus	14.2	0.1
Carpinus betulus	52.4	0.2
Fraxinus excelsior	53.1	0.2
Ulmus	0.9	-
Acacia	1.3	-
Betula	2120	10
Populus tremula	52	0.2
Alnus glutinosa	1285	6.2
Tilia	2.1	-
Populus deltoides	2.5	-
Castanea	0.7	-
Viburnum	1.0	-

Nine species entered into the Red Book of Ukraine are found within the part of the zone covered by the Iziaslav District, twenty species have been recorded in the Slavutia District and twenty five species have been recorded in the Shepetivka District. A recent survey by the Ukraine Academy of Sciences and the Ministry of Environment and Nuclear Safety identified the following species in the vicinity of KNPP (Figure 3.7).

- Listed in the Red Book: *Dactylorhiza incarnata, Dactylorhiza maculata, Dactylorhiza majalis, Epipactis helleborine, Epipactis atrorubens, Lilium martagon, Neottia nidus-avis, Lycopodium annotinum* and *Huperzia selago.*
- Considered uncommon: *Daphne mezereum, Gymnocarpium dryopteris, Melittis melissorphyllum, Polypodium vulgare, Typha laxmanii lepech, Rubus caesius, Arenaria stenophullar, Sempervivum ruthenicum* and *Luzula sylvatica.*

3.2.11.2Fauna

Fauna is represented by a large number of hunting game such as wild boar, elk, roe deer, beaver, muskrat and various wetland and water fowl. Animal species entered within the Red

Book of Ukraine present within the zone include: European mink, badger, ermine, kite, black stork, eagle owl and dormouse.

3.2.11.3Nature reserves

The 30 km zone includes 31 areas classified as nature sanctuaries or object of history and occupying 2,573 ha. These include the following:

Iziaslav District

- 5 sanctuaries of local importance
- 3 reserves
- 5 monuments of nature

Slavuta District

- 5 sanctuaries of local importance
- 3 parks – monuments of horticulture and park keeping
- 4 monuments of nature

Shepetivka District

- 3 sanctuaries of local importance
- 6 monuments of nature

Ostrog District

- 1 botanical sanctuary of national importance
- 1 monument of nature of national importance
- 5 sanctuaries of local importance
- 1 reserve
- 1 monument of nature of local importance
- 1 park of local importance

Parks in the Slavuta district include the Annopolsky park which as an area of 23 ha and contains trees of 200–300 years age, and the Krivinsky park which has an area of 30.5 ha and a variety of trees of 90–200 years age.

3.2.12 Background radiation and contamination

The Rivne Region was affected in 1986 by contamination arising from the accident at Chornobyl (Appendix E). The presence of radiocaesium (Cs-134 and Cs-137) and to a lesser extent radiostrontium (Sr-90) both in soils and, as a result of resuspension, in air, has to be taken into account when considering the impacts of past or projected discharges either from the existing NPP or the proposed new unit. However KNPP is not located close to the main areas of contamination and is outside the isoline for Cs-137 deposition of 1 Ci/km^2 (3.7 kBq/m^2) (Figure 3.8).

3.2.12.1Radionuclides in air

Radionuclides in air are sampled every seven days at the following sites.

- On the NPP site.
- In Netishin.
- In Bilotyn.
- In St Krivin.
- In Ostrog.
- In Slavuta.
- In Mezherich.
- In Mizoch.

The last site acts as a control. The location of these sites relative to the NPP is shown in Table 3.20. Between 30,000 and 45,000 m^3 of air is sampled in each seven day period using a "Typhoon-4" system. Filters are ashed for total activity measurement and combined over a three month period for radiochemical determination of Sr-90.

The results of measurements averaged for the years from 1990 to 1995 are presented in Table 3.18.

Figure 3.7
Location of endangered or rare species of plant in the vicinity of KNPP [3.2]

Legend
Early marsh orchid
Heath spotted orchid
Western marsh orchid
Broad leaved helleborine
Dark red helleborine
Martagon lily
Birds nest orchid
Interrupted clubmoss
Fir clubmoss
Common spurge olive
Oak fern
Bastard balm
Polypody
Bullrush
Great wood-rush
Sandwort
Russian horse-leek

Table 3.18
Average beta activity of atmospheric air (10^{-4} Bq/m^3) at different sampling points [3.1]

Year	Station No.								
	No. 1	No. 9	No.11	No.19	No.20	No.26	No.31	No. 34	Av.
1990	3.48	2.26	2.41	2.59	2.15	2.63	2.44	2.41	2.55
1991	2.59	2.33	1.3	2.41	2.07	2.44	2.33	2.85	2.29
1992	3.26	2.66	2.7	3.26	3.18	2.18	2.55	2.74	2.82
1993	2.63	5.66	3.59	4.18	3.7	3.59	3.18	3.03	3.70
1994	3.15	3.07	3.81	4.59	3.26	3.44	3.48	3.29	3.51
1995	3.4	3.03	4.33	3.66	4.44	3.26	3.44	3.59	3.64
Av.	3.09	3.17	3.02	3.45	3.13	2.92	2.90	3.00	

Total beta activity was 3.33 10^{-4} Bq/m^3 at the control post located at a radial distance of 35 km from the NPP.

The activity of radionuclides in the near-surface layer of atmospheric air is presented in Table 3.19.

Table 3.19
Concentration of radionuclides in the near-surface layer of atmospheric air [3.1]

Year	Average concentration of radionuclides (10^{-4} Bq/m^3)					
	Co-60	Cs-137	Cs-134	Ce-144	Be-7	Sr-90
1990		0.82			26.3	0.52
1991		0.12			12.2	0.22
1992		0.12			11.4	0.16
1993	0.0052	0.061	0.077		9.13	0.037
1994	0.30	0.054	0.041		10.4	0.026
1995		0.057	<MDA			0.026

Note: MDA = minimum detectable activity

3.2.12.2Radionuclides in atmospheric precipitation

Radionuclides in atmospheric precipitation are monitored at 24 sites around the NPP (Table 3.20).

Samples are collected every quarter and are analysed for total activity. For spectrometry and radiochemical isolation of Sr-90, samples are combined according to distance of the sampling site from the NPP as follows.

- Radius 1 - NPP site.
- Radius 2 - Sanitary-protective zone (3 km) (SPZ).
- Radius 3 - observation zone (8 km).

Figure 3.8
Surface contamination Cs-137 (Ci/km^2) following the Chornobyl accident

- Radius 4 - observation zone (15 km).
- Radius 5 - observation zone (20 km).
- Radius 6 - control post (Mizoch - 34 km).

For Sr-90, samples are combined every six months. The results are presented in Tables 3.21 and 3.22.

Table 3.20
Location of atmospheric precipitation samples [3.2]

Location	Distance from NPP (km)	Direction
Site	-	SE from stack
Site	-	NW from stack
Site	-	SW from stack
Site	-	NW from stack
Sanitary zone	3	NE
Sanitary zone	3	SW
Sanitary zone	3	SE
Sanitary zone	3	NW
Netishin	4	NW
Velbovno	6	NW
Ostrog	10	NW
Voloskivtsy	18	NW
Ozhenin	18	NW
Borisiv	13	SE
Lyutorka	16	SE
Slavuta	16	SE
Bilotyn	6	SE
Mezhirichi	9	SW
Pluzhnoye	13	SW
Dertka	14	SW
St Krivin	6	NE
Polyan	8	NE
Krupets	15	NE
Lisichye	13	NE
Mizoch	36	NW

Table 3.21
Total beta activity (Bq/m^2) of atmospheric precipitation in the KNPP area [3.2]

Year	Radius of observation					
	1	2	3	4	5	6
1990	7.77	6.66	7.40	6.29	7.40	7.77
1991	6.29	5.92	6.66	7.40	7.03	8.14
1992	5.85	6.14	7.33	7.77	8.36	8.58
1993	5.59	4.51	7.47	5.18	5.00	6.51
1994	5.96	4.33	4.44	5.25	5.03	6.44
1995	4.55	3.77	4.03	3.96	5.74	4.44
1996	4.07	2.74	5.74	4.14	3.16	5.44

Table 3.22
Radionuclide composition of atmospheric fallout in the KNPP area [3.1]

Year	Surface activity (Bq/m^2)		
	Be-7	Cs-137	Sr-90
1990	15200	1230	562
1991	5660	425	1350
1992		327	374
1993		195	44.2
1994		123	51.1
1995	9435	139	30.0
1995	7215	119	94.0

3.2.12.3Radionuclides in soil surface and vegetation

Samples of vegetation and soil are taken in the vicinity of the sedimentation posts, as are pasture grasses. After preparation, the samples of soil and vegetation are measured on a spectrometer, and then the soil samples combined by radius for radiochemical determination of Sr-90. Results are presented in Tables 3.23 and 3.24, along with results for conifer needles in Table 3.25.

Table 3.23a
Concentration of radionuclides in vegetation in the KNPP area [3.1]

Year	Concentration (Bq/kg)			
	Sr-90	K-40	Be-7	Cs-137
1990	8.14			8.88
1991	10.40			6.59
1992	5.88			4.77
1993				6.53
1994				12.70
1995		806	156	4.79

I-131 was not detected in any vegetation samples. According to “radiation control regulations” of the KNPP, since 1993 every sample of vegetation has been checked by gamma spectrometry. Results for Cs-137 are presented in Table 3.23b.

Table 3.23b
Concentration of Cs-137 in vegetation in the KNPP area [3.2]

Site code	Concentration (Bq/kg)				
	1993	1994	1995	1996	1997
A1	3.22	<MDL	5.85	14.7	1.43
B2	3.85	<MDL	7.20	5.08	2.91
B3	<MDL	7.36	5.96	4.49	4.65
B4	<MDL	<MDL	2.23	3.18	3.43
B5	1.00	9.47	2.54	5.00	3.15
B6	4.07	<MDL	4.60	7.44	2.95
B7	<MDL	5.62	1.90	2.46	6.14
B8	34.4	28.5	2.03	<MDL	2.38
B9	<MDL	<MDL	5.93	<MDL	3.14
B10	6.29	<MDL	1.90	2.57	2.71
A26	<MDL	<MDL	2.17	<MDL	2.81
B27	1.92	<MDL	2.08	<MDL	<MDL
A31	<MDL	<MDL	<MDL	2.95	0.95
A11	<MDL	<MDL	7.35	1.82	2.68
B12	<MDL	<MDL	2.95	5.36	<MDL
B17	<MDL	<MDL	5.19	<MDL	<MDL
A20	<MDL	<MDL	5.12	2.62	2.86
B21	3.59	3.92	3.08	7.81	<MDL
B22	<MDL	5.51	2.71	7.57	<MDL
B29	6.96	7.77	5.39	3.90	<MDL
B16	<MDL	<MDL	2.76	2.46	1.70
B18	<MDL	<MDL	5.60	<MDL	4.92
A19	<MDL	1.63	3.65	5.09	5.43
B30	<MDL	6.11	4.95	<MDL	2.72
B34	<MDL	3.22	2.23	<MDL	1.81

Note <MDL = less than minimum detection limit

Table 3.24
Radionuclides in surface soil in the KNPP area [3.1]

Year	Surface activity (Bq/m^2)			
	K-40	Cs-134	Cs-137	Sr-90
1990			585	229
1991			703	211
1992		38	1,010	216
1993		43	570	136
1994			438	206
1995	18,400	37	730	232

The overall activity of soils is caused mainly by the presence of isotopes of the uranium-thorium series and K-40. The presence of Cs-134 in some soil samples is the result of fallout following the accident at the Chornobyl NPP.

Table 3.25

Concentration of radionuclides in conifer needles in the KNPP area

Year	Concentration (Bq/kg)	
	Cs-137	Sr-90
1990	11.4	14.0
1991	6.33	15.2
1992	6.92	7.70
1993	6.18	2.96
1994	6.92	1.74
1995	4.63	8.95

3.2.12.4Radionuclides in drinking water, water bodies, sediments and algae

Water is sampled at the following locations.

- The Goryn river (at Netishin, Velbovno and Ostrog).
- The Gnilyi Rig (at Bilotyn).
- The Viliya river (at Mezhirich and Ostrog).
- The cooling reservoir (at the fish farm, the pump station and Ostrog).
- The "lake on kitchen gardens".
- The drainage channel of the cooling reservoir.
- Kholodny Strumok (at kitchen gardens).
- Urban beaches.
- The network water of Netishin (thermal drop 1).
- Drinking water (as supplied in the Laboratory of External Radiation Control).

Open waters are sampled twice per year (120 l) whereas other waters are sampled monthly (10 l). A selection of samples of algae and sediment are obtained at places where water samples are taken once a year.

Industrial waters are sampled twice per week (10 l). Sample locations include:

- the delivery channel;
- the removal channel;
- the spray ponds
- the drainage channels of the spray ponds;
- the sewage treatment works;
- the drainage from the industrial showers and special facility; and
- the chemical treatment works.

All samples are subject to gamma spectrometry following preliminary treatment. The results of these measurements are presented in Tables 3.26 to 3.29.

Table 3.26
Total beta activity in rivers and bodies of water (Bq/l) [3.1, 3.2]

Year	Makeup reservoir of sprinkling pond	Cooling reservoir			Drainage channel of Cooling Reservoir	Town beach	Lake at gardens	Gnilyi Rig river	Goryn river			Viliya river		Drinking water
		1	2	3					Above NNP	0.5 km below	1.5 km below	1	2	
1990	0.167		0.178		0.185	0.167	0.126	0.122	0.155	0.148	0.155	0	14.4	0.281
1991	0.122		0.170		0.126	0.137	0.152	0.122	0.196	0.185	0.166	0	12.21	0.296
1992	0.137	0.141	0.177	0.148	0.181	0.122	0.115	0.066	0.177	0.155	0.222	0	0.066	0.266
1993	0.104	0.170	0.207	0.185	0.196	0.081	0.222	0.088	0.118	0.199	0.107	0.211	0.066	0.266
1994	0.126	0.126	0.168	0.159	0.037	0.111	0.085	0.070	0.096	0.099	0.092	0.092	0.096	0.259
1995	0.063	0.122	0.115	0.052	0.129	0	0.092	0.088	0.140	0.122	0.181	0.177	0.104	0.259
1996		0.159	0.162	0.168										
1997		0.176	0.189	0.171										

Table 3.27
Concentrations of radionuclides (10^{-2} Bq/kg) in rivers and bodies of water [3.1]

Year	Radionuclide	Lake at gardens	Town beach	Goryn river			Viliya river	Makeup reservoir of sprinkling pool	Drainage channel of cooling pool	Gnilyi Rig river	Cooling Reservoir
				1	2	3					
1990	Cs-137	<MDA	7.33	6.29	<MDA	0.85	2.96	<MDA	<MDA	3.22	<MDA
	Sr-90	3.33	7.99	4.44	2.85	5.55	3.44	1.92	<MDA	3.03	4.07
1991	Cs-137	<MDA	<MDA	2.81	<MDA	1.96	2.29	1.37	5.92	<MDA	2.96
	Sr-90	3.85	1.70	3.59	1.74	2.41	1.70	2.11	2.59	2.74	5.44
1992	Cs-137	<MDA	<MDA	<MDA	<MDA	<MDA	0.88	<MDA	<MDA	0.55	0.77
	Sr-90	1.70	1.52	0.44	1.3	1.92	1.96	0.92	0.92	1.78	2.63
1993	CS-137	<MDA	<MDA	2.66	<MDA	0.33	<MDA	<MDA		<MDA	0.63
	Sr-90	1.26		1.48	0.88	1.26	1.11	1.44		1.89	1.48
1994	Cs-137	<MDA	<MDA	<MDA	<MDA	0.48	<MDA	<MDA	<MDA	<MDA	
	Sr-90	1.11	0.88	1.41	1.11	1.11	1.11	1.07		1.48	
1995	Cs-137	<MDA		<MDA	<MDA	<MDA	<MDA	<MDA		<MDA	0.74
	Sr-90										

MDA= Minimum detectable activity

Table 3.28
Concentration of radionuclides and total radioactivity (Bq/kg) in sediments [3.1]

Year	Radionuclide	Goryn river			Lake at gardens	Town beach	Viliya river	Makeup reservoir of sprinkling pond	Ginilyi Rig river	Drainage channel of cooling reservoir	Cooling Reservoir
		1	2	3							
1990	Cs-137 Sr-90 Act.										
1991	Cs-137 Sr-90 Act.										
1992	Cs-137 Sr-90 Act.	5.92 <MDA 66.60						<MDA 0.13 11.30	<MDA 2.37 27.00	<MDA 18.00 311	
1993	Cs-137 Sr-90 Act.				<MDA 1.41 4.07	0.36 <MDA 48.10	<MDA 4.44 77.70				
1994	Cs-137 Sr-90 Act.				<MDA 0.74 40.70	<MDA 1.07 40.70					
1995	Cs-137 Sr-90 Act.				<MDA 2.22 74.70	<MDA 2.22 74.70					

"act" is assumed to represent total activity
MDA = minimum detectable activity

Table 3.29
Concentrations of radionuclides and total radioactivity (Bq/kg) in algae [3.1]

Year	Radionuclide	Goryn river			Lake at gardens	Town beach	Makeup reservoir of sprinkling pool	Viliya river	Gnilyi Rig river	Coolingreservoir
		1	2	3						
1990	Cs-137 Sr-90 act.									
1991	Cs-137 Sr-90 act.									
1992	Cs-137 Sr-90 act.	<MDA <MDA 599	<MDA 18.5 958	<MDA 39.6 1590	<MDA <MDA	<MDA <MDA	<MDA 11.8 287		<MDA <MDA	
1993	Cs-137 Sr-90 act.		<MDA 7.84 1220					<MDA 11.9 1370		
1994	Cs-137 Sr-90 act.	<MDA 2.78 485		<MDA 1.33 507	<MDA 551	<MDA 2.96 1170	<MDA 11.3 400	<MDA 5.0 622		
1995	Cs-137 Sr-90 act.									

"act" is assumed to represent total activity
MDA = minimum detectable activity

Separately, Koval *et al.* [3.4] conducted sporadic monitoring of tritium in waters around KNPP during 1986. They noted an increase in tritium concentration in the cooling reservoir with time. They were unable to reach any conclusion regarding migration of tritium through various water bodies and pits within the 30 km zone.

Ground waters are monitored every month. There are twelve monitoring wells within the 30 km zone and six control wells. The volume of the sample is 5 l. Both total beta activity and tritium contents are measured.

3.2.12.5 Radionuclides in food products and products of local origin

Food samples are obtained from three collective farms close to the NPP (Netishin farm, Bilotyn farm and Mezherichi farm). Milk is obtained monthly while cattle are grazing in the open (i.e. from May to September inclusive). Other samples are obtained at harvest. Meat is not sampled.

Results are provided in Tables 3.30 and 3.31.

Table 3.30
Concentrations of radionuclides in milk (Bq/l) [3.1]

Year	K-40	Cs-137	Cs-134	Sr-90
1990		9.81	5.14	0.87
1991		5.86	1.81	0.49
1992		2.37	0.35	0.56
1993		3.00	0.58	0.08
1994		2.16		
1995	62.4	1.54	0.38	0.13

Table 3.31
Concentrations of radionuclides in local agricultural products (Bq/kg) [3.1]

Year	Radionuclide	Potatoes	Wheat	Barley	Mushrooms	Fish	Oats
1990	Cs-137	0.92	2.42	2.5	7.4	2.18	<0.37
	Cs-134						
	Sr-90	1.12	0.34	0.85	0.27	0.41	0.58
1991	Cs-137	1.26	0.15	3.18	146	2.96	2.33
	Cs-134				21.8		
	Sr-90		3.08	2.55		0.91	
1992	Cs-137	<MDA	3.11	2.38	178	1.33	0.98
	Cs-134				9.25		
	Sr-90	0.77	1.30	1.31			
1993	Cs-137		<MDA	1.11	63.8	0.99	1.41
	Cs-134				2.48		
	Sr-90					1.04	
1994	Cs-137		<MDA	0.52	51.4	0.27	<MDA
	Cs-134				1.70		
	Sr-90			0.38		0.99	
1995	Cs-137	<MDA	<MDA	<MDA	50.70	2.44	<MDA
	Cs-134	<MDA	<MDA	<MDA	0.83	<MDA	<MDA
	Sr-90						

Milk, and to a lesser extent mushrooms, show a trend in decreasing Cs-137 concentration which reflects the consequences of the Chornobyl accident of 1986. It is reported [3.1] that I-131 has not been detectable in milk samples during operation of the NPP.

3.3 References

3.1 Khmelnitsky NPP - Data for Environmental Impact Assessment - UKKEOOOOIK Kyivenergoproekt, 1996.

3.2 Information for updating of EIA for KhNPP (Parts 2 and 6) SSEC CSER, November 1997.

3.3 Review of the seismological information available at the Kyivenergoproekt Institute on the Khmelnitsky NPP and Rivne NPP sites, which forms the basis for taking decisions on the seismicity of the sites. Kyivenergoproekt, 1996.

3.4 Koval, H.N., Svarichevska, Ye V et al. The results of environmental studies of tritium content in areas affected by Ukrainian NPPs. In: Proceedings of an Academic Workshop on Ecology of the NPP 4-8 October, Odessa, 1993.